GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Chemical Engineering
Subject Code: BE04005031
Subject Name: Fluid Flow Operation

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Course

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 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

Course Outcome: After Completion of the Course, Students will be able to:

No	Course Outcomes
01	explain the fundamental principles of fluid statics and dynamics.
02	apply fluid laws and analyze fluid flow problems.
03	calculate pressure drops and flow rates in pipe networks and fittings using appropriate equations and empirical correlations.
04	interpret working principles, select and evaluate fluid machinery and flow measuring devices
05	solve chemical engineering problems involving compressible and incompressible fluid flows.

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
60	0	30	30	120	04	70	30	20	30	50	200

- ***Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Fluid static and its application:** Nature of fluids, Pressure concept, Hydrostatic equilibrium, decanters like continuous gravity, centrifugal etc.	02	5
2	**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.	05	10
3	**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	05	10
4	**Flow of incompressible fluids in Conduits and Thin Layers:** 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, form friction losses in Bernoulli's equations, separation of boundary layers in diverging channel.	06	15

5	**Flow of Compressible fluids:** Mach number, continuity equation total energy balance equation, velocity of sound, processes of compressible of flow like isentropic expansion, adiabatic frictional flow, isothermal frictional flow, velocity in nozzles.	05	10
6	**Flow past immersed bodies:** Introduction to Drag, drag coefficient, form drag, and stream lining, friction in fluids through bed of solids, fluidization, condition of fluidization, types of fluidization, application of fluidization, continuous fluidization, slurry and pneumatic transport.	05	10
7	**Transportation and Metering of fluid:** Pipe and tubing, joint and fittings selection of pipe sizes, prevention of leakage around moving parts, Different types of rotating shaft sealing systems and their selection criteria, stuffing boxes, mechanical seals, Different types of valves and their selection criteria, valves like Gate, Globe, Plug cocks, Ball, Check valve or non-return valve, steam trap, needle valve, butterfly valve, diaphragm valve, control valve, pressure safety valve, angle valve, rotary valve, etc.	05	10
8	**Fluid moving machinery:** 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, their selection criteria, comparison of devices for moving fluids.	06	15
9	**Measurement of flowing fluids:** Different types of flow meters and their selection criteria, full bore meter like venturimeter, orifice meter, coefficient of discharge of venturimeter, orifice meter, area meters like Rotameter, target meters, V-element meter, vortex shedding meters, coriolis meters, magnetic meters, ultra sonic meters, etc.,	06	15

	insertion meters like pitot tubes, anemometers, thermal meters, etc. Recent advancement in different pumps, valves and measuring devices.		

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	15	20	10	10	**5**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze; E: Evaluate and C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

- "Unit Operations of Chemical Engineering",McCabe WL, Smith JC, Harriott P, McGraw Hill Publication, 7th edition 2005.
- "Chemical Engineering"Vol.I–Fluid flow, Heat Transfer and MassTransfer; Coulson & Richardson's, Butterworth – Heinemann Publication,6th Edition.
- "Fluid Dynamics and HeatTransfer", James G.Knudson and Donald L.Katz, McGrawHill Publication
- "Fluid Mechanics for Chemical Engineers" by James O. Wilkes, Prentice Hall, 2nd Edition.
- Introduction to Fluid Mechanics" by Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, Wiley, 8th Edition.

List of Experiments: (Minimum 08 experiments need to be performed)

Sr. No.	**Experiment Title**
1	To study and verify Bernoulli's Theorem
2	To calibrate a Venturimeter and determine its coefficient of discharge
3	To calibrate an Orifice meter and determine its coefficient of discharge
4	To study a Rotameter and determine its coefficient of discharge

5	To study a Notched Weir apparatus and determine its discharge coefficient
6	Study of various pressure measurement devices
7	Study of energy losses due to friction in pipes using water
8	To study the flow pattern using Reynolds Experiment Apparatus
9	Analyze the Performance of a centrifugal pump
10	Analyze the performance of a positive displacement pump.
11	For studying the working of rotary-type positive displacement pumps.
12	To study the operation of a **fluid ejector (jet pump)**
13	To measure fluid velocity using a **Pitot tube** and compare theoretical velocity with actual velocity.

