23.3.0 FLUID MECHANICS

23.3.01 INTRODUCTION

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 Statics deals with fluids at rest under pressure while Fluid Dynamics deals with fluids in motion. Fluid Mechanics mainly deals with liquids whose properties include surface tension, density and viscosity.

The purpose of the module unit is 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.

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.

23.3.02 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

23.3.03 MODULE UNIT SUMMARY AND TIME ALLOCATION

FLUID MECHANICS

Code	Sub-Module Unit	Content	Time Hrs		
			T	P	Total
23.3.1	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	6	2	8

		losses to solve problems. • Experiments on flow rate and pipe losses			
23.3.2	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	8	2	10
23.3.3	Dimensional Analysis	• Explanation of 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	10	4	14
23.3.4	Pumps	• Principles of operation of pumps • Derivation of equations for a reciprocating pump • Derivation of equations for a centrifugal pump • Performance tests on pumps	8	4	12
Total Time			**32**	**12**	**44**

23.3.1 FLOW OF FLUIDS

Theory

23.3.1T0 *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

23.3.1C Competence

The trainee should have the ability to set up and perform an experiment on flow losses.

Content

23.3.1T1 Losses due to:
i) Friction
ii) Sudden enlargement or reduction in cross-sectional area

23.3.1T2 Derive equation for head losses due to
i) Friction
ii) Sudden reduction in area
iii) Sudden enlargement in area

23.3.1T3 Application of the equations for flow losses to solve problems.

Practice

23.3.1P0 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

23.3.1P1 Experiments on Flow rate in pipes

23.3.1P2 Determination of Pipe losses

Suggested Learning Resources

i) Text books
ii) Handouts
iii) Manometer
iv) Pilot tube
v) Venturimeter
vi) Orifice
vii) Procedure sheet
viii) Differential manometer

23.3.2 VISCOUS FLOW

Theory

23.3.2T0 *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

23.3.2C Competence
The trainee should have the ability to set up and perform an experiment on viscous flow.

Content

23.3.2T1 Explanation of viscous flow

23.3.2T2 Derivation of viscous flow between parallel surfaces
i) Coefficient of dynamic viscosity
ii) Coefficient of kinematics viscosity

23.3.2T3 Application of viscous flow equation in problem solving
i) Between parallel plates
ii) Between parallel moving plates
iii) Circular pipe

23.3.2T4 Derivation of equation for viscous flow
i) Between parallel surfaces
ii) Between parallel moving plates
iii) Circular pipes

23.3.2T5 Application of viscous flow in circular pipes equations to solve problems

Practice

23.3.2P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to
Determine viscous resistance in fluid.

Content

23.3.2P1 Measurement of viscous resistance
i) Dashpot
ii) Journal bearing

Suggested Learning Resources
i) Text books
ii) Hand outs
iii) Dashpot
iv) Journal bearing
v) Procedure sheet

23.3.3 DIMENSIONAL ANALYSIS

Theory

23.3.3T1 *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

23.3.3C Competence

The trainee should have the ability to set up perform experiments on model testing.

Content

23.3.3T1 Explanation of dimensional analysis
23.3.3T2 Explanation of the principle of fundamental homogeneity
23.3.3T3 Fundamental dimensions
23.3.3T4 Definition of units
23.3.3T5 Derived units
23.3.3T6 Physical quantities
i) Mass
ii) Force
iii) Density
iv) Velocity
v) Acceleration
23.3.3T7 Application of dimensional analysis to establish dimensionless groups
i) Reynolds number
ii) Mach number
iii) Froude number
23.3.3T8 Applications of dimensional analysis to solve problems
i) Rayleigh method (indicial method)
ii) Buckingham π theorem
23.3.3T9 Explanation of model testing
i) Geometrical similarity
ii) Dynamical similarity
23.3.3T10 Solution of problems in model testing

Practice

23.3.3P0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able to carry out tests on models

Content

23.3.3P1 Test on models
i) Geometrical similarity
ii) Dynamical similarity

Suggested Learning Resources

i) Textbooks
ii) Handouts
iii) Models
iv) Procedure sheet

23.3.4 PUMPS

23.3.4T0 *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

23.3.4C Competence

The trainee should have the ability to perform experiments on various performance tests.

