Curriculum

Three Year (Six Semesters) Diploma Course In

PAPER AND PULP TECHNOLOGY

==========

3rd Semester to 4th Semester

==========

Prepared by:

==========

Curriculum Development Cell

==========

INSTITUTE OF RESEARCH DEVELOPMENT & TRAINING U. P., KANPUR-208002

To be

Approved and Implemented by B.T.E.

U.P.

CONTENTS

PREFACE

An important issue generally debated amongst the planners and educators' world is how technical education can contribute to sustainable development of the societies struggling hard to come in the same bracket as that of the developed nations. The rapid industrialization and globalization has created an environment for free flow of information and technology through fast and efficient means. This has led to shrinking of the world, bringing people from different culture and environment together and giving rise to the concept of world turning into a global village. In India, a shift has taken place from the forgettable years of closed economy to knowledge based and open economy in the last few decades. In order to cope with the challenges of handling new technologies, materials and methods, we have to develop human resources having appropriate professional knowledge, skills and attitude. Technical education system is one of the significant components of the human resource development and has grown phenomenally during all these years. Now it is time to consolidate and infuse quality aspect through developing human resources, in the delivery system. Polytechnics play an important role in meeting the requirements of trained technical manpower for industries and field organizations.

In order to meet the requirements of future technical manpower, we will have to revamp our existing technical education system and one of the most important requirements is to develop outcome-based curricula of diploma programs. The curricula for diploma programs have been revised by adopting time-tested and nationally acclaimed scientific method, laying emphasis on the identification of learning outcomes of diploma program.

The real success of the diploma program depends upon its effective implementation. However, the best curriculum document is designed, if that is not implemented properly, the output will not be as expected. In addition to acquisition of appropriate physical resources, the availability of motivated, competent and qualified faculty is essential for effective implementation of the curricula.

It is expected of the polytechnics to carry out job market research on a continuous basis to identify the new skill requirements, reduce or remove outdated and redundant courses, develop innovative methods of course offering and thereby infuse the much needed dynamism in the system.

F.R. KHAN
Director
I.R.D.T. Kanpur

ACKNOWLEDGEMENTS

We gratefully acknowledge the guidance and contribution received from the following persons:

i) Sh. Narendra Kumar Bhushan, IAS Additional Chief Secretary, Technical Education Govt. of U.P. for his exemplary vision & approach.

ii) Sh. F. R. Khan Director I.R.D.T. Kanpur for continually motivating, guiding and taking keen interest in the review of curriculum.

iii) All the participants from industries, Polytechnics and other technical institutions for their professional inputs during curriculum workshops.

iv) CDC Officer and other concerning staff of IRDT for their support and assistance in the conduct of curriculum workshops.

v) In the last but not least would like to thanks management of the industries who spare not only their precious time but also allowed the visit of their industries to the team making the curriculum.

Ravindra Kumar
Research Assistant/
Curriculum In-charge
I.R.D.T. Kanpur

Dr. A.P. Singh
(Deputy Director/
(Curriculum Coordinator)
I.R.D.T. Kanpur

LIST OF SUBJECT EXPERTS

The following experts participated in various workshop for Developing the Curricula Structure and Contents of **Paper and Pulp Technology** at I.R.D.T. Kanpur.

1. Shri P. K. Bajpai, Ex Professor and Deen TIET Patiala.
2. Shri Faizan Ahemad, HOD G.P. Bachrawan Raebareli.
3. Smt. Namrata Pal, Lecturer G.P. Kotwan Marthura.
4. Shri Sampriti Katyanan, Lecturer G.P. Kanpur.
5. Shri Nitin Sharma, Lecturer G.P. Kanpur.
6. Miss Basudha Maurya, Lecturer G.P. Kanpur.

1. SALIENT FEATURES

1) Name of the Program	➢ Diploma in Paper & Pulp Technology
2) Duration of the Program	➢ Three years (Six Semesters)
3) Entry Qualification	➢ Matriculation or equivalent NEP-2020/NSQF Level 4 as Prescribed by State Board of Technical Education, U.P.
4) Pattern of the Program	➢ Semester Pattern
5) NSQF Level	➢ Level – 5
6) Ratio between theory and Practice	➢ 40% (Theory)/60% (Practical)

1) <u>Industrial Training/Internship:</u>

Four and six weeks of industrial training is made mandatory after the II and IV semesters during summer vacation. Total marks allotted to industrial training will be respectively 50 & 100.

In the last (6^{th} Semester) we have made the one semester Industrial training/Internship as optional along with usual classroom training.

2) <u>Audit & Pathways Subjects</u>:

As per AICTE and NEP-2020 directives, Essence of Indian Knowledge, & Tradition, Indian Constitution and Entrepreneurship & Startup subjects on Environmental Studies have beenincorporated in the curriculum.

3) <u>Student Centered Activities</u>:

A provision of 3-6 hrs per week has been made for organizing Student Centered Activities for overall personality development of students. Such activities will comprise of co–curricular activities such as expert lectures, self-study, games, hobby classes like

photography, painting, singing etc. seminars, declamation contests, educational field visits, NCC, NSS and other cultural activities, disaster management and safety etc.

4) <u>Project work:</u>

Micro/Mini/Major project work has been included in the curriculum to enable the student to get familiarized with the practices and procedures being followed in the industries and provide an opportunity to work on some live projects in the industry.

2. EMPLOYMENT OPPORTUNITIES

The following are the major employment opportunities for diploma holders in Paper And Pulp Technology:

1) Pulp and paper industries. (Govt. and public sector, Private sector companies)
2) Disposable crockery items industries.
3) Packaging industries.
4) Combustible cartridges manufacturing.
5) Printing industries like SPMCIL, Note press etc.
6) Corrugated sheets manufacturing.
7) Textile industries.
8) Paper tube industries.

3. LEARNING OUTCOMES OF THE PROGRAM

1. Program Outcomes (POs)

The Program Outcomes (POs) describe the knowledge, skills, and attitudes that students are expected to develop by the time they graduate from the Diploma in Paper and Pulp Technology program. These outcomes reflect what graduates will be capable of doing because of the learning and training received throughout the course. They represent the professional abilities and attributes that define a diploma holder in engineering.
As defined by the **National Board of Accreditation (NBA)**, the following are the seven Program Outcomes for an engineering diploma graduate:

PO1: Basics and Discipline specific Knowledge
Assimilate knowledge of basic mathematics, science and engineering fundamentals.

PO2: Problem's Analysis and solution
Identify, analyse and solve problems using standard methods and established techniques.

PO3: Design and Development
Design solutions for technical problems.
Assist in designing components, systems, or processes to meet specific requirements.

PO4: Engineering Tools, Experimentation, and Testing

Use modern engineering tools and appropriate techniques to conduct experiments as per BIS standard.

PO5: Socio/ Economic /Environmental impact assessment/remedy.
Apply relevant technologies while considering societal needs, environmental impact keeping in view sustainable and ethical responsibilities.

PO6: Project Management and Communication
Apply engineering management principles, work effectively as an individual or in a team, and communicate clearly on activities.

PO7: Lifelong Learning
Recognize the importance of continuous learning and actively pursue self-improvement to keep pace with technological developments.

At the end of the diploma program, the students will be able to:

1.	Prepare and interpret Engineering Drawings
2.	Prepare simple jobs as per specifications.
3.	Operate conventional machine for machining of components as per specifications
4.	Use cutting tools for machines and machine tools.
5.	Carry out casting and welding operation.
6.	Carry out metal forming by rolling and forgingprocesses to produce parts.
7.	Difference b/w unit operation & unit process, characterization of solid particles, size reductiontechniques i.e. crushing, grinding & milling etc. Crushing laws, screen analysis, tilt ration, sedimentation & classifiers.
8.	Prepare simple jobs as per specifications.
9.	History of pupl & paper making, Selection of rawmaterials for pulp & paper elemstry of fibrous raw materials, raw material preparation & storage recycled fiber.
10.	Introduction & properties of fluids, Manometers, fluidflow phenomena. Equation of continuity. Bernoulli's theorem, boundary layer theory.
11.	Unit conversion, gas laws, Vander wall equation, average molecular weight of gas mixture. Material balance with & without chemical reaction. Energy balance & combustion process calculations, fuel analysis.
12.	Definition of pulp & paper industry, draw flowsheets for various pulping process, use of various equipmentin pulp industry, digesters, waste paper pulping.
13.	Basic laws of heat transfer, modes of heat transfer i.e.conduction, convection & radiation, heat exchanger types & calculations, boiling & condensation, evaporators & their capacity & economy.
14.	Chemical kinetics, rate of reaction concept, Arrheniuslaw, Collision & transition state theory, activation energy, reactor types, introduction to thermodynamics, first la, second law of thermodynamics, refrigeration cycles & liquefaction process.
15.	Stock preparation by refining & beating, Fillers, sizingtheory & process control of sizing, strength enhancing additives paper stock dyeing.
16.	Apply materials balance & energy balance by using Ms excel & MAT Lab, Heat transfer problems, heat exchanger or evaporator design by Kern's method. Design of pulping digester, flow diagram of pulp paper processes & ETP.
17.	Introduction to mass transfer operation, diffusion, gasabsorption, Distillation methods, types of distillation columns, Liquid-liquid extraction, solid liquid extraction, Humidification, dehumidification & drying.
18.	Introduction of various plant utilities as water, steam & electricity. Source of water & treatment techniques,Boiler fuels, properties of steam, types of boiler, boiler mountings & accessories, Boiler acts.
19.	Pulp washing, brown stock washing, washing equipment, screening & cleaning of pulp, pulp beaching, modern bleaching processes, bleaching equipment & sequences.
20.	Levels of paper making, paper making machines &function, press designing, drying & post drying operations, calendaring, specialized papers, paper conversions, development in pulp & paper making.
21.	Concept of automatic process control, elements ofcontrol system, process characteris-

	tics, elements of process dynamics, first order & second order system, modes of control action, closed loop in automatic control.
22.	Introduction to chemical recovery systems, pulping & washing, Black liquor concentration, incineration,causticizing operation & equipment, Alternate chemical recovery processes.
23.	Use appropriate practices for conservation of energyand prevention of environment Pollution.
24.	Interpret factory acts and laws.

4. STUDY AND EVALUATION SCHEME
THIRD SEMESTER

Sr. No.	SUBJECTS	COURSE TYPE & CATEGORY	STUDY SCHEME Periods/Week			Credits	MARKS IN EVALUATION SCHEME								Total Marks of Internal & External
							INTERNAL ASSESSMENT			EXTERNAL ASSESSMENT					
			L	T	P		Th	Pr	Tot	Th	Hrs	Pr	Hrs	Tot	
3.1	MECHANICAL OPERATIONS & SOLID HANDLING	PROGRAM CORE (PRACTICUM)	2	-	4	4	-	60	60	-	-	40	3	40	100
3.2	FLUID FLOW OPERATION	PROGRAM CORE (THEORY)	2	-	-	2	40	-	40	60	3	-	-	60	100
3.3	FLUID FLOW OPERATION	PROGRAM CORE (PRACTICAL)	-	-	4	2	-	60	60	-	-	40	3	40	100
3.4	CHEMICAL PROCESS CALCULATION	PROGRAM CORE (THEORY)	3	-	-	3	40	-	40	60	3	-	-	60	100
3.5	PULP TECHNOLOGY -I	PROGRAM CORE (PRACTICUM)	1	1	2	3	40	-	40	60	3	-	-	60	100
3.6	PULP & PAPER RAW MATERIALS	PROGRAM CORE (PRACTICUM)	1	-	2	2	40	-	40	60	3	-	-	60	100
3.7	**(Q)** OPEN ELECTIVE-1 **OR**	OPEN ELECTIVE (THEORY)	2	-	-	2	50	-	50	-	-	-	-	-	N/A
	*ADVANCE SKILL DEVELOPMENT	OPEN ELECTIVE (Certification Course)					-	-	-	-	-	-	-	-	N/A
3.8	SUMMER INTERNSHIP** (4) WEEKS	SUMMER TRAINING	-	-	-	2	-	50	50	-	-	-	-	-	50
#Student Centered Activities			-	-	12	-	-	50	50	-	-	-	-	-	50
Total			**11**	**01**	**24**	**20**	**160**	**220**	**380**	**240**	**-**	**80**	**-**	**320**	**700**

NOTE:-**(Q)** It is compulsory to appear and to pass the examination, but marks will not be included for percentage and division of obtained marks.

