26.3.0 FLUID MECHANICS

26.3. 1 Introduction

This module unit is designed to equip the trainee with the necessary knowledge that will help them when dealing with various materials and equipment on a production line, workshops and other work places.

Fluid Mechanics falls under a broader area of study known as Applied Mechanics and it deals with statics and dynamics of liquids and gases. The study of Fluid Mechanics is divided into Fluid Statics and Fluid Dynamics. Fluid Mechanics is the study of liquids whose properties include surface tension, density and viscosity.

Trainees taking this module unit require prior training in relevant mathematics and mechanical science that are found in module I and module II of this course.

The instructional approach will emphasize on experiments, industrial visits and analysis of various engineering concepts.

26.3.2 General Objectives

By the end of the module unit the trainee should be able to:

a) understand the flow of fluids
b) solve problems on model testing
c) determine performance of various types of pumps

26.3.3 Module Unit Summary and Time Allocation

FLUID MECHANICS

Code	Sub-Module Unit	Content	Theory Hrs	Pract. Hrs	Time Hrs
26.3.01	Flow Of Fluids	• Losses due to friction and changes in pipe section • Derive equation for head losses due to friction and changes in pipe section • Application of the equations for flow losses to solve problems. • Experiments on flow rate and pipe losses	2	4	8
26.3.02	Viscous Flow	• Definitions of viscous flow • Definition of Coefficients of viscosity • Explanation of viscous flow • Derive equation for viscous flow • Apply the equations to solve problems • Measurement of viscous resistance	4	6	10
26.3.03	Dimensio	• Explanation of	6	4	10

	nal Analysis	dimensional analysis • Fundamental; dimensions • Derived units • Fundamental units • Physical quantities • Application of dimensional analysis to establish dimensionless groups • Applications of dimensional analysis to solve problems • Explanation of model testing • Test on models • Geometrical similarity • Dynamical similarity			
26.3.04	Pumps	• Principles of operation of pumps • Derivation of equations for a reciprocating pump • Derivation of equations for a centrifugal pump • Performance tests on pumps	10	6	16
	Total Time		**22**	**20**	**44**

26.3.01 FLOW OF FLUIDS

Theory

26.3.01T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain the losses in pipes
b) derive equations for pipe flow losses
c) apply the equations for pipe flow losses to solve problems

26.3.01C *Competence*
The trainee should have the ability to Set up and perform an experiment on flow losses

Content

26.3.01T1 Losses due to:
- Friction

- Sudden enlargement or reduction in cross-sectional area

26.3.01T2 Derive equation for head losses due to
- Friction
- Sudden reduction in area
- Sudden enlargement in area

26.3.01T3 Application of the equations for flow losses to solve problems

Practice

26.3.01P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) measure flow rate in pipes
b) determine losses in pipes

Content

26.3.01P1 Experiments on:
- Flow rate
- Pipe losses

Suggested Learning Resources
- Text books
- Handouts
- Manometer
- Pilot tube
- Venturimeter
- Orifice
- Procedure sheet
- Differential manometer

26.3.02 VISCOUS FLOW

Theory

26.3.02T0 *Specific Objectives*
By the of the sub module unit, the trainee should be able to:
a) explain viscous flow between parallel surfaces
b) derive equations for viscous flow between parallel surfaces.
c) apply equations for parallel flow to solve problems
d) derive equations for viscous flow in circular pipes
e) apply equations for viscous flow in circular pipes to solve problems

26.3.02C *Competence*
The trainee should have the ability to set up and perform an experiment on viscous flow

Content

26.3.02T1 Definitions of viscous flow

26.3.2T2 Define
- Coefficient of dynamic viscosity

- Coefficient of kinematics viscosity

26.3.02T3 Explanation of viscous flow
- Between parallel plates
- Between parallel moving plates
- Circular pipe

26.3.02T4 Derive equation for viscous flow
- Between parallel surfaces
- Between parallel moving plates
- Circular pipes

26.3.02T5 Apply the equations to solve problems

Practice

26.3.02P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to determine viscous resistance in fluid.

