GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-III

Course Title: Fluid Flow Operation
(Code: 4330502)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	3rd Semester

1. RATIONALE

Knowledge of fluid mechanics is essential for the chemical engineer because the majority of chemical-processing operations are conducted either partly or totally in the fluid phase. This course deals with basic concepts and principles in hydrostatics and hydrodynamics and their application in solving fluid - mechanics problems. Using various theoretical and practical concepts of fluid mechanics, power requirement for pumps, blowers and compressors can be determined and friction losses through pipes and fittings can also be calculated.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To maintain flow of different fluids in the chemical plants according to the process requirement.

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

1. Calculate the pressure difference using fundamental concept of fluid statics and carry out dimensional analysis.
2. Solve various fluid flow problems using governing equations.
3. Calculate Friction losses from changes in velocity or direction
4. Understand the concept of fluidization.
5. Select the metering equipments and fluid moving machinery for appropriate chemical engineering operations.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	4	7	30*	70	50	50	200

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-projectto facilitate the integration of COs, and the remaining 20 marks are the average of 2 tests to be taken during the semester for assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** -Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** (in approx. Hrs column) are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	**Practical/Exercise** (Course Outcomes in Psychomotor Domain according to NBA Terminology)	Unit No.	Approx. Hrs Required
1.	Estimate pressure drop using U-tube manometer	I	4
2.	Identify types of flow by using Reynolds's apparatus	II	4
3.	Use Bernoulli's apparatus for mechanical energy balance	III	4
4.	Estimate viscosity of water using Hagen-Poiseuille's equation	III	4
5.	Estimate friction losses through pipe, fittings and valves	IV	4
6.	Estimate friction losses through packed bed	IV	4
7.	Conduct a performance test on reciprocating pump and plot the operating characteristics	V	4
8.	Conduct the performance test on centrifugal pump and plot the operating characteristics	V	4
9.	Estimate friction losses due to sudden expansion and contraction in flow area	IV	4
10.	Determine the Co-efficient of discharge for venturi meter	VI	4
11.	Determine the Co-efficient of discharge for orifice meter	VI	4
12.	Determine the Co-efficient of discharge of the Rotameter and obtain the calibration error	VI	4
13.	Determine the Co-efficient of discharge for notches	VI	4
14.	Measure minimum fluidization velocity through fluidized bed	VII	4
		Total	**56**

Note

i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list**.**

ii. The following are some **sample** 'Process' and '#Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr.No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Handling of apparatus for precise measurements	10
2	Record observations correctly	20
3	Practice and adapt good and safe measuring techniques	10
4	Calculations, Interpretation of results and their conclusion.	20
5	Prepare report of practical in prescribed format	10
6	Solve assignment questions.	20
7	Viva-voce	10
	Total	**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way so that the desired skills are developed instudents.

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	**U-tube manometer:-** Metering Tube : Special Uniform bore thick walled Borosilicate Glass Tube, End Connection :Nozzle Type, Mounting : wall panel mounting, Fluid : Mercury, Range : 250-0-250 mm, Accuracy : + 0.5 % of FSD	01
2	**Reynolds's apparatus:**- Test Pipe: Acrylic, 25 mm dia., 800 mm long, Test pipe attached with water tank having capacity of 200 liter, Dye Reservoir : 500 ml	02
3	**Bernoulli's apparatus:**- Testing Duct: MOC-Acrylic , Type : Circular with divergent and convergent sections, Inlet Tank and Outlet Tank: Capacity : 20 lit., MOC : SS – 304 With provision for overflow and valve to stabilize the flow. Pump: MOC : SS body Type : Monoblock Power : 0.5 HP, Single phase Delivery Size : 1/2"	03
4	**Friction loss apparatus:**- Header pipe connected with four pipes, First pipe MS 0.5 inch provided with ball valve, gate valve, globe valve, union joint, Second pipe 0.5 inch without fittings for viscosity determination, Third pipe 02 inch and 0.5 inch connected by sudden expansion and contraction, Forth pipe 01 inch provided with rotameter(Range:3–30 LPH), All pipes and fittings provided with pressure tapping at suitable places. Manometer: Type : U tube, Length : 500 mm, Fluid : Mercury filled up to 200 mm in each limb.	4,5,9,12
5	**Packed bed apparatus:-** Packed Column : Material Borosilicate Glass with both end made of Stainless Steel Dia. 48 mm approx., Height 750 mm approx, Packing Material: glass spherical particles	06

