28.3.0 PRODUCTION LINE PROCESSES

28.3.1 Introduction

This module is designed to equip the trainees with knowledge skills and attitudes to enable them work as production managers in manufacturing industry. The module covers the following areas: computer programming, computer aided design, computer aided manufacture robots and robotics project planning production planning and control.

Production line Processes involves the operation of modern production line machines, Robots and computer aided design and manufacture. It also involves planning and control in industrial manufacturing.

The instructional approach will lay emphasis on demonstrations, industrial visits, industrial attachment, practical and project work. The assessment mode for this module shall be theory and practice. Some of the reference materials for this module are listed at the end of the module. The list is not exhaustive. The module unit will impart the trainees with the technical skill required to work in formal sector. Trainees undertaking this module will require knowledge of Computer skills, Engineering drawing, Mathematics and Control Systems and Instrumentation.

28.3.2 General Objectives

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

a) design a product using cad software
b) write a part program for a given product to be produced
c) work as production line operator
d) program and operate robots in a production line
e) plan a system for producing a given component
f) design products and estimate materials in production

28.3.3 Module Unit Summary and Time Allocation

PRODUCTION LINE PROCESSES

Code	Sub-Module Unit	Content	Theory Hrs	Pract Hrs	Time Hrs
28.3.1	Programming	• Common system programs • Program specification • Stages of programme development • Document the program	2	4	6
28.3.2	Computer Aided Design	• Fundamentals of Computer Aided	2	4	6

		Design • Hardware in Computer Aided Design • Computer graphics software and database			
28.3.3	Fundamentals of Numerical Control of Machine	• Application of Numerical Control • Basic components of Numerical Control system • Need for co-ordinate drawing • Need for reference of drawing • Plan of machining operations • Presentation of coded data and interpretation by the machine control unit • Numerical Control, Direct Numerical Control and Systems	2	4	6
28.3.4	Co-Ordinate System	• Standard X,Y,Z axes systems of machine slide • Supporting systems • "Floating Zero" datum point • Difference between absolute and incremental positioning • Numerical Control systems	2	4	6
28.3.5	Setting Techniques	• Tool length offsets • Techniques of establishing work datums • Coding Proving • Speeds and Feeds • Part programme	2	4	6

		editing • Fixing and clamping			
28.3.6	Machine Structure and Control System	• Major components of Numerical Control machines • Operation of slide elements • Structure of drive systems • Accuracy and reliability • Digital signals applied to control systems used in feedback • Operational characteristics of measuring devices used to determine position in the feedback loop	4	4	8
28.3.7	Tooling System	• Concepts of pre-set and qualified tooling • Use of Computer Numerical Control, control unit • Organizational requirements for tool pre-setting station • Tool identification method • Tooling identification in library	2	2	4
28.3.8	Part Programming	• Binary layout • Variation of coded information • Word address format • Advantages of using floppy disks and magnetic tapes • storage • speed of retrieving • ease of editing • Part Programming	4	4	8

		• Simulate part programs			
28.3.9	Computer Programming Systems	• Programming levels • Computing requirements for each level • Type of code output to machine • Benefits of computer part programming	4	4	8
28.3.10	Numerical Controlled Machining	• Advantages of Numerical Control machining • Characteristics of work suitable for Numerical Control machining • Economic justification of Numerical Control • Savings in the use of Numerical Control machines • Modern costing techniques	4	4	8
28.3.11	Fundamentals of Robots	• Definition of a robot • Elements of a Robotic System • Needs for using robots	2	2	4
28.3.12	Types of Robots	• Robotic classification based on mechanical configuration • Freedom of motion • Drive systems • Control systems • Functions	1	2	3
28.3.13	Performance Capabilities of Robots	• Performance Capabilities Specifications • Key Features of Robots	1	1	2
28.3.14	Programming Robots	• Programming methods • Robot programming	4	5	9

		functions • Robot programming environment • Programming activities • Basic types of robot programming languages • On-line and off-line programming languages			
28.3.15	Geometric Requirements to Computer Aided Design/Robot Linkage	• Geometric requirements to CAD/Robot linkage	1	1	2
28.3.16	Simulation	• Simulation	2	2	4
28.3.17	Adaptive Control	• Adaptive Control	1	1	2
28.3.18	Robot Operation	• Robot Operation	1	1	2
28.3.19	End of Arm Tooling	• End of arm tooling	1	1	2
28.3.20	Application Of Industrial Robots	• Application of industrial robots	1	1	2
28.3.21	Presentation Of Work to Robots in Production	• Presentation of work to robots in production	1	1	2
28.3.22	Product Design for Automatic Manufacture By Robots	• Product design for automatic manufacture by robots	2	4	6
28.3.23	Project Planning	• Identification of different types of charts • Drawing of various types of charts • Application of various types of charts	2	2	4

