University of Mumbai

No. AAMS(UG)/ 125 of 2022-23

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office circular No. UG/52 of 2021 dated 21st January, 2021, relating to the revised scheme (Rev-2019 'C' Scheme) for the B.E. in Chemical Engineering (Sem. III to VIII).

You are hereby informed that the recommendations made by the Ad-hoc Board of Studies in **Chemical Engineering** at its meeting held on 4th May, 2022 and subsequently passed in the Faculty and then by the Board of Deans at its meeting held on 5th July, 2022 **vide** item No. 6.37 (R) have been accepted by the Academic Council at its meeting held on 11th July, 2022 **vide** item No. 6.37 (R) and that in accordance therewith, the revised syllabus of **B.E. (Chemical Engineering) (Sem.- VII & VIII) (CBCS) (REV- 2019 'C' Scheme)**, has been brought into force with effect from the academic year 2022-23. (The circular is available on the University's website www.mu.ac.in).

(Dr. Shailendra Deolankar)
I/c Registrar

MUMBAI – 400 032
20th October, 2022

To

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.37 (R)/11/07/2022

****

No. AAMS(UG)/ 125 -A of 2022-23 — 20th October, 2022

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Chemical Engineering,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Information & Communication Technology,
6) The Co-ordinator, MKCL.

(Dr. Shailendra Deolankar)
I/c Registrar

Copy to :-

1. **The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
2. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
5. **The Deputy Registrar, Executive Authorities Section (EA),**
6. **The Deputy Registrar, PRO, Fort, (Publication Section),**
7. **The Deputy Registrar, (Special Cell),**
8. **The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
9. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

1. **P.A to Hon'ble Vice-Chancellor,**
2. **P.A Pro-Vice-Chancellor,**
3. **P.A to Registrar,**
4. **All Deans of all Faculties,**
5. **P.A to Finance & Account Officers, (F.& A.O),**
6. **P.A to Director, Board of Examinations and Evaluation,**
7. **P.A to Director, Innovation, Incubation and Linkages,**
8. **P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
9. **The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
10. **The Director of Board of Student Development,**
11. **The Director, Department of Students Walfare (DSD),**
12. **All Deputy Registrar, Examination House,**
13. **The Deputy Registrars, Finance & Accounts Section,**
14. **The Assistant Registrar, Administrative sub-Campus Thane,**
15. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
16. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
17. **The Assistant Registrar, Constituent Colleges Unit,**
18. **BUCTU,**
19. **The Receptionist,**
20. **The Telephone Operator,**
21. **The Secretary MUASA**

for information.

AC – 11 July, 2022

Item No. – 6.37 (R)

University of Mumbai

Revised Syllabus for

B.E. (Chemical Engineering)

(Sem. - VII to VIII)

(Choice Based Credit System)

(With effect from the academic year 2022-23)

University of Mumbai

Title of Course	B.E. (Chemical Engineering)
Eligibility	After Passing Third Year Engineering as per the Ordinance 0.6242
Passing Marks	40%
No. of years/Semesters:	4years / 8 semester
Level:	~~P.G.~~ / U.G./ ~~Diploma / Certificate~~
Pattern:	~~Yearly~~ / Semester
Status:	~~New~~ / Revised
To be implemented from Academic Year :	With effect from Academic Year: 2022-23

Dr. Parag R Gogate
Chairman
of Ad-hoc Board of Studies in
Chemical Engineering

Dr. Suresh K. Ukarande
Associate Dean,
Faculty of Science and
Technology

Dr Anuradha Majumdar
Dean,
Faculty of Science and
Technology

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this, Faculty of Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome-based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum is more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore, in the present curriculum,skill-based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for final Year of Engineering from the academic year 2022-23

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill-based activities and project-based activities. Self-learning opportunities are provided to learners. In the revision process this time, in particular Revised syllabus of ‘C ‘ scheme, wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme ‘A' and ‘B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum, overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD’s/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble to the Revision of Syllabus in Chemical Engineering

Development in all fields including Chemical Engineering along with use of software for process plant and process engineering, there is demand on academician to upgrade the curriculum in Education. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. The Curriculum must integrate knowledge of the basic and advanced sciences with problem solving and creativity abilities.

The Curriculum must be broad enough to cover all areas from design to operation of Process plants. It should be deep enough to enable the learners to carry out research and develop products to meet rapidly changing needs and demands. The major challenge in the current scenario is to ensure quality to the stakeholders. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program.

With these objectives, online meeting was organized on 30th May 2020 which was attended by heads of the departments and subject faculty of affiliating Institutes. The program objectives and outcomes were thoroughly discussed in line with AICTE guidelines and the core structure of the syllabus was formulated keeping in mind choice-based credit and grading system curriculum along with more emphasis on learning outcomes. Thus, Skilled based laboratories and Mini projects are introduced in appropriate semesters. Views from experts and UG teachers were taken into consideration and final Academic and Exam scheme was prepared with the consent of all the members involved. Subject wise online meetings were held by various subject's convenors to finalize the detail syllabus in 2020.

The Program Educational Objectives finalized for the undergraduate program in Chemical Engineering are:

1. To prepare the student for mathematical, scientific and engineering fundamentals
2. To motivate the student to use modern tools for solving real life problems
3. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social and environmental responsibilities.
4. To prepare the student in achieving excellence which will benefit individually and society at large.

Board of Studies in Chemical Engineering

Dr. Parag R Gogte- Chairman
Dr. Kalpana S. Deshmukh - Member
Dr. Sunil J.Kulkarni - Member
Dr. Ramesh S. Bhande - Member
Dr. ShyamalaP. Shingare - Member
Dr. Manisha V. Bagal– Member
Dr. Aparna N. Tamaskar– Member

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2022-2023)
Semester VII

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC701	Instrumentation Process Dynamics and Control	3	-	-	3	-	-	3
CHC702	Chemical Engineering Equipment Design	3	-	-	3	-	-	3
CHDO703X	Department Optional Course 3	3	-	-	3	-	-	3
CHDO704X	Department Optional Course 4	3	-	-	3	-	-	3
IOC701X	Institute Optional Course 1	3	-	-	3	-	-	3
CHL701	Instrumentation Process Dynamics and Control Lab	-	3	-	-	1.5	-	1.5
CHL702	Chemical Engineering Equipment Design Lab	-	3	-	-	1.5	-	1.5
CHL703	Hazard and Risk Analysis Lab	-	2	-	-	1	-	1
CHP701	Major Project I	-	6#	-	-	3	-	3
	Total	15	14	-	15	7	-	22

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC701	Instrumentation Process Dynamics and Control	20	20	20	80	3	-	-	-	100
CHC702	Chemical Engineering Equipment Design	20	20	20	80	3	-	-	-	100
CHDO703X	Department Optional Course 3	20	20	20	80	3	-	-	-	100
CHDO704X	Department Optional Course 4	20	20	20	80	3	-	-	-	100
IOC701X	Institute Optional Course 1	20	20	20	80	3	-	-	-	100
CHL701	Instrumentation Process Dynamics and Control Lab	-	-	-	-	3	25	25	-	50
CHL702	Chemical Engineering Equipment Design Lab	-	-	-	-	-	25	-	25	50
CHL703	Hazard and Risk Analysis Lab	-	-	-	-	-	25	-	25	50
CHP701	Major Project I	-	-	-	-	3	25	-	25	50
	Total	-	-	100	400	-	100	25	75	700

Department Optional Course 3 (Sem VII)

Engineering Stream (Elective Code)	Technology Stream (Elective Code)	Management Stream (Elective)
Corrosion Engineering (CHDO7031)	Fundamental of Colloids and Interface Science and Technology (CHDO7032)	Project Management for Chemical Process Industries (CHDO7033)

Department Optional Course 4 (Sem VII)

Engineering Stream (Elective Code)	Technology Stream (Elective Code)	Management Stream (Elective)
Chemical Plant Safety and Hazards (CHDO7041)	Petroleum Refining Technology (CHDO7042)	Operation Research (CHDO7043)

Institute Optional Course 1

Institute Optional Course 1 (SemVII)		
1.ProductLifecycleManagement(IOC7011)	4.DesignofExperiments(IOC7014)	7.Disaster Management and MitigationMeasures(IOC7017)
2.ReliabilityEngineering(IOC7012)	5.OperationResearch (IOC7015)	8.EnergyAuditandManagement (IOC7018)
3.ManagementInformationSystem (IOC7013)	6.CyberSecurityandLaws (IOC7016)	9.DevelopmentEngineering (IOC7019)

 # Indicates work load of Learner (Not Faculty), Faculty load for Major Project. semester VII – ½ hour per week per project group

Course Code	Course Name	Credits
CHC701	Instrumentation Process Dynamics and Control	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Engineering Physics and Engineering Chemistry.
2.Engineering Mathematics: Linear Algebra, Differential equations and Laplace Transforms
3. Basic laws of Conservations.

Course Objectives

1. To understand basics of process control system and selection of variables for control system design
2. To explaindynamic behavior of processes based on standard process inputs
3. To analyze the characteristics of different measuring instruments
4. To apply the knowledge of closed loop response in selecting different types of control modes based on process requirements.
5. To analyze the stability of closed loop systems based on Bode stability criteria
6. To apply controller performance strategies in designing and tuning controllers.

Detailed Syllabus

Module No	Course Contents	No. of Hours
1	1.1 Introduction to Process Control, Typical Control Problems, A Blending Process Example. 1.2 Control Strategies, the Rationale for Dynamic Process Models, General Modeling Principles. 1.3 Degrees of Freedom Analysis, Selection of Controlled, Manipulated and Measured Variables.	04
2	2.1 Transfer Functions of Typical Systems, First and Second Order Systems, Properties of Transfer Functionsand Transfer Functions of Systems in Series.	12

	2.2 Time Delay Processes, Linearization of Non-linear Systems, Dynamic Behavior of Processes, Standard Process inputs, Response of First Order Processes, Response of Second Order Processes, Response of Integrating Processes 2.3 Development of Empirical Models from Process data, fitting First orderusing Step Tests	
3	3.1 Introduction Standards and Calibration, Elements of MeasuringSystems, Classification of Instruments, PerformanceCharacteristics, Errors in Measurement. 3.2 Measuring Instruments:Flow Measurement, Temperature Measurement, LevelMeasurement, Pressure Measurement.Control Valve Types, Characteristics and Sizing.	08
4	4.1 Basic Control Modes, Features of PID and On-off Control, Response of Feedback Control Systems, 4.2 Closed-Loop Transfer Functions, Closed-Loop Response	04
5	5.1 Stability of closed loop systems, Frequency Response, 5.2 Stability based on Bode criteria.Gain and Phase Margins	08
6	6.1 Controller Design and Tuning (Zeigler-Nichols controller tuning) 6.2 Performance Criteria, Guidelines for common control loops	03

Course Outcomes

On completion of the course the studentwill:

1. Develop model of different dynamic systems.
2. Compute system response for various changes in input to the system based on application of Laplace Transform
3. Analyze and select measuring instruments for measuring various process parameters
4. Design controller for controlling output of a specified system
5. Compute stability analysis of a feedback control system based on Frequency response (Bode diagram)
6. Design controller parameters based on Zeigler-Nichols controller tuning method.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

5. Only **Four questions need to be solved.**

Recommended Books

1. Dale E. Seborg, Thomas F. Edga, Duncan A. Mellichamp Francis J. Doyle;Process Dynamics and ControlIII; Third Edition; John Wiley & Sons (Asia) Pvt Ltd., New Delhi - 110002
2. Donald R. Coughanowr, Steven E. LeBlanc; Process Systems Analysis and Control; Third Edition; Mcgraw-Hill Chemical Engineering series.
3. George Stephanopoulos, Chemical process Control An Introduction to Theory and Practice;; 1st Edition; Prentice Hall;1984
4. Donald P. Eckman; Industrial Instrumentation, Wiley Edition

Reference Books

1. William L. Luyben; Process Modeling Simulation and Control for Chemical Engineers; 2nd Edition; Mc-Graw Hill Publishing Co.
2. Prabir Kumar Sarkar, Advanced Process Dynamics and Control, PHI Learning Eastern Economy Edition.
3. Peter Harriott; Process Control, Tata McGraw-Hill Edition
4. S. K. Singh; Industrial Instrumentation and Control; Second Edition; Tata McGraw-Hill publishing Company Limited, New Delhi.

Semester VII

Course Code	Course Name	Credits
CHC702	Chemical Engineering Equipment Design	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory		Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral		Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	
Test-I	Test-II	Average					
20	20	20	80	03 Hrs	--	--	100

Prerequisites

1. Fundamentals of units
2. Elementary theory of engineering mechanics,
3. Engineering drawing.
4. Knowledge of heat transfer and mass transfer
5. Concepts of mechanical operations

Objectives

1. Familiarize with design preliminaries and equipment testing methods.
2. Design of pressure vessels.
3. Design of reaction vessels.
4. Design of heat exchangers.
5. Design of tall columns
6. Understand the concept of storage tank and supports.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Introduction**: Introduction to Chemical process equipment design. Nature of process equipment, Basic consideration in process equipment design, Standards, codes & their significance, equipment classification & selection, material of construction for chemical process equipment, Design pressure, Design temperature, design stress & design loads, factor of safety, Corrosion Allowance & weld joint efficiency.	04

	Equipment Inspection: Methods of Inspection of EquipmentsRadiographyUltrasoundDye PenetrationFatigue assessmenttestPressure test	
2	**Pressure vessel :** Type of pressure vessels, code & standard for pressure vessels (IS: 2825:1969).Pressure Vessel Subjected to InternalPressure. Complete design of cylindrical Pressure vessel as per IS: 2825: 1969. Study, selection & design of various Heads, material of construction of construction, openings/nozzles, Flanged joints. **High Pressure Vessels:** Theories of failure, material of construction, constructional method of highPressure vessels.Design of multi layered high pressure vessels (stress distributiondiagram).	**10**
3	**Reaction vessel :** Introduction, material ofconstruction, Classification of reaction vessels, Heating system. Types of jackets& design of plain jacket.Types of agitators & their application. Components of agitation system.Power requirement of agitators & their applications, system which includes design of shaft based on equivalent bending moment and critical speed. Design of blades & Blade assembly.	**08**
4	**Heat exchangers :** Material of construction, Design of shell and tube heat exchanger (U-tube and fixed tube sheet as per IS: 4503, TEMA standards)includes shell, tube, tube sheets, channel and channel cover, flanged joints. **Evaporators** Design of standard vertical evaporator with design of calendria and tube, flange evaporator drums andheads.	**08**
5	**Tall columns: (**distillation column) Basic features of columns, stresses in column shell.Shell thickness determination at various heights.Study ofType of column internals (plate and packed column) andsupports fortrays.	**04**
6	**Storage vessels and supports :** Study of Various types of storage vessels and application.Atmospheric vessels, vessels for storing volatile & non-volatile liquids.Storage of gases, Losses in storage vessel. Various types of roofs used for storage vessels. (calculation of variation in thickness with height only) Introduction & classification of support. (Study)	**04**

Course Outcome

On completion of the course the students should be able to:

1. Apply the concept of Chemical Engineering equipment design terminologies and equipment testing methods.
2. Design pressure and high pressure vessel.

3. Design reaction vessel and agitator.
4. Design heat exchanger and evaporator.
5. Design distillation column.
6. Illustrate and explain the concept of storage tank and types of supports

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportional to number of respective lecture
- Question paper will comprise of total **six questions, each carrying 20marks**
- **Question 1** will be compulsory and should cover **maximum contents of thecurriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3)
- Only **Four questions need to besolved.**

Recommended Books:

1. Process Equipment Design by M.V. Joshi Macmillan India.
2. Process Equipment Design- Vessel Design by E. Brownell and Edwin, H. Young. John Wiley, New York 1963.

Reference Books:

1. Chemical Engineering volume 6- Design by J.M Coulson, J.F. Richardson and P.K. Sinnot, Pregamovr press, International edition 1989.
2. Chemical Engineering Design, Fifth edition, Ray Sinnott and Cavin Towler, Elsevier, Butterworth-Heinemann publications
3. Introduction to Chemical Equipment Design- Mechanical aspects by B.C. Bhattacharya CBS Publications

Semester VII

Course Code	Course Name	Credits
CHDO7031	Corrosion Engineering (Department Optional)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Knowledge of Physical Chemistry and Electrochemistry
2. .Knowledge of reaction kinetics
3. .Knowledge of material selection.

Objectives

1. To understand corrosion and its related mechanisms and Basic terminologies.
2. Understanding different forms of corrosion and its conditions
3. To understand design aspects for corrosion prevention
4. To Understand the Methodology, Methods and Materials to prevent theCorrosion.
5. To describe the Corrosion Protection techniques, Coatings, Anodic protection, Cathodic Protection and its related topics.
6. To describe and demonstrate the Corrosion monitoring and control methods.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1.	**Introduction** Definition of corrosion, Principle of corrosion , Classification of corrosion,Consequences ofCorrosion, Functions and role of a corrosion engineer, Corrosion rate expression, What is over potential, Polarization (Activation and Concentration polarization)	6
2.	**Environmental factors and corrosion**: Corrosion in water and aqueous solutions, Corrosion in sulphur bearing solutions, Microbiologically induced corrosion, Corrosion in acidic and alkaline process streams.	5

3.	**Corrosion Electrochemistry and Thermodynamics** Electrochemical Reaction (Anodic and Cathodic process), Faraday's law, Free Energy, standard electrode potential Nernst equation	**6**
4.	**Galvanic and concentration cell corrosion:** Basic concepts, Experimental measurements, and determination of rates of galvanic corrosion, Concentration cells.	**5**
5.	**Eight forms of corrosion:** Galvanic or two metal corrosion, Crevice corrosion, pitting, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, hydrogen damage	**8**
6.	**Corrosion Prevention:** Design aspects to minimize the corrosion, Material selection, Alteration of environment, Cathodic and anodic protection, coatings	**6**

Course Outcome

On completion of the course the students will be able to:

1. Understand corrosion and its related mechanisms and Basic terminologies.
2. Classify different forms of corrosion and its conditions.
3. To describe the Corrosion Protection techniques, Coatings, Anodic protection, Cathodic Protection.
4. Apply the Methodology, Methods and Materials to prevent theCorrosion
5. The understanding the modern theory principles behind corrosion.
6. To describe and demonstrate the Corrosion monitoring and control methods.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**
Firsttestbasedon approximately40%ofcontentsandsecondtestbasedonremainingcontents (Approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total six questions, each carrying 20marks
3. Question 1 will be compulsory and should cover maximum contents of the curriculum.
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only Four questions need to be solved.

Recommended Books:

1. M.G.Fontana, Corrosion Engineering, Tata McGraw- Hill (New Delhi), 3rd Ed.

2. H. H. Uhlig: Corrosion and Corrosion Control. An Introduction to Corrosion Science and Engineering. John Wiley and Sons
3. Jones, D.A., Principles and Prevention of Corrosion, Prentice-Hall (1996).
4. Pierre R. Roberge, Corrosion engineering: principles and practice, McGraw-Hill (2008).

Reference Books:

1. G.L.Shvartz and M.M.Kristal, Corrosion of Chemical Apparatus (1959) Chapman Hall Ltd. London.
2. An introduction to Electrochemistry by Samuel Glasstone, Affiliated East West Press Private, Limited.
3. Pierre R. Roberge, Handbook of corrosion engineering, McGraw-Hill (2012). 2nd ed.

Semester VII

Course Code	Course Name	Credits
CHDO7032	Fundamental of Colloids and Interface Science and Technology (Department Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	3

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/ OR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Knowledge of chemistry, physics, physical chemistry and mathematics.
2. Knowledge of fluid mechanics
3. Knowledge of thermodynamics

Course Objectives

The overall aim of this course is to develop a broad background in colloids and interfaces which will enable students to:

1. To studyconcepts and applications of surface tension, adhesion and capillarity of liquids.
2. To study Intermolecular, nanoscale and interfacial forces in organic, polymeric, biological and aqueous systems.
3. To study Mesoscale phenomenon and its thermodynamics in application of soft matter.
4. To study mechanism of Stability of nanoparticle dispersions.
5. To study nanofluids and its application and working.
6. To study concepts of advanced and functional interfaces.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Surface Tension, Adhesion and capillarity:** Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; Apolar (van der Waals) and polar (acid-base) components of interfacial tensions.	

