Program Name : Diploma in Chemical Engineering

Program Code : CH

Semester : Fourth

Course Title : Fluid Flow Operation

Course Code : 22409

1. RATIONALE

Measurement of pressure, flow and transportation of fluids are part of routine activity in every process industry. Knowledge of fluid flow aspects is also essential for enhancing rate of heat and mass transfer. This course is intended to equip the students with fundamental aspects related to fluid flow. After learning this course students will be able to operate and troubleshoot different fluid transportation devices.

2. COMPETENCY

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

- **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:

a. Maintain the fluid parameters in chemical process.
b. Interpret the pressure drop in piping systems.
c. Maintain the flow rate of the incompressible fluid.
d. Select the relevant piping system for fluid transportation.
e. Use liquid pumping devices.
f. Use gas pumping devices.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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, ESE - End Semester Examination; PA - Progressive Assessment.**

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

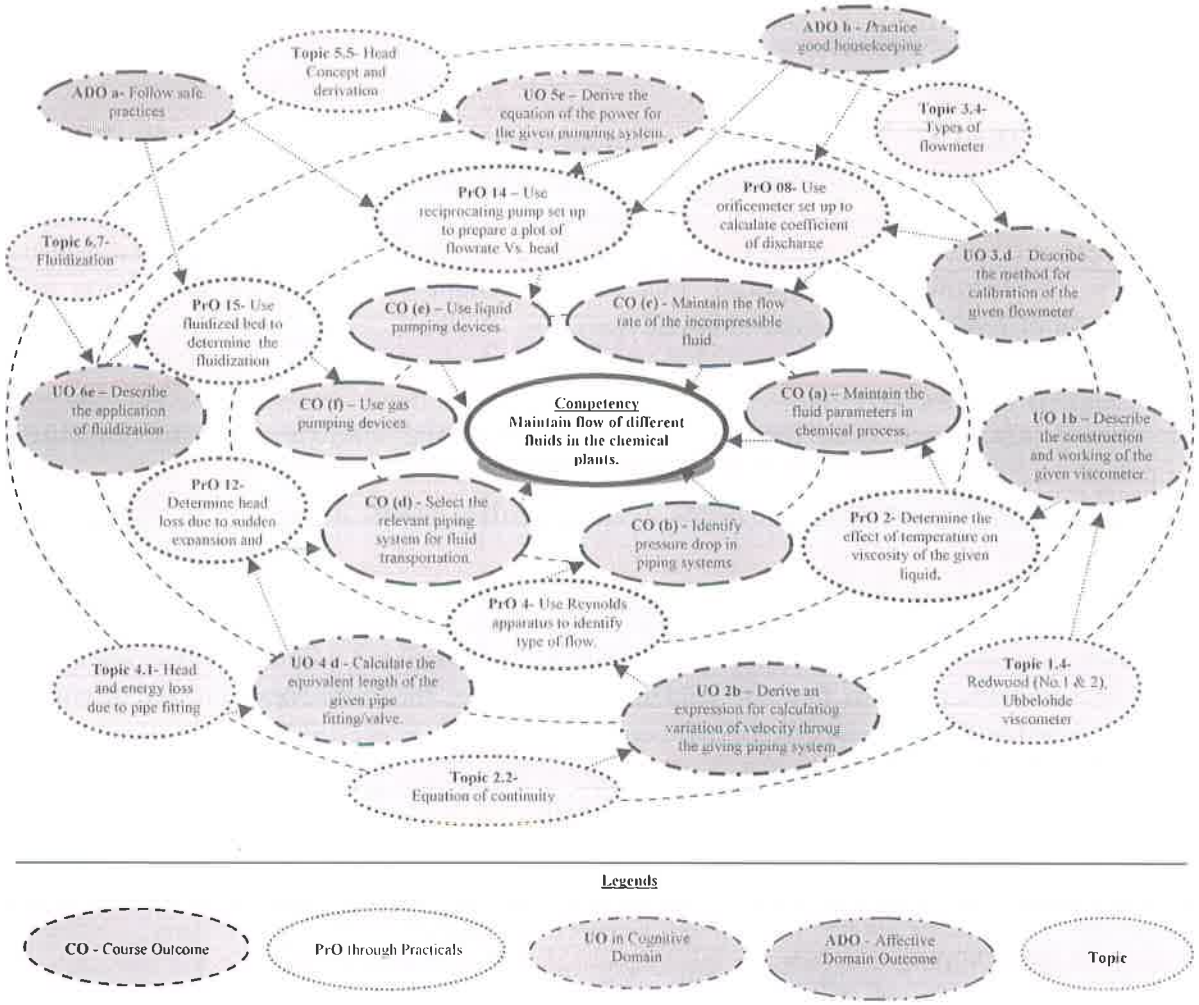

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use viscometer to measure the viscosity of starch solution of different concentration.	I	04*
2	Determine the effect of temperature on viscosity of the given liquid.	I	04
3	Use U-tube manometer for measuring differential and guage pressure.	I	04
4	Use Reynolds apparatus to identify type of flow.	II	04*
5	Use friction factor set up to determine friction factor and plot friction factor vs Reynold number for a given pipe.	II	04

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
6	Use the experimental set up to calculate viscosity of flowing fluid using Hagen Poisuillie equation.	II	04
7	Use Bernoullie's setup to identify "energy associated with flowing fluid is conserved".	III	04*
8	Use orificemeter set up to calculate coefficient of discharge and prepare calibration curve.	III	04
9	Use the venturimeter set up to calculate coefficient of discharge and prepare calibration curve.	III	04
10	Use the rotameter to measure the flowrate and prepare a curve showing relationship between area and flowrate.	III	04
11	Calculate equivalent length for globe valve, gate valve and bend/elbow.	IV	04*
12	Determine head loss due to sudden expansion and contraction.	IV	04
13	Use the centrifugal pump test rig to plot the characteristics curves.	V	04*