28.3.24	Production Planning	• Forecasting techniques • Need for product design and development • Stages of product design and development • Computer-Aided Process Planning • Benefits of Computer-Aided Process Planning	4	2	6
28.3.25	Production Control	• Objectives of production control • Activities involved in production control • Documentation used in production control • Types of inventories and their functions • Quality control • Quality control methods • Quality control and computer integrated manufacturing • Non contact inspection methods • Post process metrology	2	2	4
		Total Hours	**54**	**66**	**120**

28.3.01	**PROGRAMMING**	By the end of the sub-module unit, the trainee should be able to:
	Theory	
28.3.01T0	*Specific Objectives*	a) explain common system programs

b) explain what is meant by program specification
c) state program development stages
d) explain structured programming

28.3.01C ***Competence***
The trainee should have the ability to:
i) Write a program
Execute a program

Content

28.3.01T1 Common system programs
- Monitor
- Editor
- Interpreter
- Compiler
- Assembler
- Debugger
- Linker
- Simulator/emulator
- Utility

28.3.01T2 Program specification
- Problem definition
- Input
- Processes
- Output
- Advantages/ disadvantages

28.3.01T3 Stages of programme development in C++ and Intel 8080/8086
- Define the problem
- Design the data
- Design the program
- Code the program
- Compile the program
- Test the program
- Document the program

28.3.01T4 Structures of program documentation

Practice

28.3.01P0 *Specific Objective*
By the end of the sub-module unit, the trainee should be able to develop programs.

Content

28.3.01P1 Program development in C++ and Intel 8080/8086
- Design programs
- Code programs
- Compile programs
- Test programs
- Document programs

28.3.02 **COMPUTER AIDED DESIGN**

Theory

28.3.02T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the fundamentals of Computer Aided Design
b) describe Computer Aided Design hardware systems

c) describe computer graphics software and databases

28.3.02C *Competence*

The trainee should have the ability to:

i) Draw basic figures using computer aided design
ii) Combine basic figures to develop parts in Computer Aided Design
iii) Present drawings in orthographic projection
iv) Present working drawings using Computer Aided Design
v) Present drawing in rectangular and polar coordinates

Content

28.3.02T1 Fundamentals of Computer Aided Design

- The design process
- Applications of computers for design
- Creating manufacturing data
- Benefits of Computer Aided Design

28.3.02T2 Hardware in Computer Aided Design

- Design workstation
- Graphics terminals
- Operating input and output devices

28.3.02T3 Computer graphics software and database

- Software configuration of graphics system
- Functions of computer graphics
- Database structure and content
- Wire-frame versus solid modelling

Practice

28.3.02P0 *Specific Objectives*

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

a) Draw using Computer Aided Design
b) Combine basic figures to in Computer Aided Design
c) Present drawings in orthographic projection
d) Prepare working drawings using Computer Aided Design
e) Prepare drawings in rectangular and polar coordinates

Content

28.3.02P1 Basic figures

28.3.02P1 Parts development

28.3.02P1	Orthographic projection		
28.3.02P1	Working drawings preparation		
28.3.02P1	Rectangular and polar coordinates		
28.3.03.	**COMPUTER AIDED MANUFACTURING - FUNDAMENTALS OF NUMERICAL CONTROL OF MACHINE TOOLS**		
	Theory		
28.3.03T0	*Specific Objectives* By the end of the sub-module unit, the trainee should be able to: a) describe the application of Numerical Control in manufacture b) explain the basic components of Numerical Control system c) explain the need for drawings to be presented with rectangular or polar co-ordinates d) explain the need for drawings to be presented in X, Y and Z reference e) describe the role of planning the machining operations f) describe how the coded data is presented and interpreted by the machine control unit g) describe the differences between Numerical Control, Direct Numerical Control and Computer Numerical Control system		
28.3.03C	*Competence* The trainee should have the ability to Plan machining operation in coded data form		
	Content		
28.3.03T1	Application of Numerical Control - Metal cutting - Press work - Inspection - Assembly - Welding - Flame Cutting		
28.3.03T2	Basic components of Numerical Control system - Data Input/programming		

- Machine control unit/Central processing unit
- Machine tools

28.3.03T3 Need for co-ordinate drawing
- Ease of programming
- Component geometry definition
- Tool path definition

28.3.03T4 Need for reference of drawing
- Ease of programming
- Component geometry definition
- Tool path definition

28.3.03T5 Plan of machining operations

28.3.03T6 Presentation of coded data and interpretation by the machine control unit

28.3.03T7 Numerical Control, Direct Numerical Control and Computer Numerical Control system

28.3.04 CO-ORDINATE SYSTEM

Theory

28.3.04T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) identify the standard and x, y, z axes system of machine slide displacement in relation to varying tapes of Numerical Control machine
b) identify other supporting systems necessary for the operation of Numerical Control machine system
c) describe "Floating Zero' datum point with respect to programming and work location.
d) describe the difference between absolute and incremental positioning
e) describe the three basic types of Numerical Control system
f) classify Numerical Control machines in terms of X, Y and Z axes of operation.