	Young-Laplace equation of capillarity; examples of equilibrium surfaces, multiplicity, etc. Stability of equilibrium solutions; Contact angle and Young's equation;Determination of apolar (Van-der Waals) and acid-base components ofsurface/interfacial tensions. Free energies of adhesion; Kinetics of capillary and confined flows.	**04**
2	**Intermolecular, nanoscle and interfacial forces in organic, polymeric,biological and aqueous systems** Van der Waals, Electrostatic double layer, Acid-base interactions includinghydrophobic attraction and hydration pressure.	**08**
3	**Mesoscale thermodynamics** Gibbs treatment of interfaces; concept of excess concentration; variation ofinterfacial tensions with surfactant concentration**.** **Mesoscale phenomena in soft matter and applications** Adhesion, wetting, nucleation, flotation, patterning of soft material by self-organization and other techniques.	**08**
4	**Stability of nanoparticle dispersions:** DLVO and DLVO like theories and kinetics of coagulation plus generalprinciples of diffusion in a potential field/Brownian movement.	**08**
5	**Nanofluidics:** Stability of thin (< 100 nm) films; self-organization in confined systems; meso-patterning.	**05**
6	**Advanced and Functional Interfaces:** Superhydrophobicity, functional coatings, structural colors, nano-adhesives;nanocomposites.	**06**

Note: Video, Digital, NPTL content can be used for equipment section of each chapter /unit operation.

Course Outcomes

At the end of the course student will be able to:

1. Understand of basic nomenclature, concepts and tools of colloid and interface science and engineering; multi-phase nano-systems; mechanics and thermodynamics on small scales.
2. Understand the differences between the surface and bulk dominated regimes and behavior and exploitation of nano-behavior.
3. To understand and apply Mesoscale phenomenon and its thermodynamics in application of soft matter.
4. To appreciate mechanism of Stability of nanoparticle dispersions.
5. Be aware of nanofluids and its application and mechanism of working.
6. Comprehend concepts of advanced and functional interfaces and its application in chemical industries.

Assessment

Internal

- Assessment consists of average of two tests which should be conducted at proper interval

End Semester Theory Examination

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions to be solved
- Question no.1 will be compulsory and based on entire syllabus where in subquestions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to eachmodule.

Reference Books:

1.Principles of Colloid and Surface Chemistry, Paul C. Hiemenz, Marcel Dekker, any edition starting with the 2nd edition, 1986.
2.Miller, C. A. and P.Neogi, "Interfacial Phenomena : Equilibrium and Dynamic Effects", 2nd Edn., Marcel Dekker, NY, 2007.
3.Hiemenz, P. C., and R.Rajgopalan, "Principles of Colloid and Surface Chemistry", 3rd Edn., Marcel Dekker, NY, 1997.
4. Adamson, A. W. and Gast, A., "Physical Chemistry of Surfaces", 6th edition, John Wiley and Sons, 1997.
5. Stokes, R. J. and Evans, D.F., "Fundamentals of Interfacial Engineering", Wiley-VCH, N.Y., 1996.

Semester VII

Course Code	Course Name	Credits
CHDO7033	Project Management for Chemical Process Industries (Departmental Optional Course)	3

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
20	20	20	80	3 hrs	-	-	-	100

Prerequisites

1.Communication skills
2.Mathematical skills,
3.Analytical, logical and reasoning Skills
4.Economics

Course Objectives

1. To understand basic concepts project management and application of PM to process industries through class teaching and case studies
2.To understand project feasibility reports and
3.To learn about various clearances required to start an industry
4.To learn various project organizations
5.To learn basics of tendering and contracting
6.To learn various tools and techniques used in PM and understand role of entrepreneurship in the society for the economic growth.

Detailed Syllabus

Module no.	Topics	Contact Hours
1	**Concepts of project management:** Definition of project, project management, project types, project life cycle,Definition of project management, Project deliverables and Stakeholder management,Difference between project management and formal/product management, Role-responsibilities and skills of project manager, project overruns. **Case studies** : Superclean paperboards, DEMCO manufacturing , Accorn, Govardhan group	08
2	**Project management in process industries:** Project strategy,Project specification, Project engineering, Detailed design,Procurement, Construction,	03

	Commissioning and Closure	
3	**Feasibility report, licensing and clearances** **Feasibility reports:**Pre feasibility report,Techno economic feasibility report,Detailed project report **Contents of feasibility report**:Raw material survey, Market survey and demand study, technical study, location survey, financial survey. Types of cost estimates, Project selection criteria **Estimation of project profitability:** Payback period, Return on Investment (ROI) ,Net Present Value (NPV) , Internal Rate of Return (IRR), Benefit Cost Ratio (BCR) **Industrial license and LOI**, Various laws & regulations governing industries, Need for clearances and influences on project, List of various clearances. **Case studies:**Coal fired boilers project,Plant on river Yangtze,SIRIS pharma Hyderabad	10
4	**Project organization and contracting** Project scope, Types of WBS,Preparation of WBS,Development of responsibility matrix, development of project communication plan. The traditional management structure, Project management organizational structure: pure project, matrix, task force, Project team- responsibilities of various members. Contracts types, selection criteria,3R of contracting, types of reimbursements and tendering procedure **Case studies:**Hindustan oil company-housing project,Comfortflex,Hamad petroleum company	08
5	**Tools and techniques in project Management:** **Project scheduling and execution**: List of various tools and techniques used in project management, Project execution plan (PEP), Bar charts/GANTT charts, LOB Networking techniques PERT and CPM(critical path, float,total float,AOA and AON diagrams), Material Management- ABC and VED Analysis, Economic Order Quantity (EOQ), CAT vs RAT, Time and cost control tools and techniques.	07
6	**Entrepreneurship:** Definition, Concept of entrepreneur and entrepreneurship, Ccompetencies of entrepreneur, Classification and types of entrepreneurship,Creativity techniques for entrepreneur,Startups- pre requisites,stages,ideas and funding Case study:Any example of startup and entrepreneur	03

Course Outcome

On completion of the course the students will be able to:

1. Understand and apply concepts and knowledge of project management to manage projects in process industries
2. Apply knowledge of engineering and project management to create feasibility reports.
3. Understand how to get various clearances required to start industry by following professional ethics.
4. Prepare project organization charts, work breakdown structure,responsibility matrix,project communication plan etc to facilitate better communication and management of projects
5. To apply their knowledge to prepare tenders and contracts which will satisfy needs of society and environment
6. To use tools of PM [Cost benefit analysis,Project execution plan (PEP), Bar charts/GANTT charts, LOB,Networking techniques (PERT/CPM etc] , to analyze and solve complex problems and will be motivated to become entrepreneurs

Internal Assessment

Consisting **Two Compulsory Class Tests**

Firsttestbasedon approximately40%ofcontentsandsecondtestbasedonremainingcontents (Approximately 40% but excluding contents covered in TestI).

End Semester Theory Examination:

Question paper will comprise of 6 questions, each carrying 20 marks.

Total 4 questions need to be solved.Question No.1 will be compulsory and based on entire syllabus wherein subquestions can be asked.Remaining questions will be randomly selected from all the modules.

References:

1. Project Management,Choudhary, S.,Tata Mc Graw Hill(module 1 to 6)
2. Total Project Management,Joy, P. K.,(module 1 and 3)
3. Project Management for process Industries, Gillian Lawson,IchemE(Module 1 and 2)
4. Project Management Case Studies,Harold Kerzner,Second edition,John Wiley and Sons(for case studies)
5. Project Management-The Managerial Process,Clifford Gray, 6th edition,McGraw Hill (module 1,3,4,5)
6. Plant Design and Economics for Chemical Engineers,Klaus D Timmerhaus,5th edition,McGraw Hill(Module 3 and 5)
7. Theory and problems in financial management, Khan,M.Y.; Jain,P.K.; Second Edition,Tata McGraw Hill (Module 2 and 4)
8. Fundamentals of Financial Management, Vyuptakesh Sharan , Second Edition, Pearson publications(module 2 and 4)
9. Dynamics of entrepreneurial development and management,Vasant Desai (module 6)
10. Project Management Workbook, ICMR India (Module 1,2,3,4,5,6)
11. Entrepreneurship and Startups-Prof Nishant Dubey and Prof Mishra,NITTTR,Bhopal

Semester VII

Course Code	Course Name	Credits
CHDO7041	Chemical Plant Safety and Hazards (Department Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Fundamentals of chemical processes.
2. Knowledge of heat transfer, mass transfer and chemical reaction engineering
3. Concepts of mechanical operations.
4. Knowledge of plant operation and maintenance.

Course Objectives

1. To give overview about occupational health, industrial hygiene, accidental prevention techniques to the students.
2. To give the knowledge about fire and explosion.
3. To train the students about Fire and Explosion prevention methods and Reliefs techniques.
4. To make the student aware about safety in process and plant.
5. To train the students about hazard identification and risk assessment.
6. To train the students about safety procedures and design and expert manpower to handle the complex industrial environment.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Introduction:** History and development of safety movement, Safety programs, Need for safety, Engineering ethics, accident and loss	7

	statistics, acceptable risk, The nature of accident process, Identifying the causative and initiating factors of Industrial accidents, Accident prevention and control techniques, Plant safety inspections, Major Industrial Disasters (Case Studies) Bhopal disaster (1984), Chernobyl Disaster, Fukushima Daiichi Disaster etc. Case studies. **Industrial Hygiene:** Definition of Industrial Hygiene, Phases of industrial hygiene, Industrial Hygiene: Control Methods, Substitution, Changing the process, isolation, wet method, local exhaust ventilation, personal hygiene, housekeeping and maintenance, waste disposal, special control measures, Government Regulations, Anticipation and identification, MSDS, Evaluation workers exposure to Volatile toxicants, dust, noise, toxic vapors, Industrial Hygiene : Control	
2	**Fire and Explosions** Fire: Fire triangle, Classification of fires, Flammability characteristics of liquids and gases, Limiting oxygen concentration, ignition energy, auto ignition, autoxidation, adiabatic compression. Ignition sources, spray and mist. Common causes of industrial fires. Explosion: Detonation, Deflagration, Confined explosion, unconfined explosion, VCE, BLEVE, Problems on energy of chemical explosion.	**5**
3	**Concept to Prevent Fire and Explosion (Fire and Explosion prevention methods and Introduction to Reliefs) and Introduction to Reliefs** Inerting: vacuum and pressure purging, combined purging, Controlling Static electricity: Bonding and grounding, dip pipes, Explosion-proof equipment instruments, ventilation. Sprinklers systems. Fire-fighting systems:Different types of portable fire extinguishers, their installation, periodic inspection and operation, Replacement of Halon with safer substitutes, Fire hydrant system, Fire monitors, sprinkler system and deluge system, Carbon-dioxide flooding system, Foam Pourer system Relief concept: Principle of pressure system, Pressure, Hazards of steam, Mechanism of Steam explosion, key components and safety features of pressure system, Failure of pressure system, Hazards of overpressure and over temperature in pressure system, location of reliefs and types of relief.	**6**
4	**Chemical Reactivity and Safety In Plant Operation And Maintenance** Commitment, Awareness and Identification of reactive chemical hazards, characterization of reactive chemical using calorimeter, controlling reactive hazards. Safe procedures for plant start-up and shut-down, Pipeline colour coding for identification of contents, Safety precautions for working on pipelines, Safety in preventive and emergency maintenance work.	**6**
5	**Hazard Identification and Risk Assessment** Hazard Identification:Hazard identification and risk control approaches and techniques**,** Reactive approach-Incident recall technique (after-the-	**6**

	event approach), Proactive approaches: Critical incident review technique (before-the-event approach), Deductive technique, Inductive technique Process hazards checklists, survey, Hazard and Operability Studies (HAZOP), Maximum Credible Accident Analysis (MCAA)/Quantitative Risk Assessment (QRA), Safety review. Risk assessment: Cause/consequence finding techniques What-if, Fishbone, Why-Why, Root Cause Analysis (RCA), Event tree analysis, Fault tree analysis, Maximum Credible Accident Analysis (MCAA)/Quantitative Risk Assessment (QRA) and LOPA.	
6	**Safety Procedures and Design** Process safety Hierarchy, managing safety, best practices, procedure for safety review and accident investigation, design for process safety, runway reactions, Job safety Analysis (JSA) and investigation of accidents, First aid, Financial costs-direct and indirect, social costs of accidents, Dust explosion, factors of pentagon, causes of dust explosions and controls, handling dusts and Miscellaneous designs for fire and explosions.	**8**

Course Outcome

On completion of the course the students will be able to:

1. give overview about occupational health, industrial hygiene, accidental prevention techniques to the students.
2. Apply the knowledge about fire and explosion.
3. Design and perform Fire and Explosion prevention methods and Reliefs techniques.
4. Implement the knowledge about safety in process and plant.
5. perform hazard identification and risk assessment.
6. prepare safety procedures and design and are expert to handle the complex industrial environment.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):
1. Weightage of each module in end semester examination will be proportional to number of respective lecture
2. Question paper will comprise of total six questions, each carrying 20 marks
3. Question 1 will be compulsory and should cover maximum contents of the curriculum.
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
5. Only Four questions need to be solved.

Recommended Books:

1. Crowl, D. A. and Louvar, J. P.; Chemical Process Safety: Fundamentals with Applications; Prentice Hall, Englewood
2. K. S. N. Raju, Chemical Process Industry Safety, McGraw Hill Education
3. Roy E. Sanders, Chemical Process Safety: Learning from Case Histories, Butterworth-Heinemann publisher
4. H.W. Heinrich, Dan Petersen, and Nestor Roos, McGraw-Hill Book Company, New York / New Delhi
5.A.K.Gupta, Industrial Safety and Environment, McGraw-Hill Book Co. Ltd., New York, N.Y. USA
6. K.T. Kulkarni, Industrial Safety: Concepts and Practices , Pune VidyarthiGrihaPrakashan, 1786, SadashivPeth, Pune
7.Accident Prevention Manual for Industrial Operations (ISBN: 978-08-7-912024-5), National Safety Council USA
8. H.W. Heinrich, Dan Petersen, and Nestor Roos , Industrial Accident Prevention, McGraw-Hill Book Company, New York / New Delhi
9. K.U. Mistry, A Course in Industrial Safety, NKM Publishers, Ahmedabad

Semester VII

Course Code	Course Name	Credits
CHDO7042	Petroleum Refining Technology (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Knowledge about Formation & Origin of petroleum.
2. Composition & testing methods &basic treatment techniques.

Course Objectives

1. To understand Petroleum Refining processes & products, its evaluation & Treatment techniques.
2. To recognize the significance of petroleum refining is to convert crude oil into usefulproducts.
3. The main purpose of refining petroleum is to make the best use petroleum is a fuel.
4. To understand various cracking processes & its applications in ChemicalIndustries.
5. Describe the overall approach to petroleum refining and categorize refinery processes and Products.
6. Identify the economic and environmental drivers of petroleum refining;

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Introduction -Origin ,Formation & Composition of Petroleum::** Importance, Origin theory, Reserves in India & world. Explorationof Reserves, Types of crude, (Based on constituents, Sulphurcontents & Degree API). Indian crude reserves & productionscenario, Indian Petroleum Industry Scenario, Agencies engaged inupstream & downstream petroleum industry (Government &Private). Properties, composition, UOP Characterization factors.	04
2	**Crude Oil Assay:** Correlationindex, ASTM Distillation, Thermal properties, Crude distillation curves. Important products test & methods,Gasoline, Kerosene, Diesel.	08
3	**Crude Oil Processing & Refining**:	08

	Dehydration & desalting of crude, Heatingof crude, Overall refinery flow diagram, its processes & Products,Low boiling products –LPG production by absorption and amine techniques ,Gasoline, Kerosene & their Specifications, Arrangement of Tower, ADU & VDU, Blending of gasoline, Corrosion problem	
4	**Treatment ,Techniques & Product Specifications**: Treatment Techniques • Fraction impurities- physical and chemical • Gasoline Treatment: Cooper Chloride process, Unisol process, Dualayer process, Lead doctoring, Merox sweetening and Sulfuric Acid treatment • Treatment of lubes-Solvent treatment: Phenol extraction, Furfural extraction and Duo-sol • Wax: MEK Dewaxing and Propane Dewaxing	08
5	**Catalytic Cracking & Thermal Processes:**Thermal and catalytic Cracking • Cracking: Reactions, Theory, properties: Visbreaking • Catalytic Cracking:Houdri Fixed bed, Moving bed and Houdri Flow • FCC:Flexi cracking and Ortho Flow • Catalytic Reforming • Coking: Delayed coking, Fluid coking and Flexi coking • Hydro cracking- isomax • Alkylation: Sulfuric Acid and H.F. • Isomerization:ALCl3 Process	08
6.	**Asphalt Technology & Environmental issues:** Asphalt Technology: • Sources: Chemical Structure, Action of heat on asphalt and Types of Asphalt • Air Blowing of Bitumen • Speciality Products 1. Environmental Issues	03

Course Outcome

On completion of the course the students will be able to:

1 Recognize the significance crude petroleum and petroleum refinery.
2 Understand and express the overall objectives of fractionate crude petroleum into useful fractions.
3 Apply important physical properties of petroleum products
4 Analyze refinery processes to maximize desired petro products
5 Students will be able to understand upgradation process.
6 Identify the economic and environmental drivers of petroleum refining.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents of syllabus and second test based on remaining contents of syllabus (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportional to number of respective lecture
- Question paper will comprise of total **six questions, each carrying 20marks**
- **Question 1** will be compulsory and should cover **maximum contents of thecurriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3)
- Only **Four questions need to besolved.**

Reference Books:

1. W.L Nelson, Petroleum Refinery Engineering 4th ed, McGraw Hill.
2. Petroleum Chemistry and Refining Edited by James G. Speight, Taylor and Francis.
3. Chemical Process Industries, Austin, G.T Shrives.
4. Encyclopedia of chemical processing and design by john J. Mc Khetta; Marcel Deckker, Inc.

Recommended Text Books:

1. B.K Bhaskara Rao, Modern Petroleum Refining Process.
2. Petroleum Processing, Principles and Applications, R.J.Hengstebeck, Mc Graw Hill Book Co, 1959.
3. Fundamentals of Petroleum Chemicals Technology, P.Belov.

Semester VII		
Course Code	**Course Name**	**Credits**

CHDO7043	Operations Research (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

- Linear Algebra, Computer Programming

Course Objectives:

- Formulate a real-world problem as a mathematical programming model
- to understand Linear Programming and its applications to the models.
- To understand and solve network transportation and assignment models.
- To understand Game theory and its applications.
- To study and solve the Queuing system problems
- Understand the concept of Network flow and inventory control.