Content

26.3.02P1 Measurement of viscous resistance
- Dashpot
- Journal bearing

Suggested Learning Resources
- Text books
- Hand outs
- Dashpot
- Journal bearing
- Procedure sheet

26.3.03 DIMENSIONAL ANALYSIS

Theory

26.3.03T1 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) explain of dimensional analysis
b) explain the principle of dimensional homogeneity
c) state fundamental dimensions
d) define units
e) state derived units
f) state physical quantities
g) apply dimensional analysis to establish dimensionless groups
h) apply dimensional analysis to solve problems
i) explain model testing
j) solve problems on model testing

26.3.03C *Competence*
The trainee should have the ability to set up Perform experiments on model testing

	Content
26.3.03T1	Explanation of dimensional analysis
26.3.03T2	Fundamental dimensions
26.3.03T3	Derived units
26.3.03T4	Fundamental units
26.3.03T5	Physical quantities - Mass - Force - Density - Velocity - Acceleration
26.3.03T6	Application of dimensional analysis to establish dimensionless groups - Reynolds number - Mach number - Froude number
26.3.03T7	Applications of dimensional analysis to solve problems - Rayleigh method (indicial method) - Buckingham π theorem
26.3.03T8	Explanation of model testing - Geometrical similarity - Dynamical similarity

Practice

26.3.3P0	*Specific Objectives* By the end of the sub module unit, the trainee should be able to carry out tests on models

	Content
26.3.03P1	Test on models
26.3.03P2	Geometrical similarity
26.3.03P3	Dynamical similarity

Suggested Learning Resources
- Textbooks
- Handouts
- Models
- Procedure sheet

26.3.04 PUMPS

Theory

26.3.04T0	*Specific Objectives* By the end of the sub module unit, the trainee should be able to: a) describe the principle of operation of a pump b) derive equations for reciprocating pump c) derive equations for a centrifugal pump d) Apply the equations to solve pump problems
26.3.04C	*Competence* The trainee should have the ability to perform experiments

	on various performance tests	
	Content	
26.3.04T1	Principles of operation of: - Reciprocating pumps - Centrifugal pumps	
26.3.04T2	Derivation of equations for a reciprocating pump - Coefficient of discharge - percentage slip - Work done - Acceleration head - Friction head - Pressure head in the cylinder	
26.3.04T3	Derivation of equations for a centrifugal pump - Effective head - Manometric head - Manometric efficiency	
		- Mechanical efficiency - Discharge - Torque - Work done unit weight - Specific speed
		Practice
26.3.04P0		*Specific Objectives* By the end of the sub module unit, the trainee should be able to determine the performance of various types of pumps
		Content
26.3.04P1		Performance tests on pumps
		Suggested Learning Resources - Textbooks - Handouts - Pumps

27.3.0 CONTROL SYSTEMS AND INSTRUMENTATION

27.3.1 Introduction

This module unit is aimed at providing the trainee with theoretical and practical understanding of modern instruments and control systems in Mechanical Engineering Production.

Trainees undertaking this module require knowledge of Mathematics (differential equations and Laplace transforms), electrical and electronics principles and low and high level programming languages. Upon completion of this unit, trainees will be able to operate, diagnose, repair and service various production machines.

Engineering control systems are used for the control of physical quantities such as temperature, flow rates, liquid levels, chemical composition, speed of prime movers, position of ships and aircrafts, radar guidance, and machine tool operations.

Control system elements include various physical quantities, measuring devices, spring levers, gears, valves, gyroscopes, compressors, accumulators, bellows, motors, resistors, relays, transistors, among others. Transducers which convert such quantities into electrical signals are commonly used and the microprocessor is involved in the sophisticated control of medical equipment, engine ignition systems and domestic appliances.

The instructional approach will lay emphasis on demonstration, industrial visits, practical and project work. Some of the reference materials for the module are listed at the end of the module. The list is not exhaustive.