* Advance skill development mention at **3.7** in the table provide the scope of selecting the course as per choice from the elective list provided in the syllabus conducted by various agency of repute of duration not less than 20 Hrs (Offline/Online).

** SUMMER INTERNSHIP (4-6 WEEKS) duration to be organized after second semester exam. Evaluation will be in third semester.

Student Centered Activities will comprise of co-curricular activities like extension lectures, games, hobby clubs e.g. photography etc., seminars, declamation contests, educational field visits, N.C.C., NSS, library, Cultural Activities and self-study etc.

FOURTH SEMESTER

Sr. No.	SUBJECTS	COURSE TYPE & CATEGORY	STUDY SCHEME Periods/Week			Credits	MARKS IN EVALUATION SCHEME								Total Marks of Internal & External
							INTERNAL ASSESSMENT			EXTERNAL ASSESSMENT					
			L	T	P		Th	Pr	Tot	Th	Hrs	Pr	Hrs	Tot	
4.1	PROCESS HEAT AND MASS TRANSFER	PROGRAM CORE (THEORY)	2	1	-	3	40	-	40	60	3	-	-	60	100
4.2	PROCESS HEAT AND MASS TRANSFER	PROGRAM CORE (PRACTICAL)	-	-	6	3	-	60	60	-	-	40	3	40	100
4.3	PAPER TECHNOLOGY -I	PROGRAM CORE (THEORY)	2	1	-	3	40	-	40	60	3	-	-	60	100
4.4	STOCK PREPARATION AND ALLIED CHEMICALS	PROGRAM CORE (THEORY)	2	1	-	3	40	-	40	60	3	-	-	60	100
4.5	PULP TECHNOLOGY -II	PROGRAM CORE (THEORY)	3	1	-	4	40	-	40	60	3	-	-	60	100
4.6	ADVANCE PULPING PROCESSES	PROGRAM CORE (PRACTICAL)	-	-	4	2	-	60	60	-	-	40	-	40	100
4.7	**(Q)** OPEN ELECTIVE-2 **OR**	OPEN ELECTIVE (THEORY)	2	-	-	2	50	-	50	-	-	-	-	-	N/A
	*ADVANCE SKILL DEVELOPMENT	OPEN ELECTIVE (Certification Course)					-	-	-	-	-	-	-	-	N/A
4.8	ESSENCE OF INDIAN KNOWLEDGE AND TRADITION	AUDIT COURSE	2	-	-	-	50	-	50	-	-	-	-	-	-
#STUDENT CENTERED ACTIVITIES		-	-	-	9	-	-	50	50	-	-	-	-	-	50
Total			**13**	**4**	**19**	**20**	**160**	**230**	**390**	**240**	**-**	**120**	**-**	**360**	**750**

NOTE:- (**Q)** It is compulsory to appear and to pass the examination, but marks will not be included for percentage and division of obtained marks.

* Advance skill development mention at **4.7** in the table provide the scope of selecting the course as per choice from the elective list provided in the syllabus conducted by various agency of repute of duration not less than 20 Hrs (Offline/Online).

** SUMMER INTERNSHIP (4-6 WEEKS) duration to be organized after fourth semester exam. Evaluation will be in fifth semester.

Student Centered Activities will comprise of co-curricular activities like extension lectures, games, hobby clubs e.g. photography etc., seminars, declamation contests, educational field visits, N.C.C., NSS, library, Cultural Activities and self-study etc.

OPEN ELECTIVE-1

SR.NO.	(Q) THEORY COURSES NAME
1.	PROJECT MANAGMENT
2.	DISASTER MANAGMENT
**********	
SR.NO.	***CERTIFICATE COURSES**
1.	COURSES CONDUCTED BY CENTRE OF EXCELLENCE (ESTABLISHED BY THIRD PARTY AS: - TATA TECHNOLOGIES. etc)
2.	COURSES CONDUCTED BY INFOSYS PRINGBOARD
3.	COURSES CONDUCTED BY TCS ION
4.	COURSES CONDUCTED BY OTHER RELEVANT GOVERNMENT, INTERNATIONAL/NATIONAL ORGANIZATION OR PLATFORMS OF REPUTE
5.	COURSES CONDUCTED BY AICTE-ELIS AND CENTRALLY FUNDED TECHNICAL INSTITUTES
6.	COURSES CONDUCTED BY C-DAC
7.	COURSES CONDUCTED BY NEILIT

OPEN ELECTIVE -2

SR.NO.	(Q) THEORY COURSES NAME
1.	RENEWABLE ENERGY TECHNOLOGY
2.	INDUSTRIAL ROBOTICS
**********	
SR.NO.	***CERTIFICATE COURSES**
1.	COURSES CONDUCTED BY CENTRE OF EXCELLENCE (ESTABLISHED BY THIRD PARTY AS: - TATA TECHNOLOGIES. etc)
2.	COURSES CONDUCTED BY INFOSYS PRINGBOARD
3.	COURSES CONDUCTED BY TCS ION
4.	COURSES CONDUCTED BY OTHER RELEVANT GOVERNMENT, INTERNATIONAL/NATIONAL ORGANIZATION OR PLATFORMS OF REPUTE
5.	COURSES CONDUCTED BY AICTE-ELIS AND CENTRALLY FUNDED TECHNICAL INSTITUTES
6.	COURSES CONDUCTED BY C-DAC
7.	COURSES CONDUCTED BY NEILIT

6. GUIDELINES FOR ASSESMENTS OF STUDENT CENTERED ACTIVITIES (SCA)

It was discussed and decided that the maximum marks for SCA should be 50 as it involves a lot of subjectivity in the evaluation. The marks may be distributed as follows:

i. 15 Marks for general behaviour and discipline
(by HODs in consultation with all the teachers of the department)

ii. 10 Marks for attendance as per following:
(by HODs in consultation with all the teachers of the department)

a)	75 - 80%	6 Marks
b)	80 - 85%	8 Marks
c)	Above 85%	10 Marks

iii. * Even Semester:
25 Marks maximum for Sports/NCC/Cultural/Co-curricular/NSSactivities as per following: (by In-charge Sports/NCC/Cultural/Co-curricular/NSS)

a) State/National Level participation
b) Participation in two of above activities
c) Inter-Polytechnic level participation
d)

****Odd Semester:**

25 Marks maximum

a) Language Lab Practices
b) Group Discussion and Personality Development
c) Industrial Visits/Industrial Talks
d) Power Point Presentations and Resume Making
e) Development of Aptitude and Reasoning Skills
f) Participation in the technical Exhibitions, Symposiums, Seminars,
g) Workshops at the Institute /District/State/National Level.

3.1	MECHANICAL OPERATIONS AND SOLID HANDLING (Practicum)	L T P 2 0 4

1. COURSE OBJECTIVES

The subject gives the students the knowledge of working of individual mechanical operations and handling of solids and their significance in chemical industries. With this information, students will be able to control the operation of equipment and regulate production.

2. COURSE OUTCOMES

After completing this course, students will be able to:

- Understand the different properties of particulate solids and conduct their analysis.
- Select appropriate size reduction equipment based on its final application in various chemical industries, such as paint and pharmaceuticals.
- Apply theoretical knowledge to the fundamental design of solid-liquid and solid-gas separation operations.

3. CONTENTS

UNIT 1- Concepts and role of unit operation in process industries (02periods)

UNIT 2- Characterization of Solid Particles (05periods)

Sphere city, Particle shape, particle size, mixed particle sizes and size analysis, expressions for specific surface of mixture, average particle size (expression and meaning of terms only, no derivation)

UNIT 3- Size Reduction (05periods)

1. Crushing laws: Rittinger's law, Bond's law and Kick's law, Crushing efficiency.
2. Size Reduction Equipment: Classification and types; study of machines including Gyratory Crusher, Jaw Crusher, Grinding Rolls, Single Roll Toothed Crusher, Impact or Attrition Mill, and Ball Mill, Ultra-fine grinders such as Fluid Energy Mills.

Ex. No.	Name of Experiment	Periods
1.	To perform on experiment on Jaw crusher and find its crushing efficiency.	4
2.	To determine the crushing efficiency by a roll crusher using a sample of solid particles	5
3.	To determine the crushing efficiency of ball-mill using a sample of solid particles.	5

UNIT 4- Mechanical Separation (05periods)

1. Screening, Screen analysis, Tyler standard screen series, screen effectiveness, Types of screening equipment i.e. gyrating screens, stationary screens and vibrating screens, Screen efficiency, Screen capacity.

Ex. No.	Name of Experiment	Periods
4.	To find the sieve analysis of a given sample of solid particles by sieve shaker	**4**

UNIT-5: Filtrations: (05periods)

1. Classification of filtrations, filter media, filter aids, mechanisms of filtrations, plate and frame filter press Continuous: Vacuum filters, Rotary drum filters.
2. Separation based on the motion of particles through fluids, Gravity classifiers, clarifiers and thickeners, Batch sedimentation, centrifugal settling process, Cyclone Separators.

Ex. No.	Name of Experiment	Periods
5.	To find the rate of filtration with the help of filter press.	**4**
6.	To perform an experiment on rotary vacuum filter and find rate of filtration.	**4**
7.	To perform an experiment on cyclone separator.	**4**
8.	To perform an experiment on centrifuge	**4**

UNIT 6- Conveying of Solid Particles: (06 periods)

1. Classification of conveying **e**quipment, Belt conveyor, Screw conveyor, Chain conveyor and it's applications

Ex. No.	Name of Experiment	Periods
9.	To perform an experiment on ribbon mixer for solid-liquid mixing and find rate/time of mixing.	**5**
10.	To perform an experiment on industrial slurry mixer for solid-liquid mixing rate/time of mixing.	**5**

4.INSTRUCTIONAL STRATEGY

Mechanical operations have significant importance in the area of chemical engineering. Adequate competency needs to be developed by giving sufficient practical knowledge to mechanical operation (characterization of solid particles, size reduction, energy requirement and mechanical separation).A field visit may be conducted to expose the working of various conveyers and filtration equipment in industries.