Detailed Syllabus

Module No	Contents	Contact Hours
1	**Introduction to Operations Research:** Introduction, Structure of the Mathematical Model, Historical Standpoint, Methodology, Different Phases, Characteristics, Scope and Application of Operations Research in Chemical Engineering, Limitations of Operations Research. **Linear Programming:** Introduction, Requirement of LP, Basic Assumptions, Formulation of LP, General Statement of LP, Solution techniques of LP: Graphical method, Simplex Method Penalty Cost Method or Big M-method, Duality, Primal – Dual construction, Dual-Simplex Method, Sensitivity Analysis	10
2	**Transportation and Assignment:** Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: MODI method. Assignment Problem: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Travelling	08

	Salesman Problem	
3	**Queuing Theory:** Basis of Queuing theory, elements of queuing theory, Kendall's Notation, Operating characteristics of a queuing system, Classification of Queuing models, Preliminary examples of M/M/1:∞/FCFA/ **Sequencing:** Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines.	**06**
4	**Inventory Models**: Inventory classification, Different cost associated to Inventory, Economic order quantity, Classic EOQ Model (demand rate uniform, replenishment rate infinite), ABC analysis.	**04**
5	**Decision Analysis and Game Theory:** Decision Making under Certainty, Decision Making under Risk, Decision Under Uncertainty (ONLY NUMERICAL PROBLEMS) **Game Theory:** Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games. (ONLY NUMERICAL PROBLEMS)	**07**
6	**Network Models:** Scope and Definition of Network Models, Minimal Spanning Tree Algorithm, Shortest Route Problem, Maximal Flow Model.	**04**
	Total Hours	**39hrs**

Course Outcomes:

Learner will be able to…

- Model and solve typical OR problems using the simplex method.
- Understand the relationship between a linear program and its dual and Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems.
- Identify and Solve Queuing System.
- Understand the concept of game and Decision theory and solve problems based on the same.
- Understand the applications of network models and an inventory model and compute important performance measures.

Assessment:

Internal Assessment for 20 marks:

Consisting Two Compulsory Class Tests

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module then part (b) will be from any module other than module 3)
4. Only Four questions need to be solved.

REFERENCES:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Semester VII

CourseCode	CourseName	Credits
IOC7011	InstituteLevelOptionalSubjectI-ProductLifeCycle Management	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tofamiliarizethestudents withtheneed,benefits andcomponentsofPLM
- ToacquaintstudentswithProductDataManagement&PLMstrategies
- Togiveinsightsintonewproductdevelopmentprogramandguidelinesfordesigningand developingaproduct
- TofamiliarizethestudentswithVirtualProductDevelopment

Outcomes:

Learnerwillbeableto…

- Gainknowledgeaboutphasesof PLM,PLMstrategiesandmethodologyfor PLMfeasibilitystudyand PDM implementation.
- Illustratevariousapproachesandtechniquesfordesigninganddevelopingproducts.
- Applyproductengineeringguidelines/thumbrulesindesigningproductsformoulding, machining, sheet metal workingetc.
- Acquire knowledge in applying virtual product development tools forcomponents,machiningand manufacturingplant

Module	DetailedContents	ContactHours
01	**Introduction to Product Lifecycle Management(PLM):**ProductLifecycleManagement(PLM),NeedforPLM,ProductLifecyclePhases,OpportunitiesofGlobalization,Pre-PLMEnvironment,PLMParadigm,Importance&BenefitsofPLM, WidespreadImpactofPLM,FocusandApplication,APLM Project, Starting the PLM Initiative, PLM Applications**PLMStrategies:**Industrialstrategies,Strategyelements,its identification,selectionandimplementation,DevelopingPLMVisionandPLMStrategy,ChangemanagementforPLM.	10

02	**ProductDesign:**ProductDesignandDevelopmentProcess,EngineeringDesign,OrganizationandDecompositioninProductDesign,TypologiesofDesignProcessModels,Reference Model, Product Design in the Context of the ProductDevelopment Process, Relation with the Development ProcessPlanning Phase, Relation with the Post design Planning Phase,MethodologicalEvolutioninProductDesign,ConcurrentEngineering, Characteristic Features of Concurrent Engineering,Concurrent Engineering and Life Cycle Approach, New ProductDevelopment (NPD) and Strategies, Product Configuration andVariantManagement,TheDesignforXSystem,Objective Properties and Design for X Tools, Choice of Design for XToolsand Their Usein theDesign Process.	**09**
03	**Product Data Management (PDM):**Product and Product Data,PDMsystemsandimportance,ComponentsofPDM,Reasonfor implementingaPDMsystem,financialjustificationofPDM, barrierstoPDMimplementation.	**05**
04	**VirtualProductDevelopmentTools:**Forcomponents,machines,andmanufacturingplants,3DCADsystemsandrealistic rendering techniques, Digital mock-up, Model building,Modelanalysis,ModelingandsimulationsinProductDesign, Examples/Casestudies.	**05**
05	**IntegrationofEnvironmentalAspectsinProductDesign:**	**05**
	Sustainable Development, Design for Environment, Need forLifeCycleEnvironmentalStrategies,UsefulLifeExtensionStrategies,End-of-LifeStrategies,IntroductionofEnvironmental Strategies into the Design Process, Life CycleEnvironmentalStrategiesandConsiderationsforProduct Design.	
06	**LifeCycleAssessmentandLifeCycleCostAnalysis:**Properties, and Framework of Life Cycle Assessment, Phases ofLCA in ISO Standards, Fields of Application and Limitations ofLifeCycleAssessment,CostAnalysisandtheLifeCycleApproach, GeneralFrameworkforLCCA,EvolutionofModels forProductLifeCycleCostAnalysis.	**05**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeas

ked.

- Remainingquestions will be randomlyselected from all themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. JohnStark,"ProductLifecycleManagement:Paradigmfor21stCenturyProductRealisation",Springer-Verlag, 2004.ISBN: 1852338105
2. FabioGiudice,GuidoLaRosa,AntoninoRisitano,"ProductDesignfortheenvironment-Alife cycle approach",Taylor&Francis2006, ISBN:0849327229
3. SaaksvuoriAntti,ImmonenAnselmie,"ProductLifeCycleManagement",Springer, Dreamtech,ISBN: 3540257314
4. MichaelGrieve,"ProductLifecycleManagement:Drivingthenextgenerationofleanthinking", TataMcGrawHill, 2006,ISBN:0070636265

Semester VII

CourseCode	CourseName	Credits
IOC7012	Institute Level Optional Subject I-ReliabilityEngineering	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total

-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tofamiliarizethestudents with variousaspects ofprobabilitytheory
- Toacquaintthe studentswithreliabilityanditsconcepts
- To introduce the students tomethodsof estimating the systemreliabilityofsimpleandcomplexsystems
- TounderstandthevariousaspectsofMaintainability,AvailabilityandFMEAprocedure

Outcomes:

Learnerwillbeableto…

- Understandandapplythe conceptof Probabilityto engineeringproblems
- Applyvarious reliabilityconcepts to calculatedifferent reliability parameters
- Estimatethesystem reliabilityofsimpleandcomplex systems
- Carryouta FailureMode EffectandCriticalityAnalysis

Module	DetailedContents	Contact Hours
01	**Probability theory:** Probability: Standard definitions andconcepts;Conditional Probability, Baye'sTheorem. **ProbabilityDistributions:**CentraltendencyandDispersion;Binomial, Normal,Poisson,Weibull,Exponential,relationsbetweenthemand theirsignificance. **MeasuresofDispersion:** Mean Median, Mode, Range, MeanDeviation,StandardDeviation,Variance,SkewnessandKurtosis.	08
02	**ReliabilityConcepts:**Reliabilitydefinitions,ImportanceofReliability, QualityAssurance andReliability,BathTubCurve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate,MeanTimeToFailure(MTTF),MTBF, ReliabilityFunctions. **ReliabilityHazardModels:**ConstantFailureRate,Linearlyincreasing, TimeDependentFailureRate,WeibullModel.Distributionfunctions and reliabilityanalysis.	08
03	**SystemReliability:**SystemConfigurations:Series,parallel, mixedconfiguration,koutofnstructure,Complex systems.	05

04	**ReliabilityImprovement:**RedundancyTechniques:Elementredundancy,Unitredundancy,Standbyredundancies.Markovanalysis. SystemReliabilityAnalysis–Enumerationmethod,Cut-setmethod,Success Pathmethod,Decompositionmethod.	**08**
05	**MaintainabilityandAvailability:**Systemdowntime,DesignforMaintainability:Maintenancerequirements,Designmethods: FaultIsolationandself-diagnostics,Partsstandardizationand	**05**
	Interchangeability,ModularizationandAccessibility,RepairVsReplacement. Availability–qualitative aspects.	
06	**Failure Mode, Effects and Criticality Analysis:** Failure modeeffects analysis, severity/criticality analysis, FMECA examples.Fault tree construction, basic symbols, development of functionalreliabilityblockdiagram,Fau1ttreeanalysisandEventtreeAnalysis	**05**

Assessment

Internal

- Assessmentconsistsoftwotestswhichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. L.S.Srinath,"ReliabilityEngineering",Affiliated East-WastPress(P) Ltd., 1985.
2. CharlesE.Ebeling,"ReliabilityandMaintainabilityEngineering",TataMcGrawHill.
3. B.S.Dhillion,C.Singh,"EngineeringReliability",JohnWiley&Sons,1980.
4. P.D.T.Conor,"PracticalReliabilityEngg.", JohnWiley&Sons, 1985.
5. K.C.Kapur,L.R.Lamberson,"Reliability inEngineeringDesign",JohnWiley&Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co.Ltd.

Semester VII

CourseCode	CourseName	Credits
IOC7013	InstituteLevelOptionalSubjectI-ManagementInformation System	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives

- ThecourseisblendofManagementandTechnicalfield.
- Discuss the rolesplayedbyinformationtechnologyintoday's business anddefinevarioustechnologyarchitectureson which informationsystems arebuilt
- Defineandanalyzetypicalfunctionalinformationsystemsandidentifyhowtheymeetth eneeds of thefirm to deliver efficiencyand competitive advantage
- Identifythebasicstepsinsystemsdevelopment

Outcomes Learnerwillbeableto…

- ExplainhowinformationsystemsTransformBusiness
- Identifytheimpactinformationsystemshaveonanorganization
- DescribeITinfrastructureanditscomponentsanditscurrenttrends
- Understandtheprincipaltoolsandtechnologiesforaccessinginformationfromdatabase sto improvebusiness performance and decision making
- Identifythetypesofsystemsusedforenterprise-wideknowledgemanagementandhow theyprovide value forbusinesses

Module	DetailedContents	Contact Hours
01	IntroductionToInformationSystems(IS):ComputerBasedInformat ionSystems,ImpactofITonorganizations,andImportanceofIStoSoc iety.OrganizationalStrategy, CompetitiveAdvantagesand IS.	4
02	Data and Knowledge Management: Database Approach,BigData,DatawarehouseandDataMarts,KnowledgeMa nagement. Business intelligence (BI): Managers and Decision Making, BIforDataanalysis and PresentingResults	7
03	EthicalissuesandPrivacy:InformationSecurity.ThreattoIS, and SecurityControls	7
04	SocialComputing(SC):Web2.0and3.0,SCinbusiness-shopping,Marketing,OperationalandAnalyticCRM, E-businessandE-commerce–B2BB2C.Mobilecommerce.	7
05	ComputerNetworksWiredandWirelesstechnology,Pervasive computing,Cloud computingmodel.	6

06	InformationSystemwithinOrganization:TransactionProcessing Systems, Functional Area Information System, ERPandERPsupport ofBusiness Process. AcquiringInformationSystemsandApplications:VariousSystemdevelopment life cyclemodels.	**8**

InternalAssessment

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. KellyRainer,BradPrince,Management InformationSystems,Wiley
2. K.C.LaudonandJ.P.Laudon,ManagementInformationSystems:ManagingtheDigitalFirm, 10th Ed.,PrenticeHall, 2007.
3. D.Boddy,A.Boonstra,ManagingInformationSystems:StrategyandOrganization,PrenticeHall, 2008

Semester VII

CourseCode	CourseName	Credits
IOC7014	**InstituteLevelOptionalSubjectI-Design ofExperiments**	**03**

Course Hours			Credits Assigned		
Practical	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**

-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tounderstandtheissues andprinciples ofDesignofExperiments(DOE)
- Tolisttheguidelinesfordesigningexperiments
- Tobecomefamiliarwithmethodologiesthatcanbeusedinconjunctionwithexperimental designs forrobustness and optimization

Outcomes:

Learnerwillbeableto…

- Plandatacollection,toturndataintoinformationandtomakedecisionsthatleadtoappropriateaction
- Applythe methodstaught to reallifesituations
- Plan,analyze,andinterprettheresultsofexperiments

Module	DetailedContents	Contact Hours
01	**Introduction** 1.1 Strategyof Experimentation 1.2 TypicalApplications ofExperimentalDesign 1.3 GuidelinesforDesigningExperiments 1.4 Response SurfaceMethodology	06
02	**FittingRegressionModels** 2.1 LinearRegressionModels 2.2 EstimationoftheParametersinLinearRegressionModels 2.3 HypothesisTestinginMultipleRegression 2.4 ConfidenceIntervalsinMultipleRegression 2.5 Predictionofnewresponseobservation 2.6 Regressionmodeldiagnostics 2.7 Testingforlackof fit	08
03	**Two-LevelFactorialDesignsandAnalysis** 3.1 The 2^2 Design 3.2 The 2^3 Design 3.3 The General 2^k Design 3.4 A Single Replicate of the 2^k Design 3.5 The Addition of Center Points to the 2^k Design, 3.6 Blocking in the 2^k Factorial Design 3.7 Split-Plot Designs	07

04	**Two-LevelFractionalFactorialDesignsandAnalysis** 4.1 TheOne-Half Fractionofthe2^k Design 4.2 TheOne-QuarterFractionofthe2^k Design 4.3 TheGeneral2^{k-p} FractionalFactorialDesign 4.4 Resolution IIIDesigns 4.5 ResolutionIVandVDesigns	**07**
	4.6FractionalFactorialSplit-PlotDesigns	
05	**ConductingTests** 5.1 TestingLogistics 5.2 Statisticalaspectsofconductingtests 5.3 Characteristicsof goodandbaddatasets 5.4 Exampleexperiments 5.5 AttributeVsVariabledatasets	**07**
06	**TaguchiApproach** 6.1 CrossedArrayDesignsandSignal-to-NoiseRatios 6.2 AnalysisMethods 6.3 Robustdesignexamples	**04**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook,ResponseSurfaceMethodology:ProcessandProductOptimizationusingDesigned Experiment,3rdedition,John Wiley& Sons, New York,2001
2. D.C.Montgomery,DesignandAnalysisofExperiments,5thedition,JohnWiley&Sons, New York, 2001
3. GeorgeEPBox,JStuartHunter,WilliamGHunter,StaticsforExperimenters:Design,Innovation andDiscovery, 2ndEd.Wiley
4. WJDimond,PracticalExperimentDesignsforEngineersandScientists,JohnWileyand SonsInc.ISBN: 0-471-39054-2
5. DesignandAnalysisofExperiments(SpringertextinStatistics),Springerby A.M.Dean,andD. T.Voss
6. PhillipJRoss, “TaguchiTechnique forQualityEngineering,”McGrawHill
7. MadhavSPhadke,“QualityEngineeringusingRobustDesign,”Prentice Hall

SEM VII		
CourseCode	**CourseName**	**Credits**
IOC7015	**InstituteLevelOptionalSubjectI-OperationsResearch**	**03**

Course Hours			Credits Assigned		
Practical	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**-**	**03**	**-**	**-**	**03**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**	**--**	**--**	**100**

Objectives:

- Formulateareal-worldproblemasamathematicalprogrammingmodel.
- Understandthemathematicaltoolsthatareneededtosolveoptimizationproblems.
- Usemathematical softwareto solve theproposedmodels.

Outcomes:

Learnerwillbeableto…

- Understandthetheoreticalworkingsofthesimplexmethod,therelationshipbetweenalinearprogramanditsdual,includingstrongdualityandcomplementaryslackness.
- Performsensitivityanalysistodeterminethedirectionandmagnitudeofchangeofamodel'soptimal solution as the data change.
- Solvespecializedlinearprogrammingproblemslikethetransportationandassignmentproblems;solvenetworkmodelsliketheshortestpath,minimumspanningtree, and maximum flow problems.
- Understand the applications of integer programminganda queuing model andcomputeimportant performancemeasures

Module	DetailedContents	Contact Hours

01	**IntroductiontoOperationsResearch**: Introduction,,StructureoftheMathematicalModel,LimitationsofOperationsResearch **LinearProgramming**: Introduction,LinearProgrammingProblem, Requirements of LPP, Mathematical Formulation ofLPP,Graphicalmethod,SimplexMethodPenaltyCostMethodorBigM-method,TwoPhaseMethod,Revisedsimplexmethod,**Duality**,Primal–Dualconstruction,SymmetricandAsymmetricDual,WeakDuality Theorem,Complimentary Slackness Theorem, Main Duality Theorem,DualSimplexMethod, SensitivityAnalysis **Transportation Problem**:Formulation, solution, unbalancedTransportationproblem.Findingbasicfeasiblesolutions–Northwestcornerrule,leastcostmethodandVogel'sapproximation method.Optimalitytest:thesteppingstonemethod and MODImethod. **AssignmentProblem**:Introduction,MathematicalFormulationofthe Problem, Hungarian MethodAlgorithm,ProcessingofnJobsThroughTwoMachinesandmMachines,GraphicalMethodofTwoJobsmMachinesProblemRoutingProblem, TravellingSalesmanProblem	**14**
	IntegerProgrammingProblem: Introduction,TypesofIntegerProgrammingProblems,Gomory'scuttingplaneAlgorithm,BranchandBoundTechnique.Introductionto Decompositionalgorithms.	
02	**Queuingmodels**:queuingsystemsandstructures,single serverandmulti-servermodels,Poissoninput,exponentialservice,constantrate service,finiteandinfinite population	**05**
03	**Simulation**: Introduction,Methodology ofSimulation,BasicConcepts,SimulationProcedure,Applicationof SimulationMonte-Carlo Method:Introduction, Monte-Carlo Simulation,ApplicationsofSimulation,AdvantagesofSimulation, LimitationsofSimulation	**05**
04	**Dynamicprogramming**.Characteristicsofdynamicprogramming.DynamicprogrammingapproachforPriorityManagementemployments moothening,capitalbudgeting,StageCoach/ShortestPath,cargoloadingandReliability problems.	**05**
05	**Game Theory**. Competitive games, rectangular game, saddlepoint, minimax (maximin) method of optimal strategies, valueof the game. Solution of games with saddle points, dominanceprinciple.Rectangulargameswithoutsaddlepoint–mixed	**05**

	strategyfor2 X 2games.	
06	**InventoryModels**:ClassicalEOQModels,EOQModelwith PriceBreaks,EOQwith Shortage, ProbabilisticEOQModel,	**05**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. Taha,H.A."OperationsResearch-AnIntroduction",PrenticeHall,(7thEdition), 2002.
2. Ravindran,A,Phillips,D.TandSolberg,J.J."OperationsResearch:PrinciplesandPractice", John Willeyand Sons, 2ndEdition, 2009.
3. Hiller,F.S.andLiebermann,G.J."IntroductiontoOperationsResearch",TataMcGraw Hill, 2002.
4. OperationsResearch,S.D.Sharma, KedarNathRamNath-Meerut.
5. OperationsResearch,KantiSwarup,P.K.GuptaandManMohan,SultanChand&Sons.

