1.0 PURPOSE

This course is designed to introduce students to the fundamentals of Industrial Instrumentation. The material covered in this course will enable students to solve basic problems that are likely to be encountered in Industrial Instrumentation at the undergraduate level and in industry.

2.0 OBJECTIVES

See 6.0 General Conditions

3.0 GENERAL

Course	:	A.A.Sc. Degree in Industrial Systems Operations and Maintenance
Course Ref.	:	I401
Course Title	:	Instrumentation I
Duration	:	45 Hours
Credits	:	3
Semester	:	4

PREREQUISITE:
Successful completion of Engineering Physics.

4.0 CONTENTS

UNIT 1 - BASIC MEASUREMENT CONCEPTS

1. Performance terms and specifications – sensitivity and range and span
2. Accuracy
3. Precision
4. Repeatability
5. Range of operation
6. Difference between analogy and digital signals

UNIT 2 - SELECTION CRITERIA

1. Effects of selection criteria
2. Instrument selection
3. Flow applications

UNIT 3 - FUNDAMENTALS OF PRESSURE MEASUREMENT

1. Principles
2. Types- static pressure, dynamic pressure and total pressure
3. Technical terms

UNIT 4 - PRESSURE TRANSDUCERS

1. Mechanical – manometer
2. Bourdon tube
3. Diaphragm

UNIT 5 - PRINCIPLES OF LEVEL MEASUREMENT

1. Point source- by visual inspection
2. Gauging rod method
3. Buoyancy tape systems
4. Field effect level detection
5. Gravimetric
6. Bubbler tube
7. Pressure gauge to measure level
8. Installation considerations

UNIT 6 - CONTINUOUS SOURCE

1. Magnetic float
2. Time of flight measurement
3. Echo measurement
4. Selection considerations
5. Continuous - pressure head
6. Capacitance/resistance
7. Fiscal measurement

UNIT 7 - ORIFICE PLATE

1. Installation
2. Concentric orifice
3. Application limitations

UNIT 8 - OTHER MEASURING DEVICES

1. Venturimeter
2. Pitot tube
3. Flow over a weir

4. Rotameter
5. Vortex meter
6. Construction of swirl meter
7. Turbine flow meter
8. Positive displacement – rotating vane, rotating lobe meter
9. Positive displacement meter
10. Mass flow rate meter
11. Thermal mass flow meter

UNIT 9 - CONTROL VALVES

1. Introduction Control valve, classification, principles, Application function – isolation, ON-OFF valves
2. Flow control, directional control, protection, overpressure
3. Sliding stem valves: Plug, Globe, Cage valves, Operating conditions
4. Rotary valves: butterfly, ball valves, flow characteristics
5. Noise and cavitations: sources of noise, principles of cavitations and its effects

UNIT 10 - CONTROL VALVES FLOW CHARACTERISTICS

1. Selection and Sizing
2. Effective pressure drop
3. Control valve characteristics/trim
4. Components of a process control loop

UNIT 11 - BASIC SIZING FOR LIQUIDS

1. Selection process and formulations
2. Selection steps and sizing of control valves
3. Valve coefficient
4. Purpose
5. Pressure recovery factors
6. Application of control valves
7. Liquid sizing equations for determining volumetric flow rate
8. Metric and SI formulae
9. Valve characteristics

UNIT 12 - BASIC SIZING FOR GASES AND VAPORS

1. Selection steps and sizing of control valves for gas
2. Saturated steam
3. Superheated steam
4. Determination of valve coefficient

5. Gaseous and vapor sizing equations for determining volumetric flow rate
6. Metric and si formulae

UNIT 13 - INHERENT AND INSTALLED FLOW CHARACTERISTICS

1. Valve characteristics
2. Butterfly disc shapes
3. Butterfly valve – inherent characteristic
4. High performance characteristics
5. Flow characteristics
6. Globe valve characteristics
7. Cage valve characteristics
8. Various ball valve characteristics
9. Simple calculation data
10. Inherent characteristics
11. Installed characteristics
12. Overall process control loop
13. Closed loop control and controller
14. Importance of loop gain
15. Non-linear response conversion of gain to percentage of controller input range
16. Process pressure ratio and conclusion

UNIT 14 - ACTUATORS AND POSITIONERS

1. Purpose
2. Principles of actuators for control valves
3. Issues of size
4. Force and speed matched to valve type
5. Control valve design considerations

UNIT 15 -TYPES OF ACTUATORS

1. Pneumatic actuator types –piston and diaphragm
2. Fixed spring, rotary
3. Rack and pinion
4. Rotary vane
5. Electrical actuators – on/off control
6. Modulated control
7. Solenoid type
8. Hydraulic actuators for large valves
9. Actuator accessories

UNIT 16 - PRESSURE RELIEF VALVES

1. Safety valves- types and performance issues
2. Sizing principles and equations
3. Calculations with examples
4. Superimposed and built – up back pressure
5. Balanced pressure relief valve operation and construction
6. Balanced spindle design
7. Pilot operated type
8. Back pressure effects on pilot operated valve

5.0 DELIVERY

Methods of Delivery

- Lectures
- Tutorials
- Video Presentations
- Slide Presentations
- Laboratory exercises
- Computer Aided Learning Software

6.0 GENERAL CONDITIONS

General Instructional Objectives:

1. To provide the student with basic knowledge of the various instruments used in industry.
2. To provide students with basic knowledge of the operation and maintenance of the various instruments used in industry.
3. To provide students with the necessary skills and knowledge required to model, analyze and solve problems which involve the use of industrial instrumentation to achieve a desired result.

Specific Instructional Objectives:

After the successful completion of the course, the expected learning outcome is that the student is able to:

1. Apply the principles of operation of a range of sensors and transducers
2. Investigate an instrumentation system through configuring, troubleshooting and testing typical sensors.
3. Use a range of measurement techniques in relation to the application of industrial instruments.
4. Select appropriate instruments based on user requirements
5. Diagnose problems associated with industrial instruments.

6. Apply principles of hydraulic and pneumatic controllers in control circuits to solve problems in industry.

7.0 EVALUATION

Methods of Evaluation

- Continuous Assessment **50%**
- Final Examination **50%**

8.0 SUPPORTING DOCUMENTATION

- Course Materials
- Attendance Register
- Continuous Assessment
- Appendix 1

APPENDIX 1:

Useful References

1. Helfrick A. D., & Cooper W. D., (1994). *Modern Electronic Instrumentation and Measurement Techniques*. Simon & Schuster, Singapore
2. Johnson C. D. (2016). *Process Control Instrumentation Technology 8th Edition*. Upper Saddle, New Jersey: Pearson Education
3.

Course Schedule

DATE	***WEEK***	***LECTURER:***	***HOURS***
	1	Basic measurement concepts	3
	2	Selection criteria & Fundamentals of pressure measurement	3
	3	Pressure transducers & Principles of level measurement	3
	4	Continuous source	3
	5	Orifice plate & Other measuring devices	3
	6	MID TERM TEST	3
	7	Control valves	3
	8	Control valves flow characteristics	3
	9	Basic sizing for liquids	3
	10	Inherent and installed flow characteristics	3
	11	Inherent and installed flow characteristics	3
	12	Actuators and positioners	3
	13	Types of actuators	3
	14	Pressure relief valves	3
	15	Final Examination	3

Final Exam: