Program Name : **Diploma in Production Engineering / Production Technology**

Program Code : **PG / PT**

Semester : **Third**

Course Title : **Industrial Fluid Power**

Course Code : **22345**

1. RATIONALE

Knowledge of fluid properties, fluid flow is essential in all fields of engineering. Hydraulic systems and pneumatic systems are widely used in industrial automation systems. This subject requires knowledge of basic engineering sciences, fluid mechanics, mathematics etc. Diploma engineers come across such systems in all the segments of industries. This subject will give the students, the basic skills and knowledge of hydraulics and pneumatics which will be directly needed in the industrial environment.

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 different types of Hydraulic and Pneumatic systems.**

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. Interpret various fluid characteristics and flow problems.
b. Calculate various losses in flow through pipes.
c. Select relevant components for hydraulic and pneumatic systems.
d. Maintain hydraulic circuits / components.
e. Maintain pneumatic circuits / components.

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	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): 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.

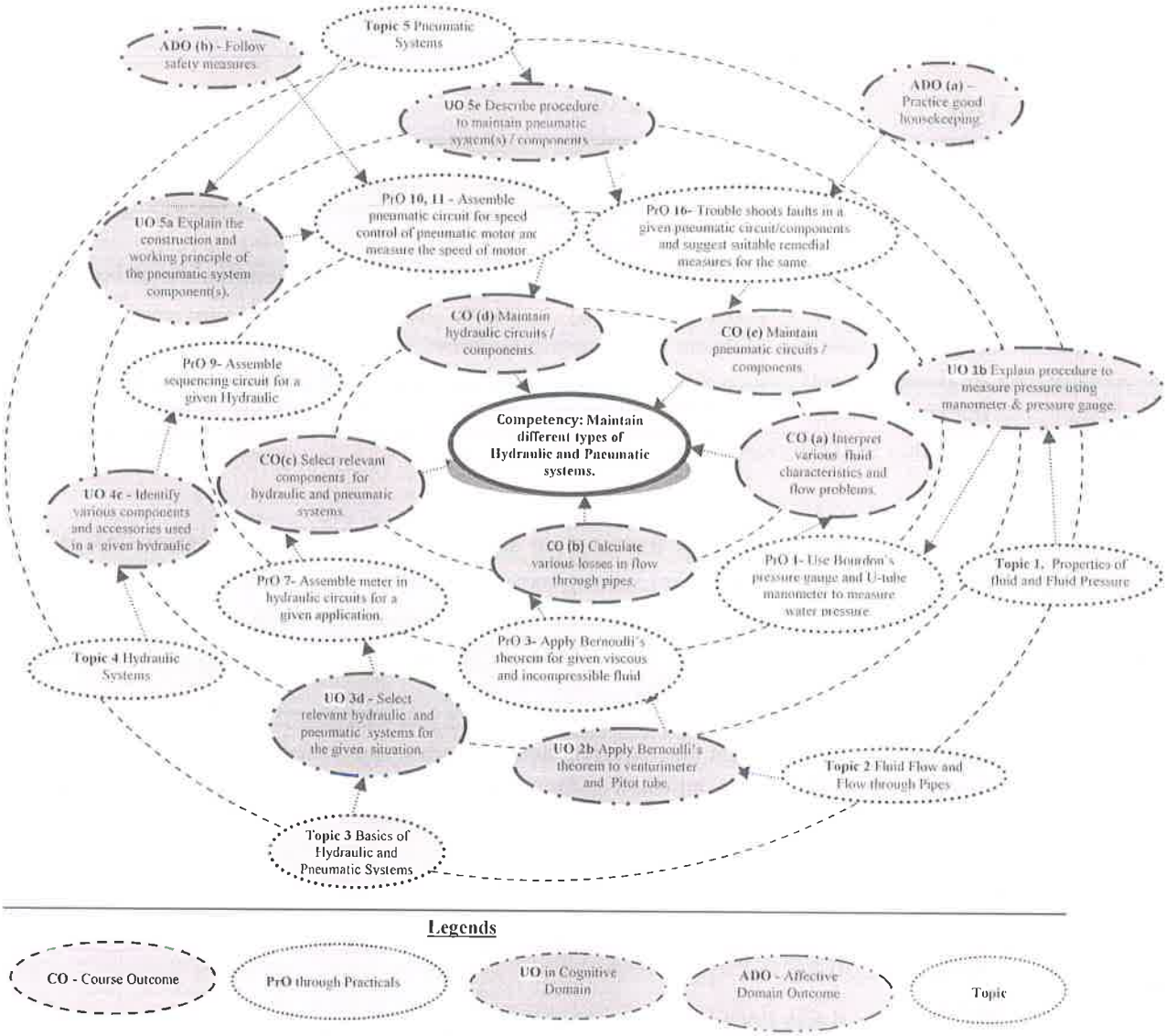

Figure 1 - Course Map

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 Bourdon's pressure gauge and U-tube manometer to measure water pressure.	I	02
2	Use measuring tank and stop watch to measure discharge of water.	I	02
3	Apply Bernoulli's theorem for given viscous and incompressible fluid.	II	02*
4	Determine coefficient of discharge of Venturimeter.	II	02*
5	Use hydraulic test rig to calculate minor frictional losses in pipe fittings for bends, a contraction and an enlargement.	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
6	Use hydraulic test rig to calculate minor frictional losses in pipe fittings for gate valve.	II	02*
7	Assemble meter in hydraulic circuits for a given application.	IV	02
8	Assemble meter out hydraulic circuits for a given application.	IV	02
9	Assemble sequencing circuit for a given Hydraulic application.	IV	02
10	Assemble pneumatic circuit for speed control of double acting cylinders for a given application.	V	02*
11	Measure the speed of double acting cylinder for assembled circuit in PrO 10.	V	02
12	Assemble pneumatic circuit for speed control of pneumatic motor.	V	02*
13	Measure the speed of pneumatic motor for assembled circuit in PrO. 12.	V	02
14	Assemble sequencing circuit for a given Pneumatic application.	V	02*
15	Troubleshoot faults in a given hydraulic circuit/components and suggest suitable remedial measures for the same.	IV	02