28.3.02C *Competence*
The trainee should have the ability to identify the standard and x, y, z axes system of machine slide displacement in relation to varying tapes of Numerical Control machine

Content

28.3.04T1 Standard X,Y,Z axes systems of machine slide
- Milling machine
- Drilling machine
- Lathe

28.3.04T2 Supporting systems
- Spindle control
- Spindle speed
- Feed rates
- Tool changing
- Coolant control

28.3.04T3 "Floating Zero" datum point
- Consideration in programming
- Work location

28.3.04T4 Difference between absolute and incremental positioning
- Dimensioning of drawing
- Cutter location with reference to work

28.3.04T3 Numerical Control systems
- Point to point position control
- Line motion control
- Contouring control

28.3.05T **SETTING TECHNIQUES**

Theory

28.3.05T0 *Specific Objectives*

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

a) describe tool length offset and how they are determined
b) describe the various techniques of establishing work datums
c) explain the need for and means of proving coding techniques
d) explain selection of speeds and feeds for various materials
e) edit part programs of machine tool
f) describe clamping requirements for various types of work

28.3.05C *Competence*

The trainee should have the ability to fix and clamp work on Numerical Control machine

Content

28.3.05T1 Tool length offsets
- Drills
- Milling cutters
- Taps
- Lathe tools

28.3.05T2 Techniques of establishing work datums

28.3.05T3 Coding Proving
- Dry run

- Graphics
- Use of soft materials

28.3.05T4 Speeds and Feeds
- Various materials
- Operations
- Tool cutting materials

28.3.05T4 Part programme editing
- Manual Data Input (MDI)
- Saving of edited programme on magnetic disks, removable storage media, CD ROMs, and internet

28.3.05T4 Fixing and clamping

Practice

28.3.05P4 *Specific Objective*
By the end of the sub-module unit the trainee should be able to hold work on Numerical Control machine

28.3.06T **MACHINE STRUCTURE AND CONTROL SYSTEM**

Theory

28.3.06T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) describe the major components in the construction of Numerical Control machines
b) describe the operation of slide elements on machines
c) describe the structure of drive systems in current use on Numerical Control machines
d) compare the accuracy and reliability of drives systems
e) describe the digital signal applied to control systems used in feed back
f) describe the operational characteristics of the measuring devices used to determine position in the feedback loop

28.3.05C *Competence*
The trainee should have the ability to operate Numerical Control machine

Content

28.3.06T1 Major components of Numerical Control machines
- Moving column
- Moving beds
- Moving slides
- Moving quills

28.3.06T2 Operation of slide elements
- Machines with electronic control system
- Machine with hydraulic control system

28.3.06T3 Structure of drive systems
- Servo
- Hydraulic
- Electro-hydraulic
- Step motors

28.3.06T4 Accuracy and reliability
- Servo
- Hydraulic
- Electro-hydraulic
- Step motors

28.3.06T5 Digital signals applied to control systems used in feedback

28.3.06T6 Operational characteristics of measuring devices used to determine position in the feedback loop

28.3.07 **TOOLING SYSTEM**

Theory

28.3.07T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) state the concept of pre-set and qualified tooling on Numerical Control and Computer Numerical Control machine
b) describe the use of a Computer Numerical Control, control unit
c) describe the organisational requirements of tool pre-setting station to be found on Numerical Control centres
d) explain tool identification method for pre-set tools located in and automated tool changer
e) describe a method of identifying tools in a tool library

28.3.07C *Competence*
The trainee should have the ability to:
i) Pre-set tools on Numerical Control and Computer Numerical Control machine
ii) Arrange tools in magazine or turret with respect to machining procedure

Content

28.3.07T1 Concepts of pre-set and qualified tooling

28.3.07T2 Use of Computer Numerical Control, control unit
- Entry of tool data for pre-set and qualified tooling
- Entry of tool offset and cutter diameter compensation to guarantee complete accuracy

