Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Sixth**

Course Title : **Hydraulic and Pneumatic Controls**

Course Code : **22650**

1. RATIONALE

There is hardly any automobile as well as manufacturing and service industry without Hydraulic and Pneumatic systems. Hydraulic, pneumatic and hydro-pneumatic systems offer ease of power transmission, enhancement of force and torque; and higher degree of automation. This is a core technology course. It provides insight to construction of Hydraulic and Pneumatic circuits, their applications in industrial and automobile systems and maintenance thereof.

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) Use principles of fluid mechanics for energy conservation.
b) Prepare a troubleshooting chart for centrifugal, reciprocating and other pumps used in fluid power system.
c) Evaluate capacities of simple hydraulic and other pumping devices.
d) Construct hydraulic and pneumatic circuits for relevant applications.
e) Maintain components of hydraulic, pneumatic and hydro-pneumatic systems..
f) Maintain hydraulic, pneumatic and hydro-pneumatic circuits and systems.

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
3	-	2	5	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.

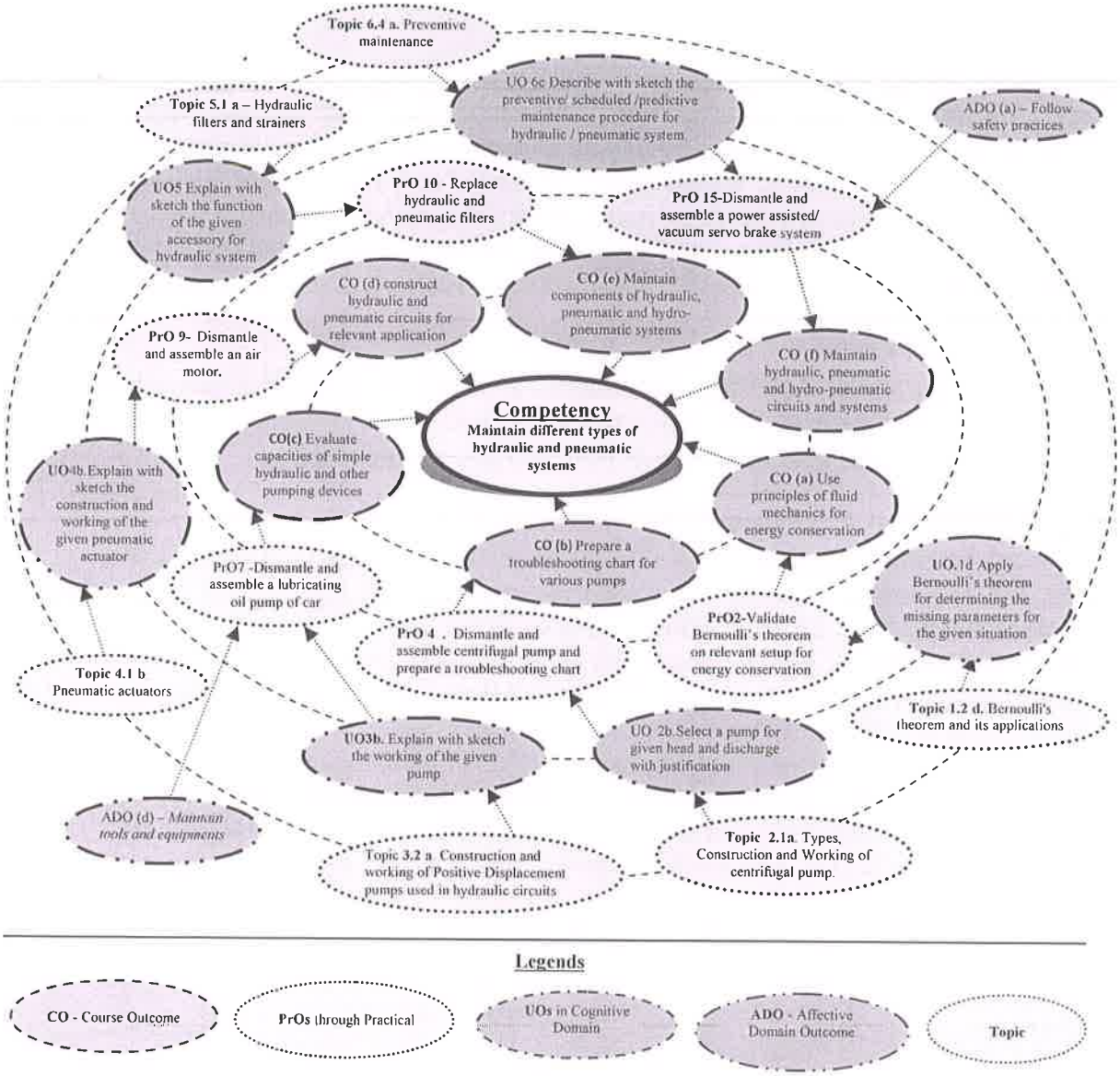

Figure 1 - Course Map

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:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Trace hydraulic circuit and components of automobile hydraulic brakes relevant to Pascal's law.	I	02*
2.	Validate Bernoulli's Theorem on relevant setup for energy	I	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	conservation.		
3.	Assess the performance of a centrifugal pump by using centrifugal pump test rig.	II	02*
4.	Dismantle/assemble centrifugal pump to prepare a troubleshooting chart.	II	02*
5.	Assess the performance of a reciprocating pump by using reciprocating pump test rig.	II	02
6.	Dismantle/assemble reciprocating pump to prepare a trouble shooting chart.	II	02
7.	Dismantle/assemble a lubricating oil pump of car.	III	02*
8.	Dismantle/assemble an air motor.	IV	02*
9.	Dismantle/assemble hydraulic and pneumatic system valves.	IV	02*
10.	Replace hydraulic and pneumatic filters.	V	02
11.	Operate double acting cylinder on a hydraulic trainer using meter-in and meter-out circuit.	VI	02*
12.	Operate two double acting cylinders using sequencing circuit.	VI	02*
13.	Dismantle/assemble a double acting hydraulic cylinder.	VI	02