27.3.2 General Objectives

By the end of the module the trainee should be able to:

a) understand the working principles of various control devices and measuring instruments
b) measure physical quantities using modern measuring instruments
c) apply modern control system techniques in industry
d) maintain and repair physical control systems
e) design and construct physical control systems

27.3.03 Module Summary and Time Allocation

CONTROL SYSTEMS AND INSTRUMENTATION

Code	Sub-Module Unit	Content	Theory Hrs	Pract Hrs	Time Hrs
27.3.01	Temperature Sensors and Transducers	• Temperature Sensors and Transducers • Operation of Temperature Sensors and Transducers • Test on temperature sensors and	2	2	4

		transducers • Assembly of temperature sensors and transducers			
27.3.02	Level Sensors and Transducers	• Level Sensors And Transducers • Operation of level sensors and transducers • Test on level sensors and transducers • Assembly and dismantling of level sensors and transducers	2	2	4
27.3.03	Displacement and Proximity Sensors and Transducers	• Displacement And Proximity Sensors and Transducers • Operation of displacement and proximity sensors and transducers • Test of displacement and proximity sensors and transducers • Assembly and dismantling of displacement and proximity sensors and transducers	2	2	4
27.3.04	Viscosity Sensors and Transducers	• viscosity sensors and transducers • Assembly and dismantling viscosity sensors and transducers	2	2	4
27.3.05	Moisture and Humidity Sensors and Transducers	• Moisture And Humidity Sensors And transducers • Operation of moisture and humidity sensors and transducers • Test of moisture and humidity sensors and transducers	1	1	2

		• Assembly and dismantling moisture and humidity sensors and transducers			
27.3.06	Flow Sensors and Transducers	• flow sensors and transducers • Operation of various types of flow sensors and transducers • Test of flow sensors and transducers • Assembly of flow sensors and transducers	2	2	4
27.3.07	Pressure Sensors and Transducers	• pressure sensors and transducers • Application of pressure sensors and transducers • Test of pressure sensors and transducers • Assembly of pressure sensors and transducers	2	2	4
27.3.08	Radiation Sensors and Transducers	• Radiation Sensors And transducers • Pyroelectric • Application of radiation sensors and • Test of radiation sensors and transducers • Assembly of radiation sensors and transducer	2	2	4
27.3.09	Stress and Strain Sensors and Transducers	• Stress and strain sensors and transducers • Application of stress and strain sensors and transducers • Test of stress and strain sensors and transducers • Assembly of stress and strain sensors and transducers	2	2	4

27.3.10	Force Sensors And Transducers	• Force sensors and transducers • Application of force sensors and transducers • Test of stress and strain sensors and transducers • Assembly of stress and strain sensors and transducer	2	2	4
27.3.11	Measuring Instruments	• Types Of Measuring Instruments • Factors Affecting Instruments Selection • Sources Of Error In Measuring Instruments • Basic Components Of An Instrument • Calibration	2	2	4
27.3.12	Force Sensors and Transducers	• Force sensors and transducers • Application of force sensors and transducers • Test of stress and strain sensors and transducers • Assembly of stress and strain sensors and transducers	2	2	4
27.3.13	Measurement of Physical Variables	• Measurements of Physical Variables	2	2	4
27.3.14	Fundamentals of Control System	• Control system terminology • Open and Closed loop	2	2	4
27.3.15	Block Diagrams	• Transfer function of systems with feedback • Block diagram • Superposition theorem	1	1	2
27.3.16	Signal Flow Graphs	• Conversion of block diagrams to signal flow • Simplification of complex loops • Masons rule	1	1	2

27.3.17	Measurement of Physical Variables	• Measurements of Physical Variables	2	2	4
27.3.18	System Modelling	• Need for modelling • Laplace transforms and differential equations of transfer functions • Transfer functions of simple networks • Practical systems	2	2	4
27.3.19	Controllers And Control Modes	• Definitions • Modes of control	2	2	4
	Actuators	• Function of an actuator • Types of actuators	1	1	2
27.3.20	Process Control	• Block diagram of a process loop • Structural model of a manufacturing process • Process control strategies • Distributed versus central control	1	1	2
27.3.21	System Modelling	• Need for modelling • Laplace transforms and differential equations of transfer functions • Transfer functions of simple networks • Practical systems	1	1	2
27.3.22	Controllers And Control Modes	• Definitions • Modes of control	2	2	4
27.3.23	Actuators	• Function of an actuator • Types of actuators	1	1	2
27.3.24	Sequence Control	• Differences between computer and PLC • Special Features of PLC • Architecture of PLCs • Operation of PLCs • Applications of PLCs • Computer Integrated	1	1	2