5. TEXT AND REFERENCE BOOKS:

1. Unit Operations of Chemical Engineering - W.L.McCabe and J.C.Smith - 6th Edition - McGraw Hill Book Co. Singapore - 2001.
2. Introduction to chemical Engineering - W.L.Badger and J.T.Banchero - Tata McGraw Hill Publishing Co.Ltd. New Delhi –1997.
3. Unit Operations –I - K A Gavhane - Nirali Publications - 2011.
4. Introduction to chemical Engineering - Ghoshal, Sanyal and Dutta - 1st Edition – Tata McGraw Hill Publishing Co.Ltd. New Delhi - 2004.

3.2	FLUID FLOW OPERATIONS (Theory)	L T P
		2 0 0

1. COURSE OBJECTIVES

The subject gives knowledge of measurement of fluid flow and various fluid transportation machinery. The knowledge gained by this subject is directly used in different subjects studied in Chemical Engineering. The knowledge of this subject helps in installation of different fluid flow and transportation machinery.

2. COURSE OUTCOMES

After studying this subject, the students will be able to:

CO1 •Distinguish between different types of fluids, concept of viscosity and Calculate flow rates.

CO2 •Calculate the power of pump required to do a certain pumping job. Understand the principles behind different flow meters.

CO3 •Install and calculate the flow rate of fluid with different flow meters in closed pipe line.

CO4 •Understand different flow control devices and to gain the knowledge of using different valves for different types of fluids and different flow situations.

CO5 •Understand the principle and working of different fluid flow machinery and Install the fluid flow machinery in closed pipe lines.

3. CONTENTS

UNIT-1: Introduction to fluids (06 Periods)

(i) Properties of fluids- Density and viscosity, Vapour pressure and surface tension, cohesion and adhesion, Hydrostatic Pressure.

(ii) Types of Fluids- Ideal and Real fluids, Compressible and Incompressible Fluids (liquid), Newtonian and Non-Newtonian fluids and Newton's Law of Viscosity.

(iii)Types of Fluid flow: Stream line flow, steady and unsteady state flow, uniform and non-uniform flow, rotational and irrotational flow, Laminar flow and turbulent flow.

UNIT-2: Pressure Measurements (02 Periods)

(i) Pressure: Types of Pressure, Atmospheric, Gauge & Absolute Pressure, Barometric Leg

(ii) List of Pressure measuring devices: U-Tube Manometer –computation of Pressure difference using U-Tube manometer - Inclined Manometer –Simple Problems in U-Tube manometer.

UNIT-3: Flow of Incompressible Fluids (08 Periods)

(i) Equation of continuity, Mass flow rate, volumetric flow rate, average velocity and mass velocity.

(ii) Introduction to Bernoulli's Theorem and its applications (derivation excluded).

(iii) Concept of Boundary layer, Form friction and skin friction.

(iv) Hagen-Poiseuille equation (derivation excluded).
(v) Construction and Comparative Application of Venturi meter, Orifice meter, Rota meter, Pitot tube.

UNIT-4: Pipe, fitting and valves (04 Periods)

(i) Type of Pipes, Standard sizes of pipes on the basis of Wall thickness, Schedule number, BWG Number, Difference between Tube and Pipe.
(ii) Joints and fittings, Gate valve, Globe valve, Ball valve, Needle valve, Non return value, Butterfly valve, Diaphragm valve, Control Valves, Solenoid Operating Valves.

UNIT-5: Transportation of Fluids (08 Periods)

(i) Pumps- Classification of Pumps, Centrifugal Pump: Parts of centrifugal pump, working of Centrifugal pump, Installation of Centrifugal Pump (Strainer, valves, NRV's explanation), priming, Cavitation, Net Positive Suction Head (NPSH).
(ii) Positive displacement Pump: Reciprocating pumps based on Fluid Handling and based on action of piston/plunger, Construction & working of Gear pump, Rotary Pump, Diaphragm pump, Screw pump.

4. INSTRUCTIONAL STRATEGY

Teacher should give small assignments to the student. Give industrial based practical problems for material and energy calculations.

5. RECOMMENDED BOOKS

1. Unit Operations of Chemical Engineering by McCabe, Smith; McGraw Hill
2. Introduction to Chemical Engineering by Badger & Banchero; McGraw Hill
3. Chemical Engineering Volume-1 by Richardson & Coulson; Pergamon Press

WEBSITES FOR REFERENCE:
1. http://swayam.gov.in

6. SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	**6**	**20**
2	**2**	**10**
3	**8**	**30**
4	**4**	**10**
5	**8**	**30**
Total	**28**	**100**

3.3	FLUID FLOW OPERATIONS (Practical)	L T P
		0 0 4

1. COURSE OBJECTIVE:

To provide hands-on experience in the working of fluid handling equipment and measuring devices.

2. COURSE OUTCOMES:

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

CO1 • Measurement of flow rate through flow meter by using flow measuring device such as Orifice meter, Venture meter, Rota-meter and weir.
CO2 • Measurement of Pressure, Density and Viscosity
CO3 • Computation of frictional losses in straight pipes.
CO4 • Demonstration of centrifugal pump and reciprocating pump.
CO5 • Demonstrate various types of valves.

3. CONTENTS

UNIT 1: Measurements of Density, Viscosity

Ex. No.	Name of Experiment	Periods
1.	Determination of Density using Density Bottle and Hydrometer.	2
2.	To measure the viscosity of different liquids (Ostwald's Viscometer or Redwood Viscometer or latest Digital Viscometers)	2

UNIT 2: Measurement of Pressure

Ex. No.	Name of Experiment	Periods
3.	Study Sketch and Demonstration of U-Tube Manometer.	3
4.	Use of U-Tube Manometer to measure vacuum generated by vacuum pump.	3

UNIT 3: Bernoulli's Theorem, Reynold's Number, Pipe Friction

Ex. No.	Name of Experiment	Periods
5.	To perform experiment on Bernoulli's Theorem and prove that the summation of pressure head, kinetic head and potential head is constant.	5
6.	To perform Reynolds Experiment and determine Reynolds number at the end of laminar region and beginning of turbulent region	5

UNIT 4: Measurement of Flow

Ex. No.	Name of Experiment	Periods
7.	Determination of coefficient of discharge of venturi meter	3
8.	Determination of coefficient of discharge of orifice meter	3
9.	Measurement of Flow using rotameter for different liquids	3
10.	Study Sketch of Pressure Transducers (Mass Flow Meters)	3

UNIT 5: Losses in Pipe Flow

Friction in pipe, Fanning's friction factor, Friction losses due to sudden expansion/reduction of pipe and in pipefittings, Definition equivalent of length of pipe fittings,

Ex. No.	Name of Experiment	Periods
11.	Determination of equivalent length of pipe fittings	6
12.	To measure the major and minor loses in pipes	6

UNIT 6: Study-Sketch or Demonstration, Working and Internals of

Ex. No.	Name of Experiment	Periods
13.	Gate valve, Globe valve, Ball valve, Needle valve, Non return value, Butterfly valve, Diaphragm valve, Control Valves and Centrifugal Pump, Reciprocating Pumps, Strainers, Solenoid Operating Valves, two way & three way Valves, Pieces of Different types of pipes like A,B,C Class, Seamless & ERW.	12

4. INSTRUCTIONAL STRATEGY

Give industrial based simple practical problems for measurement of pressure and mass flow rate. Brief description about the related equipment.

5. RECOMMENDED BOOKS AND RESOURCES

1. Unit Operations of Chemical Engineering by McCabe, Smith; McGraw Hill
2. Introduction to Chemical Engineering by Badger & Banchero; McGraw Hill
3. Chemical Engineering Volume-1 by Richardson & Coulson; Pergamon Press
4. Fluid Mechanics and Hydraulic Machines by R. K. Bansal; Laxmi Publications.
5. Animated/Real videos of related experiments/equipments.

WEBSITES FOR REFERENCE:

http://swayam.gov.in

3.4	CHEMICAL PROCESS CALCULATION (Theory)	L T P
		3 0 0

1. COURSE OBJECTIVES

This subject equips the students with basic chemical engineering calculations. It is one of the core subjects. In this subject, students learn the fundamental concepts on which chemical engineering design is based. This subject helps the student to prepare the material and enthalpy balance of a process. It also helps them to calculate the quantity of material input and output of a process plant.

2. COURSE OUTCOMES

After studying this course, the students will be able to:

CO1 • Have understanding of scope of material and balance in chemical industries. Carry out conversions of units and equations.

CO2 • Have knowledge of the solution concentrations, specific gravity, density, molarity, normality, molality in the chemical industries. Find the contents and properties of given analysed gas.

CO3 • Find out quantity of material input and outputs of various unit operations.

CO4 • Calculate material input and outputs of chemical reactions to identify excess and limiting reactants.

CO5 • Calculate the enthalpy associated with a reaction. Carry out combustion calculations, proximate analysis and ultimate analysis

3. CONTENTS

UNIT-1: Introduction (04 Periods)

(i) Introduction to material and energy balance in chemical industries
(ii) Unit conversion, S.I. system, M.K.S. system, C.G.S. system.

UNIT-2: Gases and Gas Mixture (06Periods)

(i) Boyle's law, Charle's law, Ideal Gas law, value of universal gas constant, Amagat's Law
(ii) Average molecular weight, density and composition (by weight and by mole) of gas mixture.
(iii) Various units of concentration: PPM (parts per million), PPB (parts per billion) molarity, molality, normality.

UNIT-3: Material Balance without Chemical Reaction (10Periods)

(i) Steps for solving simple material balance problems.
(ii) Solving simple problems on various unit operations like drying,evaporation, crystallization, distillation, mixing and absorption.
(iii) Concept of: By-pass streams, recycle and purge.

UNIT-4: Material Balance with Chemical Reaction (10 Periods)

(i) Limiting component, excess component, percent excess, yield, conversion,and selectivity.
(ii) Combustion: proximate and ultimate analysis, air fuel ratio in Boiler/Furnaces, Theo-

retical oxygen/air required.
(iii) Basic numerical problems on Combustion.

UNIT-5: Energy Balance (12 Periods)

(i) Definitions of Specific heat (Cp&Cv)/sensible heat, latent heat.
(ii) Hess's law and associated basic problems.
(iii) Concept of Heat of reaction, heat of combustion & heat of formation.
(iv) Adiabatic reaction and adiabatic flame temperature
(v) Calorific Value: Net and gross and its basic numerical problems.

4. INSTRUCTIONAL STRATEGY

Teacher should give small assignments to the student. Give industrial based practical problems for material and energy calculations.

5. RECOMMENDED BOOKS

1. Stoichiometry by B. I. Bhatt &S. M. Vora; McGraw Hill Publication
2. Chemical Process Principles Part-1 by O.A. Hougen and K.M. Watson.
3. Chemical Process Principles Part-1 by R.A. Rastogi
4. Solved Examples in Chemical Engineering by G.K. Ray

6. SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted (Periods)	Marks Allotted (%)
1.	**04**	**10**
2.	**06**	**15**
3.	**10**	**25**
4.	**10**	**25**
5.	**12**	**25**
Total	**42**	**100**

3.5	PULP TECHNOLGY – 1 (Practicum)	L T P
		1 1 2

1. COURSE OBJECTIVES

Making of pulp from wood or other lingo cellulosic materials is an important & essential process step for paper making. In this process, the raw material is broken down physically and/or chemicallysuch that discrete fibers are liberated that can be dispersed in water and re-formed into a paper web.The first part deals mainly with the different types of pulping processes for various types of raw materials like woody, non-woody, agro-residue based and recycled/recovered papers.