16	Troubleshoot faults in a given pneumatic circuit/components and suggest suitable remedial measures for the same.	V	02
	Total		**32**

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 12 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 setup	20
2.	Setting and operation	20
3.	Observation and recording	10
4.	Interpretation of result and conclusion	20
5.	Follow safety measures and good housekeeping.	10
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 safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. 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	**Bourdon's pressure gauge:** Dial size: 1-1/2", 2", 2-1/2" or 4", Accuracy : +/- 2-1-2 % ANSI Grade A (4" SS only), Case : 304 SS, Bezal : 304 SS Crimped, Socket: Brass or 316 SS, Bourden Tube: Brass or 316 SS, U-Tube Manometer and Manometric liquid – Mercury, Water tank and Stop Watch.	1, 2
2	**Bernoulli's theorem apparatus:** Centrifugal Pump of max. head 21 m, Water flow 1.35 liter/sec max., Motor rating: 0.37 kW, Sump tank capacity : 250 liter, High flow volumetric tank : 40 liter, Low flow volumetric tank : 6 liter, Height of working surface : 1 m above floor level.	3
3	**Discharge measurement test Rig:** Sump tank with flow: 1000 x 700 x 300 mm, Measuring tank: 400 x 600 x 250 mm, Mercury Manometers (Differential). Each line provided with flow control valve. Pressure tubes of different pipe lines are connected to common manometers through cocks. Venturimeter & Flow control valve at the end of each line.	4
4	**Test rig for frictional losses:** Centrifugal Pump of max. head 21 m, Water flow 1.35 liter/sec max., Motor rating: 0.37 kW, Sump tank capacity : 250 liter, High flow volumetric tank : 40 liter, Low flow volumetric tank : 6 liter, Height of working surface : 1 m above floor level.	5, 6
5	Plastic coated charts/models of Hydraulic and Pneumatic components, Symbols and Circuits.	7 to14
6	**A hydraulic trainer Kit – 01 Set of Standard make** Power pack unit equipped with pump, Relief valve, 3/2, 4/2, 4/3 DC valve, Pressure gauge, Flow control valve with built in Non-return valve, Single acting and double acting cylinder, hydraulic motor, Filter, Manifold assembly, Pressure Regulator, Couplings, connectors, Pipes and/or hoses etc;	7, 8, 9, 15
7	**A pneumatic trainer Kit – 01 Set of Standard make** Reciprocating air compressor, FRL unit, 3/2, 5/2 DC valve, Pressure gauge assembly, Dual pressure valve, Quick exhaust valve, Flow control valve, Single acting and double acting cylinder, Air Motor, Manifold assembly, Pressure regulator, Couplings, connectors, Pipes and/ or hoses etc;	10, 11, 12, 13, 14, 16
8	**Tool Kit:** - Basic technician tool kit with open ring spanners from 4-5 to 30-32. Allen key set 0-6 mm, Ball pin hammer, pipe wrench etc;	All

