Programme Name/s : **Chemical Engineering**
Programme Code : **CH**
Semester : **Third**
Course Title : **UTILITIES & PLANT MAINTENANCE**
Course Code : **313339**

I. RATIONALE

Diploma chemical engineers should have knowledge of chemical plant utilities such as process water & boiler feed water, steam generation, air & refrigeration, and psychrometric processes used in various chemical industries. They should also have knowledge of different methods of plant maintenance procedures used for various chemical process equipment in the chemical industry. It helps to keep all equipment in working conditions and minimizes the loss of production time due to any equipment failure.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The course should be taught and implemented with the aim to develop required skills in students so that they are able to acquire following industry outcome:
• Apply appropriate plant utilities for given chemical process industries.
• Identify various maintenance procedures for given chemical process equipment.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Select suitable method of water softening for boiler feed water and process plants.
- CO2 - Identify steam generators and non steam heating systems for chemical industries.
- CO3 - Select appropriate refrigeration system for the chemical process industry.
- CO4 - Use the humidification and dehumidification process for chemical process industries.
- CO5 - Apply relevant maintenance procedures for chemical process plant equipment.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313339	UTILITIES & PLANT MAINTENANCE	UPM	DSC	3	-	2	1	6	3	03	30	70	100	40	25	10	25@	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Differentiate temporary and permanent hardness of different water samples. TLO 1.2 Identify boiler problems for the given boiler feed water. TLO 1.3 Explain Softening processes of water.	**Unit - I Industrial Water** 1.1 Industrial water: Properties, Uses, Hard & Soft water 1.2 Hardness: Total Hardness, Permanent Hardness, Temporary Hardness, Units of hardness, Numerical 1.3 Boiler Feed water, Scale and Sludge Formation, Corrosion, Priming and Foaming, Caustic Embrittlement 1.4 Methods of water softening processes (Principle, Construction, Working and Application): a. Lime soda process(cold and hot) b. Zeolite process c. Ion exchange process d. Reverse Osmosis	Video Demonstrations Lecture Using Chalk-Board Site/Industry Visit Presentations
2	TLO 2.1 Explain properties and uses of steam in chemical industries. TLO 2.2 Classify steam generators. TLO 2.3 Explain construction and working of Lancashire boiler, Babcock and Wilcox Boiler. TLO 2.4 State functions of boiler Mountings and Accessories. TLO 2.5 Implement Boiler act in the given industries. TLO 2.6 Explain construction and Working of Thermic Fluid Heater. TLO 2.7 State properties of Thermic fluid.	**Unit - II Steam and Non- Steam Heating System** 2.1 Steam: Uses, Properties and types of steam. 2.2 Steam Generator : Classification, comparison, components of boiler. 2.3 Construction and working of: a. Lancashire boiler b. Babcock and Wilcox Boiler 2.4 Function of all boiler Mountings and Accessories. 2.5 Boiler Act : Indian Boiler Act and duties of boiler inspector. 2.6 Construction and working of non- Steam Heating System (Thermic Fluid Heater). 2.7 Properties of Thermic fluid.	Model Demonstration Video Demonstrations Site/Industry Visit Lecture Using Chalk-Board Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Explain the working principle of refrigeration. TLO 3.2 Explain COP and solve numerical based on Unit of refrigeration and COP. TLO 3.3 Use primary and secondary refrigerants. TLO 3.4 State selection criteria of refrigerants.	**Unit - III Refrigeration** 3.1 Refrigeration: Concept, Unit of Refrigeration, Coefficient of Performance (COP), Numerical. 3.2 Types of Primary and Secondary Refrigerants, Selection criteria of Refrigerants. 3.3 Refrigeration Cycle: Reverse Carnot Cycle, Bell Coleman air refrigeration Cycle, Vapor compression and absorption cycle (Li-Br absorption cycle).	Video Demonstrations Presentations Lecture Using Chalk-Board Site/Industry Visit
4	TLO 4.1 Explain process and instrument air. TLO 4.2 Identify the psychrometry properties for the given system. TLO 4.3 Solve numerical using psychrometric chart. TLO 4.4 Explain Psychrometric Processes with diagram. TLO 4.5 Select the relevant cooling tower for the given process.	**Unit - IV Air and Psychrometry** 4.1 Concept and Application of process air and instrument air. 4.2 Psychrometry, Dry Bulb Temperature, Wet Bulb Temperature, Dew Point Temperature, Adiabatic saturation temperature,Humidity, Specific Humidity, Specific Volume, Relative Humidity 4.3 Sling Psychrometer, Psychrometric Chart, Numerical on Psychrometric Chart 4.4 Psychrometric Process: Humidification and dehumidification 4.5 Cooling Tower: Principle, Construction and Working of induced draft and forced draft	Video Demonstrations Lecture Using Chalk-Board Presentations Case Study
5	TLO 5.1 State objectives of plant maintenance. TLO 5.2 Enlist types of maintenance. TLO 5.3 State Duties and responsibility of plant maintenance department.	**Unit - V Plant maintenance** 5.1 Purpose of plant maintenance. 5.2 Types of maintenance: Preventive maintenance, Predictive maintenance, Corrective maintenance, Routine / Scheduled maintenance, Emergency maintenance, Online maintenance and Shutdown maintenance. 5.3 Duties and responsibility of plant maintenance department. 5.4 Online maintenance of pump and rotameter.	Video Demonstrations Case Study Presentations Lecture Using Chalk-Board