2. COURSE OUTCOMES (CO):

After studying this course, the students will be able to:

CO1 • State basic terms and definition of pulp and paper industry.
CO2 • Understand various processes used for manufacturing of different pulp.
CO3 • Draw flowsheets for various pulping process.
CO4 • Understand use of various equipment/ Instruments for different operations in pulp industry.
CO5 • Apply different segregation and treatment processes for recycling and processes to achievecleaner environment.

3. CONTENT

UNIT 1- INTRODUCTION: (04 periods)

Basic definition and standard terms used in pulp and paper industry, Active alkali, Total alkali,Total titrable alkali, Effective alkali, White liquor, Black liquor and Green liquor, Sulphidity, Causticity and causticizing efficiency.

Ex. No.	Name of Experiment	Hours
1.	Preparation and analysis of white liquor.	2
2.	Preparation and analysis of caustic soda liquor.	2

UNIT 2- CHEMICAL PULPING: (07 periods)

2.1 ALKALINE PULPING: Introduction to standard terms used, Characteristics of alkaline pulps,Batch and continuous pulping process, Chemical composition of cooking liquor, Blow heat recovery systems, Odour emissions and its reasons, Process variable.

2.2 SULPHITE PULPING: Introduction to standard terms used, Characteristics of sulphite pulping,Process variables, Factors affecting sulphite pulping, chemical composition and preparation of cooking liquor.

2.3 PULPING PROCESS FOR DISSOVING GRADE PULP: Pre-hydrolysis of raw material – water pre-hydrolysis, acid pre-hydrolysis, Variables affecting the pre-hydrolysis, Characteristicsof pre-hydrolysate, Kraft/sulphite pulping of pre-hydrolysed material, Yield calculations. Determination of moisture in pulp and raw material.

Ex. No.	Name of Experiment	Hours
3.	Chemical pulping of agri-residues (soda process)	2
4.	Pre-hydrolysis and Kraft pulping of wood and bamboo.	2
5.	Alkaline Sulphite pulping.	2
6.	Pulp Analysis – Kappa/Permanganate number, Copper number, viscosity and lignin.	2

UNIT 3- MECHANICAL PULPING (04 periods)

Mechanical pulping processes, Process of fibre separation, Stone ground wood process, Pulping quality, characteristics and end use of pulp, Refiner - mechanical and chemical refiner, mechanical pulping process, Theory of refining, Process variables, Pulp quality, Thermo- mechanical and chemi-thermo-mechanical pulping processes, General principle of RMP, CRMP, TMP and CTMP processes.

Ex. No.	Name of Experiment	Hours
7.	Refiner mechanical pulping.	1

UNIT 4- SEMI-CHEMICAL AND CHEMI-MECHANICAL PULPING: (04 periods)

Types of processes, Process variables, pulp characteristics and uses, Composition of cooking liquor and chemical reaction during treatment, chemical treatments employed.

Ex. No.	Name of Experiment	Hours
8.	Semi-chemical and chemi-mechanical pulping	2

UNIT 5- WASTE PAPER PULPING : (04 periods)

Fiber separation of waste paper (in Hydrapulper), Deinking of waste paper, various deinking systems including enzymatic deinking, Quality of deinked pulp, Production of unbleached pulps,Process variables, Advantages of recycling of waste paper.

Ex. No.	Name of Experiment	Hours
9	Fibre classification.	2
10	Waste paper processing/deinking and evaluation	2

UNIT 6- DIFFERENT TYPES OF DIGESTERS: (05 periods)

Batch digester – Rotary & Stationary, Continuous digesters - Kamyar & Pandia. Heating methods: Direct and Indirect Methods, Digester room operations like Chip filling, liquor charging, digester relief and blow down operations. Outlines of secondary fibre pulping. Simplecalculations based on yield, Consistency and other properties. High density storage towers forbrown stock.

Ex. No.	Name of Experiment	Hours
11.	Determination of pulp consistency	2
12.	Determination of pulp freeness – CSF and extent of refining - ^{0}SR.	2
13.	Beating and refining in different laboratory beaters and refiners.	2
14.	Drainage time of pulp	1
15.	Stock sizing and evaluation of paper properties.	1
16.	Analysis of rosin and alum.	1
17.	% of solid in sizing chemical.	1
18.	Drain ability of pulp by Schopper -Riegler method	1

4. INSTRUCTIONAL STRATEGY

Teacher should explain each process techniques and use of each and every equipment used.Industrial visit can be organized in pulp and paper industries. Audio-visuals should be used to teach.

5. BOOKS RECOMMENDED

1. S.A. Rydholm, Pulping Processes, Interscience Publishers 1965
2. G.A. Smook, Handbook of Pulp and Paper Technologists, 4th Edition, Tappi Press, 2016
3. J.P. Casey (Editor), Pulp & Paper Chemistry and Technology, 3rd Edition, Vol. I, Wiley 1980
4. P. Bajpai, Biermann's Handbook of Pulp and Paper, 3rd Edition, Vol. I, Elsevier 2018

6. SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time allotted	Marks Allotted (%)

1	**4**	**16**
2	**7**	**18**
3	**4**	**16**
4	**4**	**16**
5	**4**	**16**
6	**5**	**18**
Total	**28**	**100**

3.6	**PULP AND PAPER RAW MATERIAL (Practicum)**	**L T P**
		1 - 2

1. COURSE OBJECTIVES

The overall course objective is to give students increased confidence in understanding the pulp & paper processes to interact more knowledge with process engineers and operators. The subject also involve in increase their ability to contribute to improving mill operations by Gaining a comprehensive overview of pulp & paper industry, mill operations, products, process variables, equipment, and terminology and to increase awareness of the importance of thinking on a mill wide basis. Increasing knowledge of how the P&P processes affect product properties, in order to improve product quality and troubleshooting the variations in quality.

2. COURSE OUTCOMES(CO):

After undergoing the subject, the students will be able to:

CO1 • Gain a more complete understanding of papermaking terms, equipment, process technology, science, and engineering fundamentals, operations, and variables. Use ofvarious energy sources.

CO2 • Learn how one part of the mill affects other operations.

CO3 • Understand process – product relationships, and troubleshooting product quality problems.

CO4 • Understand recycling process

3. CONTENT

UNIT 1- Paper Making Raw Materials: (04 periods)

i. Definition and History of Pulp and Paper Making, Status of Indian Paper industry, handmadepapermaking – A brief description. raw materials, Paper making raw materials

ii. Selection of pulp and paper making raw materials (a) Wood based raw materials (b) Non-woody raw materials (c) Recycled fibers (d) Synthetics fibers.

iii. Brief description of pulp and paper making process (Introduction), Description of various grades of pulp and paper, Properties of paper.

Ex. No.	Name of Experiment	Hours
1	Wood Anatomy – Identification	4

UNIT 2- Chemistry of Fibrous Raw Materials: **(03 Periods)**

i. Chemical composition of fibrous raw materials, Cellulose – Isolation, structure and Chemical properties,

ii. Cellulose derivatives-Preparation and end use, Hemicelluloses –Isolation, Importance in paper making , reaction during pulping, lignin – Isolation, structure linkage, physical & Chemicalproperties, extractives – isolation and significance in pulp & Paper making.

Ex. No.	Name of Experiment	Hours
1	Fiber identification and tissue analysis (proportion of fibers, Vessels, rays, parenchyma) anddetermination of dimensions	4
2	Proximate chemical analysis.	4
3	Determination of Alpha, Beta and Gama cellulose	4

UNIT 3- Raw Material Preparation: (03 Periods)

i. Introduction, wood handling, debarking, wood chips preparation & handling at the pulp mill,chip screening, chip storage & conveying, equipment's used for raw material preparation, chipping, chip screening & conveying, wood chip measurement, effect of chip size on pulping properties.

ii. Raw material preparation using straws, grasses and bagasse, cutters & screens for straws and grasses.

iii. Bagasse depithing – dry and wet depithing, effect of depithing on pulping and paper making properties, disposal of pith.

Ex. No.	Name of Experiment	Hours
1	Raw materials preparation chipping, chip classification, measurement	4
2	Depicting of bagasse.	3

UNIT 4- Raw Material Storage: (02 Periods)

i. Storage of conventional non-woody raw materials like bamboo, storage of non-conventional raw materials like straws, grasses and bagasse

ii. Preparation, chipping, chip screening and conveying, Effect of chip size on pulping Properties. Storage of conventional (non-woody) raw materials like Bamboo, Chip preparation.

Ex. No.	Name of Experiment	Hours
1.	Silica in raw material.	**3**

UNIT 5- Recycled Fiber: **(02 Periods)**

Introduction to fiber from recycled paper, statistics recycled fiber recovery, recycled fiber preparation, uses of recovered paper other than paper making.

Ex. No.	Name of Experiment	Hours
1	Measurement of dimensions, chip density, bulk density.	4

4. INSTRUCTIONAL STRATEGY

In addition to theoretical instructions, different activities pertaining to Environmental Studies like expert lectures, seminars, visits to green house, effluent treatment plant of any industry, rainwater harvesting plant etc. may also be organized.

5. BOOKS RECOMMENDED

1. G.A. Smook, Handbook of Pulp and Paper technologists, 4th Edition, Tappi Press, 2016
2. J.P. Casey (Editor), Pulp & Paper Chemistry and Technology, 3rd Edition, Vol. I, Wiley 1980
3. P. Bajpai, Biermann's Handbook of Pulp and Paper, 3rd Edition, Vol. I, Elsevier 2018

6. SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1.	**4**	**25**
2.	**3**	**20**
3.	**3**	**20**
4	**2**	**18**
5	**2**	**17**
Total	**14**	**100**

3.7(a)	PROJECT MANAGEMENT (Theory)	L T P
		2 0 0

1. COURSE OBJECTIVES

- To develop the idea of project plan, from defining and confirming the project goals and objectives, identifying tasks and how goals will be achieved.

- To develop an understanding of key project management skills and strategies.

2. COURSE OUTCOMES(CO):

At the end of the course the Students will be able to
CO1 Understand the importance of projects and its phases.
CO2 Analyze projects from marketing, operational and financial perspectives.
CO3 Evaluate projects based on discount and non-discount methods.
CO4 Develop network diagrams for planning and execution of a given project.
CO5 Apply crashing procedures for time and cost optimization.

4. CONTENT

UNIT-1: Concept of a project: (04 Periods

Classification of projects- importance of project management- The project life cycle-establishing project priorities (scope-cost-time) project priority matrix- work break down structure.

UNIT-2: Capital budgeting process: (06 Periods
Planning- Analysis-Selection-Financing-Implementation-Re- view. Generation and screening of project ideas- market and demand analysis- Demand forecasting techniques. Market planning and marketing research process- Technical analysis

UNIT-3: Financial estimates and projections: (06 Periods

Cost of projects-means of financing-estimates of sales and production-cost of production-working capital requirement and its financing-profitabilityprojected cash flow statement and balance sheet. Break even analysis.

UNIT-4: Basic techniques in capital budgeting: (06 Periods
Non discounting and discounting methods- pay- back period- Accounting rate of return-net present value-Benefit cost ratio-internal rate of return. Project risk. Social cost benefit analysis and economic rate of return. Non-financial justification of projects**.**

UNIT-5: Project administration: (06 Periods)
progress payments, expenditure planning, project scheduling and network planning, use of Critical Path Method (CPM), schedule of payments and physical progress, time-cost trade off.
Concepts and uses of PERT cost as a function of time, Project Evaluation and Review Techniques/cost mechanisms. Determination of least cost duration. Post project evaluation. Introduction to various Project management softwares.