14.	Troubleshoot hydraulic circuits and systems.	VI	02*
15.	Dismantle/assemble a power assisted/ vacuum servo brake system	VI	02*
16.	Troubleshoot pneumatic circuits and systems.	VI	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.	Follow safety rules and adopt standard practices for handling tools/ equipment and systems.	20
2.	Refer manufacturer specification, workshop/ operation manual and include relevant data in the journal.	20
3.	Sketching layouts, interpret results and conclusion.	30
4.	Answer to simple questions.	20
5.	Timely completion of the task and term-work.	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) Practice energy conservation.
d) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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	Venturimeter Test Rig (Venturimeter - Cast iron/ Brass/ PVC) 25 mm and 50 mm).	1
2	Practical Set-up of Bernoulli's Theorem (apparatus for verification of Bernoulli's Theorem complete with tank).	2
3	Centrifugal Pump Test rig (Constant Speed- Centrifugal pump, provided with electric motor, vacuum gauge at suction and pressure gauge on discharge pipe, gate valve on discharge). Motor suitable for main and operating characteristics.	3
4	Centrifugal pump- 1/2HP (370W) ,1400rpm.	4
5	Reciprocating pump test rig (re-circulating type unit with reciprocating pump and vacuum gauge, pressure gauge at discharge) three speed drive arrangement- pulley.	5
6	Reciprocating pump- Max. Flow rate: Up to 3728 L/Hr Max. Pressure: Up to 150 Kg/cm2. Single acting.	6
7	Gear pump of lubrication system of a vehicle.	7
8	Maintenance kit (Maintenance tool kit for hydraulic and pneumatic system).	6 to 16
9	Hydraulic and pneumatic valves- Direction control valves: Operating pressure min 10 bar Operating pressure max 50 bar, Nominal flow 80 l/min. Flow control valve: Valve size 1/4" to 2", Pressure 500bar Pressure relief valve: Flow Rate (60 l/min) Material –Brass, Pressure- 350bar.	9
10	Compressor (Two stage- two cylinder air cooled, with intercooler and after-cooler, receiver mounted, 30 to 40 m^3/hr, 3.5 KW with pressure switch, pressure gauge and safety valve mounted).	8,10,15 and 16
11	Hydraulic trainer kit consisting of power pack (motor, pump, tank, filter, breather, pressure relief valve and pressure gauge), basic components- valves- direction control valve, flow control valve, sequencing valve, bleed-off valve, pressure gauge, actuators, accumulator, rigid pipes, hoses and connectors).	11 and 12