		Manufacturing			
27.3.25	Digital Control Systems	• Definition of D D.C. • D D.C. block diagram • Application of D D.C. • Components of a D D.C. system • Supervisory computer control	2	--	2
27.3.26	Servo Systems	• Control of servo system • Servo amplifiers • Stepper motor • Characteristics curves of AC and D.C. servo motors	2	-	2
		Total Time	**46**	**42**	**88**

27.3.01 TEMPERATURE SENSORS AND TRANSDUCERS

Theory

27.3.01T0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

(a) explain the operation of various types of temperature sensors and transducers

(b) describe application of various types of temperature sensors and transducers

27.3.01C *Competence*
The trainee should have the ability to:
i) Test temperature sensors and transducers
ii) Fit a temperature sensor and transducers

Content

27.3.01T1 Temperature Sensors and Transducers
- Resistance
- Temperatures detectors
- Platinum Resistance
- Thermistors
- Transistors and Integrated Circuits(IC)

27.3.01T2 Operation of Temperature Sensors and Transducers

Practice

27.3.01P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) test temperature sensors and transducers
b) assemble and dismantle temperature sensors and transducers

Content

27.3.01P1 Test on temperature sensors and transducers

27.3.01P2 Assembly of temperature sensors and transducers

Suggested Learning Resources
- Reference books
- Manufacturers charts
- Assorted temperature sensors
- Audio visual aids
- Test instruments

27.3.02 LEVEL SENSORS AND TRANSDUCERS

Theory

27.3.02T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of various level sensors and transducer
b) describe application of various types of

level sensors and transducers

27.3.02C *Competence*
The trainee should have the ability to:
i) Test level sensors and transducers
ii) Fit a level sensor and transducers

Content

27.3.02T1 Level Sensors And Transducers
- Diaphragm
- Differential pressure
- Ultrasonic
- Radiation
- Capacitance probes
- Level gauges
- Optical level switches
- Resistance tapes

27.3.02T2 Operation of level sensors and transducers

Practice

27.3.02P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) test level sensors and transducer
b) assemble and dismantle level sensors and transducers

Content

27.3.02P1 Test of level sensors and transducers

27.3.02P2 Assembly and dismantling of level sensors and transducers

Suggested Learning Resources
- Reference books
- Manufacturers charts
- Manufacturers manual
- Assorted level sensors and transducers
- Test instruments

27.3.03 DISPLACEMENT AND PROXIMITY SENSORS AND TRANSDUCERS

Theory

27.3.03T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of various types of displacement and proximity sensors and transducers
b) describe the application of

various types of displacement and proximity sensors and transducers

27.3.03C *Competence*
The trainee should have the ability to:
i) Test a displacement and proximity sensors and transducers
ii) Fit a displacement and a proximity sensor and transducers

Content

27.3.03T1 Displacement and Proximity Sensors and Transducers
- Resistive
- Inductive
- Capacitive
- Position
- Velocity
- Acceleration

27.3.03T2 Operation of displacement and proximity sensors and transducers

Practice

27.3.03P0 *Specific Objectives*
By the end the sub-module unit, the trainee should be able to:
a) test displacement and proximity sensors and transducers
b) assemble and dismantle displacement and proximity sensors and transducers

Content

27.3.03P1 Displacement and Proximity Sensors and Transducers
- Tests

27.3.03P2 Displacement and Proximity Sensors and Transducers
- Dismantling
- Assembly

Suggested Learning Resources
- Reference books
- Manufactures charts
- Assorted displacement and proximity sensors and transducers
- Test instruments
- Assorted tools

27.3.04 VISCOSITY SENSORS AND TRANSDUCERS

Theory

27.3.04T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of various types of

viscosity sensors and transducers
b) describe the applications of various types of viscosity sensors and transducers

27.3.04C *Competence*
The trainee should have the ability to:
i) Test a viscosity sensor and transducers
ii) Fit viscosity Sensors and Transducers

Content

27.3.04T1 Viscosity sensors and transducers
- Pressure drops
- Oscillation
- Torque and weight techniques

27.3.04T2 Applications of Viscosity Sensors and transducers

Practice

27.3.04P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) test viscosity sensors and transducers
b) assemble and dismantle viscosity sensors and transducers