14	Use reciprocating pump set up to prepare a plot of flowrate Vs. head developed.	V	04
15	Use fluidized bed to determine the fluidization velocity for bed of different materials.	VI	04*
16	Use fixed bed of given material, to prepare curve of pressure drop Vs. flowrate.	VI	04
	Total		**64**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member

e. Maintain tools and equipment
f. Follow ethical practices

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Viscometer Redwood I &II	1,2
2	U tube manometer	3
3	Reynolds experiment(Transparent tube: Borosilicate Glass/Perspex, capillary tube , needle: copper, stainless steel, constant head water tank : capacity 40 liter, water circulation pump, sump tank : capacity 60 liter, stop watch	4
4	Friction factor set up : set up consists of 2/3 pipes of different diameters, connected in parallel. Pressure tappings to be provided on each pipe with manometer. Water circulation pump, flow measuring tank with piezometer, capacity 25 litre. Sump tank : capacity 50 litre	5
5	Bernoullies setup:Test section – Acrylic(1 piece), piezometer tubes-7, Tank for flow measurement with piezometer, capacity- 25 L, Sump tank capacity-70L, Inlet tank before test section- 20L	7
6	Orificemeter: Orifice plate placed between two flange with an orifice of suitable (orifice dia / pipe dia) ratio. Pressure tappings to be provided at upstream and down stream with manometer.	8
7	Venturimeter: Venturimeter for 1inch pipe line .Convergent cone -15 to 17 ^{0}. Divergent cone – 5 to 7^0. Throat dia- 1.5 to 1.8cm. Pressure tappings to be provided at upstream and throat with manometer.	9
8	Rotameter: 1 inch pipe with 5 to 50 L / minute range	10
9	Equivalent length: An experimental set up consisting of following pipe fittings: Reducer, expander, bend, elbow, gate valve, globe valve. Pump for water circulation, flow measuring tank with piezometer tube, sump tank. . Pressure tappings with manometer to be provided across each fittings	11,12
10	Centrifugal pump: Centrifugal pump coupled to 1 HPmotor,variable speed arrangement, Pressure gauge, vacuum gauge and foot valve, Energy meter or voltmeter and ammeter, flow measuring tank with piezometer tube	13
11	Reciprocating pump: Double acting, Single Cylinder Reciprocating Pump coupled with a DC Motor , RPM Indicator, measuring tank with piezometer tube and stop watch, Vacuum gauge suction line and Pressure gauge on delivery line and a sump tank.	14
12	Fluidized bed:Set up consists of Static bed with packing material , manometer with pressure tappings and rotameter.	15,16