	Size 8-10mm approx, Water tank : Material Stainless Steel, Capacity 30 Ltrs, Water Flow Measurement : By Rotameter, Pressure Drop Measurement: By Manometer, Electricity supply: 1 Phase, 220 V, 50 Hz AC, 5-15 amp combined socket with earth connection.	
6	**Centrifugal pump test rig:-** Pump: Centrifugal Type, 2800 RPM, Drive: Variable speed, Sump Tank : Made of Stainless Steel, Compatible capacity, Measuring Tank : Made of Stainless Steel, Compatible capacity, Stop Watch : Electronic Pressure Gauge : Bourdon type, Range: 0 - 4 kg/ cm^2, Vacuum Gauge : Bourdon type, Range: 0-760 mm of Hg Compound Gauge : Bourdon type, Range: -760 mm of Hg to 2 kg/cm^2, RPM measurement: RPM Indicator with Proximity sensor, Electricity supply: Single Phase, 220 VAC, 50 Hz, 5-15 Amp combined socket with earth connection	07
7	**Reciprocating pump test rig:-** Pressure Gauge:Bourdon type, RPM measurement: Digital RPM Indicator with Proximity sensor., Tanks Material:Stainless Steel, Tank Capacity:40 Liters., Sump Tank Material:Stainless Steel, Sump Tank Capacity:65 Ltrs., Pump Capacity:1 HP, Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15amp, Head:5 kg/cm2, Type of Pump : Double Acting cylinder of RPM 320,Piston Stroke : 4cm, Piston Diameter : 4.5cm, Suction pipe : 1", Delivery pipe : 3/4",Pressure gauge : 2 kg/cm2, Vacuum gauge : 0-760mm Hg.	08
8	**Venturi and Orifice meter Apparatus:-** Sump Tank: Capacity : 80 liter MOC : SS – 304 With ½" drain valve, Collection Tank: Capacity : 50 liter, MOC : SS - 304, With self graduated glass tube level indicator & 1" drain valve,Pump: Type : Monoblock MOC : SS – 304 Power : 1 HP, Single Phase,Venturimeter: Size : Suitable for 1" pipeline Dia. Ratio : 0.6-0.64 MOC : Brass With suitable Pressure tapings Arrangement, Orificemeter: Size : Suitable for 1" pipeline Dia. Ratio : 0.6-0.64 MOC : SS 304 With suitable Pressure tapings, Rotameter: Size : Suitable for 1" pipeline Range : 3 – 30 LPH Metering tube: Borosilicate Glass Valve : Needle Valve provided integral, Manometer: MOC : Borosilicate glass tube Size : 500 mm, Fluid : Mercury filled upto 200 mm in each limb, Necessary piping and valves shall be provided to supply water to various flow meters.	10,11
9	**Discharge Over Notches Apparatus:-** Flow Channel: MOC : Rectangular Open Channel of Acrylic, Size : 600 (L) * 250 (W) * 180 (H) mm, Notches: MOC : SS – 304 (Thickness – 1.6 mm), Mounting : Interchangeable, Type: 1.Rectangular, 2. 45°V, Measuring Tank: Capacity : 40 liter, MOC : SS – 304 with self graduated glass tube level indicator, Level gauge: Type : Hook and Screw gauge, Pump: MOC : SS, Type : Monoblock, Power : 0.5 HP, Single Phase	13
10	**Fluidized bed apparatus:-** Material Borosilicate Glass with both end made of Stainless Steel Dia. 48 mm (approx.), Height 750 mm	14

	(approx.) • Packing : Glass Beads • Water tank : Material Stainless Steel, Capacity 30 Ltrs. • Water Circulation : FHP Pump, Crompton/Sharp make. • Water Flow Measurement : By Rotameter • Pressure Drop Measurement : Manometer, Electricity supply: 1 Phase, 220 V AC, 50 Hz, 5-15 amp combined socket with earth connection.	

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices
c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes.

The ADOs are best developed through laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domainaccording to NBA terminology)	Topics and Sub-topics
Unit – I Fluid Staticsand its Applications	1a. Define Ideal fluid andReal fluid 1b. Differentiate between fluid statics and dynamics	1.1 Ideal fluid and Real fluid 1.2 Fundamentals of fluid statics and dynamics
	1c. Properties of fluid	1.3 Define pressure, Static pressure, Dynamic pressure,Vacuum, Density, Viscosity (Absolute and Kinematic), Specific gravity
	1d. Compare compressible and incompressible fluids	1.4 Compressible and incompressiblefluids