28.3.07T3 Organizational requirements for tool pre-setting station
- Layout of station
- Tooling for presetting
- Storage for pre-set tools
- Handling of pre-set tools

28.3.07T4 Tool identification method
- Tool number station

28.3.07T5 Tooling identification in library
- Tool coding

Practice

28.3.07P0 *Specific Objectives*
By the end the sub-module unit the trainee should be able to:
a) sequence tools with respect to machining procedure
b) load tools on Numerical Control and Computer Numerical Control machine

Content

28.3.07P1 Organizational requirements for tool pre-setting station
- machining procedure
- Tooling for presetting
- Handling of pre-set tools

28.3.07P2 Tooling sequence in relation to machining procedure

28.3.08 **PART PROGRAMMING**

Theory

28.3.08T0 *Specific Objective*
By the end of the sub-module unit, the trainee should be able to:
a) describe binary layout of ISO
b) describe how coded information in formatted blocks varies according to the machine control
c) describe word address format
d) state advantages of using floppy disks, magnetic tapes, and optical disks for line programming
e) describe part programming

28.3.08C *Competence*

The trainee should have the ability to:

i) Convert decimal to binary numbers system.
ii) Use floppy disks, magnetic tapes, and optical disks in part programming
iii) Write part program
iv) Edit part programs
v) Simulate part programs

Content

28.3.08T1 Binary layout
28.3.08T2 Variation of coded information
28.3.08T3 Word address format
28.3.08T4 Advantages of using floppy disks and magnetic tapes
28.3.08T5 storage
28.3.08T6 speed of retrieving ease of editing
28.3.08T7 Part Programming

- Languages (APT, G CODES, M-CODES GE-FANUC, and ISO CODES)
- Point to point motions, rapid and feed using rectangular co-ordinates
- Point to point motions, rapid and feed using polar co-ordinates
- Use of sub-routines for fixed cycles
- Use of canned cycles
- Use of loops and incremental values with point to point functions
- Programming using tool radius offsets to obtain sample profiles
- Mixing of both rectangular and polar co-ordinates in profile work
- Special functions (area clearance)
- Simulate part programs
- G-SIMPLE
- SMARTCAM
- PRO-ENGINEER

Practice

28.3.08P0 *Specific Objectives*

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

a) Convert decimal to binary numbers system.
b) Use floppy disks, magnetic tapes, and optical disks in part programming
c) Write part program
d) Edit part programs
e) Simulate part programs

Content

28.3.08P1 Binary layout

28.3.08P2 Use of floppy disks, magnetic tapes, and optical disks in storage of part program

28.3.08P3 Writing part program

28.3.08P4 Part Programming

- Languages (APT, G CODES and M-CODES GE-FANUC)
- point to point motions, rapid and feed using rectangular co-ordinates
- Use of sub-routines for fixed cycles
- Use of canned cycles
- Use of loops and incremental values with point to point functions
- Programming using tool radius offsets to obtain sample profiles
- Mixing of both rectangular and polar co-ordinates in profile work

28.3.08P5 Simulate part programs

- G-SIMPLE
- SMARTCAM
- PRO-ENGINEER

28.3.09 COMPUTER PROGRAMMING SYSTEMS

28.3.09T0 *Specific Objectives*

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

a) state programming level suitable for given jobs
b) describe computing requirements for each level of programming
c) state the type of computing hardware and software for given circumstances
d) explain type of code output to machine
e) compare benefits of computer part programming with manual programming

28.3.08C *Competence*

The trainee should have the ability to Compute requirements for each level

- Interpolation: Linear and circular part surfaces

Content

28.3.09T1 Programming levels

- contouring on two axes (2C)
- contouring on two axes and linear

contour on one axes (C)
- contouring on three axes (3C)

28.3.09T2 Computing requirements for each level
- Interpolation: Linear and circular part surfaces

28.3.09T3 Selection of computer hardware and software
- Peripheral devices
- Memory capacity
- Storage capacity
- Resolution
- Speed of processing
- Post processors
- Capability software
- Capability of micro-computer system
- Working memory
- Storage capacity
- Speed of processing

28.3.09T4 Type of code output to machine
- ISO

28.3.09T5 Benefits of computer part programming
- Speed in programming
- Computing requirements
- Accuracy of programmes
- Ease of editing

28.3.10 **NUMERICAL CONTROLLED MACHINING**

28.3.10T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) state main advantages of Numerical Control machining
b) describe the general characteristics of work most suitable for Numerical Control machining
c) state economic justification of Numerical Control machining
d) describe direct and indirect savings involved in the use of Numerical Control machines with those of conventional machine
e) state modern costing techniques applied to production of components on Numerical Control machines