CourseCode	CourseName	Credits
IOC7016	Institute Level Optional Subject I- Cyber Security andLaws	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tounderstandandidentifydifferenttypescybercrimeandcyber law
- TorecognizedIndianIT Act2008anditslatestamendments
- Tolearnvarioustypesof securitystandards compliances

Outcomes:

Learnerwillbeableto…

- Understandthe conceptofcybercrimeanditseffectonoutside world
- Interpret andapplyITlawinvariouslegalissues
- Distinguishdifferentaspectsofcyberlaw
- ApplyInformationSecurityStandardscomplianceduringsoftwaredesignanddevelopment

Module	DetailedContents	Contact Hours
01	**Introduction to Cybercrime:** Cybercrime definition and originsoftheworld,Cybercrimeandinformationsecurity,Classifications of cybercrime, Cybercrimeand the IndianITA2000,AglobalPerspectiveon cybercrimes.	4
02	**Cyberoffenses&Cybercrime:**HowcriminalplantheattacksSocialEngg,Cyberstalking,CybercaféandCybercrimes,Botnets,Attackvector,Cloudcomputing,ProliferationofMobileand Wireless Devices, Trends in Mobility, Credit Card Frauds inMobileandWirelessComputingEra,SecurityChallengesPosedbyMobileDevices,RegistrySettingsforMobileDevices,AuthenticationServiceSecurity,AttacksonMobile/CellPhones,Mobile Devices: Security Implications for Organizations,OrganizationalMeasuresforHandlingMobile,Devices-Related SecurityIssues,OrganizationalSecurity PoliciesandMeasuresinMobileComputingEra,Laptops	9

03	**ToolsandMethodsUsedin Cyberline** Phishing, Password Cracking, Keyloggers and Spywares, VirusandWorms,Steganography,DoSandDDoSAttacks,SQLInjection,BufferOverFlow,AttacksonWirelessNetworks,Phishing,Identity Theft (IDTheft)	**6**
04	**TheConceptofCyberspace** E-Commerce , The Contract Aspects in Cyber Law ,The SecurityAspect of Cyber Law ,The Intellectual Property Aspect in CyberLaw , The Evidence Aspect in Cyber Law ,The Criminal Aspect inCyber Law,Global Trends in Cyber Law , Legal Framework forElectronicDataInterchangeLawRelatingto ElectronicBanking,	**8**
	TheNeed foranIndianCyberLaw	
05	**IndianITAct.** Cyber Crime and Criminal Justice: Penalties, Adjudication andAppealsUndertheITAct,2000,ITAct.2008anditsAmendments	**6**
06	**InformationSecurityStandardcompliances** SOX,GLBA,HIPAA, ISO,FISMA,NERC,PCI.	**6**

Assessment

Internal

- Assessmentconsistsof twotestswhich shouldbeconductedatproper intervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. NinaGodbole,SunitBelapure,*CyberSecurity*,WileyIndia,New Delhi
2. TheIndianCyberLawbySureshT.Vishwanathan;BharatLawHouseNewDelhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers,NewDelhi.
4. CyberLaw&CyberCrimesByAdvocatePrashantMali;SnowWhitePublications, Mumbai
5. NinaGodbole,*InformationSystemsSecurity*, WileyIndia,NewDelhi
6. Kennetch J. Knapp, *Cyber Security* &*Global Information Assurance* InformationSciencePublishing.
7. WilliamStallings,*CryptographyandNetworkSecurity*,PearsonPublication
8. Websitesformoreinformationisavailableon:TheInformationTechnologyACT,2008-TIFR : https://www.tifrh.res.in
9. Websiteformoreinformation,ACompliancePrimerforITprofessional :https://www.sans.org/reading-room/whitepapers/compliance/compliance-

primer-professionals-33538

CourseCode	CourseName	Credits
IOC7017	InstituteLevelOptionalSubjectI-DisasterManagementandMitigationMeasures	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tounderstandphysics andvarious typesof disasteroccurringaroundthe world
- To identifyextent and damagingcapacityofadisaster
- Tostudyandunderstandthemeansoflossesandmethodstoovercome/minimizeit.
- Tounderstandroleofindividualandvariousorganizationduringandafterdisaster
- TounderstandapplicationofGISinthe fieldofdisastermanagement
- Tounderstandtheemergencygovernmentresponsestructuresbefore,duringandafterdisaster

Outcomes:

Learnerwillbeableto…

- Gettoknownaturalaswellasmanmadedisasterandtheirextentandpossibleeffectson the economy.
- Planofnationalimportancestructuresbaseduponthepreviushistory.
- Getacquaintedwithgovernmentpolicies,actsandvariousorganizationalstructuresassociated with an emergency.
- Gettoknowthesimpledo'sanddon'tsinsuchextremeeventsandactaccordingly.

Module	DetailedContents	Contact Hours
01	Introduction: Definition of Disaster, hazard, global and Indian scenario, generalperspective,importanceofstudyinhumanlife,Directandindirecteffectsofdisasters,longtermeffectsofdisasters. Introductiontoglobalwarmingandclimatechange.	03

02	NaturalDisasterandManmadedisasters: Natural Disaster: Meaning and nature of natural disaster,Flood,Flashflood,drought,cloudburst,Earthquake,Landslides,Avalanches,Volcaniceruptions,Mudflow,Cyclone,Storm,Storm Surge,climate change, global warming, sea level rise,ozonedepletion ManmadeDisasters:Chemical,Industrial,NuclearandFireHazards.Roleofgrowingpopulationandsubsequentindustrialization, urbanization and changing lifestyle of humanbeingsin frequent occurrences of manmadedisasters.	**09**
03	DisasterManagement,PolicyandAdministration: Disaster management:meaning,concept,importance,objectiveofdisastermanagementpolicy,disasterrisksin India,Paradigmshift	**06**
	indisastermanagement. Policy and administration: Importance and principles of disastermanagement policies, command and co-ordination of in disastermanagement,rescueoperations-howtostartwithandhowtoproceed in due course of time, study of flowchart showing theentireprocess.	
04	Institutional Framework for Disaster Management in India:Importanceof publicawareness,Preparationandexecutionofemergencymanagementprogramme.ScopeandresponsibilitiesofNational InstituteofDisasterManagement(NIDM)andNationaldisastermanagementauthority(NDMA)inIndia.Methodsandmeasurestoavoiddisasters,Managementofcasualties,setupofemergencyfacilities,importanceofeffectivecommunicationamongstdifferentagenciesinsuchsituations. UseofInternetandsoftwaresforeffectivedisastermanagement.Applicationsof GIS,RemotesensingandGPSinthis regard.	**06**
05	FinancingReliefMeasures: Ways to raise finance for relief expenditure, role of governmentagenciesandNGO'sinthisprocess,Legalaspectsrelatedtofinanceraisingaswellasoverallmanagementofdisasters.Various NGO's and the works they have carried out in the past ontheoccurrenceofvariousdisasters,Waystoapproachtheseteams.Internationalreliefaidagenciesandtheirroleinextreme events.	**09**

06	PreventiveandMitigationMeasures: Pre-disaster, during disaster and post-disaster measures in someevents in general structural mapping: Risk mapping, assessmentand analysis, sea walls and embankments, Bio shield, shelters,earlywarningandcommunication NonStructuralMitigation:Communitybaseddisasterpreparedness,risktransferandriskfinancing,capacitydevelopmentandtraining,awarenessandeducation,contingency plans.Do'sanddon'tsincaseofdisastersandeffectiveimplementationofreliefaids.	**06**

Assessment
Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. 'DisasterManagement'byHarshK.Gupta, UniversitiesPressPublications.
2. 'DisasterManagement:AnAppraisalofInstitutionalMechanismsinIndia'by O.S.Dagur,publishedbyCentreforland warfarestudies,New Delhi,2011.
3. 'IntroductiontoInternationalDisasterManagement'byDamonCopolla,Butterworth HeinemannElseveir Publications.
4. 'DisasterManagementHandbook'byJackPinkowski,CRCPressTaylorandFrancis group.
5. 'Disaster management & rehabilitation' by Rajdeep, Dasgupta, MittalPublications,New Delhi.
6. 'NaturalHazardsandDisasterManagement,VulnerabilityandMitigation–RBSingh, Rawat Publications
7. ConceptsandTechniquesofGIS–C.P.LoAlbert,K.W.Yonng–PrenticeHall(India)Publications.

(LearnersareexpectedtoreferreportspublishedatnationalandInternationallevelandupdated information available on authenticwebsites)

CourseCode	CourseName	Credits
IOC7018	Institute Level Optional Subject I- Energy Audit andManagement	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tounderstandtheimportanceenergysecurityforsustainabledevelopmentandthefundamentals ofenergyconservation.
- Tointroduceperformanceevaluationcriteriaofvariouselectricalandthermalinstallationsto facilitate theenergymanagement
- Torelatethedatacollectedduringperformanceevaluationofsystemsforidentification ofenergysavingopportunities.

Outcomes:

Learnerwillbeableto…

- Toidentifyanddescribe presentstate of energysecurityandits importance.
- To identify and describe the basic principles and methodologies adopted in energyauditof an utility.
- Todescribetheenergyperformanceevaluationofsomecommonelectricalinstallations and identifythe energysavingopportunities.
- Todescribetheenergyperformanceevaluationofsomecommonthermalinstallations and identifythe energysavingopportunities
- Toanalyzethedatacollectedduringperformanceevaluationand recommendenergysavingmeasures

Module	DetailedContents	Contact Hours
01	**EnergyScenario:** PresentEnergyScenario,EnergyPricing,EnergySectorReforms,EnergySecurity,EnergyConservationanditsImportance,EnergyConservationAct-2001anditsFeatures.BasicsofEnergyandits variousforms, MaterialandEnergy balance	04

02	**EnergyAuditPrinciples:** Definition, Energy audit- need, Types of energy audit, Energymanagement (audit) approach-understanding energy costs, Benchmarking,Energyperformance,Matchingenergyusetorequirement,Maximizingsystemefficiencies,Optimizingtheinputenergyrequirements,Fuelandenergysubstitution.Elementsofmonitoring& targeting;Energy auditInstruments;Dataand information-analysis. Financialanalysistechniques:Simplepaybackperiod,NPV, Returnoninvestment(ROI), Internalrateofreturn(IRR)	**08**
03	**EnergyManagementandEnergyConservationinElectrical**	**10**
	System: Electricitybilling,Electricalloadmanagementandmaximumdemand Control;Powerfactorimprovement,Energyefficientequipmentsand appliances, star ratings. **Energyefficiencymeasuresinlightingsystem,Lightingcontrol:**Occupancysensors,daylightintegration,anduseofintelligentcontrollers. Energyconservationopportunitiesin:waterpumps,industrialdrives,inductionmotors,motorretrofitting,softstarters,variable speeddrives.	
04	**Energy Management and Energy Conservation in ThermalSystems:** Reviewofdifferentthermalloads;Energyconservationopportunities in: Steam distribution system, Assessment of steamdistribution losses, Steam leakages, Steam trapping, Condensateandflash steam recoverysystem. General fuel economy measures in Boilers and furnaces, Wasteheat recovery, use of insulation- types and application. HVACsystem: Coefficient of performance, Capacity, factors affectingRefrigerationandAirConditioningsystemperformanceand savingsopportunities.	**10**
05	**EnergyPerformanceAssessment:** On site Performance evaluationtechniques,Case studiesbasedon:Motorsandvariablespeeddrive,pumps,HVACsystemcalculations;LightingSystem:InstalledLoadEfficacyRatio (ILER)method,FinancialAnalysis.	**04**
06	**EnergyconservationinBuildings:** EnergyConservationBuildingCodes(ECBC):GreenBuilding, LEEDrating,ApplicationofNon-ConventionalandRenewableEnergySources	**03**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheory examination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeas ked.
- Remainingquestions will be randomlyselected from all themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. HandbookofElectrical InstallationPractice,GeofryStokes,BlackwellScience
2. Designingwithlight:LightingHandbook,ByAnilValia, LightingSystem
3. EnergyManagement Handbook,ByW.C.Turner, JohnWileyandSons
4. HandbookonEnergyAuditsandManagement,editedbyA.K.Tyagi,TataEnergyRese archInstitute(TERI).
5. EnergyManagementPrinciples,C.B.Smith,PergamonPress
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E.Richardson,FairmontPress
7. HandbookofEnergyAudits,AlbertThumann,W.J.Younger,T.Niehus,CRCPress
8. www.energymanagertraining.com
9. www.bee-india.nic.in

CourseCode	CourseName	Credits
IOC7019	InstituteLevelOptionalSubjectI-DevelopmentEngineering	03

Course Hours			Credits Assigned		
Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Pre-requisite:

- Interestinsocietaldevelopment.

CourseObjective:

- To understand the characteristics of rural Society and the Scope and Nature andConstraintsof rural Development.
- To study Implications of 73rd CAA on Planning, Development and Governance ofRuralAreas
- The objective of the course is an exploration of human values, which go intomaking a ‘good’ human being, a ‘good’ professional, a ‘good’ society and a ‘goodlife’.Thecontextistheworklifeandthepersonallifeofmodern Indianprofessionals.
- TounderstandtheNatureandTypeofHumanValuesrelevanttoPlanningInstitutions.

CourseOutcome:

- Studentswill be ableto applyknowledgeforRural Development.
- Studentswill beable toapplyknowledgeforManagementIssues.
- StudentswillbeabletoapplyknowledgeforInitiativesandStrategies
- Studentswillbeabletodevelopacumenforhighereducationandresearch.
- Studentswillmastertheart ofworkingingroupofdifferentnature.
- Studentswilldevelopconfidencetotakeupruralprojectactivitiesindependently.

Module	Contents	Contact Hours
1	Introduction to Rural Development Meaning, nature and scope ofdevelopment;Natureofruralsocietyin India;Hierarchyofsettlements;Social,economicandecologicalconstraintsforrural development.	04

2	Roots of Rural Development in India Rural reconstruction andSarvodaya programme before independence; Impact of voluntaryeffortandSarvodayaMovementonruraldevelopment;Constitutional direction, directive principles; Panchayati Raj-beginningof planningand communitydevelopment;National extensionservices.	**04**
3	Post-IndependenceruralDevelopmentBalwantRaiMehtaCommittee - three tier system of rural local Government; NeedandscopeforpeopleʼsparticipationandPanchayatiRaj;Ashok MehtaCommittee-linkagebetweenPanchayatiRaj,participationand rural development.	**04**
4	RuralDevelopmentInitiativesinFiveYearPlansFiveYear	**06**
	PlansandRuralDevelopment;PlanningprocessatNational,State,RegionalandDistrictlevels;Planning,development,implementing and monitoring organizations and agencies; Urbanandruralinterface-integratedapproachandlocalplans;Developmentinitiativesandtheirconvergence;Specialcomponent plan and sub-plan for the weaker section; Micro-ecozones;Databaseforlocalplanning;Needfordecentralized planning;Sustainableruraldevelopment.	
5	Post 73rd Amendment Scenario 73rd Constitution AmendmentAct,including-XIschedule,devolutionofpowers,functionsandfinance;PanchayatiRajinstitutions-organizationallinkages; Recent changes in rural local planning; Gram Sabha - revitalizedPanchayatiRaj;Institutionalization;resourcemapping,resourcemobilizationincludingsocialmobilization;InformationTechnologyandruralplanning;Needforfurther amendments.	**04**
6	ValuesandScienceandTechnologyMaterialdevelopmentand itsvalues;thechallengeofscienceandtechnology;Valuesinplanningprofession, research andeducation.	**04**
7	Types of Values Psychological values — integrated personality;mental health; Societal values — the modern search for a goodsociety; justice, democracy,rule oflaw,values in theIndianconstitution; Aesthetic values — perception and enjoyment ofbeauty;Moralandethicalvalues;natureofmoraljudgment;Spiritual values; different concepts; secular spirituality; Relativeandabsolutevalues;Humanvalues— humanismandhumanvalues;humanrights;humanvaluesasfreedom,creativity,love andwisdom.	**06**
8	EthicsCanonsofethics;ethicsofvirtue;ethicsofduty;ethicsofresponsibility;Workethics;Professionalethics;Ethicsin planningprofession,researchandeducation	**04**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6 questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

Recommendation

Studentscantakeanyoneortwoliveprojectsbeneficialtoruralpopulationorsocietyat large.

Reference

1. ITPI,VillagePlanningandRuralDevelopment, ITPI, NewDelhi
2. Thooyavan,K.R.HumanSettlements:A2005MAPublication,Chennai
3. GoI,Constitution(73rdGoI,New DelhiAmendment)Act, GoI,NewDelhi
4. PlanningCommission,Five YearPlans, PlanningCommission
5. PlanningCommission,ManualofIntegratedDistrictPlanning,2006,PlanningCommissionNew Delhi
6. PlanningGuideto Beginners
7. Weaver,R.C.,TheUrbanComplex,Doubleday.
8. Farmer,W.P.etal,EthicsinPlanning,AmericanPlanningAssociation,Washington.
9. How,E., Normative Ethicsin Planning,Journalof PlanningLiterature,Vol.5,No.2,pp. 123-150.
10. Watson,V.,ConflictingRationalities:-- ImplicationsforPlanningTheoryandEthics,PlanningTheoryand Practice,Vol. 4, No.4, pp.395–407

Semester VII

Course Code	Course Name	Credits
CHL701	Instrumentation Process Dynamics and Control Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	3	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	25	--	50

Prerequisites

1. Basics of unit operations.
2. Engineering Physics, Engineering Chemistry and Engineering Mathematics (Linear Algebra, Differential equations and Laplace Transforms)
3. Basic laws of Conservations
4. Knowledge ofsafety and precautions to be taken in laboratories.

Lab Objectives

1. To understand dynamic behavior of process systems and equipments.
2. To analyze the characteristics of different types control valves.
3. To calibrate various measuring devices
4. To operate closed-loop control system
5. To understand the effect of controller parameters in the response of dynamic systems
6. To optimize the controller parameters in controller tuning process

List of Suggested Experiments

- Dynamic Response of First order system (Thermometer) to step input
- Dynamic Response of First order system (Liquid Level) to impulse input
- Dynamic Response of Non-Interacting system to step input
- Dynamic Response of Interacting system to step input
- Calibration of Measuring Devices.
- Dynamic Response of second order system (Manometer) to step input

- Inherent Characteristics of Control Valves
- Effective Characteristics of Control Valves
- Closed loop control system
- Open loop control system
- Tuning of control system
- Development of Empirical Model from Process Data
- Note: Virtual platforms can be used for better understanding of concepts (Virtual platform should be used for at least one Experiment).

Lab Outcome

On completion of the course the studentwill:

1. Analyze the dynamic behavior of a system for various inputs
2. Determine the characteristic parameters of a system
3. Analyze the characteristics of control valves
4. Develop Empirical Model from Process Data
5. Analyze various measuring devices
6. Tune the controller parameter

Term work

Term work should be evaluated based on performance in practical.

Practical journal:	20 marks
Attendance:	05 marks
Total:	25 marks

Practical Examination

- Duration for practical examination will be same as assigned to respective lab per week
- A student will become eligible for practical examination after completing 8 out of 10 experiments

Semester VII

Course Code	Course Name	Credits
CHL702	Chemical Engineering Equipment Design Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites

1.Fundamentals of units
2. Elementary theory of engineering mechanics,
3. Engineering drawing.
4. Knowledge of Heat and Mass transfer operations
5. Concepts of Mechanical operations

Course Objectives

1. To understand the basic of design and Construction of Pressure Vessels.
2. To understand the basic of design and Construction of High-Pressure Vessels
3. To understand the basic of construction and design of Reaction vessel and Agitator
4. To understand the basic of design and Construction of Heat transfer equipment
5. To understand the basic of design and Construction of Mass Transfer equipments.
6. To understand the basic of construction of Storage Vessel and Supports to vessel

List of Experiments (minimum eight)

Experiment no.	Details of Experiment	Lab Hours
1	Pressure Vessel	3
2	High Pressure Vessel	3
3	Reaction Vessel	3
4	Agitators	3
5	Heat Exchangers	3
6	Evaporator	3
7	Distillation Column	3
8	Storage Vessel	3
9	Supports to vessels	3
10	Autocad / PID	3

Course Outcome

On completion of the laboratory course the students will be able to:

1. Design and pictorially represent Pressure vessel.
2. Design and pictorially represent High pressure vessel.
3. Design and pictorially represent Reaction vessel and Agitator
4. Design and draw internals of Heat exchanger and Evaporator.
5. Design and represent pictorially distillation column.
6. Sketch the internals of storage tank and types of supports

Assessment:

Term Work (25 marks)

Distribution of marks will be as follows:

- Laboratory work: 15 marks
- Assignments: 05
- Attendance: 05
- **Total Marks :25**

End Semester Practical/ Oral Examination/ (25 marks)

Oral Examination will be based on experiments performed in the laboratory

Recommended Books:

1.Process Equipment Design by M.V. Joshi Macmillan India.

2.Process Equipment Design- Vessel Design by E. Brownell and Edwin, H. Young. John Wiley, New York 1963.

Reference Books:

1.Chemical Engineering volume 6- Design by J.M Coulson, J.F. Richardson and P.K. Sinnot, Pregamovr press, International edition 1989.

