Syllabus
Gyanmanjari Institute of Technology
Semester- 3 (B.Tech.)

Subject: Fluid Flow Operations-BET2CH13302

Type of course: Professional Core

Prerequisite: Basic Concepts of Engineering Mathematics and Physics.

Rationale: Fluid Flow Operations is a fundamental course in Chemical Engineering that equips students with essential knowledge of fluid transport and metering. Fluids are an integral part of chemical processes, and understanding their motion is essential for designing and operating equipment like pumps, valves, pipelines, reactors, separators and heat exchangers. This course aims to develop students' ability to analyse and solve fluid flow problems, select appropriate flow measuring devices, and understand the principles behind fluid machinery. It forms the basis for higher level chemical engineering courses like heat transfer, mass transfer, process control, energy and environment engineering, reaction engineering, utilities, piping and process equipment design.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
4	0	2	4	100	50	150

Legends: CI-Class Room Instructions; T – Tutorial; P - Practical; C – Credit; SEE - Semester End Evaluation; CCE-Continuous and Comprehensive Evaluation.

Course Content:

Sr. No	Course content	Hrs.	% Weightage
1	**Fluid Mechanics** **Theory Topics:** Fluid static and its application: nature of fluids, pressure concept, hydrostatic equilibrium, decanters like continuous gravity, centrifugal etc. Fluid flow phenomena: velocity fluid, velocity gradient and rate of shear, Newtonian and non-Newtonian fluids, viscosity and momentum flux. Reynolds number and its significance, laminar and turbulent flow. Turbulence, Reynolds stresses, eddy viscosity. Laminar and turbulent flow in boundary layers. Boundary layer formation in straight tubes, boundary separation and wake formation. Basic equations of fluid flow: mass velocity; average velocity; potential flow; streamlines, stream tubes, macroscopic momentum balance, momentum correction factor. Equation of continuity, Bernoulli's equation, corrections for fluid friction, pump work in Bernoulli's equations, angular momentum equations. **Practical:** 1. Study of fluid properties and pressure measurement. 2. Determine the viscosity of Newtonian and non-Newtonian fluids. 3. Determine Reynolds number using a Reynolds apparatus and identify the flow regime. 4. Flow visualization of laminar and turbulent flow using dye injection. 5. Flow visualization of boundary layer development using a water channel or flow demonstration unit. 6. Observe boundary layer development and flow separation using a flow visualization apparatus. 7. Demonstrate streamlines and stream tubes using flow visualization and calculate average velocity.	18	20%

8. Performance analysis of a centrifugal pump using Bernoulli's principle.
9. Determination of momentum correction factor in pipe flow.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Fluid Mechanics Experimental Analysis:** Students will perform experiments on fluid properties, pressure measurement, Reynolds number, Bernoulli's equation, continuity equation, viscosity, and pipe flow, analyze the experimental data, and compare the obtained results with theoretical values.	20	-
2	**Fluid Mechanics Self-Learning Presentation:** Students will prepare presentations, charts, or case studies on fluid flow phenomena, boundary layer development, centrifugal pumps, decanters, pressure measuring devices, and industrial applications of fluid mechanics through independent study.		10
	Total	**20**	**10**

Examination Style:

Fluid Mechanics Experimental Analysis (20 Marks)

Students will perform experiments and analyze results related to fluid properties, hydrostatic pressure, viscosity, Reynolds number, Bernoulli's equation, continuity equation, momentum balance, and friction losses in pipe flow. They will compare the experimental observations with