28.3.10C *Competence*
The trainee should have the ability to develop general characteristics of work most suitable

for Numerical Control machining

Content

28.3.10T1 Advantages of Numerical Control machining
- Increased cutting efficiency
- Reduction of setting up time
- Increased production flexibility
- Reduction of lead time
- Improved quality standards

28.3.10T2 Characteristics of work suitable for Numerical Control machining
- Quantities
- Repeatability
- Geometric shape (complexity)
- High quality standards
- High quality metal removal

28.3.10T3 Economic justification of Numerical Control
- Calculation of machine hour rate for Numerical Control and conventional machines

28.3.10T4 Savings in the use of Numerical Control machines
- Direct savings
- Indirect savings

28.3.10T5 Modern costing techniques

28.3.11 **FUNDAMENTALS OF ROBOTS**

Theory

28.3.11T0 *Specific Objectives*

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

a) define a robot
b) explain the elements of robotic system
c) explain the need for using robots

Content

28.3.11T1 Definition of a robot

28.3.11T2 Elements of a Robotic System
- Components of robot manipulator
- Control system
- Computer system

28.3.11T3 Needs for using robot

28.3.12 TYPES OF ROBOTS

Theory

28.3.12T0 *Specific Objectives*

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

a) classify robots based on mechanical configuration

b) classify robots based on Freedom of motion
c) classify robots based on Drive systems
d) classify robots based on Control systems
e) describe the functions of control system in robots

28.3.12C **Competence**

The trainee should have the ability to identify various types of robots

Content

28.3.12T1 Robotic classification based on mechanical configuration
- Rectangular co-ordinate system
- Cylindrical co-ordinate system
- Spherical co-ordinate system
- Revolute co-ordinate system

28.3.12T2 Freedom of motion
- Roll
- Pitch
- Yaw

28.3.12T3 Drive systems
- Pneumatic actuator systems
- Hydraulic actuator systems
- Electric actuator systems

28.3.12T4 Control systems

28.3.12T5 Functions
- Generating the path of motion for the manipulator
- Feedback devices
- Co-ordinate transformation
- Safety controls
- Interfaces
- Robot control through non-servo operation
- Servo-controlled robots

Practice

28.3.12P0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:
a) identify robots based on mechanical configuration
b) classify robots based on Freedom of motion
c) classify robots based on Drive systems
d) classify robots based on Control systems

Content

28.3.12P1 Classification of robots based on mechanical configuration
- Rectangular co-ordinate system

- Cylindrical co-ordinate system
- Spherical co-ordinate system
- Revolute co-ordinate system

28.3.12P2 Classification of robots based on freedom of motion
- Roll
- Pitch
- Yaw

28.3.12P3 Classification of robots based on drive systems
- Pneumatic actuator systems
- Hydraulic actuator systems
- Electric actuator systems

28.3.12P4 Classification of robots based on control systems

28.3.13 PERFORMANCE CAPABILITIES OF ROBOTS

Theory

28.3.13T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the performance capability of a robot
b) outline the features of a robot

28.3.12C *Competence*
The trainee should have the ability to perform various capabilities specifications of robots

Content

28.3.13T1 Performance Capabilities Specifications
- Axes of motion
- Work envelope
- Speed
- Acceleration
- Payload capacity
- Accuracy
- Resolution
- Repeatability
- Reliability

28.3.13T2 Key Features of Robots
- Quality
- Serviceability
- Safety
- Modularity
- Dexterity

28.3.14 **PROGRAMMING ROBOTS**

Theory

28.3.14T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain programming methods
b) describe robot programming functions

c) describe robot programming environment
d) describe robot programming activities
e) describe basic types robot programming languages
f) describe on-line and off-line programming languages

28.3.14C **Competence**
The trainee should have the ability to develop simple robot program

Content

28.3.14T1 Programming methods
- Guiding
- Teach pedant
- Off-line programming

28.3.14T2 Robot programming functions
- World modelling
- Path generation
- Sensing
- Programming support

28.3.14T3 Robot programming environment

28.3.14T4 Programming activities

28.3.14T5 Basic types of robot programming languages

28.3.14T6 On-line and off-line programming languages

Practice

28.3.14T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to develop simple programs to manipulate robots

Content

28.3.14T1 Programming methods
- Guiding
- Teach pedant
- Off-line programming

28.3.15 GEOMETRIC REQUIREMENTS TO CAD/ROBOT LINKAGE

Theory

28.3.15T0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to outline the geometric requirements to Computer Aided Design/Robot linkage

28.3.15C **Competence**
The trainee should have the ability to transform geometric information into co-ordinates

Content

28.3.15T1 Geometric requirements to Computer Aided Design/Robot linkage

28.3.16 SIMULATION

Theory

28.3.16 *Specific Objective*
By the end of the sub-module unit the trainee should be able to explain how simulation is carried out.