S. No.	Equipment Name with Broad Specifications	PrO. No.
12	Pneumatic trainer kit consisting of compressor, basic components- FRL unit, valves- direction control valve, flow control valve, safety valve, sequence valve, connectors and hoses.	16

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– Overview of Fluid mechanics.	1a. Define the given property of fluid. 1b. Graphically represent relation between given pressures. 1c. Select a device for measurement of pressure for the given condition with justfication. 1d. Apply Bernoulli's theorem for determining the missing parameters for the given situation. 1e. Calculate coefficient of velocity/ discharge of liquid in the given section under steady flow in given device.	1.1 **Fluid Fundamentals.** a. Classification of fluids, properties of fluids like specific weight, specific gravity, viscosity. Specifications of hydraulic oil b. Pascal's law. c. Types of fluid flow- steady, unsteady, laminar, turbulent, one, two and three dimensional flow, uniform and non uniform flow, **Pressure Measurement.** d. Concept of atmospheric pressure, gauge pressure, vacuum and absolute pressure. e. Pressure gauges - Piezometer tube, simple and differential manometer. Bourdon's tube pressure gauge. 1.2 **Hydrodynamics.** a. Basic principles of fluid flow,Law of continuity and its applications. b. Energy possessed by the liquid in motion. c. Bernoulli's theorem and its applications such as Venturimeter, orifice-meter and Pitot tube.
Unit – II Hydraulic Devices	2a. State limitations of suction head for given NPSH. 2b. Select a pump for given head and discharge with justification 2c. Differentiate the given pumps on the basis of the given parameter 2d. Explain with sketches the construction, working and application of the given pump.	2.1 **Centrifugal Pumps** a. Types, construction and working of centrifugal pump, Types of casing. Need of priming. b. Heads, losses and efficiencies of centrifugal pump, Cavitation and net positive suction head (NPSH) c. Fault finding and remedies. d. Pump selection. 2.2 **Reciprocating Pumps** a. Construction and working of single and double acting reciprocating pump. b. Positive and negative slip. c. Air vessels - function and advantages. d. Power and efficiencies of reciprocating pump. (No analytical treatment)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		e. Reasons of cavitation and separation. f. Comparison between reciprocating and centrifugal Pump. 2.3 **Submersible pump**- Construction working and application.
Unit– III Miscellaneous Fluid Machines	3a. Explain with sketch the working of the given hydraulic device. 3b. Explain with sketch the working of the given pump. 3c. Differentiate the given pumps on the basis of the given characteristics. 3d. Differentiate the given pumps on the basis of the given applications.	**3.1 Simple Hydraulic Devices.** a. Working principles, construction and applications of hydraulic jack, hydraulic crane, hydraulic lift, hydraulic press. **3.2 Other Pumping Devices** a. Construction and working of positive Displacement pumps used in hydraulic circuits: gear type, vane type, plunger types (swash plate, bent axis, axial and radial). Comparison of above pumps for various characteristics and their applications.
Unit– IV Basic Components of Hydraulic and Pneumatic Systems	4a. Explain with sketch the construction and working of the given hydraulic actuator 4b. Explain with sketch the construction and working of the given pneumatic actuator 4c. Select the relevant valves for given hydraulic circuit with justification 4d. Select the relevant valves for given hydraulic system with justification	4.1 **Hydraulic and Pneumatic actuators** a. Hydraulic actuators - hydraulic cylinders (single, double acting and telescopic) – construction and working, hydraulic motors (gear and piston type) –construction and working. b. Pneumatic Actuators - Pneumatic cylinders (single and double acting) -construction and working, air motors (vane and piston type) - construction and working. 4.2 **Valves for Hydraulic and Pneumatic systems** a. Classifications of valves, poppet, ball, needle, throttle, pressure control, directional control, sequencing, rotary spool, sliding spool two position, multi position, non-return valves and proportionating valve. b. Construction and operation of above valves.
Unit– V Accessories of Hydraulic and Pneumatic Systems	5a. Explain with sketch the function of the given accessory for hydraulic system. 5b. Explain with sketch the function of the given accessory for pneumatic system 5c. Compare the given	5.1 **Filters** a. Hydraulic filters and strainers – full flow and proportional types, function and working, difference between filters and strainers. b. Pneumatic filters –screen type and mechanical type, function and working, FRL unit. 5.2 **Hoses and connectors for hydraulic and pneumatic systems**- Types, construction