Reference Books:

1. Project planning, analysis, selection, implementation and review – Prasannachandra – TataMcGraw Hill
2. Project Management – the Managerial Process – Clifford F. Gray & Erik W. Larson - McGrawHill
3. Project management - David I Cleland - Mcgraw Hill International Edition, 1999

4. Project Management – Gopala krishnan – Mcmillan India Ltd.
5. Project Management-Harry-Maylor-Peason Publication

SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	**4**	**12**
2	**6**	**22**
3	**6**	**22**
4	**6**	**22**
5	**6**	**22**
Total	**28**	**100**

3.7 (b)	DISASTER MANAGEMENT (Theory)	L T P
		2 0 0

1. COURSE OBJECTIVES

Following are the objectives of this course:

- To learn about various types of natural and man-made disasters.

- To know pre- and post-disaster management for some of the disasters.
- To know about various information and organisations in disaster management in India.
- To get exposed to technological tools and their role in disaster management

2. COURSE OUTCOMES(CO):

Students will be able to

After competing this course, student will be:

- Acquainted with basic information on various types of disasters
- Knowing the precautions and awareness regarding various disasters
- Decide first action to be taken under various disasters
- Familiarised with organisation in India which are dealing with disasters
- Able to select IT tools to help in disaster management

3. CONTENTS

UNIT – I: Understanding Disaster (04 Periods)

Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management.

UNIT – 2: Types, Trends, Causes, Consequences and Control of Disasters (06 Periods)

Geological Disasters (earthquakes, landslides, tsunami, mining); Hydro-Meteorological Di- sasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, forest fire);

Technological Disasters (chemical, industrial, radiological, nuclear) and Manmade Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemi- cals and biological disasters) Global Disaster Trends – Emerging Risks of Disasters – ClimateChange and Urban Disasters.

UNIT- 3: Disaster Management Cycle and Framework (06 Periods)

Disaster Management Cycle – Paradigm Shift in Disaster Management.

Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Micro zonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness.

During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief and Rehabilitation –

Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment; IDNDR, Yokohama Stretegy, Hyogo Frame- work of Action.

UNIT– 4: Disaster Management in India (06 Periods)

Disaster Profile of India – Mega Disasters of India and Lessons Learnt.

Disaster Management Act 2005 – Institutional and Financial Mechanism,

National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national),Non-Government and Inter Governmental Agencies

UNIT– 5: Applications of Science and Technology for Disaster Management (06 Periods)

Geo-informatics in Disaster Management (RS, GIS, GPS and RS).

Disaster Communication System (Early Warning and Its Dissemination).

Land Use Planning and Development Regulations, Disaster Safe Designs and Constructions, Structural and Non Structural Mitigation of Disasters

S&T Institutions for Disaster Management in India

1. References

1. Publications of National Disaster Management Authority (NDMA) on Various Templates andGuidelines for Disaster Management
2. Bhandani, R. K., An overview on natural & man-made disasters and their reduction, CSIR,New Delhi
3. Srivastava, H. N., and Gupta G. D., Management of Natural Disasters in developing countries,Daya Publishers, Delhi
4. Alexander, David, Natural Disasters, Kluwer Academic London
5. Ghosh, G. K., Disaster Management, A P H Publishing Corporation
6. Murthy, D. B. N., Disaster Management: Text & Case Studies, Deep & Deep Pvt. Ltd.

2. **SUGGESTED DISTRIBUTION OF MARKS**

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	**4**	**12**
2	**6**	**22**
3	**6**	**22**

4	**6**	**22**
5	**6**	**22**
Total	**28**	**100**

4.1	**PROCESS HEAT AND MASS TRANSFER(Theory)**	**L T P**
		2 1 -

1. COURSE OBJECTIVES

Most of the Chemical Engineering operations will involve heat and mass addition or heat and mass removal in one way or the other. It is, therefore, extremely necessary to have good understanding about the heat and mass transfer mechanisms. This subject enables the students

to apply this knowledge for understanding the performances of various heat transfer and mass equipment such as heat exchangers, condensers, evaporators, distillation, boiling point diagrams, extraction operation, humidification and drying processes etc. used in almost all chemical and related industries. The subject has experiments as well, to be aware of the facts involved in actual process.

2. COURSE OUTCOMES

After the completion of this course, the students will be able to:

CO1 • To understand different modes of heat transfer, conduction, convection and radiation.

CO2 • Analyze heat exchanger performance using LMTD and use it for parallel or counter flow, Recognize the various types of heat exchanger working principle, and basic geometries of heat exchanger.

CO3 • Understand the concept of boiling, condensation and evaporation.

CO4 • To know the concept of rate of mass transfer diffusion and distillation.

CO5 • To know the concept of Humidification, extraction and drying.

3. CONTENT

UNIT 1- MODE OF HEAT TRANSFER: (08 Periods)

Conduction, Convection and Radiation, Fourier's Law, Thermal conductivity, one dimensional steady state heat conduction through a plane wall and composite wall, Insulation and insulating materials, critical thickness of insulation, physical properties of insulating materials

Natural and Forced convection, Individual heat transfer coefficients and overall heat transfer coefficients. dimensional analysis and significance of various dimensional groups such as Reynolds number, Prandtl number, Nusselt number, Grashof number.

Reflection, absorption and transmission of radiation, Emissive power, Wein's displacement law, Stefan Boltzmann Law, Planck's law, Kirchhoff's law, Concept of black body, Grey body.

UNIT 2- HEAT EXCHANGERS: (08 Periods)

Introduction, classification, individual and overall heat transfer coefficient, fouling factor, LMTD for parallel and countercurrent heat exchangers, construction and description of:- Concentric double pipe, Shell and tube (1-1heat exchanger and1-2 heat exchanger), Plate type heat exchanger, Basic of extended surface equipment (fins) and its application.

UNIT 3- BOILING & CONDENSATION, EVAPORATORS: (09 Periods)

Bubble and film boiling, Concept of condensation, types of condensation i.e. drop wise and film wise condensation

Evaporation Capacity, Evaporation Economy (steam economy), construction and description of open pan, long type vertical evaporator, and agitated thin film evaporator, multiple effect evaporator, feeding arrangements- forward, backward, mixed and parallel feed.

UNIT 4- DIFFUSION AND DISTILLATION: (12 Periods)

Definition of diffusion, Rate of diffusion in Mass Transfer, Fick's law, diffusion in the gas phase-Equimolecular counter diffusion, diffusion through a stationary gas (Stefan's Law), Mass. Transfer Coefficient.

DISTILLATION:

Various distillation methods: -
flash distillation, Differential distillation, Batch distillation, Vacuum and Steam distillation, Azeotropic and Extractive distillation.

Vapour liquid equilibrium diagram, Raoult's law; Relative volatility, constant boiling mixtures, Reflux ratio, equilibrium plate, Location of feed plate. Sub cooled reflux, Total reflux, Minimum reflux ratio Entrainment; Mc-Cable Thiele diagram.

UNIT 5- EXTRACTION AND DRYING (06 Periods)

EXTRACTION:

Applications of extraction, Choice of solvent, steps of extraction operation, Solid Liquid extraction, construction and description of Moving Bed type oil seed extractor. Liquid extractor; description and construction of Mixer settler extraction system.

DRYING:
General drying behavior- Critical moisture content, equilibrium moisture content: Description and construction of dryer: Tray & Rotary dryer.

4. INSTRUCTIONAL STRATEGY

Field visit will make the students familiar with different types of heat exchangers and different types of evaporators. This will also make the students aware of auxiliary equipment/models/supports used in paint industries. Along with the theoretical part, emphasis should be given to problem solving and practices.

5. RECOMMENDED BOOKS

1. Mass Transfer Operations by Treybal, Kogakusha Publication
2. Introduction to Chemical Engineering by Badger and Banchero, McGraw Hill Publication
3. Unit Operation of Chemical Engineering by McCabe and Smith; McGraw Hill Publication
4. Chemical Engineers Handbook by Perry and Chilton, McGraw Hill Publication
5. Mass Transfer Operations by Kiran D. Patil, Nirali Publication
6. Heat Transfer by Chapman, MacMillan Publication.

7. Process Heat Transfer by Kern, McGraw Hill Publication.
8. Heat Transfer by McAdams, McGraw Hill Publication.
9. Heat Transfer by KA Gavahane, Nirali Publications.
10. Process Heat Transfer by Kern DQ, McGraw Hill Book, New York
11. Heat Transfer Principles and Applications by K Dutta; Prentice Hall, India.

6. SUGGESTED DISTRIBUTION OF MARKS

Topic No.	Time Allotted (Periods)	Marks Allotted (%)
1	08	20
2	09	20
3	09	20
4	12	25
5	06	15
Total	42	100

4.2	PROCESS HEAT AND MASS TRANSFER(Practical)	L T P

		0 0 6

1. COURSE OBJECTIVES

Most of the Chemical Engineering operations will involve heat and mass addition or heat and mass removal in one way or the other. It is, therefore, extremely necessary to have good understanding about the heat and mass transfer mechanisms. This subject enables the students to apply this knowledge for understanding the performances of various heat transfer and mass equipment such as heat exchangers, condensers, evaporators, distillation, boiling point diagrams, extraction operation, humidification and drying processes etc. used in almost all chemical and related industries. The subject have experiments as well, to be aware of the facts involved in actual process.

2. COURSE OUTCOMES

After the completion of this course, the students will be able to:

CO1 • To understand different modes of heat transfer, conduction, convection and radiation

CO2 • Analyze heat exchanger performance using LMTD and use it for parallel or counter flow, Recognize the various types of heat exchanger working principle, and basic geometries of heat exchanger.

CO3 • Understand the concept of boiling, condensation and evaporation

CO4 • To know the concept of rate of mass transfer diffusion and distillation

CO5 • To know the concept of Humidification, extraction and drying.

3. CONTENT

LIST OF EXPERIMENTS

Ex. No.	Name of Experiment	Hours
1	To determine the thermal conductivity of metal rod.	08
2	To determine thermal conductivity (insulating powder) by measuring apparatus.	06
3	To determine heat transfer coefficient, laboratory scale set up- Natural and forced convection	08
4	Laboratory- scale shell and tube heat exchangers apparatus setup.	06
5	Laboratory- scale double pipe heat exchanger for heat transfers coefficient apparatus setup.	08
6	To study and the construction of an open pan evaporator.	06
7	Laboratory scale single effect evaporator setup	08

8	Solid and liquid diffusion apparatus	08
9	Distillation packed column apparatus setup	06
10	Liquid liquid extractor laboratory-scale setup.	06
11	Laboratory scale tray dryer setup	08
12	Laboratory scale cooling tower setup.	06

4. INSTRUCTIONAL STRATEGY

Field visit will make the students familiar with different types of heat exchangers and different types of evaporators. This will also make the students aware of auxiliary equipment/models/supports used in paint industries. Along with the theoretical part, emphasis should be given to problem solving and practices.