32.3.16C **Competence**
The trainee should have the ability to simulate robot movement in tool change

Content
28.3.16T1 Simulation

Practice

28.3.16P0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to simulate robot movement

Content
28.3.16P1 Simulation

28.3.17 **ADAPTIVE CONTROL**

28.3.17T0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to explain adaptive control in robots

28.3.17C *Competence*
The trainee should have the ability to modify program during operation

Content
28.3.17T1 Adaptive Control

28.3.18 ROBOT OPERATION

Theory

28.3.18T0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to describe modes of operation of a robot

28.3.18C *Competence*
The trainee should have the ability to operate a robot to pick a part and place in production

Content
28.3.18T1 Robot Operation
- Pick and place
- Point to point
- Continuous path
- Controlled path

Practice

28.3.18P0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to operate a robot

Content

28.3.18P1 Robot Operation
- Pick and place

28.3.19 **END OF ARM TOOLING**

Theory

28.3.19T0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to describe operation of end of arm tooling

28.3.19C *Competence*
The trainee should have the ability to operate a robot to grip

Content

28.3.19T1 End of arm tooling

Practice

28.3.19P0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to operate end of arm tooling of robot

Content

28.3.19P1 End of arm tooling

28.3.20 APPLICATION OF INDUSTRIAL ROBOTS

Theory

28.3.20T0 *Specific Objectives*
By the end of the sub-module unit the trainee should be able to describe applications of industrial robots

28.3.20C *Competence*
The trainee should have the ability to:
i) Operate a robot in loading
ii) Operate a robot in machining
iii) Operate a robot in tool change.

Content

28.3.20T1 Application of industrial robots
- Material handling
- Machine tending
- Welding
- Arc welding
- Surface coating
- Machining
- Assembly
- Inspection

Practice

28.3.20P0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to describe applications of industrial robots

Content

28.3.20P1 Application of industrial robots in
- loading
- machining
- material handling

28.3.21 PRESENTATION OF WORK TO ROBOTS IN PRODUCTION

Theory

28.3.21T0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to describe presentation of work to robots in production.

28.3.21C *Competence*
The trainee should have the ability to present the work of robots in production

Content

28.3.21T1 Presentation of work to robots in production

28.3.22 PRODUCT DESIGN FOR AUTOMATIC MANUFACTURE BY ROBOTS

Theory

28.3.22T0 *Specific Objective*
By the end of the sub-module unit the trainee should be able to describe product design for automatic manufacture by robots

28.3.22C *Competence*
The trainee should have the ability to design a part for automatic production.

Content

28.3.22T1 Product design for automatic manufacture by robots

Practice

28.3.22P0 *Specific Objectives*
By the end of the sub-module unit the trainee should be able to design product for automatic manufacture by robots

Content

28.3.22P1 Design product for automatic manufacture by robots

28.3.23 PROJECT PLANNING

Theory

28.3.22T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) identify different types of charts
b) draw various types of charts
c) apply various types of charts

28.3.25C *Competence*

	The trainee should have the ability to: i) Use Routing techniques ii) Use Scheduling techniques iii) Use Loading techniques iv) Use quality control methods	b) prepare work breakdown structures c) draw networks d) determine critical paths of networks e) techniques in production control f) apply quality control methods.
	Content	
28.3.23T1	Identification of different types of charts - Bar - Gantt - Activity Sampling - Critical Path Method (CPM) and Part Evaluation and Review Technique (PERT)	
28.3.23T2	Drawing of various types of charts	
28.3.22T3	Application of various types of charts - Maintenance - Production projects	
	Practice	
28.3.23P0	*Specific Objectives* By the end of the sub-module unit, the trainee should be able to: a) draw different types of charts	
		Content
		28.3.25P1 Routing in production control
		28.3.25P2 Scheduling in production control
		28.3.25P3 Loading in production control
		28.3.25P4 Quality control
		Suggested Learning Resources - Reference books
		Content
		28.3.23P1 Types of charts - Bar - Gantt - Activity Sampling - Draw Bar chart - Gantt chart
		28.3.23P2 Prepare work break down structures
		28.3.23P3 Draw a network
		28.3.23P4 Determine the Critical Path - Networks Critical Path Method (CPM) and Part Evaluation and

Review Technique (PERT)

28.3.24 PRODUCTION PLANNING

Theory

28.3.24T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe forecasting techniques in production
b) describe the need for product planning
c) state stages of product design and development
d) describe computer-aided process planning
e) describe computer-aided process planning