Content

27.3.04P1 Test on viscosity sensors and transducers

27.3.04P2 Assembly and dismantling of viscosity sensors and transducers

Suggested Learning Resources
- Reference books
- Manufactures charts

-Assorted viscosity sensors and transducers

27.3.05 MOISTURE AND HUMIDITY SENSORS AND TRANSDUCERS

Theory

27.3.05T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of various types of moisture and humidity sensors and transducers
b) describe the application of various types of moisture and

humidity sensors and transducers

27.3.05C *Competence*
The trainee should have the ability to:
i) Test moisture and humidity sensor and transducers
ii) Fit moisture and humidity sensors and transducers

Content

27.3.05T1 Moisture and Humidity Sensors And
- Hygrometric
- Dew Point Sensing Techniques

27.3.05T2 Operation of moisture and humidity sensors and transducers

Practice

27.3.05P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) test moisture and humidity sensors and transducers
b) assemble and dismantle moisture and humidity sensors and transducers

Content

27.3.05P1 Test of moisture and humidity sensors and transducers

27.3.05P2 Assembly and dismantling moisture and humidity sensors and transducers

Suggested Learning Resources
- Reference books
- Manufactures charts
-Assorted moisture and humudity sensors and transducers

27.3.06 FLOW SENSORS AND TRANSDUCERS

Theory

27.3.06T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of various types of flow sensors and transducers
b) explain the operation of various types of flow sensors and transducers

27.3.06C *Competence*
The trainee should have the ability to:

i) Test flow sensors and transducers
ii) Fit a flow sensors and transducers

Content

27.3.06T1 Flow Sensors And transducers
- Orifice plate
- Venturi tubes and flow nozzle
- Turbine

27.3.06T2 Operation of various types of flow sensors and transducers

Practice

27.3.06P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) test flow sensors and transducers
b) assemble and dismantle flow sensors and transducers

Content

27.3.06P1 Test of flow sensors and transducers

27.3.06P2 Assembly of flow sensors and transducers

Suggested Learning Resources
- Reference books
- Manufactures charts

-Assorted flow sensors and transducers

27.3.07 PRESSURE SENSORS AND TRANSDUCERS

Theory

27.3.07T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of the various types of pressure sensors and transducers
b) explain the application of various types of pressure sensors and transducers

Content

27.3.07T1 Pressure sensors and transducers
- Inductive
- piezoelectric
- Capacitive
- Strain gauge
- Potentiometric

27.3.07T2 Application of pressure sensors and transducers

Practice

27.3.07P0 *Specific Objectives*
By the end the sub-module unit the

	trainee should be able to: a) test pressure sensors and transducers b) assemble and dismantle pressure sensors and transducers	By the end the sub-module unit the trainee should be able to: a) explain the operation of the various types of radiation sensors and transducers b) explain the application of various types of radiation sensors and transducers
	Content	
27.3.07P1	Test of pressure sensors and transducers	
27.3.07P2	Assembly of pressure sensors and transducers	
27.3.07C	**Competence** The trainee should have the ability to: i) Test pressure sensors and transducers ii) Fit pressure sensors and transducers	27.3.08C *Competence* The trainee should have the ability to: i) Test radiation sensors and transducers ii) Fit radiation sensors and transducers
	Suggested Learning Resources - Reference books - Manufactures charts -Assorted pressure sensors and transducers	*Content* 27.3.08T1 Radiation Sensors - Thermal photo detectors - Thermocouple - Pyroelectric o Photon detectors o Photo-emission o Photoconductive o photovoltaic
27.3.08	**RADIATION SENSORS AND TRANSDUCERS**	27.3.08T2 Application of radiation sensors and
	Theory	**Practice**
27.3.08T0	*Specific Objectives*	27.3.08P0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) test radiation sensors and transducers
b) assemble and dismantle radiation sensors and transducers

Content

27.3.08P1 Test of radiation sensors and transducers

27.3.08P2 Assembly of radiation sensors and transducers

Suggested Learning Resources

- Reference books
- Manufactures charts
- Assorted radiation sensors and transducers