Major Equipment Required:

Venturimeter, Orificemeter, Rotameter, Centrifugal and other types of pumps, Notch apparatus, Pipe networks with valves, joints, and fittings (Hydraulic Bench), Bernoulli's Apparatus.

Useful Resources / Open-Source Learning Platforms:

1. **NPTEL** (National Programme on Technology Enhanced Learning) video lectures
2. **MIT Open Course Ware (OCW)** – Lectures on Fluid Dynamics
3. Virtual Labs – Ministry of Education (India)
4. Simulation Tools like Fluent, COMSOL, DWSIM, SimScale

Self –Learning activity can include the following:

Sr. No.	Activity	No. of Hours	Total Hours Claimed	Evaluation Criteria
1	**Assignments on Fluid Flow Phenomena** (Properties and Classification of Fluids, Fluid Statics and Manometer Calculations, Application of Bernoulli's Equation, Flow Regimes and Reynolds Number Analysis, Frictional Losses in Pipes	Completing five assignments (3h each)	15	Evaluated based on assignment submission

	and Fittings etc.)			
2	**Technical Video Demonstration** on Flow Measurement Devices (Venturimeter, Orificemeter), Analysis of Pumps and Performance Curves etc.	Watching video content and Preparing a report (5h)	05	Assessment based on understanding the content, report and presentation reflecting learning outcomes.
3	**Flow Simulation** using tools like FLUENT, COMSOL, or DWSIM to simulate fluid flow in pipes, valves, or equipment.	Simulation Practice of any one project (10 h)	10	Reviewed based on Implementation, result accuracy and efficiency of coding solutions.
4	**Literature Review and Concept Mapping**: Review 3–5 research papers on Compressible Flow and Mach Number, Pipe Network Design and Head Loss Estimation	Literature reading: 5h Concept Map creation: 5h	10	Relevance of literature, clarity and technical quality of the concept map
5	**Case Study Analysis on Fluid Transport in Chemical Industries** Study real-world pipeline failures or pump selection in industries (e.g., oil & gas, water treatment) and present lessons learned.	Data collection, literature reading, analysis and reporting (10 h)	10	Understanding and technical quality of the content
6	**Field Visit Reflection** visit a process plant and document observations related to fluid transport equipment	Visit 6 h, literature reading 6 h and report preparation 3 h (total 15 hours)	15	Understanding and technical quality of the content
7	**Online Course** (MOOC/NPTEL/SWAYAM/edX, etc.) on Fluid Flow Operations in chemical engineering	Minimum course duration of 15 hours	15	Assessment through an examination at the end of the course.

				Certificate submission required
8	**Independent Course Project** Exploring Emerging Techniques) or Applying Fluid Flow Principles to Solve Complex Industrial Problems **Like:** Modeling of Notches and Weirs, Efficiency analysis of fluid moving machinery such as pumps and blowers, pipe network optimization, Computer-aided design or analysis of flow systems	Literature review/Analysis/ Solution Development (10h) + Report writing and preparation (5h)	15	Evaluated based on originality, technical depth, research findings, solution and presentation
9	**Producing Technical Videos** related to the Subject Content	Content development (10h) + Video creation and uploading on the department/college website (5h)	15	Reviewed based on the quality and effectiveness of the video content
10	**Developing Posters, Charts, or PowerPoint Presentations** on Subject related Advanced Technical Topics	Designing and presenting visual content	10	Assessed based on creativity, clarity, and presentation skills
11	**Design and development of** fluid flow experimental setups	Designing setup 5h, Developing 10 h, and testing 5 h (total 20 h)	20	Assessment based on concept, design and prototype developed.

Guidelines for Faculty:

- The activities listed above are suggestive, and faculty members have the flexibility to select and modify them as needed.
- The total self-learning hours remain fixed at 45 hours, ensuring comprehensive coverage of numerical methods in chemical engineering.
- Faculty can adjust the distribution of hours across different activities while maintaining a balanced learning approach.

- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective recordkeeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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