28.3.24C *Competence*
The trainee should have the ability to carry out computer –aided process planning

Content

28.3.24T1 Forecasting techniques
- Qualitative
- Quantitative

28.3.24T2 Need for product design and development
- optimization of material resources
- optimization of manufacturing process
- reduction of costs
- Simplification
- Scrap rates and efficiency factors
- Standardization
- Specification
- Market requirement

28.3.24T3 Stages of product design and development
- Idea generation
- Preliminary design
- Analysis
- Evaluation
- Functional design
- Final Design
- Prototyping
- Production design

28.3.24T4 Computer-Aided Process Planning
- Automated process planning
- Retrieval type process planning system
- Generative process planning systems

28.3.24T5 Benefits of Computer-Aided Process Planning

28.3.25 PRODUCTION CONTROL

Theory

28.3.25T0 *Specific Objectives*

	By the end of the sub-module unit, the trainee should be able to: a) explain the objectives of production control b) describe the activities involved in production control c) describe the documentation used in production control d) explain the types of inventories and their functions e) explain quality control f) describe quality control methods g) describe quality control and computer integrated manufacturing h) describe non contact inspection methods	
28.3.24C	*Competence* The trainee should have the ability to carry out Computer Aided Quality Control and Computer Integrated Manufacturing	
	Content	
28.3.25T1	Objectives of production control - achievement of planned objectives - cost effectiveness	
28.3.25T2	Activities involved in production control - Processing - Estimating - Dispatching - Programming	
28.3.25T3	Documentation used in production control - Job cards - Work order (route card) - Demand note - Control sheet - Internal delivery note - Progress or move note	
28.3.25T4	Types of inventories and their functions - Store size - Buffer - Anticipated - Fixed reorder quantity system - Fixed time interval system	
28.3.25T5	Quality control - Need for quality control - Total quality management o Quality of design o Selection of appropriate process and equipment o Choice of o Training of personnel Equipment	
28.3.25T6	Quality control methods	

- Statistical
- Part by part analysis

28.3.25T7 Computer Aided Quality Control and Computer Integrated Manufacturing
- Objectives of Computer Aided Quality Control (CAQC)
- The Computer in Quality Control (QC)
- Coordinate measuring machine
- Advantages of Computer Numerical Control (CNC) operation of Computer
- Integrated Manufacturing (CIM)

28.3.25T8 Non contact inspection methods
- Laser interferometric measuring system
- Laser telemetric measuring system
- Vision system
- Non-contact CNC CMM

28.3.25T9 Post process metrology

Practice

28.3.25P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) apply routing techniques in production control
b) apply scheduling techniques in production control
- use loading Computers and appropriate software

29.3.0 FOUNDRY TECHNOLOGY

29.3.1 Introduction

This module unit has been designed to equip the trainee with the necessary knowledge, skills and attitudes required in casting of metallic and plastic components and machine parts. The graduates of this module will be able to work in both formal and informal industrial sectors.

Foundry technology is the study of producing components and machine parts by casting. The process of casting involves pattern making, making of moulds, melting and pouring of molten metal into the moulds and fettling.

In this module unit, various casting methods such as sand casting, investment casting, shell moulding, die casting, centrifugal casting and plastic moulding are covered.
The instructional approach will lay emphasis on demonstrations, industrial visits, practical, project work and industrial attachment.
The assessment mode for this module shall be mainly practical.
Some of the reference materials for this module are listed at the end of the module.

Trainees undertaking these modules require knowledge in engineering materials, engineering drawing, bench work, fitting and machining.

29.3.2 General Objectives

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

a) practice safe working habits in foundry workshop
b) develop patterns for specific foundry applications
c) operate equipment used in various casting processes in the workshop
d) produce high quality moulds for various casting processes
e) perform various casting processes
f) carry out quality control measures when casting
g) acquire skills necessary for proper use, care and maintenance of tools and equipment in a foundry workshop

29.3.3 Module Unit Summary and Time Allocation

FOUNDRY TECHNOLOGY

Code	Sub-Module	Content	Theory Hrs	Pract Hrs	Time Hrs
29.3.01	Safety	• Principles of developing safety policy • Classes of fires • Procedure of fire fighting • Causes of fire	2	2	4
29.3.02	Casting Process	• Types of casting processes	4	4	8