	theoretical values, interpret the results, and answer viva questions based on the principles, industrial applications, and significance of fluid mechanics ***Industrial Applications of Fluid Mechanics (10 Marks)*** Students shall prepare and present charts, posters, models, or PowerPoint presentations explaining industrial applications of fluid mechanics in pumps, pipelines, pressure measurement systems, decanters, chemical process equipment, and fluid transport systems. The presentation should include the working principle, applications, advantages, limitations, and labeled diagrams wherever necessary		
2	**Flow of Incompressible Fluids in Conduits and Thin Layers** **Theory Topics:** Flow of incompressible fluids in Conduits and Thin Layers in pipes. Relation between skin friction and wall shear, friction factor laminar flow in pipes, kinetic energy correction factor and momentum correction factor for laminar flow of Newtonian fluids. Hagen-Poiseuille equation, Fanning equation, effect of roughness. Friction factor chart, friction factor inflow through channels of non-circular cross section. Equivalent diameter, hydraulic radius, friction from changes in velocity or direction. Flow through sudden enlargement of cross section. Flow through sudden contraction of cross section. Effect of fittings and valves. Friction losses in Bernoulli's equations, separation of boundary layers in diverging channel. **Practical:** 10. Study the construction and working of the Reynolds Apparatus and Bernoulli's Apparatus. 11. Determine the friction factor and pressure drop through a straight pipe using a pipe friction apparatus. 12. Determine the friction factor and pressure loss in laminar flow using a pipe friction apparatus.	18	20%

13. Determine the pressure drop in smooth and rough pipes and compare the experimental friction factors with theoretical values.
14. Determine the friction factor using the Moody chart and calculate pressure drop in circular and non-circular ducts using hydraulic diameter.
15. Measure pressure losses across different pipe fittings (elbow, valve, sudden expansion, and sudden contraction) and compare the experimental values with theoretical calculations.
16. Determine the head loss due to sudden contraction using a pipe flow apparatus and compare the experimental results with theoretical calculations
17. Measure pressure losses across different pipe fittings and valves using a pipe flow apparatus and determine the corresponding loss coefficients.
18. Solve numerical problems based on the Bernoulli equation incorporating friction losses and head loss calculations.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
I	**Pipe Flow Performance Analysis:** Students will perform experiments to determine friction factor, pressure losses, hydraulic radius, equivalent diameter, and energy losses in pipe flow systems. They will analyze the effect of pipe roughness, fittings, valves, sudden enlargement/contraction, and validate Hagen–Poiseuille, Fanning, and Bernoulli equations using experimental observations.	20	

2	**Industrial Pipeline System Study:** Students will independently study and present industrial pipeline networks, flow measurement techniques, pipe fittings, valves, flow separation, and pressure loss reduction methods through charts, posters, models, case studies, or PPTs with appropriate engineering calculations and labeled diagrams.		10
	Total	**20**	**10**

Examination Style:

Pipe Flow Performance Analysis (20 Marks)

Students will perform experiments to evaluate friction factor, hydraulic radius, equivalent diameter, major and minor losses, and flow characteristics in conduits. They will compare experimental results with theoretical predictions using the Hagen–Poiseuille equation, Fanning equation, and Bernoulli's equation, followed by interpretation of results and viva questions based on industrial pipe flow systems.

Industrial Pipeline System Study (10 Marks)

Students shall prepare and present charts, posters, models, case studies, or PowerPoint presentations explaining industrial applications of pipe flow systems, pipeline design, pressure loss analysis, valves and fittings, flow measurement, and energy-efficient fluid transport. The presentation should include the working principle, industrial significance, advantages, limitations, engineering calculations wherever applicable, and neatly labeled diagrams.

3	**Flow of Compressible Fluids and Flow Past Immersed Bodies** **Theory Topics:** Introduction to Compressible Flow and Mach Number. Difference Between Compressible and Incompressible Flow. Continuity Equation	18	20

	and Total Energy Balance Equation for Compressible Flow. Velocity of Sound and Fundamentals of Compressible Flow. Isentropic Expansion and Adiabatic Frictional Flow. Isothermal Frictional Flow and Flow Through Nozzles. Drag Force and Drag Coefficient. Form Drag. Streamlining, and Flow Around Immersed Bodies. Flow Through Packed Beds (Bed of Solids). Fluidization: Principles, Types, and Applications, Continuous Fluidization, Slurry Transport, and Pneumatic Transport. **Practical:** 19. Study the operation of a converging-diverging nozzle or perform a simulation to determine Mach number and classify different compressible flow regimes. 20. Analyze experimental or simulation data to compare pressure, density, and velocity variations in compressible and incompressible flow systems. 21. Analyze mass flow rate and continuity equation using nozzle or duct flow experimental data/simulation. 22. Determine the velocity of sound and Mach number using compressible flow simulation or experimental data from a converging–diverging nozzle. 23. Analyze pressure, temperature, and Mach number variations during isentropic expansion using nozzle flow data or simulation. 24. Study the pressure and velocity distribution in converging and converging–diverging nozzles using experimental data or simulation. 25. Determine the drag coefficient of different immersed bodies using wind tunnel data, water channel experiments, or CFD simulation. 26. Determine the pressure drop across a packed bed at different flow rates and compare the experimental results with the Ergun equation.		