2.Chemical Engineering Design, Fifth edition, Ray Sinnott and Cavin Towler, Elseveir, Butterworth-Heinemann publications

3. Introduction to Chemical Equipment Design- Mechanical aspects by B.C. Bhattacharya CBS Publications

Semester VII

Course Code	Course Name	Credits
CHL703	Hazard and Risk analysis Lab	01

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites

Knowledge of Physics,Chemistry,Mathematics,Process Calculations,Process Equipment Design,Process Engineering, Heat and Mass transfer,Thermodynamics,Chemical Reaction Engineering,Fluid flow and Process Safety.

Course Objectives

1.To give the knowledge about fire and explosion.
2.To train the students about Fire and Explosion prevention methods and Reliefs techniques.
3.To make the student aware about safety in process and plant.
4.To train the students about hazard identification and risk assessment.
5.To train the students about safety procedures and design and expert manpower to handle the complex industrial environment.
6.to use RAST and CHEF tools to analyze industrial accidents, hazards and risk.

List of Experiments (minimum eight)

Download RAST and CHEF tools from AIChE Website.It is available for FREE.This is readymadetemplate which can be used in MS Excel/Libre office Calc.Enable Macros before using it.Also download **A Tutorial for the Risk Analysis Screening Tool (RAST) and CHEF.**

A total of 5 case studies need to be solved by using RAST-CHEF.

Download 5 case studies available on AIChE website. Complete Hazard Identification and Risk Analysis (HIRA) study for following cases:

1. Chlorine Rail Car
2. CAI and Arnel-Confined Space Explosion
3. BP Texas City-Refinery explosion and fire
4. Phillips Petroleum Company-Explosion and Fire
5. T2 Industries-Runaway Reaction and Explosion

Case study data is not fully provided for below cases.Find the relevant data from internet and enter the values.Asmost of these case studies are reported **AFTER** accidents and you are going to do a riskanalysis **BEFORE** accident,anticipate **MORE** scenarios.The students will have to imagine moreaccident prone scenarios in following case studies and not only the reported ones.

6. A Massive Fire, BLEVEs, and $5 Million Damages after a Mechanic Improperly Removes a Valve Actuator-102-106, Roy E. Sanders
7. An Eight-Inch Elbow Ruptures from Internal Corrosion and A Blast Results in Worldwide Feed stocks Disruptions and An Eight-Inch Line Ruptures in Mexico City and over 500 People Die-120-121,Roy E. Sanders
8. Flixborough, England,23-25,Crowl, D. A.
9. Seveso, Italy,26-27
10. A Well-Intended Change Yields a Storage Tank Collapse, 32-36, Roy E. Sanders
11. A Severe Pump Explosion Surprises Employees, 168-170

A total of 3 practical's need to be performed from below experiments

1. Flash point
2. Fire point
3. Fire Extinguishers
4. Flammability limits of gases
5. Industrial Safety Awareness (Lecture by Industry Person/ Visit to Industry)
6. Safety Audit Format
7. Electrical Safety Awareness (Expert lecture by Electrical Background Person)

Course Outcome

At the end of the course students will be

1. able to apply the knowledge of mathematics, science, engineering fundamentals for identifying causative and initiating factors of accidents.
2. able to carry out Hazard and Risk analysis by using principles ofsciences and engineering.
3. able to develop fire and explosion index and chemical exposure index by analyzing and interpreting of available data.
4. able to use IT tools such as RAST-CHEF to understand and evaluate situations causing industrial fire, explosions and evaluate risk.
5. able to prepare scenario list- guidance and maximum allowable response time for particular chemical plant/equipment
6. Students should be able to prepare Risk Assessment Matrix and Risk summery for particular plant to avoid accidents,for betterment of environment,society and communicate itwith higher authorities

Assessment:

Term Work (25 marks)

Distribution of marks will be as follows:

Laboratory Work and Journal : 20 marks

Attendance	: 05 marks
Total Marks	: 25 Marks

End Semester Practical Examination/orals (25 marks)

Practical Oral Examination will be based on experiments performed in the laboratory.

Reference Books

1. Incidents that define process safety; Centre for Chemical Process Safety, AIChE,Wiley
2. More incidents that define process safety; Centre for Chemical Process Safety,AIChE,Wiley,2020
3. Chemical Process Safety Learning from Case Histories; 3rd Edition; Roy E. Sanders; Elsevier Butterworth–Heinemann 2005
4. Chemical Process Safety: Fundamentals with Applications; Crowl, D. A. and Louvar, J.P.; Prentice Hall, Englewood
5. Chemical Process Industry Safety; K. S. N. Raju, McGraw Hill Education
6. Avoiding Greenhouse Gas Emissions The Essential Role of Chemicals 17 Case Studies; International Council of Chemical Associations.

Semester VII

Course Code	Course Name	Credits
CHP701	Major Project I	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
	6#	-		3	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

 # Workload of learner, not faculty for project I. faculty load : semester VII – ½ hour per week per project group

Prerequisites

1. Detail knowledge of applied chemistry.
2. Fundamentals of unit operations.
3. Mass and energy balance calculations
4. Knowledge of chemical engineering economics [Demand supply analysis, rate of interests, profitability methods, depreciation methods]
5. Report writing, feasibility studies.

Objectives

1. To be able to identify advanced topic in chemical engineering based on the technology, its application, and its future potential. (Problem identification)
2.To demonstrate a sound technical knowledge of the selected project topic which should be focused on solutions to industrial, societal, and environmental problems with the application of sustainable technology.
3. To carry out market study on the product and find demand supply gap for manufacturing projects.
4. To carry out thorough literature survey on the selected topic and identify research gaps for research projects.
5. To carry out profitability analysis for the selected product and technical/economic feasibility study.

6. To communicate the literature review, proposed work at various platforms for further suggestions, improvement.

Outcomes

After the completion of this project work., Students will be able to

1. Identify advanced topic in chemical engineering based on the technology, its application, and its future potential.
2. Demonstrate a sound technical knowledge of the selected project topic focused on solutions to industrial, societal, and environmental problems with the application of sustainable technology.
3. Carry out market study on the product and find demand supply gap for manufacturing projects.
4. Carry out thorough literature survey on the selected topic and identify research gaps for research projects.
5. Carry out profitability analysis for the selected product.
6. Communicate the literature review, proposed work at various platforms for further suggestions, improvement.

Guidelines:

- Project groups: Groups can be formed with minimum TWO and not more than FOUR students per group.
- Students should spend considerable time in applying all the concepts studied.
- Students are advised to take up industrial/ experimental/ simulation and/or optimization-based topics for their project.
- Students should report their guides with their work on weekly basis.
- For Project oral, external examiners, preferably from industrial background should be appointed.
- For term work marks, punctuality of the students, timely submission of the weekly progress report should be considered along with presentation before guide and departmental expert panel at the end of semester and record of the same should be maintained.

Exam Guidelines

Term Work – 25 Marks:

[• Presentation – 10 Marks • Report -15 Marks]

Oral – 25 Marks

University of Mumbai
Program Structure for B.E. Chemical Engineering (Revised 2022-2023)
Semester VIII

Semester VIII

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
CHC801	Modelling Simulation and Optimization	3	-	-	3	-	-	3
CHDO805X	Department Optional Course 5	3	-	-	3	-	-	3
CHDO806X	Department Optional Course 6	3	-	-	3	-	-	3
IO802X	Institute Optional Course 2	3	-	-	3	-	-	3
CHL801	Modelling Simulation and Optimization Lab	-	3	-	-	1.5	-	1.5
CHL802	Software application in Chemical Engineering Lab	-	3	-	-	1.5	-	1.5
CHP801	Major Project II	-	12#	-	-	6	-	6
	Total	12	18	-	12	9	-	21

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract /Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
CHC801	Modelling Simulation and Optimization	20	20	20	80	3	-	-	-	100
CHDO805X	Department Optional Course 5	20	20	20	80	3	-	-	-	100
CHDO806X	Department Optional Course 6	20	20	20	80	3	-	-	-	100
IO802X	Institute Optional Course 2	20	20	20	80	3	-	-	-	100
CHL801	Modelling Simulation and Optimization Lab	-	-	-	-	3	25	25	-	50
CHL802	Software application in Chemical Engineering Lab	-	-	-	-	-	25	-	25	50
CHP801	Major Project II	-	-	-	-	-	50	-	100	150
	Total			80	320	-	100	25	125	650

Department Optional Course 5 (Sem VIII)

Engineering Stream (Course Code)	Technology Stream (Course Code)	Management Stream (Course Code)
Energy System Design (CHDO8051)	Advanced Separation Technology (CHDO8052)	Financial Management (CHDO8053)

Department Optional Course 6 (Sem VIII)

Engineering Stream (Course Code)	Technology Stream (Course Code)	Management Stream (Course Code)
Fuel Cell Electrochemical Engineering (CHDO8061)	1. Biotechnology (CHDO8062) 2. Nanotechnology (CHDO8063)	Chemical Waste Management (CHDO8064)

Institute Optional Course 2(SemVIII)

1.ProjectManagement(ILO8021)	4.HumanResourceManagement(ILO8024)	7.IPRandPatenting (ILO8027)
2.FinanceManagement(ILO8022)	5.ProfessionalEthicsandCSR(ILO8025)	8.DigitalBusinessManagement(ILO8028)
3.EntrepreneurshipDevelopmentandManagement(ILO8023)	6. Research Methodology(ILO8026)	9.EnvironmentalManagement(ILO8029)

 # indicates work load of Learner (Not Faculty), Faculty load-for Major Project.semester VIII – 1 hour per week per project group

Semester VIII		
Course Code	**Course Name**	**Credits**
CHC801	**Modelling Simulation and Optimization**	**03**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	**-**	**-**	**03**	**-**	**-**	**03**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**	**--**	**--**	**100**

Prerequisites

- Linear Algebra, Process Calculations, Computer Programming

Course Objectives

1. To make students understand writing and solving models of chemical engineering system.
2. To make students understand sequential and equation-oriented simulation of complete flow sheets.
3. To make students understand writing and solving systems of nonlinear equations for single and multiple units.
4. To make students understand simulation of complete flow sheets.
5. To make students understand optimization of single and multiple units.
6. To make students understand artificial neural network principles.

Detailed Syllabus

Module No	Contents	Contact Hrs
1	Modeling Aspects: Definition of process model, physical and mathematical modeling, classification of models, model building, classification of mathematical methods Mathematical Models of Chemical Engineering Systems: Introduction, uses of mathematical models, scope of coverage, principles of formulation, fundamental laws, continuity equations, energy equations, equation of motion, equationof state, equilibrium, kinetics.	**06**

2	Examples of Mathematical Models of Chemical Engineering Systems: Introduction, series of isothermal, constant-hold up CSTR, CSTR with variable holds up, two heated tanks, gas-phase, pressurized CSTR, non-isothermal CSTR, single-component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup. Degree of Freedom analysis Concept of design and rating problem incontext of selection variables after DOF analysis.	**08**
3	Artificial Neural Network–Based Models., Applications of ANNs in Chemical Engineering, Advantages of ANN-Based Models. Limitations of ANN-Based Models.	**04**
4	Introduction to Simulation, Sequential and Equation oriented Simulation, Flowsheet topology analysis, Recycle, Partitioning and Tearing of flow sheets. Simulation Examples, Williams Otto Flowsheeting	**08**
5	Numerical Methods for solving sets of nonlinear equations, Newton's method with Armijo Line search, Successive substitution. Solution for models developed in module 2	**08**
6	Introduction to Optimization. Unconstrained single and multi-variable non-linear optimization. Numerical methods for single and multivariable optimization.	**05**

Course Outcomes:

1. The students will be able to write and solve models of chemical engineering system.
2. The students will be able to carry out sequential and equation oriented simulation of complete flow sheets.
3. The student will be able to optimize typical chemical processes.
4. The students will able to solve a process simulation.
5. The students will able to use basics of numerical methods
6. The students will able to understand artificial neural network principles.

Internal Assessment

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20marks.
- Total 4 questions need to besolved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can beasked.
- Remaining questions will be randomly selected from all themodules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Reference

1. William Y.Luyben, Process Modelling simulation and control for chemical Engineer,

Second edition McGraw Hill
2. Thomas Edger, David M. Himmelbleau, Optimization of chemical processes, 2nd Ed., JohnWiley
3. Lorenz T. Beigler, Ignacio E. Grossman, Arthur W. Wesburg, Systematic Methods of Chemical Process Design, PrenticeHall
4. Ashok Kumar Verma , Process Modelling and Simulation in Chemical , Biochemical andEnvironmental Engineering, CRC Press Taylor and Francis Group

Semester VIII

Course Code	Course Name	Credits
CHDO8051	Energy System Design (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Prerequisites

1. Knowledge of basics of energy.
2. Knowledge of basic concepts of heat transfer.
3. Knowledge of basic concepts of thermodynamics.
4. Knowledge of mass transfer operations like distillation.
5. Knowledge of mathematics.
6. Preliminary knowledge of economics.

Course Objectives

1. Students should know the sources of energy, present status of energy and importance of energy conservation.
2. Students should understand the importance, concepts and methodologies of energy management and audit to improve energy efficiency of industrial operations and conserve the energy.
3. Students should be aware about best energy efficient technologies and practices to be followed in process industries.
4. Students should learn to apply the energy conservation techniques like heat exchanger networking and heat integration in chemical process units.
5. Students should know importance and ways of waste heat recovery and cogeneration.
6. Students should understand various sources of renewable energy sources and their advantages over conventional energy sources.

Detailed Syllabus

Module No	Content	Contact Hours

1	**Energy Scenario:** Classification of Energy sources: Commercial & non-commercial, Primary & Secondary, Renewable & non-renewable; Energy consumption patterns; Indian energy scenario; Sectoral energy consumption; Energy needs of growing economy; Energy intensity on purchasing power parity (PPP) basis; Energy pricing, Energy security; Energy strategy for the future; Energy conservation and its importance	**03**
2	**Energy Management & Audit:** Definition, Need and Types of Energy Audit; Energy audit methodology; Energy Management (Audit) Approach; Understanding Energy Costs; Benchmarking Energy Performance; Matching energy use to energy requirements; Maximizing system efficiencies; Optimizing the input energy requirements; Fuel and Energy substitution;Instrumentation used in energy audit; Safety considerations during energy audit; Post audit analysis; Minimum one Case study; ECO analysis based on simple payback period.	**06**
3	**Energy Efficient Technologies:** Energy efficient techniques for lighting system, motors, belt and drives system, fans and pumps system, compressed air system; steam system, refrigeration system.	**03**
4	**Energy Integration in Process Industries and Process Units:** Temperature Pinch analysis – Temperature interval method & Composite curve method; Design of Heat Exchanger Network (HEN) using Pinch analysis; Design of HEN with minimum number of Heat Exchangers; Breaking Loop and Stream Splitting method for HEN Design; Concept of Threshold approach temperature difference and Optimum approach temperature difference. Heat Integration in Distillation column; Reboiler flashing, Heat pumping, Vapor recompression in distillation column.	**12**
5	**Waste Heat Recovery (WHR) and Cogeneration:** Waste heat sources; Quality and Classification of waste heat and its applications; Benefits of WHR; WHR Equipments: Recuperators, Radiation/Convective Hybrid Recuperator, Ceramic Recuperator, Regenerator, Heat wheel, Heat pipe, Waste heat boiler, Economizer, Heat pumps. Definition of Cogeneration and few Basic concepts; Types of Thermodynamic cycles as basis for Cogeneration: Brayton cycle, Rankine cycle, Topping cycle, Bottoming cycle, Combined cycle; Types of Cogeneration system: Steam turbine system, Gas turbine system, Diesel engine system, Distributed cogeneration system.	**10**
6	**New and Renewable Energy Sources:** Concept of new and renewable energy; Solar energy; Wind energy; Tidal energy; Geothermal energy; Energy from waste and Biomass.	**05**

Course Outcome

On completion of the course the students will be able to:

1. Understand the present energy status and major steps to be taken to conserve the energy.
2. Know the importance of energy management program, how to carry it and follow the same when they will actual start working in industries.
3. Be aware about best energy efficient practices and will follow the same in future wherever they work.
4. To carry out Heat exchanger networking and learn other heat integration techniques to conserve the energy.
5. Identify sources of waste heat in industry, know the techniques to recover and reuse the waste heat and have knowledge about cogeneration technique.
6. Understand various renewable energy sources, their applications and preference over non-renewable energy sources.

Assessment

- Internal Assessment consists of two tests which should be conducted at proper intervals.
- End Semester theory examination Question paper will comprise of 6 questions each carrying 20 marks; Total 4 questions need to be solved; Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked; Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books:

1. Seider W. D., and Seader J. D. and Lewin D. R., Process Design Principles, John Wiley and Sons Inc., 1988.
2. Douglas J. M., Conceptual Design of Chemical Process, McGraw Hill Book Co., 1988.
3. Biegler L. T., Grossman E. I. and Westerberg A. W., .Systematic Methods of Chemical Process Design., Prentice Hall International Ltd., 1997.
4. Wayne C. Turner, Steve Doty (Ed.), Energy Management Hand Book, John Wiley and Sons, 2000.

Reference Books:

1. Robin Smith, Chemical Process Design and Integration, Wiley India, 2005.
2. Serth, Robert W., Process Heat Transfer Principles and Applications, Elsevier Science & Technology Books, 2007.
3. P K Nag, Power Plant Engineering, The McGraw-Hill Publishing Company Limited.
4. H.M.Robert, J.H.Collins, Handbook of Energy Conservation-Volume 1, CBS Publishers & Distributors.
5. D. P. Kothari, K. C. Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI Learning Pvt Ltd, Second Edition.
6. https://www.beeindia.gov.in

Semester VIII

Course Code	Course Name	Credits
CHDO8052	Advanced Separation Technology (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hours	--	--	--	100

Prerequisites

1. Mass transfer operations
2. Conventional separation processes

Course Objectives

1 Learn about various adsorbents and to design adsorption column
2 Distinguish the application of supercritical extraction.
3 Familiarize with advanced distillation techniques
4 To have the knowledge of liquid chromatographic process.
5 Distinguish various membranes.
6 Development of specificmembrane processes.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Adsorption Process:** Adsorbent such as activated carbon, molecular sieves of various types, activated alumina. Their characteristics and applications. Regeneration & activation of adsorbents. Thermal & pressure swing process. Fixed bed, moving bed, Design of adsorption column for separationand purification. Industrial examples and related numerical.	08
2	**Super critical extraction** Working principle, advantages and disadvantages of supercritical solvents over conventional liquid solvents, advantages and disadvantages of supercritical extraction over liquid- liquid extraction. Commercial applications of supercritical extraction.	06

3	**Advanced distillation techniques** Molecular, reactive and extractive distillation techniques.	**04**
4	**Liquid Chromatographic Process:** Basic concept of chromatography, phenomena and characterization. Typical chromatographic separation systems for preparative chromatography. Applications of chromatography in enzymes and other Industrial separations.	**07**
5	**Membranes:** Introduction to the membrane process, Characterization of membranes: Characterization of porous membranes, characterization of ionic membranes, characterization of non-ionic membranes. Transport process in membrane driving force. Characteristic flux behavior in pressure driven membrane preparation, membrane fouling, methods to reduce fouling. Types of modules: plate and frame, spiral wound, tubular, capillary, hollow fibre modules and liquid membranes.	**08**
6	**Membrane processes:** Introduction to reverse osmosis, nanofiltration, ultrafiltration, microfiltration, dialysis, membrane distillation. Numericals based on reverse osmosis and dialysis techniques	**06**

Course Outcomes

On completion of the course the students will be able to:

1 Identifythe various adsorbents and to design adsorption column.
2 Choose the separation by supercritical extraction.
3 Choose the appropriate separation techniques
4 Understand the application of chromatography.
5 Select, maintain and design various membrane processes.
6 Assess the various techniques of modern separation processes

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests.**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportional to number of respective lecture.
- Question paper will comprise of total **six questions, each carrying 20marks.**
- **Question 1** will be compulsory and should cover **maximum contents of thecurriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3).
- Only **Four questions need to besolved.**

Recommended Books:

1. Ruthven, D.M., Principles of Adsorption & Adsorption Processes, A Wiley- Interscience publication, (1984).
2. Coulson and Richardson's, Chemical Engineering, Vol.2,5th ed, Elsevier.
3. Treybal, R.E, Mass Transfer Operations, McGraw Hill.