Content

23.3.4T1 Principles of operation of:
- i) Reciprocating pumps
- ii) Centrifugal pumps

23.3.4T2 Derivation of equations for a reciprocating pump
- i) Coefficient of discharge
- ii) percentage slip
- iii) Work done
- iv) Acceleration head
- v) Friction head
- vi) Pressure head in the cylinder

23.3.4T3 Derivation of equations for a centrifugal pump
- i) Effective head
- ii) Manometric head
- iii) Manometric efficiency
- iv) Mechanical efficiency
- v) Discharge
- vi) Torque
- vii) Work done unit weight
- viii) Specific speed

23.3.4T4 Application of centrifugal pumps equations to solve problems

Practice

23.3.4P0 *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

23.3.4P1 Performance tests on pumps

Suggested Learning Resources
- i) Textbooks
- ii) Handouts
- iii) Pumps
- iv) Procedure sheet

24.3.0 CONTROL SYSTEMS AND INSTRUMENTATION

24.3.01 Introduction:

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, springs 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.

24.3.02 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

24.3.03 Module Unit Summary And Time Allocation

Control Systems And Instrumentation

Code	Sub Module Unit	Content	Time Hrs		
			T	P	Total
24.3.1	Temperature Sensors and Transducers	• Temperature Sensors and Transducers • Operation of Temperature Sensors and Transducers • Test on temperature sensors and transducers • Assembly of temperature sensors and transducers	3	1	4
24.3.2	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	3	1	4
24.3.3	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	3	1	4
24.3.4	Viscosity Sensors and Transducers	• viscosity sensors and transducers • Assembly and dismantling viscosity sensors and	2	2	4

		transducers			
24.3.5	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 • Assembly and dismantling moisture and humidity sensors and transducers	3	1	4
24.3.6	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
24.3.7	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
24.3.8	Radiation Sensors and Transducers	• Radiation Sensors And transducers • Pyroelectric • Application of radiation sensors and • Test of radiation sensors and transducers • Assembly of radiation	2	2	4

		sensors and transducer			
24.3.9	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
24.3.10	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 transducers	2	2	4
24.3.11	Measuring Instruments	• Types of Measuring Instruments • Factors Affecting Instruments Selection • Sources of Error in Measuring Instruments • Basic Components of An Instrument • Calibration	6	2	8
24.3.12	Measurement of Physical Variables	• Measurements of Physical Variables	4	4	8
24.3.13	Fundamentals of Control System	• Control system terminology • Open and Closed loop	3	1	4
24.3.14	Block Diagrams	• Transfer function of systems with feedback • Block diagram • Superposition theorem	2		2

24.3.15	Signal Flow Graphs	• Conversion of block diagrams to signal flow • Simplification of complex loops • Masons rule	2		2
24.3.16	System Modelling	• Need for modelling • Laplace transforms and differential equations of transfer functions • Transfer functions of simple networks • Practical systems	3	1	4
24.3.17	Controllers and Control Modes	• Definitions • Modes of control	2	2	4
24.3.18	Actuators	• Function of an actuator • Types of actuators	1	1	2
24.3.19	Process Control	• Block diagram of a process loop • Structural model of a manufacturing process • Process control strategies • Distributed versus central control	1	1	2
24.3.20	Sequence Control	• Differences between computer and PLC • Special Features of PLC • Architecture of PLCs • Operation of PLCs • Applications of PLCs • Computer Integrated Manufacturing	2	2	4
24.3.21	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	4
24.3.22	Servo Systems	• Control of servo system • Servo amplifiers • Stepper motor • Characteristics curves	2	2	4

		of AC and D.C. servo motors			
Total Time			**54**	**34**	**88**

24.3.1 TEMPERATURE SENSORS AND TRANSDUCERS

Theory

24.3.1T0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) explain the operation of various types of temperature
b) sensors and transducers
c) describe application of various types of temperature sensors
d) and transducers

24.3.1C Competence
The trainee should have the ability to:
i) Test temperature sensors and transducers
ii) Fit a temperature sensor and transducers