27. Determine the minimum fluidization velocity of a packed bed and observe different fluidization regimes.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Compressible Flow and Fluidization Experiment:** Students will perform experiments to analyze Mach number, compressible flow through nozzles, velocity of sound, drag coefficient, pressure drop through packed beds, and fluidization characteristics. They will compare experimental observations with theoretical principles and interpret the engineering significance of the obtained results.	20	
2	**Industrial Applications of Compressible Flow and Fluidization:** Students will prepare and present charts, posters, models, case studies, or PowerPoint presentations on industrial applications of nozzles, fluidized bed reactors, pneumatic conveying, slurry transport, packed beds, and drag reduction techniques through independent study.		10
	Total	**20**	**10**

Examination Style:

	Compressible Flow and Fluidization Experiment (20 Marks) Students will perform experiments related to compressible fluid flow, Mach number, nozzle performance, drag force, packed bed pressure drop, and fluidization characteristics. They will analyze experimental data, compare the results with theoretical predictions, interpret the engineering significance of the observations, and answer viva questions based on industrial applications and design considerations. **Industrial Applications of Compressible Flow and Fluidization (10 Marks)** Students shall prepare and present charts, posters, models, or PowerPoint presentations explaining industrial applications of compressible flow, nozzles, fluidized bed reactors, packed beds, pneumatic conveying, slurry transport, and drag reduction techniques used in chemical and process industries. The presentation should include the working principle, industrial applications, advantages, limitations, engineering significance, and neatly labeled diagrams wherever necessary.		
4	**Fluid Moving Machinery** **Theory Topics:** Pumps: its characteristics like developed head power requirement suction lift and cavitations. Different types of pumps and their selection criteria. Positive displacement pumps like reciprocating, rotary pumps, diaphragm pump, centrifugal pumps and its theory. Characteristic of head capacity relation, pump priming, cavitation, characteristic curves and affinity laws for centrifugal pump, multistage centrifugal pump. Axial flow pump, turbine pump, seal less or leak proof pumps, electromagnetic pump, vertical centrifugal pump, air lift pump, peristaltic pump, etc. Fans, blowers like positive displacement, centrifugal blowers, compressor efficiency. Different types of vacuum pumps and jet ejectors, selection criteria. Selection and comparison of	18	20

fluid moving devices. Energy efficiency and pumping systems, modern trends and industrial applications.

Practical:

28. Determine pump performance characteristics (Head–Discharge and Efficiency Curves).
29. Identify suitable pumps for different industrial applications based on operating conditions.
30. Study the construction and working of a centrifugal pump and identify its components.
31. Study the construction and working of reciprocating and rotary pumps.
32. Study the characteristic curves of a centrifugal pump and determine the Best Efficiency Point (BEP).
33. Verification of Affinity Laws for Centrifugal Pumps.
34. Determine the efficiency and performance characteristics of a compressor using experimental or manufacturer data.
35. Study the construction and working of a laboratory vacuum pump and steam jet ejector (or simulation/video demonstration).
36. Study and compare the performance characteristics of a centrifugal pump, blower, and compressor using laboratory models or simulation software.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Fluid Moving Machinery Performance Evaluation:** Students will perform experiments to determine pump head, discharge, efficiency, characteristic curves, affinity laws, compressor efficiency, and the performance of pumps, fans, blowers, vacuum	20	

	pumps, and jet ejectors. They will analyze the experimental data, compare the results with theoretical principles, and recommend suitable fluid-moving equipment for given operating conditions.		
2	**Industrial Equipment Selection and Case Study:** Students will independently investigate and present industrial applications of pumps, compressors, fans, blowers, vacuum pumps, and jet ejectors through charts, posters, models, case studies, or PowerPoint presentations. They shall justify equipment selection based on process requirements, operating conditions, efficiency, and energy considerations.		10
	Total	**20**	**10**

