COURSE TITLE	**GENERATIVE AI FOR CHEMICAL ENGINEERS**
COURSE CODE	**01CH0412**
COURSE CREDITS	**1**

Objective:

1 To enable students to apply prompt engineering and generative AI techniques for solving chemical engineering problems, performing data analysis, visualizing processes, and creating smart process views for chemical systems and industrial operations.

Course Outcomes: After completion of this course, student will be able to:

1 Apply generative AI techniques and prompt design principles to generate chemical engineering solutions using text, code, and visualization.

2 Apply AI-assisted techniques to create 2D/3D process flow diagrams, equipment visualization, and smart views of chemical plants.

3 Analyze chemical engineering datasets using generative AI for statistical analysis, visualization, and simulation interpretation.

4 Analyze the effectiveness of generative AI approaches including prompting techniques in solving process engineering and interdisciplinary problems.

5 Evaluate risks, limitations, and ethical aspects of using prompt engineering and AI in chemical industry applications.

Pre-requisite of course: Basic knowledge of Chemical Engineering fundamentals, process calculations, and basic programming or spreadsheet analysis.

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
0	0	2	0	0	0	25	25

Contents : Unit	Topics	Contact Hours
Total Hours		

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Introduction to Generative AI in Chemical Engineering** Introduction, Importance of generative AI in chemical process industries and research, Rise of in-context learning and few-shot prompting, Illustrations with chemical engineering examples (reactor design, heat exchanger calculations)	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
2	**Fundamentals of Prompt Design in Generative AI** Prompt components: Instruction, Context, Input, Output; Deterministic vs diverse responses; Exercise: Writing a Python program to calculate reaction rate or heat duty	2
3	**Generative AI for Chemical Engineering Tasks** Summarization: Reaction engineering, transport phenomena concepts; Question Answering: Solving numerical problems step-by-step; Classification: Fluids (Newtonian/non-Newtonian), catalysts (homogeneous/heterogeneous); Role Playing: AI as process engineer / plant safety auditor / environmental engineer; Code generation: Programs for reaction kinetics or mass balance calculations; Reasoning: Stepwise derivation of rate laws	4
4	**Prompting Techniques in Generative AI** Few-shot prompting, Chain-of-Thought prompting, Zero-shot CoT prompting ("Let's think step by step"), Exercise: Deriving design equations for a CSTR or PFR step-by-step	2
5	**Advanced Generative AI Techniques** Self-consistency prompting, Generated knowledge prompting, Program-Aided Language Models (PAL) for engineering computation, ReAct: reasoning and tool interaction, Exercise: Automated calculation of reactor conversion or distillation stages	2
6	**Data Analysis with Generative AI** Prompting for data cleaning and preprocessing of plant datasets; Generating statistical summaries (mean, variance, regression); Creating plots: conversion vs time, temperature profiles, distillation composition curves; Integration with simulation tools (Aspen Plus / DWSIM datasets); Case Study: AI-generated plots of reaction conversion vs time	2
7	**Visualization Techniques in Chemical Engineering** 2D Visualization: process flow diagrams, charts, contour maps (temperature/concentration fields); 3D Visualization: reactors, distillation columns, heat exchangers, Exercise: Generate 3D visualization of a distillation column with trays	2
8	**Image & Model Generation** 2D image creation: PFDs, P&ID style diagrams; 3D equipment creation: CSTR, shell-and-tube heat exchanger, Exercise: Create 3D image of a catalytic reactor with labeled parts	2
9	**Smart View Creation for Chemical Processes** AI-driven visual explanation of process flows, Visual storytelling: mass flow through distillation column, Case Study: dynamic visualization of a chemical reactor operation	2
10	**Risks & Responsible AI Usage** Prompt injection, Prompt leaking, Responsible AI deployment in chemical industries	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
11	**Interdisciplinary Applications of Prompt Engineering** Electrical integration: instrumentation and sensors in chemical plants, Computer science integration: process monitoring dashboards and web tools	2
12	**Chemical Industries problem: Capstone Project** Students develop an AI-assisted solution for a chemical engineering problem; Possible topics: Reactor optimization, Energy analysis of distillation, Wastewater treatment modeling, Process safety risk analysis, Deliverables: AI-generated code, 2D/3D process visualization, Data analysis and plots, Ethical evaluation of AI use, etc	4
Total Hours		**28**

Textbook :

1 Language Models are Few-Shot Learners, Brown, T. B., ArXiv, 2020

2 Understanding Generative AI, Jeffries, D., Ex Libris Group, 2021

References:

1 Introduction to Prompt Engineering: Concepts and Applications, Introduction to Prompt Engineering: Concepts and Applications, Sachin Jain, Rohit Singh Rajput, Rohit Chhabra, Shubham Patel, OpenAI Documentation, 2025

2 Mastering Prompt Engineering, Mastering Prompt Engineering, Anand Nayyar, Ajantha Devi Vairamani, Kuldeep Singh Kaswan, Morgan Kaufmann Publishers, 2025

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
10.00	10.00	30.00	30.00	20.00	0.00

Instructional Method:

1 The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, Quiz, brainstorming, MOOCs etc.

2 The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.

3 Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

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Instructional Method:

4	Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory

Supplementary Resources:

1	https://github.com/openai/openai-cookbook
2	https://www.coursera.org/learn/generative-ai-with-llms
3	https://cognitiveclass.ai/courses/prompt-engineering-for-everyone