# GUJARAT TECHNOLOGICAL UNIVERSITY

## CHEMICAL ENGINEERING

FLUID FLOW OPERATION
**SUBJECT CODE:** 2130502
B.E. Semester: III

**Type of course:** Chemical Engineering

**Prerequisite:** Basic Concepts of Engineering Mathematics and Physics.

**Rationale:** Chemical Engineering has to do with industrial processes in which raw materials are processed and separated into the useful products. The behavior of fluids is important to process engineering and constitutes one of the foundations for the study of the unit operations.

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | | Practical Marks | | | |
| L | T | P | C | ESE (E) | PA (M) | | PA (V) | | PA (I) | |
| | | | | | PA | ALA | ESE | OEP | | |
| 3 | 0 | 2 | 5 | 70 | 20 | 10 | 20 | 10 | 20 | 150 |

**Content:**

| Sr. No. | Topic | Teaching Hours | Module Weightage (%) |
|---|---|---|---|
| **1.** | **Fluid static and its application:** Nature of fluids, Pressure concept, Hydrostatic equilibrium, decanters like continuous gravity, centrifugal etc. | 02 | 40 |
| **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 | |
| **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 | |
| **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, 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 | 07 | |

| | | | |
|---|---|---|---|
| | Bernoulli's equations, separation of boundary layers in diverging channel. | | |
| **5.** | **Flow of Compressible fluids:**<br>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. | 04 | 60 |
| **6.** | **Flow past immersed bodies:**<br>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. | 04 | |
| **7.** | **Transportation and Metering of fluid:**<br>Pipe and tubing, joint and fittings selection of pipe sizes, prevention of leakage around moving parts, stuffing boxes, mechanical seals, valves like Gate, Globe, Plug cocks, Ball, Check valves. | 06 | |
| **8.** | **Fluid moving machinery:**<br>Pumps its characteristics like developed head power requirement suction lift and cavitations; positive displacement pumps like reciprocating, rotary pumps, centrifugal pumps and its theory, characteristic of head capacity relation, pump priming, fans, blowers like positive displacement, centrifugal blowers, compressor efficiency, vacuum pumps, jet ejectors, comparison of devices for moving fluids. | 08 | |
| **9.** | **Measurement of flowing fluids:**<br>Full bore meter like venturimeter, orifice meter, coefficient of discharge of venturimeter, orifice meter, area meters like Rotameter, target meters, vortex-shedding meters, coriolis meters, magnetic meters etc., insertion meters like pitot tubes etc. Recent advancement in different pumps, valves and measuring devices. | 08 | |
| **10.** | **Dimensional Analysis:**<br>Different methods of dimensional analysis applied to fluid flow problems. | 05 | |

**Reference Books:**


- "Unit Operations of Chemical Engineering", McCabe W L, Smith J C, Harriott P, Mc Graw Hill Publication, 7th edition 2005.
- "Chemical Engineering" Vol. I – Fluid flow, Heat Transfer and Mass Transfer; Coulson & Richardson's, Butterworth – Heinemann Publication, 6th Edition.
- "Fluid Dynamics and Heat Transfer", James G. Knudson and Donald L. Katz, Mc Graw Hill Publication


**Course Outcome:** After learning the course the students should be able:

1. To create a vision of understanding the momentum transfer process.
2. To analyze fluid flow concepts.
3. To review the practical importance and relevance of fluid flow in process industry.
4. To be able to utilize the technological methods in problem solving in process plant.
5. To build a bridge between theoretical and practical concepts used in industry.

**List of Experiments and Open Ended Projects:**

Minimum **5** practicals to be performed and remaining Open-ended Projects / Study Reports / Latest outcomes in technology study**:-**

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Projects / Study Reports / Latest outcome in technology.

2. Literature survey including patents and research papers of fundamental process
- Design based small project **or**
- Study report based on latest scientific development **or**
- Technology study report/ modeling/ simulation/collection report **or**
- Computer based simulation/ web based application/ analysis presentations of basic concept field which may help them in Chemical engineering.

3. These can be done in a group containing maximum **three** students in each.
4. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.
5. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to study the design module of given task.
6. In the semester student should perform **minimum** 5 set of experiments and complete **one small open ended dedicated project** based on engineering applications. This project along with any performed experiment should be **EVALUATED BY EXTERNAL EXAMINER.**

**PRACTICALS (ANY FIVE):**

| Sr. No. | List of Experiments |
|---|---|
| **1.** | To study and verify Bernoulli's Theorem |
| **2.** | To calibrate Venturi meter and obtain it's coefficient of discharge. |
| **3** | To calibrate an Orifice meter and obtain it's coefficient of discharge. |
| **4.** | To study a Rota meter and obtain it's coefficient of discharge. |
| **5.** | To Study Notched Weirs Apparatus and obtain its discharge coefficient. |
| **6.** | Study of Pressure measurement devices. |
| **7.** | Friction Vs. Re losses in Pipe Friction using water. |
| **8.** | To study Reynolds's Experiment Apparatus. |
| **9.** | Centrifugal Pump testing. |

**Open Ended Project fields:-**

**Students are free to select any area of fluid flow technology** based on Chemical engineering applications to define Projects. Some suggested projects are listed below:

- Carry out project on Notches and Weirs
- Designing of various fluid flow experiments set up.
- Projects on fluid moving machinery etc.

**Major Equipments:**

Venturi meter, Orifice meter, Rotameter, Various pumps, Notches, Pipes and Valves etc...

**List of Open Source Software/learning website:**

1) Literature available in any laboratory manual of Fluid Flow Operation.
2) NPTEL
3) MIT Open course lecture on Fluid dynamics.

**ACTIVE LEARNING ASSIGNMENTS**: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.