S. No.	Equipment Name with Broad Specifications	PrO. No.
9	Simulation Software for Hydraulic and Pneumatic circuits.	7 to14

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Properties of fluid and Fluid Pressure	1a. Differentiate between specified types of pressure. 1b. Explain with sketches the procedure to measure pressure using the specified type of manometer and different types of pressure gauges. 1c. Calculate centre of pressure and total pressure of the given type of regular immersed body. 1d. Calculate pressure head for a given condition.	1.1 **Properties of Fluid:** Density, Specific gravity, Specific volume, Specific Weight, Dynamic viscosity, Kinematic viscosity, Surface tension, Capillarity, Vapour pressure, Compressibility, Types of fluids: Ideal, Real, Newtonion, Non-Newtonion, Plastic. 1.2 **Fluid Pressure and Pressure Measurement:** Concept of atmospheric pressure, Gauge pressure and vacuum pressure, Pressure head measurement by U-tube manometer and Bourdon's pressure gauge. Pascal's Law, concept of static pressure, pressure head, centre of pressure and total pressure for rectangular & circular plane surfaces immersed in liquid in horizontal, vertical and inclined position.
Unit– II Fluid Flow and Flow Through Pipes	2a. Use continuity equation for a given conditions. 2b. Apply Bernoulli's theorem to the given device to determine the given parameter. 2c. Apply laws of fluid friction for the given data. 2d. Determine the specified losses in flow through pipes, fittings and valves with the given data.	2.1 **Fluid Flow:** Types of fluid flows, Rate of flow (Discharge), law of continuity, Reynolds's number, Energies possessed by flowing liquids like pressure, kinetic and potential energy, total energy equation, Bernoulli's theorem with proof and its application to Venturimeter and Pitot tube. 2.2 **Flow Through Pipes:** Laws of fluid friction (Laminar and turbulent flow), Darcy's equation and Chezy's equation for frictional losses, Minor losses in fittings and valves.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– III Basics of Hydraulic and Pneumatic Systems	3a. Explain the physical characteristics and functions of given hydraulic oils. 3b. Select the relevant fluid for given hydraulic and Pneumatic Systems with justification. 3c. Select relevant filter for the given hydraulic and pneumatic systems with justification. 3d. Select relevant hydraulic and pneumatic systems for the given situation with justification.	3.1 Essential physical characteristics and functions of hydraulic Oils, Classification - Mineral based, Fire resistant and Biodegradable Oils, ISO Viscosity Grades of Oils. 3.2 Filters: Contaminations, Need, Types & location of filter. 3.3 General layout, Applications, Merits and limitations of hydraulic and Pneumatic Systems, Hydraulic and Pneumatic Symbols as per ISO.
Unit-IV Hydraulic Systems	4a. Explain with sketches the types, material, functions, and/or working principal of the given hydraulic system component(s). 4b. Select the relevant actuators for the given situation with justification. 4c. Identify the components and accessories used in the given hydraulic circuit diagram. 4d. Describe the procedure to maintain the specified hydraulic component/system. 4e. Construct with explanation the hydraulic circuit for the given situation.	4.1 Centrifugal Pump: Classification of Pumps, Construction, principle of working, priming methods, Water hammer and cavitation phenomenon, Trouble Shooting. 4.2 Positive displacement Pumps: - Construction, working principle and applications of Vane pump, gear pump, rotor pump, screw pump & piston Pump. 4.3 Pressure control Valves: Construction, principle of working of pressure relief valve - direct, pilot operated, Sequence valves. 4.4 Direction control valves: - spool valve - 2/2, 4/2, 4/3 methods of actuation. Types of different center positions. Pilot operated check valve. 4.5 Flow control valves: pressure compensated, non-pressure compensated flow control valve, 4.6 Actuators: Classification of actuators, Construction & working principle of Rotary Actuators - Hydraulic motors, Linear Actuators - Cylinders - single acting, double acting. 4.7 Accessories: Types, Material and functions of Pipes, Hoses, Fittings, Seals and gaskets, Accumulators. 4.8 Circuits: Speed control of actuator, Meter-in, Meter-out, sequencing circuit using sequence valve & Motion synchronization circuit.
Unit –V Pneumatic	5a. Explain with sketches the types, material, functions and/or	5.1 Types and Selection of air compressors for pneumatic systems.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Systems	working principal of the given pneumatic system component(s). 5b. Identify the components and accessories used in the given pneumatic circuit diagram. 5c. Select the relevant air compressors for given situation with justification. 5d. Select actuators for given situation with justification. 5e. Describe the procedure to maintain the specified pneumatic component/system. 5f. Construct with explanation the pneumatic circuit for the given situation.	5.2 Air Receiver, FRL unit. 5.3 Valves: Construction and working principle of Pressure regulating valves, Direction control valves, Flow control valves, Time Delay valve, Quick exhaust valve, twin Pressure valve. 5.4 Actuators: Construction and working principal of Rotary Actuators - Pneumatic motors, Linear Actuators – Cylinders - single acting double acting. 5.5 Accessories: Types, Material and functions of Pipes, Hoses and fittings. 5.6 Circuits: Speed control of actuator, 'Meter-in', 'Meter-out', Roller operated Sequencing and dual control circuit.