4. Ruthven,D.M; Farooq,S; Knaebel,K.S, Pressure Swing Adsorption, VCH, (1994).
5. Snyder, L.R; Kirkland,J.J, Introduction to Modern Liquid Chromatography, 2 ed., A Wiley- Interscience publication (1979)
6. Scott R.P.W, Liquid Chromatography for the Analyst, Marcel Dekker,Inc, (1994).
7. Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publishers (1997).
8. E.J. Hoffman, Membrane Separations Technology, Gulf Professional Publishing. (2003)
9. Kaushik Nath, Membrane Separation Processes, Prentice Hall of India (2008).
10. C. J. King, Separation Processes.2nd ed,2013 McGraw Hill

Reference Books:

1. Membrane Handbook - Editors W.S. Winston Ho, K.K. Sirkar, Van Nostrand Reinhold Publication.
2. J. D. Seader and E. J. Henely, Separation Process Principles.2nd ed,John Wiley & Sons

Semester-VIII

Course Code	Course Name	Credits
CHDO8053	Financial Management (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

The concepts of basic Mathematics as well as a few concepts of higher mathematics.

Course Objectives

1. Overview of Indian financial system, instruments and market.
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy
4. Overview of Indian financial system, instruments and market
5. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
6. Knowledge about sources of finance, capital structure, dividend policy

Detailed Syllabus

Module No	Course Contents	Contact Hours
1.	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Introduction to Financial Accounting** Scope and importance of Financial Accounting. classification of accounts, Preparation of Journal, Ledger , Cash book & Trial balance **Financial Management:** Concept of business finance, Goals & objectives of financial management.	05
2.	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity	8

	Due; Continuous Compounding and Continuous Discounting.	
3.	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Statement:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, **Financial Ratio Analysis:** Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis	**08**
4.	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	**09**
5.	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. Bonds (Types, features & utility).	**03**
6.	**Capital Structure and Dividend Policy:** Factors Affecting an Entity's Capital Structure; Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure ;Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	**06**

Course Outcome

On completion of the course the students will be able to:

1. understand and define basic terminology used in finance and accounts •
2. Prepare& appraise Financial Statements and evaluate a company in the light of different measurement systems.
3. Analyze the risk and return of alternative sources of financing.
4. Estimate cash flows from a project, including operating, net working capital, andcapital spending.
5. Estimate the required return on projects of differing risk ,to estimate the cash flows from an investment project, calculate the appropriate discount rate, determine the value added from the project, and make a recommendation to accept or reject the project
6. Describe and illustrate the important elements in project finance

Internal Assessment (20 Marks):

Consisting Two Compulsory Class Tests.Firsttestbasedonapproximately40%ofcontentsandsecondtestbasedonremainingcontents(approximately40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

1.Weightage of each module in end semester examination will be proportional to number of respective lectures.

2.Question paper will comprise of total **six questions, each carrying 20marks.**

3.Question 1 will be compulsory and should cover **maximum contents of the curriculum.**

4.Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3)

5. Only **Four questions need to besolved.**

Recommended Books:

A Textbook of Financial Cost And Management Accounting, Dr. P. PERIASAMY,HH Publication

Reference Books:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi

Semester VIII

Course Code	Course Name	Credits
CHDO8061	Fuel Cell Electrochemical Engineering (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

- Basic knowledge of physics, electrochemistry, electrical properties, thermodynamics, reaction kinetics and transport phenomenon.

Course Objectives

1. To understand the basic elements of electrochemistry which are required for fuel cell.
2. Tostudy different types of fuel cells and their working
3.To analyze performance and operation of fuel cell.
4. Toapply thermodynamic principles to fuel cell and related processes.
5. To study Fuel Cell Reaction Kinetics
6. Tounderstand Fuel Cell Charge Transport processes.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Introduction to Electrochemistry**- redox reactions, Revision of concepts of electrochemical cells, Spontaneity of Redox Reaction, Cell Emf Dependency on Changes in Concentration, Nerst equation, Concentration Cells, corrosion, electrodialysis, Quantitative Electrolysis and Faraday's Laws. Introduction to Electrochemical Engineering- Scope and Applications, **Basic Elements of Electrochemistry**- Electric charge, electric current, cathod, anode, chemical kinetics.	4
2	**Fuel cell fundamentals-** Scheme of a proton-conducting fuel cell, Types of Fuel Cells; Design, Proton Exchange Membrane Fuel Cells (PEMFCs), Phosphoric Acid Fuel Cell (PAFC), Solid Acid Fuel Cell (SAFC),High-temperature Fuel Cells, Hydrogen-oxygen Fuel Cell, Comparison of Fuel Cell Types, Efficiency of Leading Fuel Cell Types, Theoretical Maximum Efficiency, Cogeneration, applications, Market and economics. **Fuel cell-**	12

	Operation, Fuel cell performance, fuel cell and environment,Hydrogen production and storage. Safety issues and cost expectation and life cycle analysis of fuel cells.	
3	**Fuel Cell Thermodynamics-** Heat and work potential of a fuel, Relationship between Gibbs Free Energy and Electrical Work, Relationship between Gibbs Free Energy and Reaction Spontaneity, Relationship between Gibbs Free Energy and Voltage, Standard Electrode Potentials: Computing Reversible Voltages, fuel cell efficiency.	7
4	**Fuel Cell Reaction Kinetics-** introduction to electrode kinetics, activation energy and reaction rate, calculating net rate of a reaction, rate of reaction at equilibrium: exchange current density, potential of a reaction at equilibrium: Galvani potential, potential and rate: Butler–Volmer equation, exchange currents and electrocatalysis: how to improve kinetic performance, simplified activation kinetics: tafel equation.	6
5	**Fuel Cell Charge Transport-** charge transport and a voltage loss, characteristics of fuel cell charge transport resistance, physical meaning of conductivity, fuel cell electrolyte classes.	6
6.	**Fuel Cell Mass Transport-** transport in electrode versus flow structure, transport in electrode: diffusive transport, transport in flow structures: convective transport.	4

Course Outcome

On completion of the course the students will be able

1 To apply the concepts of Electrical Potential, Electrical Field, Electrostatic Work, Voltage, Current, Electrochemical Potential, Activation Energy, Electrode & Electrochemical Equilibrium

2 To formulate and calculate relevant transport phenomena such as migration and the characteristics of (diluted) electrolytes. Relate the conversion of matter to the transport of electrical charge.

3 To apply the underlying concepts, methods and application of fuel cell technology.

4 To apply thermodynamic principles to fuel cell processes.

5 To carry out fuel cell kinetics.

6 To understand fuel cell transport processes.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents of syllabus and second test based on remaining contents of syllabus (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportional to number of respective lecture

- Question paper will comprise of total **six questions, each carrying 20 marks**
- **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
- Only **Four questions need to be solved.**

Books

Sr. No	Abbreviations	Name of the book and edition	Authors	publication
TEXT BOOKS				
1	T_1	Electrochemistry and Electrochemical Engineering(Module 1-2)	Lenny Hart	Library Press
2	T2	Fuel Cell Fundamentals(3-6)	Ryan O'hayre, Suk-Won Cha , Whitney G. Colella , Fritz B. Prinz	John Wiley & Sons, Inc
3	T3	Principles of fuel cells(Module 2)	Liu, H	Taylor & Francis, N.Y. (2006).
REFERENCE BOOKS				
1	R1	Fuel Cells and Hydrogen Production- A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition	Editor-in-Chief Robert A. Meyers. Timothy E. Lipman • Adam Z. Weber Editors	Springer
2	R2	Handbook of Electrochemistry	Cynythia G Zoski	Elsevier 2007

Semester VIII

Course Code	Course Name	Credits
CHDO8062	Biotechnology (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Knowledge of biology, chemistry,and pharmaceutical sciences in chemical engineering.
2. As biotechnology transforms everything from medicine to agriculture.

Course Objectives

1. At the end of the course the students should understand the basic concept of biotechnology. They should be able to classify micro-organisms, understand cell structure and basic metabolism.
2. Students should be able to understand basic knowledge about biological polymers.
3. Students should be able to understand basic knowledge about enzyme technology.
4. Students should understand role of biotechnology in medical field and industrial genetics.
5. Students should know importance of biotechnology in agricultural, food and beverage industries, environment, energy and chemical industries.
6. Students should understand to how to recover biological products.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Introduction:** Traditional and modern applications of biotechnology. Classification of micro-organisms. Structure of cells, types of cells. Basic metabolism of cells.	03
2	**Biological polymers:** Lipids, Proteins, Amino acids, Nucleic acids, Carbohydrates, Macronutrients and micronutrients. PRODUCTION OF BIOMASS: Production of baker's yeast, starter cultures, algae, mushrooms & single cell proteins from different	05

	substrates.	
3	**Enzyme Technology:** Nomenclature and classification of enzymes. Enzyme kinetics. Microbial growth kinetics. Michaels Menten Kinetics, Immobilized enzyme kinetics, Immobilization of enzymes. Industrial applications of enzymes.	08
4	**Biotechnology in health care and genetics:** Pharmaceuticals and bio-pharmaceuticals, antibiotics, vaccines and monoclonal antibodies, gene therapy. Industrial genetics, protoplast and cell fusion technologies, genetic engineering& protein engineering, Introduction to Bio-informatics. Potential lab biohazards of genetic engineering. Bioethics	08
5	**Applications of biotechnology:** Biotechnology in agriculture, food and beverage industries, chemical industries, environment and energy sectors.	08
6.	**Product recovery operations:** Dialysis, Reverse osmosis, ultrafiltration, microfiltration, chromatography, electrophoresis, Electrodialysis, crystallization and drying.	07

Course Outcome

On completion of the course the students will be able to:

1 The students will be able to demonstrate understanding of modern engineering techniques used in biotechnology
2 Students will have deep knowledge of biological polymers, enzymes,cell and metabolism.
3 The students will be able to utilize engineering skills and high end recent advances in biotechnology
4 The students will be able to examine effectively and demonstrate professional and ethical responsibilities
5 Students will be able to estimate how biotechnology used and helps in agricultural, food and beverage industry, chemical industries, pharmaceutical, environment and energy sectors.
6 Students will be able to improve how biological products are recovered.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents of syllabus and second test based on remaining contents of syllabus (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportional to number of respective lectures
- Question paper will comprise of total **six questions, each carrying 20marks**
- **Question 1** will be compulsory and should cover **maximum contents of thecurriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3)
- Total only**Four questions need to besolved.**

Reference Books:

1. Shuller M.L. and F. Kargi. 1992. Bioprocess Engineering, Prentice-Hall, Englewood Cliffs, NJ.
2. Bailey. J.E. and Ollis D.F. 1986, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, New York.

Recommended Text Books:

1. Kumar H.D., Modern Concepts of Biotechnology, Vikas Publishing House Pvt. Ltd.
2. Gupta P.K., Elements of Biotechnology, Rastogi Publications
3. Inamdar, Biochemical Engineering, Prentice Hall of India.
4. Biotechnology: Food Fermentations Ed. VK Joshi, Ashok Pandey Educational Publishers and Distributors, New Delhi 1999

Semester VIII

Course Code	Course Name	Credits
CHDO8063	Nanotechnology (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

1. Engineering Physics and Engineering Chemistry.
2. Fluid flow operations, Heat Transfer Operations & Thermodynamics
3. Particle Size Measurement

Course Objectives

1.To understand the basic scientific concepts of nanoscience and nanotechnology.
2. Toanalyse the properties of various nano biomaterials.
3. To study properties of various carbon nanotubes.
4. To be able to characterize various Nanostructures.
5. To be able to estimate the properties values of nanomaterials.
6. To understand applications of nanotechnology in various fields.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Fundamentals of Science behind Nanotechnology**: 1.1 Electron , Atom and Ions, Molecules, Metals, Biosystems, Molecular Recognition, 1.2 Electrical Conduction and Ohms Law, Quantum Mechanics and Quantum Ideas, Optics	03
2	**Fullerenes:** 2.1 Combustion Flame Synthesis, Crystal Formation, Sintering,Organic Synthesis Method 2.2 Super Critical Oligomerization, Solar Process, and Electric Arc Process.	04
3	**Carbon Nanotubes (CNT):** 3.1 Synthesis of CNT, Electric Arc Discharge Process,	06

	3.2 Laser Ablation Process, CVD 3.3 Physical Properties of CNTs, Morphology of CNT.	
4	**Nano structuring Methods:** 4.1 Vacuum Synthesis, Gas Evaporation Tech, Condensed Phase Synthesis. 4.2 Sol Gel Processing, Polymer Thin Film, Atomic Lithography, Electro deposition, Plasma Compaction. **Characterization of Nanostructures:** 4.3 Transmission Electron Microscope, Scanning Electron Microscope, 4.4 Microwave Spectroscopy, Raman Microscopy, X ray Diffraction.	**12**
5	**Calculations in Nanotechnology :** 5.1 Particle Size Distribution, Particle Size & Measurement Methods. 5.2 Fluid Particle Dynamics, Particle Collection Mechanisms, Particle Collection Efficiency.	**08**
6	**NanoBiology**: 6.1 Interaction between Biomolecules & Nanoparticle Surface. 6.2 Interactions in the binding of Proteins with Nanoparticles. 6.3 Different Types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies, Application.	**06**

Course Outcome

On completion of the course the students will be able to:
1. Understand the essential concepts used in nanotechnology.
2. Identify various types of nanomaterial.
3. Learn various fabrication methods in nanotechnology.
4. Implement characterize methods of nanostructures.
5.Estimate the particle size and its fluid interactions.
6. Determine Interaction of Biomolecules & Nanoparticles.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**
Firsttestbasedonapproximately40%ofcontentsandsecondtestbasedonremainingcontents(approximately40% but excluding contents covered in TestI).

End Semester Examination (80 marks):
- Weightage of each module in end semester examination will be proportional to number of respective lectures
- Question paper will comprise of total **six questions, each carrying 20marks**
- **Question 1** will be compulsory and should cover **maximum contents of thecurriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3)
- Only **Four questions need to besolved.**

Recommended Books:

1. Nano-The Essentials, Understanding Nanoscience and Nanotechnology, T. Pradeep
2. Nanotechnology: Basic Calculations for Engineers and Scientists - Louis Theodore, A John Willy & Sons

Reference Books:

1. Nano-structuring Operations in Nanoscale Science and Engineering- Kal Ranganathan Sharma, McGraw-Hill Companies.
2. Nanotechnology: A Gentle Introduction to the Next Big Idea-By Mark Ratner, Daniel Ratner.
3. Introduction to Nanotechnology- Charles P. Poole, Jr. and Frank J. Owens, John Wiley & Sons, 2003.

Semester VIII

Course Code	Course Name	Credits
CHDO8064	Chemical Waste Management (Departmental Optional Course)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Prerequisites

- Knowledge of environmental chemistry and fundamentals of environmental engineering.

Course Objectives

1.To assess the activities involved for the proposed and determine the type, nature and estimated volumes of waste to be generated;
2. To identify major pollutant and any potential environmental impacts from the generation of waste at the site;
3. To recommend appropriate waste handling measures / routings in accordance with the current legislative and administrative requirements; and
4. To categorise waste material where practicable (inert material / waste fractions) for disposal considerations i.e. public filling areas / landfill.
5. To ensure the protection of the environment through effective waste management operation.
6. To strive increased self-sufficiency in the management of hazardous waste to minimise the hazardous waste.

Detailed Syllabus

Module No	Course Contents	Contact Hours
1	**Introduction:** Chemical waste management overview. Chemical waste classification, Types of industries and industrial pollution – Characteristics of industrial wastes – Population equivalent – Bioassay studies – effects of industrial effluents on streams, sewer, land, sewage treatment plants and human health. Environmental legislations related to prevention and control of industrial effluents and hazardous wastes.	8
2	**Pollution from major industries:** Sources, Characteristics, waste treatment flow sheets for selected	8

	industries such as Textiles, Pharmaceuticals, Sugar, Paper, distilleries, Refineries, fertilizer, thermal power plants – Wastewater reclamation concepts	
3	**Supporting Industrial Activities and Wastes Generation:** Water treatment and supply systems including soft water, RO water and DM water units, Power systems and captive power units like DG sets and turbines, Boilers and steam systems, Amenities and work environment, Housekeeping, Effluent treatment plants.	6
4	**Waste Handling and Waste Minimization**: Handling, labelling, packaging and disposal procedures for Hazardous chemical waste management. Source reduction, Waste segregation schemes, Waste recycling and reuse, Pre-treatment of wastes; USEPA's waste management hierarchy Multimedia and integrated approaches to waste management, Pollution prevention programs.	6
5	**Waste Treatment and Disposal**: Overview of waste treatment technologies, Domestic wastewater and trade effluent treatment plants, Operation and control of wastewater treatment plants and air pollution control systems, Disposal of treated effluents.	5
6.	**Risk Management**: Chemical emergency response overview, workers safety, contingency plan, Emergency procedures, **Hazardous Management:** State-wise,Status of Hazardous Waste Generation (e-waste) Status of Common Hazardous Waste Treatment,Storage and Capacities,Disposal Facilities.	6

Course Outcome

On completion of the course the students will be able to:

1 Evaluate the subject from the technical, legal and economical points by learning of chemical waste management.

2 Examine the technical points that are required to set up a waste management system.

3 Evaluate recovery, treatment and disposal alternatives according to properties of industrial wastes.

4 Talent to gain knowledge with handling and reduction of waste in a wide perspective

5 Evaluate recovery, treatment and disposal alternatives according to properties of industrial waste

6 Ability to identify hazardous waste and environmental problems, understand, and solve their effects on universal and social scales

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents of syllabus and second test based on remaining contents of syllabus (approximately 40% but excluding contents covered in TestI).

End Semester Examination (80 marks):

- Weightage of each module in end semester examination will be proportional to number of respective lectures
- Question paper will comprise of total **six questions, each carrying 20marks**
- **Question 1** will be compulsory and should cover **maximum contents of thecurriculum.**
- **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 thenpart (b) will be from any module other than module3)
- Only **Four questions need to besolved.**

Sr. No	**Abbreviations**	**Name of the book and edition**	**Authors**	**publication**
TEXT BOOKS				
1	T_1	Handbook of Chemical and Biological waste management	Cavallini S., Cerutti F	CBRN Centres of Excellence,EU
REFERENCE BOOKS				
1	R_1	Waste Water treatment, disposal and Reuse	Metcalf et al.	Tata McGraw-Hill publishing company Limited.
2	R_2	Pollution control in process industries	Mahajan S.P	Tata McGraw-Hill publishing company Limited.
3	R_3	Solid and Hazardous Waste Management	By (author) Daniel Dela Torre	Publisher Arcler Education Inc

CourseCode	CourseName	Credits
IOC8021	InstituteLevelOptionalSubjectII-ProjectManagement	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives;

- To familiarize the students with the use of a structured methodology/approach foreach and every unique project undertaken, including utilizing project managementconcepts,tools and techniques.
- To appraise the students with the project management life cycle and make themknowledgeable aboutthe variousphasesfrom projectinitiationthroughclosure.