Content

24.3.1T1 Temperature Sensors and Transducers
i) Resistance
ii) Temperatures detectors
iii) Platinum Resistance
iv) Thermistors
v) Transistors and Integrated Circuits (IC)

24.3.1T2 Operation of Temperature Sensors and Transducers

Practice

24.3.1P0 *Specific Objectives*
By the end of the sub-module unit the trainee should be able to:
e) test temperature sensors and transducers
f) assemble and dismantle temperature sensors and transducers

Content

24.3.1P1 Test on temperature sensors and transducers

24.3.1P2 Assembly of temperature sensors and transducers

Suggested Learning Resources
i) Reference books
ii) Manufacturers charts
iii) Assorted temperature sensors
iv) Audio visual aids
v) Test instruments

24.3.2 LEVEL SENSORS AND TRANSDUCERS

Theory

24.3.2T0 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

Content

24.3.2T1 Level Sensors And Transducers
i) Diaphragm
ii) Differential pressure
iii) Ultrasonic
iv) Radiation
v) Capacitance probes
vi) Level gauges
vii) Optical level switches
viii) Resistance tapes

24.3.2T2 Operation of level sensors and transducers

Practice

24.3.2P0 *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

24.3.2P1 Test of level sensors and transducers
24.3.2P2 Assembly and dismantling of level sensors and transducers

24.3.2C Competence
The trainee should have the ability:

i) test level sensors and transducers
ii) fit a level sensor and transducers

Suggested Learning Resources

i) Reference books
ii) Manufacturers charts
iii) Manufacturers manual
iv) Assorted level sensors and transducers
v) Test instruments

24.3.3 DISPLACEMENT AND PROXIMITY SENSORS AND TRANSDUCERS

Theory

24.3.3T0 *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

24.3.3C *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

24.3.3T1 Displacement and Proximity Sensors and Transducers
i) Resistive
ii) Inductive
iii) Capacitive
iv) Position
v) Velocity
vi) Acceleration

24.3.3T2 Operation of displacement and proximity sensors and transducers

Practice

24.3.3P0 *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

24.3.3P1 Displacement and Proximity Sensors and Transducers
i) Tests

24.3.3P2 Displacement and Proximity Sensors and Transducers
i) Dismantling
ii) Assembly

Suggested Learning Resources
i) Reference books
ii) Manufactures charts
iii) Assorted displacement and proximity sensors and transducers
iv) Test instruments
v) Assorted tools

24.3.4 VISCOSITY SENSORS AND TRANSDUCERS

Theory

24.3.4T0 *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

Content

24.3.4T1 Viscosity sensors and transducers
i) Pressure drops
ii) Oscillation
iii) Torque and weight techniques

24.3.4T2 Applications of Viscosity Sensors and transducers

Practice

24.3.4P0 *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

24.3.4P1 Test on viscosity sensors and transducers

24.3.4P2 Assembly and dismantling of viscosity sensors and transducers

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

Suggested Learning Resources
i) Reference books
ii) Manufactures charts
iii) Assorted viscosity sensors and transducers
iv) Test instruments

24.3.5 MOISTURE AND HUMIDITY SENSORS AND TRANSDUCERS

Theory

24.3.5T0 *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
b) sensors and transducers
c) describe the

application of various types of moisture and humidity sensors and transducers

24.35C 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

24.3.5T1 Moisture and Humidity Sensors And
i) Hygrometric
ii) Dew Point Sensing Techniques

24.3.5T2 Operation of moisture and humidity sensors and transducers

Practice

24.3.5P0 *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

24.3.5P1 Test of moisture and humidity sensors and transducers

24.3.5P2 Assembly and dismantling moisture and humidity sensors and transducers

Suggested Learning Resources

i) Reference books
ii) Manufactures charts
iii) Assorted moisture and humidity sensors and transducers
iv) Test instruments

24.3.6 FLOW SENSORS AND TRANSDUCERS

Theory

24.3.6T0 *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

Content

24.3.6T1 Flow Sensors And transducers
i) Orifice plate
ii) Venturi tubes and flow nozzle

iii) Turbine

24.3.6T2 Operation of various types of flow sensors and transducers

Practice

24.3.6P0 *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

24.3.6P1 Test of flow sensors and transducers

24.3.6P2 Assembly of flow sensors and transducers

24.3.6C ***Competence***
The trainee should have the ability to:
i) Test flow sensors and transducers
ii) Fit a flow sensors and transducers