Examination Style:

Fluid Moving Machinery Performance Evaluation (20 Marks)

Students will conduct experiments to evaluate the performance of pumps, fans, blowers, compressors, and other fluid-moving devices by determining parameters such as head, discharge, efficiency, characteristic curves, cavitation effects, and affinity laws. They will analyze the experimental observations, compare them with theoretical predictions, recommend appropriate equipment for industrial applications, and answer viva questions based on the working principles, operating characteristics, and engineering significance of fluid-moving machinery.

	Industrial Equipment Selection and Case Study (10 Marks) Students shall prepare and present charts, posters, models, case studies, or PowerPoint presentations explaining the industrial applications and selection of pumps, compressors, fans, blowers, vacuum pumps, and jet ejectors used in chemical and process industries. The presentation should include the working principle, selection criteria, operating characteristics, advantages, limitations, energy efficiency, industrial significance, and neatly labeled diagrams wherever necessary.		
5	**Measurement of Flowing Fluids** **Theory Topics:** Introduction to flow measurement and selection criteria. Full-bore flow meters: venturi meter and orifice meter. Coefficient of discharge of venturi and orifice meters. Area flow meters: rotameter. Target meters and v-element meters. Vortex shedding flow meters, coriolis mass flow meters. Magnetic and ultrasonic flow meters. Insertion flow meters: pitot tubes, anemometers and thermal flow meters. Recent advancements in pumps, valves and measuring devices. **Practical:** 37. Identification and study of different flow meters. 38. Study the construction and working of venturi meter and orifice meter. 39. Comparison of coefficient of discharge of venturi and orifice meters. 40. Study the construction, working and calibration of a rotameter. 41. Measurement of flow rate using a rotameter and comparison with theoretical values. 42. Study the construction and working of target meter. 43. Demonstration of flow measurement using a v-element meter. 44. Study the construction and working of magnetic and ultrasonic flow meters.	18	20

45. Demonstration of flow measurement using magnetic and ultrasonic flow meters.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Flow Measurement and Instrument Performance Analysis:** Students will perform experiments to calibrate and evaluate the performance of Venturi meters, Orifice Meters, Rotameters, Pitot Tubes, and other flow measuring devices. They will determine the coefficient of discharge, flow rate, velocity, and compare the experimental results with theoretical values while selecting suitable measuring instruments for different industrial applications.	20	
2	**Industrial Flow Measurement Systems:** Students will prepare and present charts, posters, models, case studies, or PowerPoint presentations on the working principles, selection criteria, recent advancements, and industrial applications of flow meters, control valves, pumps, and flow		10

	measurement systems used in chemical and process industries.		
	Total	**20**	**10**

Examination Style:

Flow Measurement and Instrument Performance Analysis (20 Marks)

Students will perform experiments to calibrate and analyze the performance of different flow measuring devices such as venturi meters, orifice meters, rotameters, pitot tubes, and other industrial flow meters. They will determine parameters such as coefficient of discharge, flow rate, and velocity, compare the experimental observations with theoretical values, interpret the engineering significance of the results, and answer viva questions based on the principles, calibration techniques, instrument selection, and industrial applications.

Industrial Flow Measurement Systems (10 Marks)

Students shall prepare and present charts, posters, models, or PowerPoint presentations explaining the working principles, selection criteria, recent advancements, and industrial applications of flow meters, control valves, pumps, and flow measurement systems used in chemical and process industries. The presentation should include the operating principle, industrial applications, advantages, limitations, selection criteria, and neatly labeled diagrams wherever necessary.

Suggested Specification table with Marks (Theory): 100

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	15	25	30	15	10	5

Course Outcome:

After learning the course, the students should be able to:	
CO1	Explain the fundamental principles of fluid statics and dynamics.
CO2	Apply fluid laws and analyze fluid flow problems.
CO3	Calculate pressure drops and flow rates in pipe networks and fittings using appropriate equations and empirical correlations.
CO4	Interpret working principles, select and evaluate fluid machinery and flow measuring devices
CO5	Solve chemical engineering problems involving compressible and incompressible fluid flows.