27.3.09 STRESS AND STRAIN SENSORS AND TRANSDUCERS

Theory

27.3.09T0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) explain the operation of the various types of stress and strain sensors and transducers
b) explain the application of various types of stress and strain sensors and transducers

27.3.09C *Competence*

The trainee should have the ability to:

i) Test stress and strain sensors and transducers
ii) Fit stress and strain sensors and transducers

Content

27.3.09T1 Stress and strain sensors and transducers

- Metallic strain gauge
- Semiconductor strain gauge
- Piezoelectric stress sensors

27.3.09T2 Application of stress and strain sensors and transducers

Practice

27.3.09P0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) test stress and strain sensors and transducers
b) assemble and dismantle stress

and strain sensors and transducers

Content

27.3.09T1 Test of stress and strain sensors and transducers

27.3.09T2 Assembly of stress and strain sensors and transducers

Suggested Learning Resources

- Reference books
- Manufactures charts

-Assorted stress and strain sensors and transducers

27.3.10 FORCE SENSORS AND TRANSDUCERS

Theory

27.3.10T0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) explain the operation of the various types of force sensors and transducers
b) explain the application of various types of force sensors and transducers

27.3.10C *Competence*

The trainee should have the ability to:

i) Test stress and strain sensors and transducers
ii) Fit stress and strain sensors and transducers

Content

27.3.10T1 Force sensors and transducers

- Piezoelectric
- Capacitive
- Reluctive

27.3.10T2 Application of force sensors and transducers

Practice

27.3.10P0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) test stress and strain sensors and transducers
b) assemble and dismantle stress and strain sensors and transducers

Content

27.3.10P1 Test of stress and strain sensors and transducers

27.3.10P2 Assembly of stress and strain sensors and transducers

Suggested Learning Resources

- Reference books
- Manufactures charts

-Assorted force sensors and transducers

27.3.11 MEASURING INSTRUMENTS

Theory

27.3.11T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:

a) classify instruments
b) explain the factors affecting instruments selection
c) explain the sources of error in measuring instruments
d) explain the important basic components of an instrument system

27.3.11C *Competence*
The trainee should have the ability to calibrate a measuring instrument

Content

27.3.11T1 Types of Measuring Instruments
- Indicating
- Recording
- Controlling

27.3.11T2 Factors Affecting Instruments Selection
- Accuracy
- Precision
- Resolution capacity
- Reliability
- Cost
- Static and dynamic response

27.3.11T3 Sources Of Error In Measuring Instruments
- Manufacturing error
- Design error
- Operational error
- Environmental error
- Application error

27.3.11T4 Basic Components Of An Instrument
- Sensing Element
- Amplifying Elements
- Signal Modifiers or Converters

Practice

27.3.11P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to calibrate a measuring instrument

Content

27.3.11P1 Calibration

Suggested Learning Resources
- Reference books
- Manufactures charts

Measuring instruments
- Indicating
- Recording
- Controlling

27.3.12 MEASUREMENT OF PHYSICAL VARIABLES

Theory

27.3.12T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to describe various ways of measuring physical variables

27.3.12C *Competence*
The trainee should have the ability to measure:
i) Physical Variables
ii) displacement
iii) Measure force
iv) Measure torque
v) Measure strain
vi) Measure stress
vii) Measure angular velocity
viii) Measure temperature
ix) Measure liquid level
x) Measure flow

Content

27.3.12T1 Measurements of Physical Variables
- Displacement
- Force
- Torque
- Strain
- Stress
- Angular velocity
- Temperature
- Liquid level
- Flow

Practice

27.3.12P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) measure displacement
b) measure force
c) measure torque
d) measure strain
e) measure stress
f) measure angular velocity
g) measure temperature
h) measure liquid level
i) measure flow

Content

27.3.12P1 Measurements of Displacement
27.3.12P2 Measurements of Force
27.3.12P3 Measurements of Torque
27.3.12P5 Measurements of Stress
27.3.12P6 Measurements of Angular velocity
27.3.12P7 Measurements of Temperature
27.3.12P8 Measurements of Liquid level

27.3.12P9 Measurements of Flow

Suggested Learning Resources
- Reference books
- Manufactures charts
- Measuring instruments