Suggested Learning Resources
i) Reference books
ii) Manufactures charts
iii) Assorted flow sensors and transducers
iv) Test instruments

24.3.7 PRESSURE SENSORS AND TRANSDUCERS

Theory

24.3.7T0 *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

24.3.7T1 Pressure sensors and transducers
i) Inductive
ii) piezoelectric
iii) Capacitive
iv) Strain gauge
v) Potentiometric

24.3.7T2 Application of pressure sensors and transducers

Practice

24.3.7P0 *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

Content

24.3.7P1 Test of pressure sensors and transducers

24.3.7P2 Assembly of pressure sensors and transducers

24.3.7C Competence

The trainee should have the ability to:

i) Test pressure sensors and transducers
ii) Fit pressure sensors and transducers

Suggested Learning Resources

i) Selected pressure sensors and
ii) Reference books
iii) Field visits
iv) Assorted pressure sensors and transducers
v) Test instruments

24.3.8 RADIATION SENSORS AND TRANSDUCERS

Theory

24.3.8T0 *Specific Objectives*

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

24.3.8T1 Radiation Sensors
i) Thermal photo detectors
ii) Thermocouple
iii) Pyroelectric
iv) Photon detectors
v) Photo-emission
vi) Photoconductive
vii) photovoltaic

24.3.8T2 Application of radiation sensors and

Practice

24.3.8P0 *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

24.3.8P1 Test of radiation sensors and transducers

24.3.8P2 Assembly of radiation sensors and transducers

24.3.8C *Competence*

The trainee should

have the ability to:
i) Test radiation sensors and transducers
ii) Fit radiation sensors and transducers

Suggested Learning Resources
i) Selected radiation sensors and transducers
ii) Reference books
iii) Field visits
iv) Test instruments
v) Test instruments

24.3.9 STRESS AND STRAIN SENSORS AND TRANSDUCERS

Theory

24.3.9T0 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

24.3.9C 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
24.3.9T1 Stress and strain sensors and transducers
i) Metallic strain gauge
ii) Semiconductor strain gauge
iii) Piezoelectric stress sensors
24.3.9T2 Application of stress and strain sensors and transducers

Practice

24.3.9P0 *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
24.3.9T1 Test of stress and strain sensors and transducers
24.3.9T2 Assembly of stress and strain sensors and transducers

Suggested Learning

Resources

i) Selected stress and strain sensors and
ii) Reference books
iii) Field visits
iv) Test instruments

24.3.10 FORCE SENSORS AND TRANSDUCERS

Theory

24.3.10T0 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

24.3.10C 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

24.3.10T1 Force sensors and transducers

i) Piezoelectric
ii) Capacitive
iii) re

24.3.10T2 Application of force sensors and transducers

Practice

24.3.10P0 *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

24.3.10P1 Test of stress and strain sensors and transducers

24.3.10P2 Assembly of stress and strain sensors and transducers

Suggested Learning Resources

i) Selected force sensors and transducers
ii) Reference books
iii) Field visits

24.3.11 MEASURING INSTRUMENTS

Theory

24.3.11T0 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

24.3.10C Competence

The trainee should have the ability to calibrate a measuring instrument.

Content

24.3.11T1 Types of Measuring Instruments
- i) Indicating
- ii) Recording
- iii) Controlling

24.3.11T2 Factors Affecting Instruments Selection
- i) Accuracy
- ii) Precision
- iii) Resolution capacity
- iv) Reliability
- v) Cost
- vi) Static and dynamic response

24.3.11T3 Sources Of Error In Measuring Instruments
- i) Manufacturing error
- ii) Design error
- iii) Operational error
- iv) Environmental error
- v) Application error

24.3.11T4 Basic Components Of An Instrument
- i) Sensing Element
- ii) Amplifying Elements
- iii) Signal Modifiers or Converters

Practice

24.3.11P0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to
calibrate a measuring instrument