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	accessories of pneumatic / hydraulic systems on basis of the given parameters. 5d. Classify the given hydraulic/pneumatic accessories on the given parameters 5e. Explain with sketches the construction and application of the given pneumatic / hydraulic system accessory.	and applications. 5.3 **Seals and gaskets for hydraulic and pneumatic systems**-Types, function and construction of commonly used seals and gasket materials.
Unit– VI Hydraulic, Pneumatic and Hydro-pneumatic Circuits and Systems	6a. Explain with sketches the symbols used in the construction of the given circuits. 6b. Explain with sketch the working of the given system. 6c. Describe with sketch the specified maintenance procedure for the given system. 6d. Sketch specified circuit using the given components for the given application.	6.1 **Hydraulic Circuits and Systems** a. Hydraulic symbols b. Meter in, meter out, bleed off, sequencing. c. Introduction to electro-hydraulics – concept, principles and applications d. Applications of hydraulic circuits – hydraulic power steering, hydraulic brakes, milling machine, hydraulic press, 6.2 **Simple Pneumatic Circuits and Systems** a. Pneumatic symbols b. Speed control circuit, Sequencing circuit and time delay circuit. c. Applications of pneumatic circuits – air brake, low cost automation in industries, pneumatic power tools (drill, nut runner, hammer and grinder). d. Comparison of hydraulic and pneumatic circuits. **6.3 Hydro-pneumatic circuit and system** a. Hydro-pneumatic rams. b. Brake booster of truck/ bus c. Pin lift of pneumatic moulding machines **6.4 Maintenance of hydraulic, pneumatic and hydro-pneumatic systems.** a. Preventive maintenance b. Scheduled maintenance c. Predictive maintenance

***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	Overview of Fluid mechanics	08	06	06	--	12
II	Hydraulic Devices	08	--	04	06	10
III	Miscellaneous Fluid Machines	06	--	04	04	08
IV	Basic Components of Hydraulic and Pneumatic Systems	10	04	04	08	16
V	Accessories of Hydraulic and Pneumatic Systems	04	--	04	04	08
VI	Hydraulic, Pneumatic and Hydro-pneumatic Circuits and Systems	12	04	04	08	16
Total		**48**	**14**	**26**	**30**	**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 specifications of pump and compressor for specific applications.
d) Collect specifications of different types of valves for specific applications.
e) Collect specifications, and material relevant information for different hoses.
f) Collect specifications and material relevant information for fittings/connectors.
g) Collect scheduled maintenance data relevant to hydraulics and pneumatics from MSRTC/ Bus depot/ Workshop.
h) Collect data of various hydraulic jacks used for specific application.
i) Collect specifications of hydro-pneumatic / pneumatic ram.
j) Collect specifications for pneumatic tools like nut runner, hand drill, grinder.