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Explain the concept of alkalinity of water.	1	Determine total alkalinity of well water.	2	CO1
LLO 2.1 Explain concept of temporary and permanent hardness to calculate total hardness of water.	2	* Determine the total, temporary and permanent hardness of borewell water / tap water/ lake water.	2	CO1
LLO 3.1 Explain the concept of pH. LLO 3.2 Demonstrate the process of pH measurement using pH meter.	3	Determine pH of various acidic and alkaline water using pH meter.	2	CO1
LLO 4.1 Describe principle, construction and working of Reverse Osmosis plant. LLO 4.2 Explain the concept of Total Dissolved Solid (TDS).	4	* Analyze raw water, RO water and rejected RO water quality based on Total Dissolved Solid (TDS), pH and Conductivity.	2	CO1

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Explain the concept of dryness fraction. LLO 5.2 Calculate dryness fraction of steam.	5	Calculate the dryness fraction of steam at different pressure and temperature conditions by using a steam table.	2	CO2
LLO 6.1 Demonstration of various boiler mountings and accessories.	6	* Identify boiler mountings and accessories of boiler by visiting any chemical plant.	2	CO2
LLO 7.1 Explain concept of entropy, enthalpy and specific heat.	7	* Calculate enthalpy and entropy of steam at various pressures by using a Steam Table.	2	CO2
LLO 8.1 Identify parts of refrigeration system.	8	* Identify different parts of the domestic refrigerator in view of compressor, condenser, expansion valve and evaporator.	2	CO3
LLO 9.1 Explain concept of vapor compression refrigeration cycle. LLO 9.2 Calculate Coefficient of Performance.	9	Calculate Coefficient of Performance (COP) of vapor compression refrigeration cycle.	2	CO3
LLO 10.1 Explain construction and working principle of pressure gauge. LLO 10.2 Selection of appropriate pressure of air depending upon applications.	10	Measure different air pressures of cycle, motorcycle, car and heavy vehicles by using a pressure gauge.	2	CO4
LLO 11.1 Explain the effect of range and approach values on cooling tower.	11	Determine % efficiency of cooling tower.	2	CO4
LLO 12.1 Calculate all Psychrometric properties by using psychrometric chart at various locations.	12	* Determine psychometric properties like DPT, % Relative humidity, specific enthalpy and specific volume at various DBT and WBT by using psychrometric chart.	2	CO4
LLO 13.1 Explain the concept of DBT and WBT. LLO 13.2 Explain construction and working of a sling psychrometer. LLO 13.3 Use a sling psychrometer for measuring relative humidity.	13	* Calculate the relative humidity of outer atmosphere by using sling psychrometer.	2	CO4
LLO 14.1 Explain concept of centrifugal pump.	14	* Perform maintenance procedure for the Centrifugal Pump	2	CO5
LLO 15.1 Explain the concept of ball mill.	15	Perform maintenance procedure for the ball mill in the laboratory.	2	CO5
LLO 16.1 Explain the concept of heat exchanger.	16	Perform maintenance procedure for shell and tube heat exchanger in the laboratory.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Prepare a table of types of thermic fluids on the basis of temperature ranges and applications in chemical industry.
- Refer to the boiler manufacturing companies' websites like Thermax, Forbes Marshall, Alfa Laval etc. and prepare a report on boilers manufactured by them.
- Prepare a report on problems with solutions that occurred in boiler operation w.r.t priming, foaming, caustic embrittlement, corrosion, scale and sludge formation.
- Make a report on boiler mountings and accessories with their function.
- Visit textile / sugar/ chemical / dairy / pharmaceutical / fertilizer/ paper industry and prepare a report on utilities used by them for different processes.
- Visit the industry and identify source of waste heat to run waste heat recovery boiler.
- Visit the municipality water treatment plant and prepare a report on Physical, Chemical and Biological treatment process.
- Visit the Malls/Offices / Theatre and prepare a report on the humidification and dehumidification process used.