	1e. Derive and apply equation of pressure in static fluid.	1.5 Derivation of equation of pressure in static fluid
	1f. Describe different types of manometers 1g. Derive equation ofpressure difference 1h. Explain differential pressure cell	1.6 Principle construction and workingof: Simple U-tube manometer, Inclined manometer 1.7 Derive equation of pressure difference for U-tube manometer 1.8 Differential pressure cell
	1.i Solve simple numerical	1.9 Numerical based on pressure and manometer
Unit– II Fluid–Flow Phenomena and basic equations of fluid flow	2a. Explain velocity change across cross section	2.1 Velocity field, velocity gradient,shear stress and rate of shear
	2b. Explain effect of solid boundary	2.2 Boundary layer & it's formation In straight tubes
	2c. Compare Newtonian and Non-Newtonian fluids with	2.3 Newtonian and Non-Newtonian fluid
	2d. Describe Reynold'sexperiment	2.4 Reynold's experiment and Reynolds Number
	2e. Solve simple numerical	2.5 Numerical based on Reynolds Number
Unit– III Basic Equations of Fluid Flow	3a. Define velocities	3.1 Average velocity and mass velocity
	3b. Derive continuity equation	3.2 Continuity equation for mass balance in steady flow
	3c. Derive Bernoulli's equation	3.3 Bernoulli's equation and correctionsin Bernoulli's equation

Unit	**Major Learning Outcomes (Course Outcomes in Cognitive Domainaccording to NBA terminology)**	**Topics and Sub-topics**
	3d. Use Hagen-Poiseuille's Equation	3.4 Hagen-Poiseuille's Equation
	3e. Solve simple numerical	3.5 Numerical based on basic equations
Unit–IV Friction in Flowing Fluid	4a. Describe roughness of pipe	4.1 Roughness of pipe
	4b. Explain hydraulic radius and equivalent diameter	4.2 Hydraulic radius and equivalent diameter
	4c. Use friction factor chart	4.3 Friction factor chart
	4d. Explain friction losses	4.4 Friction losses from: (a) Sudden expansion of cross section (b) Sudden contraction of cross section 4.4.1 Friction loss in fittings and valves
Unit– V Transportation of fluid	5a. Compare pipe and tube	5.1 Introduction of pipe and tube 5.2 Birmingham wire gauge(BWG) and schedule no.
	5b. Describe fittings & joints	5.3 Types and uses of fittings and joints

	5c. Select valve for particular application	5.4 Construction and working of valves like: (a) Gate valve (b) Globe valve (c) Check valve (d)Butterfly valve (e) Ball valve (f) Control valve(Air to open and Air to close)
	5d. Classify pumps	5.5 Classification of pumps
	5e. Explain pumps with their startup shut and down procedure	5.6 Construction and working of centrifugal, reciprocating and rotary pump
	5f. Explain characteristics of centrifugal pump	5.7 Explain characteristics of centrifugal pump
	5g. Calculate NPSH, head and power for centrifugal pump	5.8 Developed head and power requirement in centrifugal pump
		5.9 NPSH, and Cavitation in centrifugal pump
		5.10 Numerical based on NPSH, efficiency, head and power
	5h. Explain Fan, Blower, Compressor, Vacuum pump and jet ejectors	5.11 Introduction to Fan, Blowers, Compressors, Vacuum pump and jet ejectors
Unit– VI Flow Measurement	6a. Classify flow measuring devices	6.1 Classification of flow measuring devices
	6b. Describe and select flow meters	6.2 Construction, working principles and application of flow meters like Venturi meter, Orifice meter, Rotameter, weirs, Magnetic flow meter
	6c. Derive equation of flow rate	6.3 Derivation of equation of flow rate through Orifice meter, Venturi meter.

Unit	**Major Learning Outcomes (Course Outcomes in Cognitive Domainaccording to NBA terminology)**	**Topics and Sub-topics**
	6e. Solve simple numerical	6.4 Numerical of Orifice meter, Venturi meter
Unit– VII Fluidization	7a Explain Fluidization	7.1 Fluidization and its industrial applications
	7b Discuss Drag, Drag coefficient, Stokes' law	7.2 Drag and drag coefficient Stokes' law
	7c Explain the condition of fluidization.	7.3 Condition for Fluidization
	7d Define minimum fluidization velocity	7.4 Minimum fluidization velocity