5. RECOMMENDED BOOKS

1. Mass Transfer Operations by Treybal, Kogakusha Publication
2. Introduction to Chemical Engineering by Badger and Banchero, McGraw Hill Publication
3. Unit Operation of Chemical Engineering by McCabe and Smith; McGraw Hill Publication
4. Chemical Engineers Handbook by Perry and Chilton, McGraw Hill Publication
5. Mass Transfer Operations by Kiran D. Patil, Nirali Publication
6. Heat Transfer by Chapman, MacMillan Publication.
7. Process Heat Transfer by Kern, McGraw Hill Publication.
8. Heat Transfer by McAdams, McGraw Hill Publication.
9. Heat Transfer by KA Gavahane, Nirali Publications.
10. Process Heat Transfer by Kern DQ, McGraw Hill Book, New York
11. Heat Transfer Principles and Applications by K Dutta; Prentice Hall, India.

4.3	**PAPER TECHNOLOGY –I (Theory)**	**L T P**
		2 1 -

1. COURSE OBJECTIVES

This subject deals with the important process steps to prepare the pulp, obtained from different raw materials, for paper making (called stock preparation). In addition to some physical treatments, it also involves addition of different non-fibrous materials to get the desired properties of different types of papers.

2. COURSE OUTCOMES(CO):

After going through this subject, the students will be able to

- Perform stock preparation with carrying out refining and beating
- Gain a broad perspective by exploring the various type of pulp refining mechanism influencedby external factors and refined pulp characterizations.
- Analyze the refining process affecting factors and influence of refining process on paperqualities
- Select the types of fillers considering the required properties of paper according to end use
- Become familiar with general sizing theory of paper including variable and process control ofsizing.
- Use the strength enhancing additives and their retention in paper fabrication with the knowledge and shortcomings associated with fibre flocculation
- Develop technical competency of paper stock dyeing including process control and colourmatching

3. CONTENTS

UNIT1- STOCK PREPARATION: (06 Periods)

Introduction to stock preparation and its importance. Pulp chests. Beating and refining, mechanism of refining, types of refiners. Pulp characterization, refining of different types of pulp fibers, refining of pulp mixtures. Factors affecting refining, Effect of refining on paper properties. Refining requirements of different types of paper. Blending of pulp.

UNIT 2- INTERNAL SIZING: (06 Periods)

Internal sizing of paper, theory of sizing, different types of sizing. Use of rosin sizing, alkyl ketene dimer (AKD) sizing, alkyl succinic anhydride (ASA) sizing. Effect of pH on sizing, variables and process control in sizing. Method of addition of sizing chemicals.

UNIT 3-ROLES OF FILLERS: (08 Periods)

Roles of fillers in paper making, types of fillers, selection criteria. Addition of fillers and their retention. Effect of fillers on optical, surface and strength properties of paper. Methods of addition fillers. Retention of additives during paper making, theory of retention, Zeta potential and its effect on retention of additives, common retention aids, fiber flocculation.

UNIT 4- STRENGTH ENHANCING ADDITIVES: (06 Periods)

Introduction to strength enhancing additives. Use of starch, CMC and other gums. Wet strength enhancing additives, mechanism of wet strength development, Preparation and method of addition.

UNIT 5- DYEING OF PAPER : (04 Periods)

Reason of dyeing, Role of dyes and pigments, types of dyes, factors associated with dyeing of paper stock. Two sidedness and reasons for the same, colour matching and process control.

4.TEXT BOOKS

1. G.A. Smook, Handbook of Pulp and Paper technologists, 4th Edition, Tappi Press, 2016
2. J.P. Casey (Editor), Pulp & Paper Chemistry and Technology, 3rd Edition, Vol. II & III, Wiley1980
3. P. Bajpai, Biermann's Handbook of Pulp and Paper, 3rd Edition, Vol. II, Elsevier 2018

5. INSTRUCTIONAL STRATEGY

While imparting instructions, teacher should show various types of raw materials of paper manufacturing to the students. Students should be asked to collect various types of available pulp fibers, fillers, dyes etc. in the market. Visits to industry should be planned to demonstrate making process and use of dyes.

6. SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	**08**	**20**
2	**08**	**20**
3	**10**	**25**
4	**08**	**20**
5	**08**	**15**
Total	**42**	**100**

4.4	STOCK PREPRATION AND ALLIED CHEMICALS (Theory)	L T P
		2 1 -

1. COURSE OBJECTIVES:

Understand the Fundamentals of Stock Preparation, analyse the Role of Allied Chemicals to Develop Process Optimization Skills. Application of Environmental and Sustainability Considerations. Conduct Experimental and Analytical Evaluations

2. COURSE OUTCOMES(CO):

On successful completion of this course, the student will be able to

CO1: Understand the basic concepts, process steps & process parameters of sulphate pulping.

CO2: Understand the basic concepts, process steps & process parameters Sulphite Pulping, Mechanical Pulping & Semi Chemical Pulping.

CO3: Understand the basic concepts, process steps & process parameters pretreatment and pulping of rags and waste paper.

CO4: Understand the process of Washing & Screening and Centric Cleaning.

CO5: Understand the bleaching process and their sequences.

3. CONTENT

UNIT1- SULPHATE PULPING (9 Periods)

1.1 - Introduction to chemical pulping – Introduction to sulphate pulping process – Advantages and disadvantage of sulphate pulping Standard terms (Applicable only to pulping process) – Complete cooking cycle of batch digester wit reference to stationary vertical digester – Illustration of RDH/Super Batch process. – Uses of black liquor –

1.2 - Air pollution – Problems to calculate the volumes of WL and BL using bath ratio of a stationary digester – Chemical reactions in alkaline pulping- Process variables in sulphate cooking: i) Amount of alkali (as effective alkali) ii) Alkali Concentration iii) Sulphidity iv) Time and Temperature – Hfactor

(a short note with definition only) – Equipment's details : Digester – Below tank – Preheater – Regenerators – Recuperators.

UNIT2- SULPHITE PULPING, MECHANICAL PULPING & SEMI CHEMICAL PULPING (9 Periods)

2.1 Sulphite Pulping: Outline of the process with block diagram – Sulphite

pulping – Raw material suitability - A table of difference between sulphate and sulphite pulping – A qualitative treatment only on dissolving grade pulping.

2.2 Mechanical Pulping: Introduction to the types of mechanical pulping- A block diagram and simple description of ground wood pulping process – Description of grinding with a neat diagram - Limitations of ground wood pulps.

2.3 Semi Chemical Pulping: Principle and scope – Advantages of SC process – Properties of SC pulps – A note on pulp yield –Types of SC process – NSSC (bath process and typical cooking conditions) A note on α, β and Ɣ celluloses.

UNIT 3- PUPLING AND PRETREATMENT OF RAGS & DEINKING (06 Periods)

3.1 Pulping and Pretreatment of Rags: Properties and uses of rag pulps- A note on pulping of cotton linters.

3.2 Deinking: Process description with plant Diagram, Deinking(wastepaper treatment)- Advantages and disadvantages of deinked stock- A brief note on deinking chemicals- A qualitative account on deinking plant- Shrinkage and yield of Deinking- Properties and uses of Deinked pulps.

UNIT 4- WASHING & SCREENING AND CENTRIC LEANING (9 Periods)

4.1 Washing: Reasons for washing – Chemical losses substances removed during washing – Washing efficiency – Dilution factor and displacement ratio (Qualitative treatment only) – Types of washing
equipment's – Diagram and description of diffusion washer and rotary drum washer –
4.2 - A complete diagram of a typical three stage countercurrent washing
system – Twin roll press – Operational factors affecting washing efficiency – A note on knotter – Unit operations in washing
4.3 - Screening and Centric leaning: Introduction-Screening and principles–Nature of impurities – Important variables in screening – Cascading principle of centric leaners – A typical flow diagram of modern screening plant and its description.

UNIT 5- BLEACHING (09 Periods)

5.1 - Bleaching: Introduction and aims of bleaching – Bleaching chemicals – Principles of their chemical analysis – Bleach ability of pulps – Single stage and multistage bleaching – Chlorine water system and its significances in bleaching – Peroxide and Hydrosulphite bleaching – Chlorine-di-oxide treatment – Bleaching with a reducing agent.
5.2 - Introduction to Elemental chlorine-free bleaching process – Introduction to enzyme bleaching process – Chemical reactions in bleaching – Variables in bleaching – Bleaching equipment's – Safety – Materials of construction.
5.3 - Auxiliary equipment's – Oxygen bleaching of mechanical pulps – A flow diagram with description of CEH/CEHH sequence only.

4. TEXT BOOKS & REFERENCES:

• Gary A. Smook, "Handbook for Pulp & Paper Technologists (The SMOOK Book)", 4th Edition, Tappi Press, 2016.

• Monica Ek, Göran Gellerstedt, Gunnar Henriksson, "Pulp and Paper Chemistry and Technology: Pulping Chemistry and Technology", 1st Edition, Walter de Gruyter, 2009.

• Pratima Bajpai, "Chemical Additives for the Pulp and Paper Industry", 1st Edition, CRC Press, 2015.

Web-based/Online Resources:

• TAPPI (Technical Association of the Pulp and Paper Industry) - Website: TAPPI

• PaperChem (The Centre for Paper Research) - Website: PaperChem

• The Pulp and Paper Wiki - Website: Pulp and Paper Wiki

5. INSTRUCTIONAL STRATEGY

1. Inquiry-Based Learning strategy encourages students to explore concepts by asking questions, investigating solutions, and developing knowledge through handson activities and experimentation.

2. Project-Based Learning involves students working on complex, real-world projects over an extended period, which allows them to apply their knowledge in practical situations.

3. In a flipped classroom, students are introduced to new content at home through video lectures or readings, while classroom time is used for engaging in interactive activities, discussions, and problem-solving exercises.

6. SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	9	22
2	9	22
3	6	12
4	9	22
5	9	22
Total	42	100

4.5	PULP TECHNOLOGY –II (Theory)	L T P
		3 1 -

1. COURSE OBJECTIVES

After the pulp is prepared from the raw material, it has to be thoroughly washed and screenedfor removing the uncooked raw material. This pulp is brown in color. For produc-

ing white paper, the pulp has to be bleached in multi-stage bleaching systems using different processesand bleaching agents. This subject deals with the pulp washing, screening and bleaching processes.

2. COURSE OUTCOMES(CO):

On successful completion of this course, the student will be able to

- After studying this course, the students will be able to:
- Describe pulp washing with special reference to brown stock washing.
- Use different washing equipment for pulp washing.
- Draw flowsheets for various bleaching sequences.
- Analyse techniques for screening and cleaning of pulp.
- Understand the pulp bleaching and its processes.

3. CONTENTS

UNIT 1-BROWN STOCK WASHING (12 period)

Objectives of pulp washing, Study of pulp washing on multi-stage rotary vacuum filters. Counter-current washing of brown stock washer. Construction and working of a rotary vacuum filter, operating procedure, including startup and shutdown. Generation and maintenance of vacuum. Concept of dilution factor and elementary calculations. Washing losses, process variables affecting the washing efficiency.

UNIT 2- WASHING EQUIPMENT'S (10 periods)

Washing equipment other than rotary vacuum filters like horizontal belt washers and diffusion washers – working principles and operational aspects. Factors affecting brown stock washing and displacement efficiency, construction, working of 3-stage dilution/extraction pulp washing system.

UNIT 3- SCREENING AND CLEANING OF PULP (13 periods)

Screening and cleaning of pulps, reasons for pulp screening and cleaning, undersized constituents in unscreened pulp, Objectives and mechanisms of screening and cleaning. Variable affecting screening efficiency. Type of screens and their process design. Use ofcentrifugal cleaners (centric leaners), variables affecting centrifugal cleaning. Types of centrifugal cleaners. Theory and operation of centrifugal cleaners.