Micro project

- Prepare model on Bab-Cock and Wilcox boiler.
- Prepare a model of economizer / air preheater.
- Prepare a psychrometric chart and explain various psychrometric properties.
- Prepare animation video on working of refrigeration process.
- Prepare animation video on working of any Boiler.
- Select the appropriate utilities for the following industries: Steel industry, glass industry, textile industry, rubber industry, chemical industry.
- Visit the seasonable industries like the sugar industry, food processing industry and prepare a report of various maintenance activities carried out.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Test tubes (15 ml capacity)	1,2,3,4
2	Measuring Cylinders (10 ml, 50ml 100ml)	1,2,3,4
3	Beakers (50, 100, 250 ml)	1,2,3,4
4	Burette (50ml, L.C.: 0.1 ml)	1,2,3,4
5	Conical Flasks (100 ml, 250 ml)	1,2,3,4
6	Volumetric flask (100, 250, 500 ml)	1,2,3,4
7	Pipette (10 ml, 25 ml)	1,2,3,4
8	Acid and alkali Proof hand gloves	1,2,3,4
9	Bourdon tube type pressure gauge	10
10	Cooling tower	11
11	Standard Psychrometric chart	12
12	Sling psychrometer or Whirling hygrometer (0 to 50 C range)Body material : Plastic or wood	13
13	Weighing Balance (Digital Display, 300 g, Sensitivity. 0.01 g)	3
14	pH meter with Calibration arrangement Suitable for 0-14 pH range and Temperature compensating and calibration arrangement.	3,4

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
15	Buffer solutions 4 , 7 and 9.2 pH	3,4
16	Digital TDS meter	4
17	Steam table book	7

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Industrial Water	CO1	10	4	4	8	16
2	II	Steam and Non- Steam Heating System	CO2	10	4	4	8	16
3	III	Refrigeration	CO3	9	2	4	8	14
4	IV	Air and Psychrometry	CO4	8	2	4	6	12
5	V	Plant maintenance	CO5	8	2	4	6	12
Grand Total				**45**	**14**	**20**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering : 60 % weightage to process. 40 % weightage to product

Summative Assessment (Assessment of Learning)

- End of Term Examination (Lab. performance), Viva-voce

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	3	3	2	3	2	3			
CO2	2	2	1	2	2	-	2			
CO3	3	2	1	2	2	-	2			
CO4	3	2	1	2	2	1	2			
CO5	2	3	-	3	1	2	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	P. C. Jain and Dr. Monika Jain	Engineering Chemistry	Dhanpatrai Publications, New Delhi, 2008, ISBN-978-87-403-0363-6

Sr.No	Author	Title	Publisher with ISBN Number
2	Powel S. T.	Industrial Water	Mc. Graw Hill, New York, 2009, ISBN 9781118843727
3	P. L. Ballaney	Thermal Engineering	Khanna Publication, New Delhi 1975, ISBN 9788174090317
4	Rajput R. K.	A Textbook of Refrigeration and Air Conditioning	Kataria S. K. and sons, New Delhi 2003, ISBN13:9789350142554
5	James K. Carson	Refrigeration : Theory and Applications	Mc. Graw Hill, New York, 2009, ISBN: 078-87-403-0363-6
6	Sathiyamoorthy Manickkam	Chemical Plant Utilities	Lambert Academic Publishing, October 2016, ISBN: 978-3-659-97828-9
7	Kraus, Milton N.	Safe and Efficient Plant Operation and Maintenance	Mc. Graw Hill Inc. New York US, 1980, ISBN: 978-0070107076
8	R. K. Jain	Plant maintenance engineering and management	Khanna Publication, ISBN: 9789392549090
9	Sushil Kumar Shrivastava	Maintenance Engineering	S. Chand and company, ISBN: 9788121926447

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.sciencedirect.com/bookseries/advances-in-chemical-engineering	Chemical Engineering books
2	https://wbboilers.gov.in/sites/default/files/actsrules/Boilers_Act_1923.pdf	Indian Boiler Regulation Act 1923
3	https://www.vedantu.com/jee-main/chemistry-hardness-of-water	Temporary, Permanent and Total Hardness of Water
4	https://www.intarcon.com/en/refrigeration-system/	Refrigeration System
5	https://website.maintenanceconnection.com/resources/blog-posts/3-elements-maintenance-success-chemical-industry	Maintenance success in the Chemical Industry
6	https://www.google.com/search?q=nptel+videos+on+chemical++plant+maintenance	Plant Maintenance
7	https://onlinecourses.nptel.ac.in/noc23_me31/preview	Problems on Steam
8	https://archive.nptel.ac.in/courses/103/107/103107211/	Chemical Process Utilities, Boiler water treatment
9	https://onlinecourses.nptel.ac.in/noc23_me31/preview	Vapor compression Refrigeration Cycle
10	https://home.iitk.ac.in/~gtm/thermodynamics/ui/Course_home-36.htm	Psychrometer chart, Humidification and Dehumidification operation
11	https://onlinecourses.nptel.ac.in/noc23_me31/preview	Cooling Tower Types and performance

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students