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

			Distribution of Theory Marks

Unit	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
I	Fluid Statics and itsApplications	06	02	03	04	09
II	Fluid–Flow Phenomena	05	02	03	02	07
III	Basic Equations of Fluid Flow	06	02	06	02	10
IV	Friction in Flowing Fluid	04	02	02	02	06
V	Transportation of Fluid	10	05	08	05	18
VI	Flow Measurement	08	04	07	04	15
VII	Fluidization	03	01	02	02	05
	Total	**42**	**18**	**31**	**21**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questionsto assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, the following are the suggested student- related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform the following activities in groupand prepare small reports of about 5 pages for each activity. They should also collect/record physical evidence such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Make a survey on types of valves and pumps we use domestically.
b) Prepare a report on fluid flow through open channel in your city/village.
c) Draw and report water distribution system of chemical engineering department building.
d) Make a chart/poster on Mechanical seal and stuffing box.
e) Determine the energy consumption and efficiency of existing pumps of laboratory.
f) Collect different parts of various pumps from scrap yard.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (*MOOCs*) may be used to teach various topics/subtopics.
b) Guide student(s) in undertaking micro-projects/activities.
c) Different types of teaching methods i.e. video demonstration, activity based learning,

case study, m-learning need to be employed by teachers to develop the outcomes.

d) Some *of the topics/sub-topics* which are relatively simpler or descriptive are to be given to the students for *self-learning* but to be assessed using different assessment methods.
e) Teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course
g) OERs, Vlab, and Olabs may be used to teach for the teaching of different concepts.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application-based, internet-based, workshop- based, laboratory-based, or field-based. Each micro-project should encompass two or more COs which are the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the microproject should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course.The students ought to submit micro-project by the end of the semester (so that they develop industry- oriented COs.

A suggestive list of micro-projects is given here. This should relate highly to the competency of the course and the COs. Similar micro-projects could be added by the concerned course teacher.

a) Prepare a model to demonstrate flow through open channels.
b) Prepare a chart on different types of vacuum pumps.
c) Prepare a chart on various types of manometers.
d) Prepare a power point presentation on classification and demonstration of valves.
e) Develop a friction factor chart experimentally.
f) Prepare a model/chart/poster on pneumatic and hydraulic conveying.
g) Prepare a chart that classifies fluid on various bases.
h) Prepare a power point presentation on blowers and compressors.
i) Prepare a power point presentation on classification and demonstration of flow measuring devices.
j) Prepare a power point presentation on various methods to join pipes and tubes.
k) Make a report on Cavitation, its identification and prevention.
l) Prepare a power point presentation pertaining to friction loss in fittings and valves.
m) Make a chart on selection criteria of pumps and valves.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Unit Operations of ChemicalEngineering	McCabe, Warren L.,Julian C. Smith	McGraw Hill Publication, New York 2004 (Seventh Edition)
2	Introduction to ChemicalEngineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York 2004 (Seventh Edition)
3	Unit Operations of Chemical Engineering Vol-I	Chattopadhyay, P.	Khanna Prakashan, New Delhi, 1996
4	A text book of Fluid Mechanics	Khurmi, R.S.	S. Chand Publication, New Delhi 2002
5	Unit Operation –I	Gavhane, K.A.	Nirali Prakashan, Pune 2009
6	A Textbook Of Fluid Mechanics And Hydraulic Machines	Dr. R. K. Bansal	Publisher: Laxmi Publications, 2005 ISBN 10: 8131808157 ISBN 13: 9788131808153
7	Fluid Mechanics: Fundamentals and Applications	John. M. Cimbala Yunus A. Cengel	McGraw Hill Publication, New York 2006 (1st edition) ISBN 0–07–247236–7

14. SUGGESTED LEARNING WEBSITES

a) https://ndl.iitkgp.ac.in/
b) https://www.vlab.co.in/
c) https://nptel.ac.in/
d) http://www.nzifst.org.nz/unitoperations/flfltheory.htm
e) https://www.slideshare.net/AjinkyaKhandizod/fluid-flow-operations-applications-of-fluid-mechanics-rheological-classifications-of-fluid

15. PO-COMPETENCY-CO MAPPING

Semester III	Fluid Flow Operation(4330502)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline-specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimen-tation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning

Competency	Use principles of Fluid Flow Operation in chemical engineering applications						
CO1. Calculate the pressure difference using fundamental concept of fluid statics and carry out dimensional analysis.	3	3	-	3	-	2	2
CO2. Solve various fluid flow problems using governing equations.	3	3	-	3	-	-	2
CO3. Calculate Friction losses from changes in velocity or direction	2	2	-	2	-	1	-
CO4.Understand the concept of fluidization.	2	-	-	2	-	1	-
CO5. Select the metering equipments and fluid moving machinery for appropriate chemical engineering operations	3	3	2	3	3	3	2

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Ms. Y S Patel Lecturer in Chemical Engg.	G P Gandhinagar		yaminipatel2016@gmail.com
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