27.3.13 FUNDAMENTALS OF CONTROL SYSTEM

Theory

27.3.13T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) define control system terms
b) distinguish between open and closed loop systems

27.3.13C *Competence*
The trainee should have the ability to identify open loop and closed loop control systems

Content

27.3.13T1 Control system terminology
- Control
- System
- Control system - Natural system
- Man made system
- Hybrid system
- Controlled and reference variables

27.3.13T2 Open and Closed loop
- Feedback
- Features of open loop systems
- Features of closed loop system
- Advantages and disadvantages

Practice

27.3.13P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to identify open and closed loop systems

Content

27.3.13P1 Open and Closed loop
- Features of open loop systems
- Features of closed loop system

Suggested Learning Resources
- Reference books
- Manufactures charts

27.3.14 BLOCK DIAGRAMS

Theory

27.3.14T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:

a) derive overall transfer function of simple systems with feedback
b) reduce block diagrams to canonical representation
c) use superposition theorem to reduce multi-input systems

27.3.14C *Competence*
The trainee should have the ability to use superposition theorem to reduce multi-input systems

Content

27.3.14T1 Transfer function of systems with feedback
- Feedback
- open loop

27.3.14T2 Block diagram
- Block diagrams of single input signal system
- Block diagrams of multi-input signal system

27.3.14T3 Superposition theorem

Suggested Learning Resources
- Reference books
- Block diagram

27.3.15 SIGNAL FLOW GRAPHS

Theory

27.3.15T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) convert block diagrams to signal flow graphs
b) simplify complex loops
c) apply mason's rule

27.3.14C *Competence*
The trainee should have the ability to convert block diagrams to signal flow graphs

Content

27.3.15T1 Conversion of block diagrams to signal flow

27.3.15T2 Simplification of complex loops

27.3.15T3 Masons rule

Suggested Learning Resources
- Reference books

27.3.16 SYSTEM MODELLING

Theory

27.3.16T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the need for modelling
b) use Laplace transforms and

differential equations to represent system transfer functions
c) define a transfer function and explain its dependency on frequency

27.3.16C *Competence*
The trainee should have the ability to represent practical systems with transfer functions and reduce them to canonical form.

Content

27.3.16T1 Need for modelling

27.3.16T2 Laplace transforms and differential equations of transfer functions

27.3.16T3 Transfer functions of simple networks

- Practical systems

Practice

27.3.16P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to represent practical systems with transfer functions and reduce them to canonical form

Content

27.3.16P1 Practical systems

Suggested Learning Resources

- Reference books

27.3.17 CONTROLLERS AND CONTROL MODES

Theory

27.3.17T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) define terms relating to controllers
b) explain controller modes and contrast the various modes

27.3.17C *Competence*
The trainee should have the ability to identify the control mode utilized by a given control system

Content

27.3.17T1 Definitions

- Process load
- Process lag
- Self regulation
- Control lag
- Dead time

27.3.17T2 Modes of control

- Two position and floating
- Proportional mode
- Integral mode
- Composite control modes

Practice

27.3.17P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to Identify the control mode utilized in a given practical control system

Content

27.3.17P1 Modes of control
- Two position and floating
- Proportional mode
- Integral mode
- Composite control modes

Suggested Learning Resources
- Reference books

27.3.18 ACTUATORS

Theory

27.3.18T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the function of an actuator
b) outline common types of actuators

27.3.18C *Competence*
The trainee should have the ability to:
i) Test Solenoids, Pneumatic and Hydraulic actuators
ii) Fit Solenoids, Pneumatic and Hydraulic actuators

Content

27.3.18T1 Function of an actuator
27.3.18T2 Types of actuators
- Solenoids
- Digital stepper motor drives
- AC and DC motors
- Pneumatic
- Hydraulic

Practice

27.3.18P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) test solenoids, pneumatic and hydraulic actuators
b) fit solenoids, pneumatic and hydraulic actuators

Content

27.3.18P1 Tests of actuators
- Solenoids
- Pneumatic
- Hydraulic

27.3.18P2 Fitting actuators
- Solenoids
- Pneumatic
- Hydraulic

Suggested Learning Resources
- Reference books

27.3.19 PROCESS CONTROL

Theory

27.3.19T0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) draw a block diagram of a process control loop and describe each element
b) describe the structural model of a manufacturing process
c) explain process control strategies
d) describe the differences between centralized control, optionally distributed control and fully distributed control