UNIT 4-PULP BLEACHING (13 periods)

4.1 Objectives and fundamentals of pulp bleaching. Important bleaching agents, their advantages and disadvantages. Brightness as a measure of pulp bleaching, Storage, handling and safety of chlorine and chlorine dioxide based bleached agents, introduction to chlorine free bleaching. Bleaching processes for chemical, mechanical, semi-chemical and waste paper pulps. Single and multi-stage bleachingsystem for chemical pulps. Chlorine water

system, chlorination, alkali extraction, useof hypochlorite and chlorine dioxide in bleaching operation. Chemical reactions and process parameters.

4.2 Recent bleaching process – use of hydrogen peroxide, oxygen, ozone, per acids, bio-bleaching. Non-wood fibre bleaching systems. Preparation of various bleaching chemicals.

UNIT 5- BLEACHING EQUIPMENT AND SEQUENCES (08 periods)

Introduction of common bleaching sequences. Flow sheets for important bleaching sequences like CE, CEHH, CEHD, CEHP, CEHDED, OCEDED, CED with emphasis onoperational measures and equipment used.

4. TEXT BOOKS

1. S.A. Rydholm, Pulping Processes, Interscience Publishers 1965
2. G.A. Smook, Handbook of Pulp and Paper Technologists, 4th Edition, Tappi Press, 2016
3. J.P. Casey (Editor), Pulp & Paper Chemistry and Technology, 3rd Edition, Vol. I, Wiley 1980
4. P. Bajpai, Biermann's Handbook of Pulp and Paper, 3rd Edition, Vol. I, Elsevier 2018
5. R.P. Singh, Bleaching of Pulp, TAPPI Press 1979

5. INSTRUCTIONAL STRATEGY

Teacher should explain each process techniques and use of each and every equipment used. Industrial visit can be organized in pulp and paper industries. Audio-visuals should be used toteach.

6. SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	**12**	**20**
2	**10**	**15**
3	**15**	**25**
4	**15**	**25**
5	**8**	**15**
Total	**56**	**100**

4.6	**ADVANCED PULPING PROCESSES (Practical)**	**L T P** **- - 4**

1. COURSE OBJECTIVES

Advanced pulping processes refer to modern technologies and methods used to improve the efficiency, sustainability, and quality of pulp production in the paper industry. These processes aim to overcome the limitations of traditional pulping methods by reducing

environmental impact, enhancing the quality of the pulp, and increasing the overall efficiency of the production process. Students will be given the idea of testing various grade of paper. The status of Indian industries in relation to paper testing should be imparted to them.

2. COURSE OUTCOMES(CO):

On successful completion of this course, the student will be able to

CO1: Test basic properties of paper like Basis weight, thickness.

CO2: Test strength properties of paper like Surface strength, Bursting & Tensile.

CO3: Test physical properties of paper like smoothness, Softness & Porosity.

CO4: Test optical properties of Brightness and Opacity of paper.

CO5: Test bonding strength of paper.

3. CONTENT

LIST OF EXPERIMENTS

Ex. No.	Name of Experiment	Hours
6.	1. Basis weight, thickness, density and bulk	6
7.	2. Bursting strength and burst factor	6
8.	3. Tearing strength and tear factor	6
9.	4. Tensile strength and breaking length	6
10.	5. Brightness and Opacity of paper	6
11.	6. Surface strength of paper(Wax pick)	6
12.	7. Water absorbency - Cobb's method	6
13.	8. Smoothness, softness and porosity	6
14.	9. Degree of sizing	6
15.	10. Determination of ply bond.	6

4. INSTRUCTIONAL STRATEGY

Teacher should explain each process techniques and use of each and every equipment used. Industrial visit can be organized in pulp and paper industries. Audio-visuals should be used to teach.

5. TEXT BOOKS

• Pulp and Paper Manufacture by J. P. Casey, Interscience Publishers.

• Papermaking Science and Technology by Sih-Chin Lee, Springer

• Handbook of Pulp and Paper Technology edited by K. V. Sarkanen and C. L. Chow, Wiley-Interscience

TAPPI: Offers a wealth of information on pulp and paper technology, including webinars, conferences, and publications.

• Pulp and Paper Magazine of Canada: Provides industry news, market analysis, and technical articles.

• American Forest & Paper Association (AF&PA): Offers information on the pulp and paper industry, including sustainability and environmental initiatives.

• European Confederation of the Paper Industry (CEPI): Provides information on the European pulp and paper industry, including industry trends and statistics.

4.7 (a)	RENEWABLE ENERGY TECHNOLOGY (Theory)	L	T	P
		2	0	0

1. COURSE OBJECTIVES

The aim of this course is to help the student to attain the following industry identified competencythrough various teaching learning experiences:

- Maintain the renewable energy technology equipment.

2. COURSE OUTCOMES

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associatedwith the above mentioned competency:

- Maintain ocean thermal energy technologies
- Maintain the optimised working of solar PV and CS power plants.
- Maintain the optimised working of large wind power plants
- Maintain the optimised working of small wind turbines.
- Maintain the optimised working of biomass-based power plants.

3. CONTENT

UNIT – 1 Ocean Energy Technologies (04 Periods)

Ocean energy map of India and its implications; Specification, Construction and working of the fol-lowing ocean energy technologies:

- Tidal power technologies
- Wave power technologies
- Marine current technologies
- Ocean Thermal Energy Conversion (OTEC) technologies

UNIT –2 Solar PV and Concentrated Solar Power Plants (06 Periods)

- Solar Map of India: Global solar power radiation, Solar PV
- Concentrated Solar Power (CSP) plants, construction and working of: Power Tower, Parabolic
  Trough, Parabolic Dish, Fresnel Reflectors
- Solar Photovoltaic (PV) power plant: components layout, construction, working.
- Rooftop solar PV power system

UNIT –3 Large Wind Power Plants (06 Periods)

Wind Map of India: Wind power density in watts per square meter, Lift and drag principle; long path theory, Geared type wind power plants: components, layout and working, Direct drive type wind power plants: components, layout and working, Constant Speed Electric Generators: Squirrel Cage Induction Generators (SCIG), Wound Rotor Induction Generator (WRIG), Variable Speed Electric Generators: Doubly-fed induction generator (DFIG), wound rotor synchronous generator (WRSG), permanent magnet synchronous generator (PMSG).

UNIT–4 Small Wind Turbines (06 Periods)

- Horizontal axis small wind turbine: direct drive type, components and working.
- Horizontal axis small wind turbine: geared type, components and working.
- Vertical axis small wind turbine: direct drive and geared, components and working.
- Types of towers and installation of small wind turbines on roof tops and open fields.

- Electric generators used in small wind power plants.

UNIT–5 Biomass-based Power Plants (06 Periods)

- Properties of solid fuel for biomass power plants: bagasse, wood chips, rice husk, municipal waste.
- Properties of liquid and gaseous fuel for biomass power plants: Jatropha, bio-diesel gobar gas.
- Layout of a Bio-chemical based (e.g. biogas) power plant.
- Layout of a Thermo-chemical based (e.g. Municipal waste) power plant.
- Layout of a Agro-chemical based (e.g. bio-diesel) power plant.

4. TEXT BOOKS/REFERNCE BOOKS

1. O.P. Gupta, Energy Technology, Khanna Publishing House, New Delhi
2. Neill, Simon P.; Hashemi, M. Reza: Fundamentals of Ocean Renewable Energy: GeneratingElectricity from the Sea, Academic Press, ISBN:978-0-12-810448-4
3. David M. Buchla, Thomas E. Kissell, Thomas L. Floyd, Renewable Energy Systems, PearsonEducation New Delhi , ISBN: 9789332586826,
4. Rachel, Sthuthi, Earnest, Joshua; -Wind Power Technologies, PHI Learning, New Delhi, ISBN:978-93-88028-49- 3; E-book 978-93-88028-50-9
5. Deambi, Suneel: From Sunlight to Electricity: a practical handbook on solar photovoltaic ap-plication; TERI, New Delhi ISBN:9788179935736
6. Gipe, Paul: Wind Energy Basics, Chelsea Green Publishing Co; ISBN: 978-1603580304
7. Wizelius, Tore, Earnest, Joshua - Wind Power Plants and Project Development, PHI Learning,New Delhi, ISBN:978-8120351660
8. Kothari, D.P. et aL: Renewable Energy Sources and Emerging Technologies, PHI Learning,New Delhi, ISBN: -978-81-203-4470-9
9. Bhadra, S.N., Kastha, D., Banerjee, S, Wind Electrical Systems installation; Oxford University
   Press, New Delhi, ISBN: 9780195670936.

5. SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	**4**	**12**
2	**6**	**22**
3	**6**	**22**
4	**6**	**22**

5	**6**	**22**
Total	**28**	**100**

4.7 (b)	**INDUSTRIAL ROBOTICS (Theory)**	**L T P**
		2 0 0

1. COURSE OBJECTIVES

This course aims to equip students with foundational and advanced knowledge of industrial robotics, including robot anatomy, programming, kinematics, and control systems. Students will learn to design, simulate, and operate robotic systems used in manufacturing. Emphasis is placed on automation integration, safety protocols, and real-world applications, preparing

learners for careers in robotics engineering, industrial automation, and smart manufacturing environments.

2. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that **Students will be able to**

CO1• Comprehend and adhere to industry health and safety guidelines while working with robots' vehicles to mitigate hazards.

CO2• Differentiate coordinate systems and define the custom or user-defined coordinate frames.

CO3• Develop simple robot programs that incorporate various types of movements along with their respective parameters.

CO4• Integrate robot with different automation components i.e., PLC HMI, conveyor etc.

CO5• Create variety of innovative ideas and develop creative approaches to problem-solving.

3. CONTENT

UNIT 1- INTRODUCTION TO INDUSTRIAL SAFETY PRACTICES AND INTRODUCTION TO INDUSTRIAL ROBOTICS (4Periods)

Fire Extinguishers & its Types, safely handling Tools & Equipment, Use of proper Tools & Equipment & its maintenance, OSH & practices to be observed as a precaution.

Introduction of Robots and their Importance in Manufacturing and Production, Applications of robots in manufacturing and assembly for which they can be efficiently utilized, Role of robots and automation systems in boosting the safety at dangerous manufacturing tasks, Structure and functions of robot System (Basic Package) and additional Equipment, Major Applications of Robots-Pick and Place, Arc Welding, Ultrasonic welding, Part Transfer, Packing, Palletizing. Type of End of arm tools and differences between them: Handling tools - Pneumatic Gripper, Vacuum Gripper, Hydraulic Gripper, Hydraulic Gripper, and Servo-Electric Gripper. Welding guns – Arc Welding guns, Spot welding guns. Robotic cell and its various components. Cycle time and its importance. Operator job in robotic cell. Safety procedure for Programmer and an Operator.