Instructional Method:

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

From the content 10% topics are suggested for flipped mode instruction.

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

The internal evaluation will be done on the basis of Active Learning Assignment.

Reference Books:

[1] "Unit Operations of Chemical Engineering", McCabe WL, Smith JC, Harriott P. McGraw Hill Publication, 7th edition 2005.

[2] Chemical Engineering" Vol.I–Fluid flow, Heat Transfer and Mass Transfer; Coulson & Richardson's, Butterworth – Heinemann Publication,6th Edition.

[3] "Fluid Dynamics and Heat Transfer", James G.Knudson and Donald L.Katz, McGrawHill Publication

[4] "Fluid Mechanics for Chemical Engineers" by James O. Wilkes, Prentice Hall, 2nd Edition.

[5] Introduction to Fluid Mechanics" by Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, Wiley, 8th Edition.

Suggested Assessment Guidelines

Module–1: Fluid Mechanics

Fluid Mechanics Experimental Analysis: (20 Marks)

Criteria	Description	Marks
Fluid Property Analysis	Correct determination of fluid properties, hydrostatic pressure, viscosity, Reynolds number, and flow characteristics.	5
Experimental Procedure	Proper execution of experiments related to Bernoulli's equation, continuity equation, pressure measurement, and flow visualization.	5
Data Analysis	Accurate calculation and comparison of experimental results with theoretical values.	5
Observation & Viva	Proper interpretation of experimental observations and answering viva questions related to fluid statics and fluid flow principles.	5
Total		**20**

Module–2: Flow of incompressible fluids in Conduits and Thin Layers

Pipe Flow Performance Analysis: (20 Marks)

Criteria	Description	Marks
Flow Characteristics	Correct determination of friction factor, hydraulic radius, equivalent diameter, and flow regime.	5
Experimental Procedure	Proper performance of experiments related to Hagen–Poiseuille equation, Fanning equation, Bernoulli's equation, and pressure losses.	5

Data Analysis	Accurate calculation of major/minor losses, kinetic energy correction factor, and momentum correction factor.	5
Observation & Viva	Proper interpretation of pipe flow behavior and answering viva questions related to industrial piping systems.	5
Total		20

Module–3: Flow of Compressible fluids and Flow past immersed bodies

Compressible Flow and Fluidization Experiment: (20 Marks)

Criteria	Description	Marks
Flow Analysis	Correct determination of Mach number, velocity of sound, drag coefficient, and pressure drop through packed beds.	5
Experimental Procedure	Proper execution of experiments on nozzle performance, drag measurement, fluidization, and compressible flow.	5
Data Analysis	Accurate calculation of flow parameters and comparison of experimental observations with theoretical principles.	5
Observation & Viva	Proper interpretation of compressible flow and fluidization behavior and answering viva questions related to industrial applications.	5
Total		**20**

Module–4: Fluid Moving Machinery

Fluid Moving Machinery Performance Evaluation: (20 Marks)

Criteria	Description	Marks
Equipment Performance	Correct determination of pump head, discharge, efficiency, compressor efficiency, and characteristic curves.	5
Experimental Procedure	Proper performance of experiments on pumps, fans, blowers, compressors, and vacuum pumps.	5
Performance Analysis	Accurate evaluation of cavitation effects, affinity laws, and equipment selection based on operating conditions.	5

Observation & Viva	Proper interpretation of equipment performance and answering viva questions related to fluid-moving machinery.	5
Total		**20**

Module–5: Measurement of Flowing Fluids

Flow Measurement and Instrument Performance Analysis: (20 Marks)

Criteria	Description	Marks
Instrument Analysis	Correct calibration and operation of venturi meter, orifice meter, rotameter, pitot tube, and other flow measuring devices.	5
Experimental Procedure	Proper execution of experiments related to flow rate, velocity, and coefficient of discharge measurements.	5
Data Analysis	Accurate calculation of flow parameters and selection of suitable flow measuring instruments for industrial applications.	5
Observation & Viva	Proper interpretation of experimental results and answering viva questions related to flow measurement techniques and industrial instrumentation.	5
Total		**20**