***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	Properties of fluid and Fluid Pressure	12	04	04	04	12
II	Fluid Flow and Flow Through Pipes	12	04	06	04	14
III	Basics of Hydraulic and Pneumatic Systems	10	06	04	02	12
IV	Hydraulic Systems	16	04	08	06	18
V	Pneumatic Systems	14	04	06	04	14
Total		**64**	**22**	**28**	**20**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student 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 journal of practicals.

b. Undertake micro-projects
c. Collect information about different types of pumps, pressure measuring devices, filters, power packs, accumulators, compressors, pipes & hoses etc, from local market and from internet. Comparison (types, specification, material, size range, market price, applications etc;) of various models manufactured by different manufacturers. The market survey is to be completed in a group of (max.) three to four students and the report of the same is to be included as part of term work.
d. Collect oil samples used for hydraulic systems and prepare a report based on properties, name of manufacturers, detailed technical specifications, trade names, costs, packing sizes.
e. Study of any one mobile hydraulic system such as in earth moving equipments or any one stationary hydraulic system such as in any machine tool and its detailed report.
f. Study of any one pneumatic circuit such as circuits used in special purpose machines, low cost automation systems, material handling systems and its detailed report.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning 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 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 Guide student(s) in undertaking micro-projects
f Demonstrate students thoroughly before they start doing the practice.
g Encourage students to refer different websites to have deeper understanding of the subject.
h Observe continuously and monitor the performance of students in Lab.

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-projects 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. Students should build up the circuits on computer using software and simulate the flow of fluid during the operation. Afterwards, they themselves can physically connect the circuit on the hydraulic/pneumatic trainer and run the circuit.
b. Design based Problems / Open Ended Problem: Student can be given an application of a power transmission system for which they can evaluate the functional requirements and design appropriate circuit. They must identify the components, and relevant parameters. The application must involve use of hydraulics/pneumatics and/or combinations of different power transmission systems.
c. Perform repairing and / or replacement of defective components in the oil hydraulic / pneumatic system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Hydraulics and Fluid Mechanics including Hydraulic Machines	Modi P. N, Seth S. M.	Standard Book House, New Delhi. ISBN-13: 978-8189401269
2	A Textbook of Fluid Mechanics and Hydraulic Machines	R. K. Bansal	Lakshmi publication. ISBN-13: 978-8131808153
3	Fluid Power with application's	Esposito Anthony	Pearson Education, Inc 2000. ISBN : 1292023872
4	Oil Hydraulic system - Principles and maintenance	Majumdar S. R.	McGraw Hill Publications, New Delhi, ISBN: 0-07-463748-7
5	Pneumatics Systems - Principles and maintenance	Majumdar S. R.	McGraw Hill Publications, New Delhi, ISBN: 0-07-460231-4
6	Hydraulic and Pneumatic Power For Production Industrial Hydraulics	Stewart D.	Industrial Press INC. 200, Madison Avenue, New-York 10016, ISBN: 0-8311-1114-3
7	Industrial Hydraulic	Pippenger John. Tyler Hicks	McGraw Hill Publications, New Delhi, ISBN: 0-88275-776
8	Industrial Hydraulics Manual	Vickers Perry	Vickers Systems International (Company Manual)
9	Basic Pneumatic manual	Festo	Festo (Company Manual)

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a http://nptel.ac.in/courses
b Various system components' manufacturers' catalogues.
c Open source software