UNIT 2- JOGGING OF ROBOT (6Periods)

Turn ON /OFF Steps of Robot, Checking Robotic cell Health, Introduction to Teach pendent and key functions, Industrial robot Coordinate system, Different coordinate systems in Robots, Defining X, Y, Z co-ordinate system, Jogging Robot using Teach pendant in different Modes of coordinate systems: Joint co-ordinate system, rectangular co-ordinate system, and User or object co-ordinate system, Tool co-ordinate system, TCP (Tool centre point definition) i.e., TCP File. , Creating user defined work objects i.e., user coordinate frame File.(Box, circle, triangle work object definition)

UNIT 3- PROGRAMMING OF A OF ROBOT USING TEACH PENDANT

(6Periods)

Robot Program Structure, Different Motion Types used in Programming (PTP, Linear, Circular, Spline): Move J (PTP) , Move L (Linear) , Move C (Circular) , Move S (Spline) ; Different Motion Parameters used in Program Point Recording, Basic Program creation using Motion types and parameters, Path optimization for smooth robot movement and cycle time, Safety instructions to be followed while loading and unloading of parts.

UNIT 4- ROBOT INTEGRATION WITH PLC, HMI AND OTHER EQUIPMENT

(6Periods)

PLC and robot communication and HMI, Conveyor system and its communication with PLC, Methods to create fencing and safety equipment's, Steps to work with two different types of Robots at same project, Tool mounting on Robot Flange, Different connections of grippers (Electric, Pneumatic etc.).

Unit 5- ROBOT PROGRAMMING WITH ADVANCE LEVEL INSTRUCTIONS

(6Periods)

Loop control instructions, Arithmetic and Logical instructions, Shift instructions, Interfacing End of arm tools to Robot using robot I/O, establishing communication between Robot I/O and PLC modules, Function Keys in Pendant for Arc welding and Material Handling robot, MIG welding Instructions in Robot, MIG welding Program and how to optimize it, Material Handling Program and how to optimize it.

* Case studies and Mini Project should be carried out throughout the semester.

4. TEXT BOOKS/REFERNCE BOOKS

1. **Modern Robotics: Mechanics, Planning, and Control**
   Authors: Kevin M. Lynch, Frank C. Park
   Publisher: Cambridge University Press
2. **Robot Modelling and Control**
   Authors: Mark W. Spong, Francesco Bullo
   Publisher: Wiley
3. **Springer Handbook of Robotics**
   Editors: Bruno Siciliano, Oussama Khatib
   Publisher: Springer
4. **Robotics for Engineers**
   Author: Yoram Koren
   Publisher: McGraw-Hill
5. **Robotic Engineering: An Integrated Approach**
   Author: Richard D. Klafter, Thomas A. Chmielewski, Michael Negin
   Publisher: Prentice Hall

5. INSTRUCTIONAL STRATEGY

Combine theoretical instruction with hands-on training using robotic arms and simulation software. Use lectures, demonstrations, and lab sessions to teach robot programming, kinematics, and control. Incorporate project-based learning, real-world case studies, and

industry visits. Assess through practical tasks, quizzes, and group projects to reinforce industrial robotics applications.

6. SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1	4	12
2	6	22
3	6	22
4	6	22
5	6	22
Total	28	100

4.8	ESSENCE OF INDIAN KNOWLEDGE AND TRADITION	L T P
		2 - -

COURSE OBJECTIVE:

Understand the fundamental aspects of the Indian Knowledge System, its integration with modern science, principles of Yoga and holistic healthcare, and practical applications in contemporary contexts.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to demonstrate knowledge of the

following topics:

- Overview, importance, and relevance of the Indian Knowledge System, including Vedas, Upavedas, Vedangas, and Upangas.
- Relevance of science and spirituality, and contributions of ancient Indian science and technology.
- Basic principles of Yoga, benefits of holistic healthcare, and integration with modern healthcare.
- Practical applications and case studies of the Indian Knowledge System's relevance today.

COURSE CONTENTS

Unit 1: Introduction to Indian Knowledge System (16 Periods)

Overview of Indian Knowledge System

- Importance and relevance
  - Introduction to the Vedas
  - Upavedas
  - Vedangas
  - Upangas

Unit 2: Modern Science and Indian Knowledge System (06 Periods)

- Relevance of Science and Spirituality,
- Science and Technology in Ancient India,

Unit 3: Yoga and Holistic Healthcare (04 Periods)

- Basic principles of Yoga
- Benefits of holistic healthcare practices
- Integration with modern healthcare

Unit 4: Case Studies / Assignment (02 Periods)

- Practical Applications / Case studies demonstrating the relevance of Indian Knowledge System in modern times

Assessment

Viva -Voce Exam

EVALUATION METHODOLOGY

1. EVALUATION METHOD for THEORY

	Internal Assessment (40 marks)				**External Assessment (60 marks)**
	IA 1	**IA 2**	**IA 3**	**IA 4**	
Mode	**Written Test**	**Written Test**	**Attendance and Assignments**	**Pre – Semester Examination**	**End Semester Examination**
Portion	2 units	2 units	Regularly	All units	All units
Duration1hr	1hr	1hr	1hr	3hrs	3hrs

Exam Marks	20	20	20	60	60
Converted to	10	10	15	15	60
Tentative Schedule	5th Week	10th Week	Regularly	12th -13th Week	

IA1 and IA2: A written assessment test worth 20 marks should be conducted for two units. The marks earned (20 marks) will be converted to 10 marks. The best of the two assessments will be evaluated for an internal 10-mark assessment.
IA3: Assignments given after the completion of each unit, along with attendance throughout the semester, will be assessed for a total of 15 marks.
IA4: The pre-semester examination should follow the end-semester examination question pattern. The marks should be adjusted to 15 for internal assessment.

SUGGESTED DISTRIBUTION OF MARKS

Topic	Time Allotted (Periods)	Marks Allotted (%)
1		
2		
3		
4		
5		
Total		**100**

2. EVALUATION METHOD for <u>PRACTICAL</u>

	Internal Assessment (60 marks)				**External Assessment (40 marks)**
	IA 1	**IA 2**	**IA 3**	**IA 4**	
Mode	**Practical Test**	**Practical Test**	**Attendance and Practical Documentation**	**Practical Test and Quiz – Viva Voce**	**Practical Examination**
Portion	50% Practical	50% practical	All practical	All practical	All practical
Duration	3hrs	3 hrs	Regularly	Regularly	3hrs
Exam Marks	20	20	20	20	40

Tentative Schedule	5th Week	10th Week	Regularly	12th -13th Week	

IA1 and IA2: Complete all exercises and experiments as outlined and retain them for the practical test. The test should be conducted in accordance with the evaluation scheme. The best of the two practical tests will be internally evaluated for a total of 20 marks.

IA3: Maintain a practical file for each exercise while ensuring attendance throughout the semester. Submit the required documents for the practical file, quiz, and practical test along with a valid certificate (Progress Card). This will be assessed for 20 marks.

IA4: The pre-semester practical examination, quiz, and viva-voce should follow the end-semester practical examination pattern, with marks adjusted to 20 for internal assessment.

SUGGESTED DISTRIBUTION OF MARKS FOR **INTERNAL** EVALUATION

Part	Description	Marks Allotted
A.	Objective	**5**
B.	Circuit Diagram	**5**
C.	Procedure and Connections	**10**
D.	Observation Table and Calculation	**10**
E.	Result and its Discussion, Conclusion	**10**
F.	Practical Test	**20**
	Total	**60**

SUGGESTED DISTRIBUTION OF MARKS FOR **EXTERNAL** EVALUATION

Part	Description	Marks Allotted
A.	Objective	**5**
B.	Circuit Diagram	**5**
C.	Procedure and Connections	**5**
D.	Observation Table and Calculation	**5**
E.	Result and its Discussion, Conclusion	**10**
F.	Viva-Voce	**10**
	Total	**40**

3. EVALUATION METHOD for <u>PRACTICUM (Practical External)</u>

	Internal Assessment (60 marks)				**External Assessment (40 marks)**
	IA 1	**IA 2**	**IA 3**	**IA 4**	
Mode	**Practical Test**	**Practical Test**	**Attendance and Practical Documentation**	**Micro Project**	**Practical Examination**
Portion	50% practical	50% practical	All practical	All practical	All practical
Duration	3hrs	3 hrs	Regularly	Regularly	3hrs
Exam Marks	20	20	20	20	40

Tentative Schedule	5th Week	10th Week	Regularly	12th -13th Week	

- **IA1 and IA2:** Complete all exercises and experiments as instructed and retain them for the practical test. The test should be conducted according to the evaluation scheme. The best of the two practical tests will be internally assessed for a total of 20 marks.
- **IA3:** Maintain a practical file for each exercise, ensuring attendance throughout the semester. Submit the required documents for the practical file, quiz, practical test, and end-semester examination, along with a valid certificate (Progress Card). This will be evaluated by 20 marks.
- **IA4:** Submit a micro-project report along with a fabrication model or analysis report. The performance of each student in the group will be assessed by both the laboratory supervisor and an internal examiner. This evaluation will contribute 20 marks.

SUGGESTED DISTRIBUTION OF MARKS FOR **INTERNAL** EVALUATION

Part	Description	Marks Allotted
A.	Objective	**5**
B.	Circuit Diagram	**5**
C.	Procedure and Connections	**10**
D.	Observation Table and Calculation	**10**
E.	Result and its Discussion, Conclusion	**10**
F.	Mini Project	**20**
	Total	**60**

SUGGESTED DISTRIBUTION OF MARKS FOR **EXTERNAL** EVALUATION

Part	Description	Marks Allotted
A.	Objective	**5**
B.	Circuit Diagram	**5**
C.	Procedure and Connections	**5**
D.	Observation Table and Calculation	**5**
E.	Result and its Discussion, Conclusion	**10**
F.	Viva-Voce	**10**
	Total	**40**

4. EVALUATION METHOD for PRACTICUM (Theory External)

	Internal Assessment (40 marks)						External Assessment (60marks)
	IA 1		IA 2		IA 3	IA 4	
Mode	**Written Test**	**Practical Test**	**Written Test**	**Practical Test**	**Attendance and Pre Semester Examination**	**Practical Documentation and Micro Project**	**End Semester Examination**
Portion	2 units	50% Practical	2 units	50% Practical	All units	All Practical	All units
Duration	1hr	3hrs	1hr	3 hrs	3hrs	Regularly	3hrs
Exam Marks	10	20	10	20	60	60	60
	30		30				
Converted to	10		10		15	15	60
Tentative Schedule	5th Week		10th Week		Regularly	12th -13th Week	

IA1 and IA2: A written assessment test worth 10 marks should be conducted for two units. Complete all exercises and experiments as outlined and retain them for the practical test worth 20 marks. The practical test should be conducted in accordance with the evaluation scheme. The total marks earned (30 marks) will be converted to 10 marks. The best of the two assessments will be internally evaluated for a total of 10 marks.

IA3: Attendance and the pre-semester examination should follow the end-semester examination question paper pattern. The marks should be adjusted to 15 for internal assessment.

IA4: Maintain a practical file for each exercise. Submit the required documents for the practical file, quiz/viva-voice, practical test, and end-semester examination, along with a valid certificate (Progress Card). This will be assessed for 40 marks. Additionally, submit a micro-project report along with a fabrication model or analysis report. The performance of each student in the group will be evaluated by both the laboratory supervisor and an internal examiner. The total of 60 marks will be converted to 15 marks.

SUGGESTED DISTRIBUTION OF MARKS FOR **INTERNAL** EVALUATION FOR IA4

Part	Description	Marks Allotted
A.	Objective	**5**
B.	Circuit Diagram	**5**
C.	Procedure and Connections	**5**
D.	Observation Table and Calculation	**5**
E.	Result and its Discussion, Conclusion	**10**
F.	Attendance & Mini Project	**10**
	Total	**40**