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fluid Flow Properties	1a. Apply concept of pressure and velocity gradient in the given piping system. 1b. Explain with sketches the construction and working of the given viscometer with sketch. 1c. Classify the fluid on the basis of the given criteria. 1d. Calculate the pressure exerted by the given liquid column.	1.1 Fluid: Definition, pressure gradient, velocity gradient. 1.2 Fluid static and dynamics: concept and applications. 1.3 Viscosity: Origin of viscosity and methods of expression (dynamic viscosity and kinematic viscosity) units and interconversion, neumerical. 1.4 Redwood (No.1 & 2), Ubbelohde viscometer: Principle, construction working and application. 1.5 Newtons law of viscosity. 1.6 Types of fluids : Ideal and real, compressible and incompressible, Newtonian and non Newtonian fluids. 1.7 Hydrostatic equilibrium: Concept and its application in pressure measurement (derivation and elementary problems) Pressure exerted by height of liquid column, differential, guage and absolute pressure measurement by U tube manometer.
Unit-II Fluid Flow Parameters	2a. Calculate velocity and flow rate of the given fluid. 2b. Derive an expression for calculatiog variation of velocity through the giving piping system 2c. Calculate Reynolds number for deciding type of the given flow. 2d. Calculate head loss due to friction from the given data. 2e. Explain with sketches the velocity distribution curve of fluid for the given type of flow.	2.1 Concept of average, point and mass velocity.Volumetric and mass flow rate of fluids , units and interconversion. 2.2 Equation of continuity: Derivation and application. 2.3 Types of flow, demonstration by Reynolds experiment.Concept of lower and upper critical velocity. 2.4 Types of friction, definition of Fanning and Darcy Weisbatch friction factor, derivation of friction factor, relationship between friction factor and Reynold number. 2.5 Velocity distribution across the pipe, relationship between point velocity, average velocity and maximum velocity and its derivation. 2.6 Derivation of Hagen Poiseuille equation and its application.
Unit– III Incompre	3a. Compute the interconversion of energy	3.1 Different types of energy associated with flowing fluids such as pressure energy.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
ssible Fluid Flow Measure ment	at different points in pipe with the given data using Bernoulli's equation. 3b. Explain with sketches the construction and working principle of the given type of flowmeter with sketch. 3c. Derive flow equation for a given flow meter. 3d. Explain with sketches the method for calibration of the given flowmeter. 3e. Calculate the flow rate of the given fluid using variable headmeter.	kinetic energy and potential energy. 3.2 Statement, assumption and derivation of Bernoulli's equation for incompressible fluids and correction. 3.3 Bernoulli's equation: Significance and application, graphical representation of energy variation, flow path for venture test section. 3.4 Types of flowmeter : Variable area and variable head flow meter principle, construction, working and application, calibration of Orifice meter, Venturimeter, Pitot tube and Rotameter.
Unit– IV Pipe Fittings and Valves	4a. Sketch the given pipe fitting/valve. 4b. Identify the relevant pipe fitting for the given application with justification. 4c. Explain the classification of valves using the given criteria. 4d. Calculate the equivalent length of the given pipe fitting/valve.	4.1 Pipe and Tube: definition and comparison. 4.2 Safe working: definition, pressure and allowable stress, Schedule no. and Birmingham wire gauge (BWG). 4.3 Pipe fittings: application, coupling, bend, elbow, tee, cross, reducer, expander, plug, union, hex and barrel nipple. 4.4 Valves: Classification, on/off valve (ball valve/gate valve/plug valve) flow regulating/throttling valve(globe valve/needle valve/ diaphragm valve), unidirectional valve(lift check/swing check valve), safety valve, pressure reducing valve. 4.5 Head and energy loss due to pipe fitting, Concept of equivalent length of pipe fittings and valves numerical. 4.6 Rupture disc: Principle, construction, working and application
Unit –V Liquid Pumping Devices	5a. Explain with sketches the working of the given pump. 5b. Describe with sketches the the construction of the given pump. 5c. Explain with sketches the the characteristics curves for the given pump. 5d. Identify the priming in the given pump with	5.1 Pumping of fluids: Importance of pump. 5.2 Classification of pumps (Centrifugal and positive displacement pump) 5.3 Principle, construction, working and application of centrifugal pump , reciprocating (piston, plunger and diaphragm) pump, rotary pump(gear pump), dosing (piston and peristaltic) pump. 5.4 Power reqirement of centrifugal pump and reciprocating pump (derevation).