Outcomes:

Learnerwillbeableto…

- Applyselectioncriteriaandselect anappropriate projectfromdifferent options.
- Writeworkbreak downstructureforaproject and develop aschedulebasedonit.
- Identifyopportunitiesandthreatstotheprojectanddecideanapproachtodealwiththem strategically.
- UseEarned valuetechniqueanddetermine&predictstatus ofthe project.
- Capturelessonslearnedduringprojectphasesanddocumentthemforfuturereference

Module	DetailedContents	Contact Hours
01	**ProjectManagement Foundation:** Definitionofaproject,ProjectVsOperations,Necessityofprojectmanagement, Tripleconstraints,Projectlifecycles(typical & atypical) Project phases and stage gate process. Roleof project manager. Negotiations and resolving conflicts. Projectmanagement in various organization structures. PM knowledgeareasas perProject ManagementInstitute(PMI).	5
02	**InitiatingProjects:** Howtogetaprojectstarted,Selectingprojectstrategically,Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor andcreatingcharter;Projectproposal.Effectiveprojectteam, Stagesofteamdevelopment&growth(forming,storming,norming&performing),team dynamics.	6

03	**ProjectPlanningandScheduling:** WorkBreakdownstructure(WBS)andlinearresponsibilitychart,Interface Co-ordinationandconcurrentengineering,Projectcostestimation and budgeting, Top down and bottoms up budgeting,Networking and Scheduling techniques. PERT, CPM, GANTTchart.IntroductiontoProjectManagementInformationSystem (PMIS).	**8**
04	**PlanningProjects:** Crashingprojecttime,Resourceloadingandleveling,Goldratt'scriticalchain,ProjectStakeholdersandCommunicationplan.	**6**
	Risk Management in projects: Risk management planning, Riskidentification and risk register. Qualitative and quantitative riskassessment,Probabilityandimpactmatrix.Riskresponse strategiesforpositiveandnegativerisks	
05	**5.1 ExecutingProjects:** Planning monitoring and controlling cycle. Information needsandreporting,engagingwithall stakeholdersoftheprojects. Teammanagement,communicationandprojectmeetings. **5.2 MonitoringandControllingProjects:** Earned Value Management techniques for measuring value ofworkcompleted;Usingmilestonesformeasurement;changerequestsand scopecreep.Project audit. **5.3 ProjectContracting** Projectprocurementmanagement,contractingand outsourcing,	**8**
06	**6.1 ProjectLeadership andEthics:** Introduction to project leadership, ethics in projects.Multiculturaland virtual projects. **6.2 ClosingtheProject:** Customer acceptance; Reasons ofproject termination, Varioustypes ofproject terminations (Extinction, Addition, Integration,Starvation),Process of project termination, completing a finalreport;doingalessonslearnedanalysis;acknowledgingsuccessesandfailures;Projectmanagementtemplatesandother resources;Managingwithoutauthority;Areasoffurtherstudy.	**6**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbeconducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentire syllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionalto numberofhoursassignedtoeachmodule

References

1. Jack Meredith & Samuel Mantel,ProjectManagement:A managerialapproach,WileyIndia, 7th Ed.
2. AGuidetotheProjectManagementBodyofKnowledge(PMBOK® Guide),5th Ed,Project Management InstitutePA, USA
3. GidoClements,ProjectManagement,CengageLearning.
4. Gopalan,ProjectManagement,,WileyIndia
5. Dennis Lock,ProjectManagement, GowerPublishingEngland,9thEd.

CourseCode	CourseName	Credits
IOC8022	InstituteLevelOptionalSubjectII-FinanceManagement	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- OverviewofIndianfinancialsystem,instruments andmarket
- Basicconceptsofvalueofmoney,returnsandrisks,corporatefinance,workingcapitaland its management
- Knowledgeaboutsourcesoffinance, capitalstructure,dividendpolicy
-

Outcomes:

Learnerwillbeableto…

- UnderstandIndianfinancesystem andcorporatefinance
- Takeinvestment,finance as wellasdividenddecisions

Module	DetailedContents	Contact Hours
01	**OverviewofIndianFinancialSystem:**Characteristics,Components and Functions of FinancialSystem. **FinancialInstruments:**Meaning,CharacteristicsandClassification of Basic Financial Instruments — Equity Shares,Preference Shares, Bonds-Debentures, Certificates of Deposit,and TreasuryBills. **Financial Markets:** Meaning, Characteristics and Classificationof FinancialMarkets—CapitalMarket,Money MarketandForeignCurrencyMarket **FinancialInstitutions:**Meaning,CharacteristicsandClassification of Financial Institutions — Commercial Banks,Investment-MerchantBanks andStock Exchanges	06

02	**Concepts of Returns and Risks:** Measurement of HistoricalReturns and Expected Returns of a Single Security and a Two-securityPortfolio;MeasurementofHistoricalRiskandExpectedRiskofaSingleSecurityandaTwo-securityPortfolio. **Time Value of Money:** Future Value of a Lump Sum, OrdinaryAnnuity,andAnnuityDue;PresentValueofaLumpSum,Ordinary Annuity, and Annuity Due; Continuous CompoundingandContinuous Discounting.	**06**
03	**OverviewofCorporateFinance:**ObjectivesofCorporateFinance; Functions of Corporate Finance—Investment Decision,FinancingDecision, andDividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—BalanceSheet,ProfitandLossAccount,andCashFlowStatement;PurposeofFinancialRatioAnalysis;LiquidityRatios;EfficiencyorActivityRatios;ProfitabilityRatios;CapitalStructureRatios;StockMarket Ratios;Limitationsof RatioAnalysis.	**09**
04	**CapitalBudgeting:**MeaningandImportanceofCapitalBudgeting; Inputs for Capital Budgeting Decisions; InvestmentAppraisalCriterion—AccountingRateofReturn,PaybackPeriod, Discounted Payback Period, Net Present Value(NPV),Profitability Index, Internal Rate of Return (IRR), and ModifiedInternalRate of Return (MIRR) **WorkingCapitalManagement:**ConceptsofMeaningWorking Capital; Importance of Working Capital Management;FactorsAffectinganEntity'sWorkingCapitalNeeds;Estimation of Working Capital Requirements; Management ofInventories;ManagementofReceivables;andManagementof CashandMarketableSecurities.	**10**
05	**Sources of Finance:** Long Term Sources—Equity, Debt, andHybrids; Mezzanine Finance; Sources of Short Term Finance—TradeCredit,BankFinance,CommercialPaper;ProjectFinance. **CapitalStructure:**FactorsAffectinganEntity'sCapitalStructure;OverviewofCapitalStructureTheoriesandApproaches—NetIncomeApproach,NetOperatingIncomeApproach;Traditional Approach,andModigliani-MillerApproach.Relation betweenCapital StructureandCorporate Value;ConceptofOptimalCapitalStructure	**05**
06	**Dividend Policy:** Meaning and Importance of Dividend Policy;Factors Affecting an Entity's Dividend Decision; Overview ofDividendPolicyTheoriesandApproaches—Gordon's Approach,Walter'sApproach,andModigliani-MillerApproach	**03**

Assessment
Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentire syllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionalto numberofhoursassignedtoeachmodule

References

1. FundamentalsofFinancialManagement,13th Edition(2015)byEugeneF.BrighamandJoelF.Houston;Publisher:Cengage Publications,NewDelhi.
2. AnalysisforFinancialManagement,10th Edition(2013)byRobertC.Higgins;Publishers:McGraw HillEducation, New Delhi.
3. IndianFinancialSystem,9th Edition(2015)byM.Y.Khan;Publisher:McGrawHillEducation, New Delhi.
4. FinancialManagement,11th Edition(2015)byI.M.Pandey;Publisher:S.Chand(G/L)& CompanyLimited, New Delhi.

CourseCode	CourseName	Credits
IOC8023	Institute Level Optional Subject II- EntrepreneurshipDevelopmentand Management	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Toacquaintwithentrepreneurshipandmanagementof business
- Understand Indianenvironmentforentrepreneurship
- IdeaofEDP, MSME

Outcomes:

Learnerwillbeableto…

- Understandthe conceptofbusinessplanandownerships
- Interpretkeyregulationsandlegalaspectsofentrepreneurshipin India
- Understandgovernment policiesforentrepreneurs

Module	DetailedContents	ContactHours
01	**OverviewOfEntrepreneurship:**Definitions,RolesandFunctions/ValuesofEntrepreneurship,HistoryofEntrepreneurship Development, Role of Entrepreneurship in theNationalEconomy,FunctionsofanEntrepreneur,Entrepreneurshipa ndForms of BusinessOwnership RoleofMoneyandCapitalMarketsinEntrepreneurialDevelopment:Con tributionofGovernmentAgenciesinSourcinginformation forEntrepreneurship	04
02	**Business Plans And Importance Of Capital ToEntrepreneurship:** Preliminary and Marketing Plans,ManagementandPersonnel,Start-upCostsandFinancingaswell as Projected Financial Statements, Legal Section,Insurance,SuppliersandRisks,AssumptionsandConclusion,Capital and its Importance to the Entrepreneur**EntrepreneurshipAndBusinessDevelopment:**StartingaNewBusiness,BuyinganExistingBusiness,NewProductDevelopment,BusinessGrowthandtheEntrepreneurLawanditsRelevancetoBusinessOperations	09

03	Women's Entrepreneurship Development, Socialentrepreneurship-roleandneed,EDPcell,roleofsustainability andsustainabledevelopmentforSMEs, casestudies,exercises	**05**
04	**Indian Environmentfor Entrepreneurship:** key regulationsandlegalaspects,MSMEDAct2006anditsimplications,schemesandpoliciesoftheMinistryofMSME,roleandresponsibilitiesofvariousgovernmentorganisations,departments, banks etc., Role of State governments in terms ofinfrastructuredevelopmentsandsupportetc.,Publicprivatepartnerships,NationalSkilldevelopmentMission,CreditGuaranteeFund,PMEGP, discussions,groupexercisesetc	**08**
05	**Effective Management of Business:** Issues and problems facedby micro and small enterprises and effective management of MandSenterprises(riskmanagement,creditavailability,technologyinnovation,supplychainmanagement,linkagewithlargeindustries),exercises,e-Marketing	**08**
06	**Achieving Success In The Small Business:** Stages of the smallbusiness life cycle, four types of firm-level growth strategies,Options– harvestingorclosingsmallbusinessCriticalSuccessfactorsofsmallbusiness	**05**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. Poornima Charantimath, Entrepreneurship development- Small BusinessEnterprise,Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd,Entrepreneurship,latest edition, TheMcGrawHillCompany
3. DrTNChhabra,EntrepreneurshipDevelopment,SunIndiaPublications,NewDelhi
4. DrCNPrasad,SmallandMediumEnterprisesinGlobalPerspective,NewcenturyPublications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, HimalayaPublishingHouse
6. Maddhurima Lall,ShikahSahai,Entrepreneurship,ExcelBooks
7. RashmiBansal,STAYhungrySTAYfoolish, CIIE, IIMAhmedabad

8. LawandPracticerelatingtoMicro,SmallandMediumenterprises,TaxmannPublicatio nLtd.
9. Kurakto,Entrepreneurship-PrinciplesandPractices,ThomsonPublication
10. Laghu UdyogSamachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

CourseCode	CourseName	Credits
IOC8024	InstituteLevelOptionalSubjectII-HumanResourceManagement	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- To introduce the students with basic concepts, techniques and practices of thehumanresourcemanagement.
- ToprovideopportunityoflearningHumanresourcemanagement(HRM)processes, related with the functions, and challenges in the emerging perspectiveoftoday'sorganizations.
- Tofamiliarizethestudentsaboutthelatestdevelopments,trends&differentaspectsof HRM.
- Toacquaintthestudentwiththeimportanceofinter-personal&inter-groupbehavioral skills in an organizational setting required for future stable engineers,leaders and managers.

Outcomes:

Learnerwillbeableto…

- Understand the concepts, aspects, techniques and practices of the human resourcemanagement.
- UnderstandtheHumanresourcemanagement(HRM)processes,functions,changesand challengesin today's emergingorganizational perspective.
- Gainknowledge aboutthelatestdevelopmentsandtrendsinHRM.
- Apply the knowledge of behavioral skills learnt and integrate it with in interpersonal and intergroup environment emerging as future stable engineers andmanagers.

Module	DetailedContents	Contact Hours

01	**IntroductiontoHR** • HumanResourceManagement-Concept,ScopeandImportance,InterdisciplinaryApproachRelationshipwithotherSciences,CompetenciesofHRManager,HRMfunctions. • Humanresourcedevelopment(HRD):changingroleofHRM – HumanresourcePlanning,Technologicalchange,Restructuringandrightsizing,Empowerment,TQM,Managingethical issues.	**5**
02	**OrganizationalBehavior(OB)** • IntroductiontoOBOrigin,NatureandScopeofOrganizationalBehavior,RelevancetoOrganizationalEffectivenessand Contemporaryissues • Personality:MeaningandDeterminantsofPersonality,Personality development,PersonalityTypes,Assessmentof PersonalityTraitsforIncreasingSelfAwareness	**7**
	• Perception:AttitudeandValue,EffectofperceptiononIndividualDecision-making,Attitude andBehavior. • Motivation:TheoriesofMotivationandtheirApplicationsforBehavioralChange(Maslow,Herzberg, McGregor); • Group Behavior and Group Dynamics: Work groups formaland informal groups and stages of group development. TeamEffectiveness:Highperformingteams,TeamRoles,crossfunctionaland self-directed team. • Casestudy	
03	**OrganizationalStructure&Design** • Structure,size,technology,Environmentoforganization;OrganizationalRoles&conflicts:Conceptofroles;roledynamics;roleconflictsand stress. • Leadership: Concepts and skills of leadership, Leadership andmanagerialroles,Leadershipstylesandcontemporaryissuesinleadership. • Power and Politics: Sources and uses of power; Politics atworkplace,Tacticsand strategies.	**6**
04	**HumanresourcePlanning** • Recruitment and Selection process, Job-enrichment,Empowerment -Job-Satisfaction,employeemorale. • Performance Appraisal Systems:Traditional&modernmethods,PerformanceCounseling, CareerPlanning. • Training&Development:IdentificationofTrainingNeeds,TrainingMethods	**5**

05	**EmergingTrendsin HR** • Organizationaldevelopment;BusinessProcessRe-engineering(BPR),BPRasatoolfororganizationaldevelopment , managing processes & transformation in HR.OrganizationalChange,Culture,Environment • CrossCulturalLeadershipandDecisionMaking**:**CrossCulturalCommunicationanddiversityatwork**,**Causesofdiversity,managingdiversitywithspecialreferencetohandicapped,womenandageingpeople,intracompany culturaldifferenceinemployeemotivation.	**6**
06	**HR&MIS** Need,purpose,objectiveandroleofinformationsysteminHR,ApplicationsinHRDinvariousindustries(e.g.manufacturingR&D, Public Transport, Hospitals, Hotels and service industries**StrategicHRM** RoleofStrategicHRMinthemodernbusinessworld,ConceptofStrategy,StrategicManagementProcess,ApproachestoStrategicDecisionMaking;StrategicIntent–CorporateMission,Vision, Objectives andGoals **LaborLaws&IndustrialRelations** EvolutionofIR,IRissuesinorganizations,OverviewofLaborLawsinIndia;IndustrialDisputesAct,TradeUnionsAct,Shops andEstablishmentsAct	**10**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbeconducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. StephenRobbins,OrganizationalBehavior,16th Ed,2013
2. VSPRao,Human ResourceManagement, 3rd Ed, 2010,Excel publishing
3. Aswathapa,Humanresourcemanagement: Text&cases,6th edition, 2011
4. C.B.MamoriaandSVGankar,DynamicsofIndustrialRelationsinIndia,15thEd,2015, HimalayaPublishing, 15thedition, 2015
5. P.SubbaRao,EssentialsofHumanResourcemanagementandIndustrialrelations,5thEd , 2013, HimalayaPublishing
6. LaurieMullins,Management&OrganizationalBehavior,LatestEd,2016,PearsonPublications

CourseCode	CourseName	Credits
IOC8025	Institute Level Optional Subject II- Professional EthicsandCorporatSocial Responsibility(CSR)	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tounderstandprofessionalethicsinbusiness
- Torecognizedcorporatesocialresponsibility

Outcomes:

Learnerwillbeableto…

- Understandrightsanddutiesofbusiness
- Distinguishdifferentaspects ofcorporate socialresponsibility
- Demonstrateprofessionalethics
- Understandlegalaspectsofcorporatesocialresponsibility

Module	DetailedContents	ContactHours
01	**Professional Ethics and Business:** The Nature of BusinessEthics;EthicalIssuesinBusiness;MoralResponsibilityandBlame;Utilitarianism:WeighingSocialCostsand Benefits; RightsandDutiesof Business	04
02	**Professional Ethics in the Marketplace:** Perfect Competition;Monopoly Competition; Oligopolistic Competition; Oligopoliesand PublicPolicy **ProfessionalEthicsandtheEnvironment:**DimensionsofPollution and Resource Depletion; Ethics of Pollution Control;Ethicsof Conserving Depletable Resources	08
03	**ProfessionalEthicsofConsumerProtection:**MarketsandConsumer Protection; Contract View of Business Firm's Dutiesto Consumers; Due Care Theory; Advertising Ethics; ConsumerPrivacy **ProfessionalEthicsofJobDiscrimination:**NatureofJobDiscrimination;Extent ofDiscrimination; ReservationofJobs.	06

04	**IntroductiontoCorporateSocialResponsibility:**PotentialBusiness Benefits—Triple bottom line, Human resources, Riskmanagement,Supplierrelations;Criticismsandconcerns— Natureof business; Motives; Misdirection. Trajectoryof CorporateSocial ResponsibilityinIndia	**05**
05	**CorporateSocialResponsibility:**ArticulationofGandhianTrusteeship CorporateSocialResponsibilityandSmallandMediumEnterprises(SMEs)inIndia,CorporateSocialResponsibilityandPublic-Private Partnership (PPP)inIndia	**08**
06	**Corporate Social Responsibility in Globalizing India:** CorporateSocialResponsibilityVoluntaryGuidelines,2009issuedbytheMinistryofCorporateAffairs,Governmentof	**08**
	India,LegalAspectsofCorporateSocialResponsibility— CompaniesAct,2013.	

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. BusinessEthics:TextsandCasesfromtheIndianPerspective(2013)byAnandaDasGupta; Publisher: Springer.
2. CorporateSocialResponsibility:ReadingsandCasesinaGlobalContext(2007)byAndrew Crane,DirkMatten,LauraSpence; Publisher:Routledge.
3. BusinessEthics:ConceptsandCases,7thEdition(2011)byManuelG.Velasquez;Publisher: Pearson, NewDelhi.
4. CorporateSocialResponsibilityinIndia(2015)byBidyutChakrabarty,Routledge,New Delhi.