Content

24.3.11P1 Calibration

Suggested Learning Resources

- i) Selected measuring instruments
- ii) Reference books
- iii) Field visits

24.3.12 MEASUREMENT OF PHYSICAL VARIABLES

Theory

24.3.12T0 Specific Objectives

By the end the sub-module unit the trainee should be able to
describe various ways of measuring

physical variables

Content

24.3.12T1 Measurements of Physical Variables
- i) Displacement
- ii) Force
- iii) Torque
- iv) Strain
- v) Stress
- vi) Angular velocity
- vii) Temperature
- viii) Liquid level
- ix) Flow

Practice

24.3.12P0 Specific Objectives

By the end the sub-module unit the trainee should be able to
- i) measure
- ii) displacement
- iii) force
- iv) torque
- v) strain
- vi) stress
- vii) angular velocity
- viii) temperature
- ix) liquid level
- x) flow

Content

24.3.12P1 Measurements of Displacement

24.3.12P2 Measurements of Force

24.3.12P3 Measurements of Torque

24.3.12P4 Measurements of Strain

24.3.12P5 Measurements of Stress

24.3.12P6 Measurements of Angular velocity

24.3.12P7 Measurements of Temperature

24.3.12P8 Measurements of Liquid level

24.3.12P9 Measurements of Flow

24.3.12C Competence

The trainee should have the ability to measure Physical Variables
- i) Displacement
- ii) Measure force
- iii) Measure torque
- iv) Measure strain
- v) Measure stress
- vi) Measure angular velocity
- vii) Measure temperature
- viii) Measure liquid level
- ix) Measure flow

Suggested Learning Resources
- i) Selected measuring instruments
- ii) Reference books
- iii) Field visits

24.3.13 FUNDAMENTALS OF CONTROL SYSTEM

Theory

24.3.13T0 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

24.3.13C Competence

The trainee should have the ability to identify open loop and closed loop control systems.

Content

24.3.13T1 Control system terminology
- i) Control
- ii) System
- iii) Control system - Natural system
- iv) Man made system
- v) Hybrid system
- vi) Controlled and reference variables

24.3.13T2 Open and Closed loop
- i) Feedback
- ii) Features of open loop systems
- iii) Features of closed loop system
- iv) Advantages and disadvantages

Practice

24.3.13P0 *Specific Objectives*

By the end the sub-module unit the trainee should be able to identify open and closed loop systems

Content

24.3.13P1 Open and Closed loop
- i) Features of open loop systems
- ii) Features of closed loop system

Suggested Learning Resources
- i) Reference books
- ii) Audio visual aids

24.3.14 BLOCK DIAGRAMS

Theory

24.3.14T0 *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

Content

24.3.14T1 Transfer function of systems with feedback

i) Feedback
ii) open loop

24.3.14T2 Block diagram
- i) Block diagrams of single input signal system
- ii) Block diagrams of multi-input signal system

24.3.14T3 Superposition theorem

Suggested Learning Resources
- i) Reference books
- ii) Audio visual aids

24.3.15 SIGNAL FLOW GRAPHS

Theory

24.3.15T0 *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

Content

24.3.15T1 Conversion of block diagrams to signal flow

24.3.15T2 Simplification of complex loops

24.3.15T3 Masons rule

Suggested Learning Resources
- i) Reference books
- ii) Audio visual aids

24.3.16 SYSTEM MODELLING

Theory

24.3.16T0 *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

Content

24.3.16T1 Need for modelling

24.3.16T2 Laplace transforms and differential equations of transfer functions

24.3.16T3 Transfer functions of simple networks
- i) Practical systems

Practice

24.3.16P0 *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

24.3.16P1 Practical systems

Suggested Learning Resources

i) Reference books
ii) Audio visual aids
iii) Practical systems

24.3.17 CONTROLLERS AND CONTROL MODES

Theory

24.3.17T0 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

24.3.17C Competence

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

24.3.17C Competence

The trainee should have the ability to identify the control mode utilized by a given control system.