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification. 5e. Derive the equation of the power for the given pumping system.	5.5 Head: Concept and derivation, Net positive suction head (NPSH), air binding, priming, cavitation. 5.6 Characteristic curves of centrifugal pump, operation and trouble shooting, NPSH, Power required, head developed, numerical.
Unit –VI Gas Pumping Devices	6a. Describe with sketches the construction of the given fan. 6b. Explain with sketches the working principal of the given blower. 6c. Explain with sketches the the construction and application of the given compressor. 6d. Explain with sketches the given vacuum generating device. 6e. Explain with sketches the the application of fluidization for the given system.	6.1 Devices for transportation of gas/air (fan, blower and compressor) 6.2 Induced draft and Forced draft fan: principle, construction and working 6.3 Centrifugal blower: Principle, construction, working and application 6.4 Centrifugal and reciprocating compressor: Principle, construction, working and application 6.5 Fan, blower and compressor: Comparision on the basis of range, 6.6 Vacuum generating devices: Principle , construction,working and application of Steam jet ejector, Oil ring and water ring vacuum pumps 6.7 Fluidization: Concept, minimum fluidization velocity and applications

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fluid flow properties	8	4	2	4	10
II	Fluid flow parameters	14	2	4	6	12
III	Incompressible fluid flow measurement	14	2	6	8	16
IV	Pipe fittings and valves	8	2	4	2	8
V	Liquid pumping devices	12	2	4	8	14
VI	Gas Pumping devices	8	2	4	4	10
Total		**64**	**14**	**24**	**32**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, 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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare power point presentation about different types of valves.
b. Refer "www.vlab.co.in" and study any one relevant report.
c. Download the sketch of different valves used in a laboratory setup.
d. Download the videos related to measurement of dimension for glass tube in rotameter setup.
e. Visit website of pump manufacturer and download brochure of different types of pumps.

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/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the LOs/COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Use Flash/Animations to explain various theorems in circuit analysis
f. Guide student(s) in undertaking micro-projects

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, 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 in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **Collection of sample:** Collect different samples of pipe fittings and valves from scrapyard.
b. **Prepare cut section:** Prepare cut section of pipe fittings/valves.
c. **Industry visit:** Visit nearby industry and prepare the report on different fitting and valves.

d. **Visit pumping station**: Visit water pumping station of municipal or local body and prepare a report on pumps and piping arrangement.
e. **Fabricate Venturi tube**: Fabricate Venturi tube using plastic pipes/fittings and prepare experimental setup demonstrating its use as pumping device.
f. **Collection of sample:** Collect the sample of different grades of lubricating and machine oil.
g. **Prepare model**: Prepare a model of gear pump/diferent types of impellers using thermocole.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Unit Operations of Chemical Engineering	Mc Cabe, W. L. Smith	Mc Graw Hill Publication, New York, 2004, ISBN -9789339213237
2	Chemical Engineering	Coulson, J. M. and Richardson J.F.	Asian Books Private Ltd, New Delhi, 1980, ISBN: 8186299106
3	Perry's Chemical Engineer's Hand Book	Don W Green, Robert. H. Perry	Mc Graw Hill Publication New York, 2008, ISBN:9780071422949
4	Fluid mechanics and Hydraulic machinery	Bansal, R.K.	Laxmi Publication, New Delhi, 2017, ISBN: 978-8131808153
5	Introduction to Chemical Engineering	Badger, W. L., Banchero, J.T.	Mc Graw Hill Publication, New York, 1955, ISBN: 9780074630501
6	Hydraulics and Fluid Mechanics	Modi, P.N. Seth, S.M.	Standard Book House, New Delhi, 2015, ISBN: 81-900893-74-4

14. SOFTWARE/LEARNING WEBSITES

i. www.vlab.co.in
ii. www.nptel.ac.in
iii. www.pumpsindia.com


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