27.3.19C *Competence*

The trainee should have the ability to: draw a block diagram of a process control loop and describe each element

Content

27.3.19T1 Block diagram of a process loop
- Process
- Measurement
- Comparator
- Controller
- Control element

27.3.19T2 Structural model of a manufacturing process
- Input variables
- Output variables

27.3.19T3 Process control strategies
- Feedback control
- Regulatory control
- Feed forward control
- Pre-planned control
- Steady state optimal control
- Adaptive control

27.3.19T4 Distributed versus central control
- Centralized control,
- Optionally distributed control
- Fully distributed control
- Suggested Learning Resources
- Reference books
- Audio visual aids
- Field visits

Suggested Learning Resources
- Reference books

27.3.20 SEQUENCE CONTROL

Theory

27.3.20T0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to:

a) explain the difference between a computer and a Programmable Logic Controllers (PLCs)
b) describe the special features of PLC
c) describe architecture of a PLC
d) describe the operation of a PLC
e) explain the application of a PLC

27.3.21C *Competence*

The trainee should have the ability to diagnose and repair faults in a PLC

Content

27.3.20T1 Differences between computer and PLC
- Real-time operation
- Environmental consideration
- Programming languages and techniques
- Maintenance and trouble shooting

27.3.20T2 Special Features of PLC
- Cost
- Versatility
- Flexibility
- Expandability
- Maintenance
- Accuracy

27.3.20T3 Architecture of PLCs
- Central processing unit
- Input devices (Modules)
- Output devices (Modules)
- Power supply
- Input components
- Output components
- Memory
- Programming unit (console)

27.3.20T4 Operation of PLCs

27.3.20T5 Applications of PLCs
- CNC machine tools
- Computer Integrated Manufacturing
- Suggested Learning Resources
- Reference books
- Audio visual aids
- Field visits

Suggested Learning Resources
- Reference books

Architecture of PLCs
- Central processing unit
- Input devices (Modules)
- Output devices (Modules)
- Power supply
- Input components
- Output components
- Memory

- Programming unit (console)
-

27.3.21 DIGITAL CONTROL SYSTEMS

Theory

27.3.21T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) define Direct Digital Control (DDC)
b) draw a DDC block diagram
c) explain the application of DDC
d) explain the components of a DDC system
e) describe supervisory computer control and its application

27.3.21C *Competence*
The trainee should have the ability to explain the components of a DDC system

Content
27.3.21T1 Definition of DDC
27.3.21T2 DDC block diagram
27.3.21T3 Applications of DDC
27.3.21T4 Components of a DDC system
- and sensors
- Actuators and sensors
- Analogue controller
- Recording and display devices
- Set-point dial and comparator

27.3.21T5 Supervisory computer control
- Block Diagram
- Application

Suggested Learning Resources
- Reference books

27.3.21 SERVO SYSTEMS
Theory

27.3.21T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) describe control of position, speed (acceleration and torque) of servo mechanisms
b) explain the operation of servo system amplifiers
c) explain the operation and control of a stepper motor
d) plot the characteristic curves of a typical ac and dc servo-motors
e) describe the effects of amplifier gain

on servo-system performance

27.3.21C *Competence*
The trainee should have the ability to diagnose and repair faults in servo motors

Content

27.3.21T1 Control of servo system
- AC servo
- DC servo
- Difference between DC and AC servos
- Practical systems

27.3.21T2 Servo amplifiers
- DC
- AC
- Phase sensitive rectifiers
- Applications

27.3.21T3 Stepper motor
- Construction
- Operation
- Control Circuits
- Calculations
- Interfacing
- Applications

27.3.21T4 Characteristics curves of AC and DC servo motors

27.3.21T5 Amplifier and servo systems performance

Practice

27.3.21P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) operate a servo motor
b) diagnose and repair faults in a servo motor
c) service a servo motor

Content

27.3.21P1 Operation of servo motors

27.3.21P2 Diagnoses and repair of servo motors

Suggested Learning Resources
- Reference books
-AC and DC servo motors