CourseCode	CourseName	Credits
IOC8026	InstituteLevelOptionalSubjectII-ResearchMethodology	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- TounderstandResearch andResearchProcess
- Toacquaintstudentswithidentifyingproblemsforresearchanddevelopresearchstrategies
- To familiarize studentswiththe techniques ofdatacollection,analysisof dataandinterpretation

Outcomes:

Learnerwillbeableto…

- Prepareapreliminaryresearchdesignforprojectsintheirsubjectmatterareas
- Accuratelycollect,analyzeand reportdata
- Presentcomplex dataorsituationsclearly
- Reviewandanalyzeresearchfindings

Module	DetailedContents	Contact Hours
01	**IntroductionandBasicResearchConcepts** **1.1** Research–Definition;ConceptofConstruct,Postulate,Proposition,Thesis,Hypothesis,Law,Principle.Researchmethods vs Methodology **1.2** NeedofResearchinBusinessandSocialSciences **1.3** ObjectivesofResearch **1.4 Issues**andProblemsinResearch **1.5** CharacteristicsofResearch:Systematic,Valid,Verifiable,Empiricaland Critical	09
02	**TypesofResearch** **2.1.** BasicResearch **2.2.** AppliedResearch **2.3.** DescriptiveResearch **2.4.** Analytical Research **2.5.** EmpiricalResearch **2.6**QualitativeandQuantitativeApproaches	07

03	**ResearchDesignandSampleDesign** **3.1** Research Design–Meaning,TypesandSignificance **3.2** Sample Design – Meaning and Significance Essentials of agoodsamplingStagesinSampleDesignSamplingmethods/techniques SamplingErrors	**07**
04	**Research Methodology** **4.1**Meaningof ResearchMethodology **4.2**.StagesinScientificResearchProcess: **a.** IdentificationandSelectionofResearchProblem **b.** FormulationofResearchProblem	**08**
	c. Reviewof Literature **d.** FormulationofHypothesis **e.** FormulationofresearchDesign **f.** SampleDesign **g.** DataCollection **h.** DataAnalysis **i.** Hypothesistestingand InterpretationofData **j.** PreparationofResearchReport	
05	**FormulatingResearchProblem** **5.1**Considerations:Relevance,Interest,DataAvailability,Choiceofdata,Analysisofdata,GeneralizationandInterpretationof analysis	**04**
06	**Outcomeof Research** **6.1** Preparationofthe reportonconclusionreached **6.2** ValidityTesting&EthicalIssues **6.3** SuggestionsandRecommendation	**04**

Assessment

Internal

- Assessmentconsistsoftwotestswhichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. Dawson,Catherine,2002,PracticalResearchMethods,NewDelhi,UBSPublishersDistributors.
2. Kothari,C.R.,1985,ResearchMethodology-MethodsandTechniques,NewDelhi,WileyEasternLimited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide forBeginners,(2nd ed), Singapore, Pearson Education

CourseCode	CourseName	Credits
IOC8027	InstituteLevelOptionalSubjectII-IPRand Patenting	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tounderstandintellectualpropertyrightsprotectionsystem
- TopromotetheknowledgeofIntellectualPropertyLawsofIndiaaswellasInternationaltreatyprocedures
- TogetacquaintancewithPatentsearchandpatentfilingprocedureandapplications

Outcomes:

Learnerwillbeableto…

- understand IntellectualPropertyassets
- assistindividuals andorganizations incapacitybuilding
- workfordevelopment,promotion,protection,compliance,andenforcementofIntellectualPropertyandPatenting

Module	DetailedContents	Contact Hours
01	**Introduction to Intellectual Property Rights (IPR)**:Meaning ofIPR, Different category of IPR instruments - Patents, Trademarks,Copyrights,IndustrialDesigns,Plantvarietyprotection,Geographicalindications, Transfer oftechnologyetc. **ImportanceofIPRinModernGlobalEconomicEnvironment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR,IPRas an instrument of development	05
02	**EnforcementofIntellectualPropertyRights:**Introduction,Magnitude of problem, Factors that create and sustaincounterfeiting/piracy, International agreements, Internationalorganizations(e.g.WIPO,WTO)activeinIPRenforcement**IndianScenarioofIPR:**Introduction,HistoryofIPRinIndia,OverviewofIPlawsinIndia,IndianIPR,Administrative Machinery,Majorinternationaltreatiessignedby India,Procedureforsubmittingpatentand Enforcementof IPRatnationalleveletc.	07

03	**EmergingIssuesinIPR:**ChallengesforIPindigitaleconomy,e-commerce,humangenome,biodiversityandtraditionalknowledge etc.	**05**
04	**BasicsofPatents:**DefinitionofPatents,Conditionsofpatentability, Patentable and non-patentable inventions, Types ofpatent applications (e.g. Patent of addition etc), Process Patent andProduct Patent, Precautions while patenting, Patent specificationPatentclaims,Disclosuresandnon-disclosures,Patentrightsand infringement,Methodofgettingapatent	**07**
05	**PatentRules:**Indianpatentact,Europeanscenario,USscenario, Australiascenario,Japanscenario,Chinesescenario,Multilateraltreatieswhere Indiaisamember(TRIPSagreement,Paris conventionetc.)	**08**
06	**ProcedureforFilingaPatent(NationalandInternational):**LegislationandSalientFeatures,PatentSearch,DraftingandFiling Patent Applications, Processing of patent, Patent Litigation,PatentPublicationetc,Timeframeandcost,PatentLicensing, PatentInfringement **Patentdatabases:**Importantwebsites,Searchinginternational databases	**07**

Assessment

Internal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions willberandomlyselected from all themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. RajkumarS.Adukia,2007,AHandbookonLawsRelatingtoIntellectualPropertyRightsinIndia,TheInstituteofChartered AccountantsofIndia
2. KeaylaBK,Patentsystemandrelatedissuesataglance,PublishedbyNationalWorking Group on PatentLaws
3. TSengupta,2011,IntellectualPropertyLawinIndia, KluwerLawInternational
4. TzenWongandGrahamDutfield,2010,IntellectualPropertyandHumanDevelopment:CurrentTrendsandFutureScenario,Cambridge UniversityPress
5. Cornish,WilliamRodolph&Llewelyn,David.2010,IntellectualProperty:Patents,Copyrights,TradeMarksandAlliedRight,7th Edition,Sweet&Maxwell
6. Lous Harns, 2012, Theenforcement ofIntellectual Property Rights:A CaseBook,3rd Edition, WIPO
7. PrabhuddhaGanguli,2012,IntellectualPropertyRights,1stEdition,TMH
8. RRadhaKrishnan&SBalasubramanian,2012,IntellectualPropertyRights,1stEdition

,Excel Books
9. MAshokKumarandmohdIqbalAli,2-11,IntellectualPropertyRights,2ndEdition,Serial Publications
10. KompalBansalandPraishitBansal,2012,FundamentalsofIPRforEngineers,1stEdition, BS Publications
11. EntrepreneurshipDevelopmentandIPRUnit,BITSPilani,2007,AManualonIntellectual PropertyRights,
12. MathewYMaa,2009,FundamentalsofPatentingandLicensingforScientistsandEngineers, World ScientificPublishingCompany
13. N S Rathore, S M Mathur, PritiMathur, AnshulRathi**,** IPR: Drafting,InterpretationofPatentSpecificationsandClaims**,**NewIndiaPublishingAgency
14. VivienIrish,2005,IntellectualPropertyRightsforEngineers, IET
15. HowardBRockman,2004,IntellectualPropertyLawforEngineersandscientists,Wiley-IEEEPress

CourseCode	CourseName	Credits
IOC8028	Institute Level Optional Subject II - Digital BusinessManagement	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Tofamiliarizewithdigitalbusinessconcept
- ToacquaintwithE-commerce
- TogiveinsightsintoE-businessanditsstrategies

Outcomes:

Thelearnerwill beableto…..

- Identifydriversofdigitalbusiness
- Illustratevariousapproachesandtechniques forE-businessandmanagement
- PrepareE-businessplan

Module	Detailedcontent	Contact Hours
1	**Introductionto Digital Business-** Introduction,Backgroundandcurrentstatus,E-marketplaces,structures,mechanisms,economicsandimpacts.Difference betweenphysical economyand digitaleconomy. **Drivers of digital business**- Big Data & Analytics, Mobile, CloudComputing, Social media, BYOD, and Internet of Things (digitallyintelligentmachines/services).OpportunitiesandChallengesin DigitalBusiness,	09

2	**OverviewofE-Commerce** **E-Commerce**-Meaning, Retailing ine-commerce-productsandservices, consumer behavior, market research and advertisement.B2B-E-commerce-selling and buying in private e-markets, publicB2Bexchangesandsupportservices,e-supplychains,Collaborative Commerce, Intra business EC and Corporate portals.ther E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasivecomputing.ECStrategyandImplementation-ECstrategyandglobalEC,EconomicsandJustificationof EC,UsingAffiliatemarketingtopromoteyoure-commerce business,Launchinga successfulonlinebusinessandECproject,Legal,EthicsandSocietalimpacts of EC.	**06**
3	**Digital Business Support services**: ERPase–businessbackbone, knowledge Tope Apps, Information and referral system**Application Development:** Building Digital business Applicationsand Infrastructure	**06**
4	**Managing E-Business**-Managing Knowledge,Management skillsfor e-business, Managing Risks in e –business. Security Threats toe-business-SecurityOverview,ElectroniccommerceThreats, Encryption, Cryptography, Public Key and Private Key	**06**
	Cryptography,Digitalsignatures,DigitalCertificates,SecurityProtocols over Public Networks: HTTP, SSL, Firewall as SecurityControl,PublicKeyInfrastructure(PKI)forSecurity,Prominent CryptographicApplications	
5	**E-Business Strategy**-E-business Strategic formulation-AnalysisofCompany'sInternalandexternalenvironment,Selectionof strategy, E-business strategy into Action, challenges and E-Transition(Processof DigitalTransformation)	**04**
6	**Materializinge-business:FromIdeatoRealization**-Businessplanpreparation. **CaseStudiesandpresentations**	**08**

AssessmentInternal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.
- Total4 questions needto be solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestionscanbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachmodule

References

1. A textbookonE-commerce**,**Er Arunrajan Mishra,DrWK Sarwade,NehaPublishers&Distributors, 2011
2. E-commercefromvisiontofulfilment,EliasM.Awad,PHI-Restricted,2002
3. DigitalBusinessandE-CommerceManagement,6th Ed,DaveChaffey,Pearson,August2014
4. IntroductiontoE-business-ManagementandStrategy,ColinCombe,ELSVIER,2006
5. DigitalBusinessConceptsandStrategy,EloiseCoupey,2nd Edition,Pearson
6. TrendandChallengesinDigitalBusinessInnovation,VinocenzoMorabito,Springer
7. DigitalBusinessDiscourseErikaDarics,April2015,PalgraveMacmillan
8. E-Governance-ChallengesandOpportunitiesin:Proceedingsin2nd InternationalConferencetheoryand practiceofElectronicGovernance
9. PerspectivestheDigitalEnterprise–AframeworkforTransformation,TCSconsultingjournal Vol.5
10. MeasuringDigitalEconomy-Anewperspective-DOI:10.1787/9789264221796-enOECD Publishing

CourseCode	CourseName	Credits
IOC8029	Institute Level Optional Subject II- EnvironmentalManagement	03

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Objectives:

- Understandandidentifyenvironmentalissuesrelevantto Indiaandglobalconcerns
- Learnconceptsof ecology
- Familiariseenvironmentrelatedlegislations

Outcomes:

Learnerwillbeableto…

- Understandthe conceptofenvironmentalmanagement
- Understandecosystemandinterdependence, food chainetc.
- Understandandinterpret environmentrelatedlegislations

Module	DetailedContents	Contact Hours
01	IntroductionandDefinitionofEnvironment:SignificanceofEnvironment Managementfor contemporary managers, Careeropportunities. EnvironmentalissuesrelevanttoIndia,SustainableDevelopment,and TheEnergyscenario.	10
02	GlobalEnvironmentalconcerns:GlobalWarming,AcidRain,OzoneDepletion,HazardousWastes,Endangeredlife-species, Loss of Biodiversity, Industrial/Man-made disasters,Atomic/Biomedicalhazards, etc.	06
03	ConceptsofEcology:Ecosystemsandinterdependencebetween livingorganisms,habitats,limitingfactors,carryingcapacity,foodchain, etc.	05
04	ScopeofEnvironmentManagement,Role&functionsofGovernmentasaplanningandregulatingagency. EnvironmentQualityManagementandCorporateEnvironmentalResponsibility	10
05	TotalQualityEnvironmentalManagement,ISO-14000,EMS certification.	05

06	General overview of major legislations like EnvironmentProtectionAct,Air(P&CP)Act, Water(P&CP)Act,Wildlife ProtectionAct,ForestAct,Factories Act,etc.	**03**

AssessmentInternal

- Assessmentconsistsoftwotests whichshouldbe conducted atproperintervals.

EndSemestertheoryexamination

- Questionpaperwillcomprise of6questionseachcarrying20questions.

- Total4 questionsneed tobe solved
- Questionno.1willbecompulsorybasedonentiresyllabuswhereinsubquestions canbeasked.
- Remainingquestions will berandomlyselected fromall themodules
- Weightageofmarksshouldbeproportionaltonumberofhoursassignedtoeachm odule

References

1. EnvironmentalManagement:PrinciplesandPractice,CJBarrow,Routledge PublishersLondon, 1999
2. AHandbookofEnvironmentalManagementEditedbyJonC.LovettandDavid G.Ockwell,EdwardElgarPublishing
3. EnvironmentalManagement,TV Ramachandra and VijayKulkarni, TERIPress
4. IndianStandardEnvironmentalManagementSystems — RequirementsWithGuidance ForUse, Bureau OfIndian Standards, February2005
5. EnvironmentalManagement:AnIndianPerspective,SNCharyandVinodVy asulu,MaclillanIndia,2000
6. IntroductiontoEnvironmentalManagement,MaryKTheodoreandLouiseT heodore,CRC Press
7. EnvironmentandEcology,MajidHussain,3rd Ed. AccessPublishing.2015

SEMESTER VIII

Course Code	Course Name	Credits
CHL801	Modelling simulation and Optimization Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Termwork/Practical/ Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	PR/OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	--	25	50

Prerequisites

- Linear Algebra, Process Calculations, Computer Programming

Concept of Experiment:

Students should be able to simulate process models using computer program or mathematical and chemical engineering software such as COCOO/DWSIM/Unisim,/CW sim,/ChemCAD,/Hysys/ Aspen Plus / or any simulator.

Course Objectives

1. To study the types of various mathematical models of engineering processes;
2. To provide an overview of the possibilities of process simulation as a tool for computer systems analysis, which minimizes risks and costs in experimentation.
3. To familiarize students with the techniques of modeling of engineering processes and of the developed model optimization;
4. To introduce students to different commercial software to simulate the chemical processes from the design stage to the control and optimization;
5. To provide the background needed by the chemical engineers to carry out computer-aided analyses of large-scale chemical processes.
6. Demonstrate the ability to use a process simulation

Minimum TEN experiments must be performed.

- Simulation of pipe and pump network flows
- Simulation of linear and nonlinear systems
- Simulation of mass transfer process - distillation
- Simulation of mass transfer process- Absorption
- Simulation of Heat Transfer Process like Shell and tube heat exchanger
- Simulation of chemical reactor like batch, Semi batch, Continuous reactor
- Simulation of Multicomponent flash calculation for ideal and nonideal system
- Simulation of flowsheet calculation (Any chemical manufacturing process)

- Optimization of chemical processes.
- Experiments based on computer program or mathematical and chemical engineering software

Course outcomes

1. Students will learn different types of simulation techniques.

2. Students will apply simulation techniques to solve complex system issues and to select feasible, solutions

3.Student will able to calculate the different physicochemical and thermodynamic properties chemicals;

4.Students will able to understand and analyse simulation of various separation process

5.Students will able to apply optimization parameter in distillation process

6.Students will learn to simulate the models for the purpose of optimum control by using software.

Term work

Term work shall be evaluated based on performance in practical.

Practical Journal: 20 marks

Attendance: 05marks

Total: 25marks

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Semester VIII

Course Code	Course Name	Credits
CHL802	Skilled based lab: Software application in Chemical Engineering Lab	1.5

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR/OR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Prerequisites:

1. The students should have knowledge of design of unit operation & unit process
2. The students should have knowledge of Mathematics & to solve differential equations
3. They should be aware about basic principles of linear algebra & computer programing
4. The students should have knowledge of Transport phenomenon
5. The students should be aware about selection of Thermodynamic packages

Course Objectives:-

1. To make students understand advantages of software application in chemical engineering.
2. To make students identify and use the software for optimization of the processes in chemical industries.
3. To make students understand writing and solving design problem of chemical engineering System.
4. To make students to design Mass & Heat transfer Equipment's by using various chemical engineering software.
5. To make students understand Material and energy balance through simulation of complete flow sheet of chemical plant.
6. To make students to optimize the process parameters by using chemical engineering software.

List of Experiments (minimum eight)

Experiment No.	Details of Experiment	Lab Hours
1	Simulation of Pipe Network (Pressure drop, Friction factor Head Losses, Pump Power, NPSH)	3
2	Simulation of Heat Transfer Equipment's(Heater and Cooler ,Double Pipe or Shell and Tube Heat exchangers, Plate Type Heat Exchanger)	3
3	Simulation of Chemical Reactors (Plug Flow or Continuous	3

	Stirred Tank Reactor, Bubble Column Reactor)	
4	Simulation of distillation Column (Separation of Butanol and Water system)	3
5	Simulation of Pressure Swing Azeotropic Distillation (Methanol and Acetone)	3
6	Simulation of Advanced Divded Distillation Column (Benzene-Toluene-Xylene)	3
7	Simulation of Thermodynamic cycles (Rankin cycle or Vapor Compression Cycle ,Vapor Absorption cycle)	3
8	Simulation of Extractive Distillation (MethylCycloHexane/Toluene)	3
9	Simulation of Absorption and Desorption Column	3
10	Simulation of any hydrogenation process	3

Students should be able to simulate process models using computer program or chemical engineering software such as COCOO/DWSIM/Unisim,/ CWsim, /ChemCAD,/Hysys/ Aspen Plus /CFD or any simulator.

Course Outcomes:

1. Students will become aware of application of software in chemical engineering.
2. Students will be able to identify and use the software for optimization of the processes in chemical industries.
3. The students will be able to design unit operation and unit process by using chemical engineering software .
4. The student will be able to do the material and energy balance of chemical plant
5. The student will be able to optimize typical chemical processes.
6. The students will be able to solve the trouble shooting problem in chemical plants by using various chemical engineering software's.

Assessment:

Term Work (25 marks)

Distribution of marks will be as follows:

Laboratory work: 20 marks

Attendance: 05 marks

End Semester Orals (25 marks)

Orals on experiments done in the laboratory

Reference Book

1. William Y.Luyben, Process Modelling simulation and control for chemical Engineer, Second edition McGraw Hill.

2. Process Engineering and Design: Shuchen B. Thakore, Bharat I Bhatt, Second Ed., McGraw Hill Education(I) Private Limited,2011.

Source http://www.chemsep.org/

https://pubs.acs.org/doi/10.1021/acs.iecr.6b04939

Semester VIII

Course Code	Course Name	Credits
CHP801	Major Project II	06

Course Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	12#	-	-	06	-	06

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	100	150

 # indicates work load of Learner (Not Faculty), for Major Project; Faculty load: semester VIII – 1 hour per week per project group

Prerequisites

1. Detail knowledge of applied chemistry, unit operations, reaction engineering, heat transfer.
2. Basics of process engineering and economics.
3. Basics of mathematics, process equipment design.
4. Fundamentals of modeling and simulation and related software.

Objectives

1.To demonstrate a sound technical knowledge of the selected project topic which should be focused on solutions to industrial, societal and environmental problems with the application of sustainable technology.
2. To undertake problem formulation and solution.
3. To develop flowsheet and PID diagram for manufacturing projects as applicable.
4. To design engineering solutions to complex problems utilizing a systems approach.
5. To design and carry out experimental runs and validate the results.
6. To communicate the findings with engineers and the community at large in written and oral form.

Outcomes

After the completion of project work., Students will be able to
1. Demonstrate a sound technical knowledge of the selected project topic related to industrial, societal and environmental problems with the application of sustainable technology.
2. Carry out problem formulation and solution.
3.Develop flowsheet and PID diagram for manufacturing projects as applicable.
4. Design and perform experiments and analyze results for research project. In case of manufacturing project, develop complete flow sheet and PID diagram.
5. Apply knowledge of the chemical engineering subjects for interpretation and analysis of experimental results and formulate a model and use suitable software for comparing results and optimize the parameters as and when required.

6. Write research article, project report and present the findings before experts and society at large.

Guidelines:

- Project groups: Groups can be formed with minimum TWO and not more than FOUR students per group.
- Students should spend considerable time in applying all the concepts studied.
- Students are advised to take up industrial/ experimental/ simulation and/or optimization-based topics for their project.
- Students should report their guides with their work on weekly basis.
- For Project oral, external examiners, preferably from industrial background should be appointed.
- For term work marks punctuality of the students, timely submission of the weekly progress report should be considered along with presentation before guide and departmental expert panel and record of the same should be maintained.

Exam Guidelines

Term Work – 50 Marks:

- Presentation – 20 Marks
- Project Report -30 Marks

Oral – 100 Marks