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 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-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 is given here. Similar micro-projects could be added by the concerned faculty:

Note: Material required for the following micro-projects may be obtained from scrap yard/ garage/ service center.

a) Prepare a chart for selection of pump/ compressor for given application while ensuring energy conservation and high productivity; referring to the different manufacturers' catalogues including different characteristics- main and operating; machinery handbooks and IS codes. (This micro-project fulfills CO a, CO b and CO c).
b) Make an exploded view board model of the given aggregate from the following. Following steps should be strictly followed. (This micro-project fulfills CO b and CO d)
   i. Centrifugal pump of cooling system of an automotive engine enlisting the details of heat carried away by the cooling system, pressure, flow rate, temperature range and rotational speed.
   ii. Lubricating pump of an automotive engine- enlisting the details of pressure, flow rate, rotational speed and service limits relevant to component dimensions referring service manual.
   iii. Air compressor of truck braking system- enlisting the details of free air displacement (FAD), maximum pressure, rotational speed and service limits relevant to component dimensions referring service manual.
   iv. Wheel cylinder/ tandem master cylinder of a vehicle braking system- enlisting the details of operating pressure, force developed and service limits relevant to component dimensions referring service manual.
c) Prepare a board mounted kit of hoses and connectors used in hydraulic/ pneumatic system. (This micro-project fulfills CO d and CO f).
d) Prepare a troubleshooting chart for different defects of the centrifugal pump. (This micro-project fulfills CO b and CO c)

e) Prepare demonstration model of hydraulic jack/ hydraulic press/ hydraulic crane/ earth moving machines- using water and injection syringes of different sizes. (CO d and CO e).

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Hydraulic and Fluid Mechanics	Modi, P. N.; Seth , S.M.	Standard Book House, Delhi, 2017 ISBN-13: 978-8189401269
2	Industrial Hydraulics	Pippenger, Hicks	McGraw Hill Int.Mumbai,1979 ISBN-13: 978-0070501409
3	Introduction To Hydraulics And Pneumatics	Ilango, S. Soundararajan, V.	PHI Learning Private Limited, New Delhi, 2011 ISBN: 978-8120344068
4	Fluid Power	Esposito, Anthony	PEARSON Education, Noida, Delhi, ISBN-13: 978-8177585803
5	Hydraulic and Pneumatic Controls	Sundaram, S.K.	S. Chand, Pune, 2006. ISBN-13: 978-8121926355
6	Industrial Hydraulics Manual	Vickers	Vickers system international Ltd. Pimpri, Pune – 411018, 1999. ISBN-13: 978-0963416209

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) http://nptel.ac.in
b) https://www.youtube.com/watch?v=06hWnWnNOFE
c) https://www.youtube.com/watch?v=c6gwU7IHtlo
d) https://www.youtube.com/watch?v=8CRMUKwrhUQ
e) https://www.youtube.com/watch?v=KgphO-u7MlQ
f) https://www.youtube.com/watch?v=YeYd0htafwo
g) https://www.youtube.com/watch?v=jsMJbJQkGTs
h) https://www.youtube.com/watch?v=K5B7uZpOHNQ
i) https://www.youtube.com/watch?v=b0_bGKHHHPM
j) https://www.youtube.com/watch?v=t6RiX5HDKQg
k) https://www.youtube.com/watch?v=z1gVxYfiSr0&pbjreload=10
l) https://www.youtube.com/watch?v=BEpQFZ5BG8c
m) https://www.youtube.com/watch?v=RjLaU8nFnzE
n) https://www.youtube.com/watch?annotation_id=annotation_2640300455&feature=iv &src_vid=O_ktD2pRghQ&v=iLAcfiIXsQw