Content

24.3.17T1 Definitions
i) Process load
ii) Process lag
iii) Self regulation
iv) Control lag
v) Dead time

24.3.17T2 Modes of control
i) Two position and floating
ii) Proportional mode
iii) Integral mode
iv) Composite control modes

Practice

24.3.17P0 *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

24.3.17P1 Modes of control
i) Two position and floating
ii) Proportional mode
iii) Integral mode
iv) Composite control

modes

Suggested Learning Resources

i) Reference books
ii) Audio visual aids
iii) Physical control systems

24.3.18 ACTUATORS

Theory

24.3.18T0 *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

24.3.18C Competence

The trainee should have the ability to:

i) Test Solenoids, Pneumatic and Hydraulic actuators
ii) Fit Solenoids, Pneumatic and Hydraulic actuators

Content

24.3.18T1 Function of an actuator

24.3.18T2 Types of actuators

i) Solenoids
ii) Digital stepper motor drives
iii) A.C. and D.C. motors
iv) Pneumatic
v) Hydraulic

Practice

24.3.18P0 *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

24.3.18P1 Tests of actuators

i) Solenoids
ii) Pneumatic
iii) Hydraulic

24.3.18P2 Fitting actuators

i) Solenoids
ii) Pneumatic
iii) Hydraulic

Suggested Learning Resources

i) Reference books
ii) Audio visual aids

24.3.19 PROCESS CONTROL

Theory

24.3.19T0 *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

Content

24.3.19T1 Block diagram of a process loop
- i) Process
- ii) Measurement
- iii) Comparator
- iv) Controller
- v) Control element

24.3.19T2 Structural model of a manufacturing process
- i) Input variables
- ii) Output variables

24.3.19T3 Process control strategies
- i) Feedback control
- ii) Regulatory control
- iii) Feed forward control
- iv) Pre-planned control
- v) Steady state optimal control
- vi) Adaptive control

24.3.19T4 Distributed versus central control
- i) Centralized control,
- ii) Optionally distributed control
- iii) Fully distributed control

Suggested Learning Resources

i) Reference books
ii) Audio visual aids
iii) Field visits

24.3.20 SEQUENCE CONTROL

Theory

24.3.20T0 *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

Content

24.3.20T1 Differences between computer and PLC
- i) Real-time operation
- ii) Environmental consideration
- iii) Programming languages and techniques
- iv) Maintenance and trouble shooting

24.3.20T2 Special Features of PLC
- i) Cost
- ii) Versatility
- iii) Flexibility
- iv) Expandability
- v) Maintenance
- vi) Accuracy

24.3.20T3 Architecture of PLCs
- i) Central processing unit
- ii) Input devices (Modules)
- iii) Output devices (Modules)
- iv) Power supply
- v) Input components
- vi) Output components
- vii) Memory
- viii) Programming unit (console)

24.3.20T4 Operation of PLCs

24.3.20T5 Applications of PLCs
- i) CNC machine tools
- ii) Computer Integrated Manufacturing

Suggested Learning Resources
- i) Reference books
- ii) Audio visual aids
- iii) Field visits

24.3.21 DIGITAL CONTROL SYSTEMS

Theory

24.3.21T0 *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

Content

24.3.21T1 Definition of DDC

24.3.21T2 DDC block diagram

24.3.21T3 Applications of DDC

24.3.21T4 Components of a DDC system and sensors
- i) Actuators and sensors
- ii) Analogue controller
- iii) Recording and display devices
- iv) Set-point dial and

comparator

24.3.21T5 Supervisory computer control
- i) Block Diagram
- ii) Application

Suggested Learning Resources
- i) Reference books
- ii) Audio visual aids
- iii) Field visits

24.3.21 SERVO SYSTEMS

Theory

24.3.21T0 *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

Content

24.3.21T1 Control of servo system
- i) AC servo
- ii) DC servo
- iii) Difference between DC and AC servos
- iv) Practical systems

24.3.21T2 Servo amplifiers
- i) DC
- ii) AC
- iii) Phase sensitive rectifiers
- iv) Applications

24.3.21T3 Stepper motor
- i) Construction
- ii) Operation
- iii) Control Circuits
- iv) Calculations
- v) Interfacing
- vi) Applications

24.3.21T4 Characteristics curves of AC and DC servo motors

24.3.21T5 Amplifier and servo systems performance

Suggested Learning Resources
- i) Reference books
- ii) Audio visual aids
- iii) Field visits