		• Definition of sand casting • Steps in sand casting			
29.3.03	Sand Casting Tools and Equipment	• Foundry tools and equipment • Foundry tools and equipment	2	2	4
29.3.04	Pattern Making	• Types of patterns • Pattern making materials • Pattern design	4	4	8
29.3.05	Moulding	• Types of moulding • Moulding processes • Factors in selecting a moulding process • Testing methods for moulds and moulding sand	4	4	8
29.3.06	Core Making	• Types of cores • Core making and baking process • Tools and equipment • Types of sand	4	4	8
29.3.07	Gating System	• Element of a gating system • Types of gates • Characteristics of gates	2	2	4
29.3.08	Melting and Pouring	• Melting process • Types of melting furnaces • Pouring techniques • Pyrometers • Melt additives	4	4	8
29.3.09	Cleaning and Inspection	• Casting defects • Cleaning processes • Testing and inspection	4	4	8
29.3.10	Die Casting	• Types of die design • Types of die casting processes	4	6	10
29.3.11	Centrifugal	• Types of centrifugal	4	4	8

	Casting	casting • Centrifugal casting process			
29.3.12	Investment Casting	• Investment process • Types of investment casting • Design of investment die	6	6	12
29.3.13	Shell Moulding	• Process of shell moulding • Material used in shell moulding • Equipment in shell moulding	6	6	12
29.3.14	Plastic Processing Methods	• Processing methods • Types of plastics	6	8	14
Total Time			**56**	**60**	**116**

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

a) explain the principles of developing an effective safety policy
b) identify different types of fires
c) observe the procedure of fighting fires
d) explain causes of fire in the foundry workshop

29.3.01 **SAFETY**

Theory

29.3.01T0 *Specific Objectives*

29.3.01C *Competence*

The trainee should have the ability to observe correct safe working procedures

Content

29.3.01T1 Principles of developing safety policy

29.3.01T2 Classes of fires
- Class A
- Class B
- Class C
- Class D

29.3.01T3 Procedure of fire fighting

29.3.01T4 Causes of fire

Practice

29.3.01P0 *Specific Objectives*

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

a) identify different types of fires
b) practice relevant fire drills

Content

29.3.01P1 Classes of fires
- Class A
- Class B
- Class C
- Class D

29.3.01P2 Fire drills

Suggested Learning Resources
- Factories Act
- Fire fighting equipment

29.3.02 CASTING PROCESS

Theory

29.3.02T0 *Specific Objectives*

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

(a) describe the types of casting processes
(b) describe sand casting
(c) identify steps in sand casting

29.3.02C *Competence*

The trainee should have the ability to follow the correct procedure for sand casting

Content

29.3.02T1 Types of casting processes
- Sand casting
- Special casting processes

29.3.02T2 Definition of sand casting

29.3.02T3 Steps in sand casting
- Pattern making
- Moulding
- Core making
- Metal melting and pouring
- Cleaning and inspection

Practice

29.3.02P0 *Specific Objectives*

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

a) identify steps in sand casting
b) prepare sand for moulding
c) operate sand shifting machine
d) analyse sand for correct quality

Content

29.3.02P1 Steps in sand casting
- Pattern making
- Moulding
- Core making
- Metal melting and pouring
- Cleaning and inspection

29.3.02P2 Moulding preparation

29.3.02P3 Analyses

Suggested Learning Resources
- Casted models

29.3.03 SAND CASTING TOOLS AND EQUIPMENT

Theory

29.3.03T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) classify foundry tools and equipment
b) describe the uses of various types of tool and equipment

29.3.03C *Competence*
The trainee should have the ability to select correct tools and equipments given task

Content

29.3.03T1 Foundry tools and equipment
- Hand tools
  - shovel
  - handle riddle\Trowel
- Mechanical tools
  - power riddles
  - sand mixers
  - sand aerator
- Containers
  - moulding boxes
  - ladles
  - crucibles

29.3.03T2 Foundry tools and equipment
- Vent wire
- Strike off bar
- Draw spike

Practice

29.3.03P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) identify the correct tools for a given task

b) use the correct tools

Content

29.3.03P1 Tools and equipment identification
- Hand tools
  - Shovel
  - Handle riddle\Trowel
- Mechanical tools
  - power riddles
  - sand mixers
  - sand aerator
- Containers
  - moulding boxes
  - ladles
  - crucibles

29.3.03P2 Foundry tools and equipment application
- Vent wire
- Strike off bar
- Draw spike

Suggested Learning Resources
- Sand casting tools

29.3.04 PATTERN MAKING

Theory

29.3.04T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe different types of patterns
b) select materials for pattern making
c) design a pattern for a given casting

29.3.04C *Competence*
The trainee should have the ability to produce a pattern for a given casting

Content

29.3.04T1 Types of patterns

29.3.04T2 Pattern making materials
- Wood
- Plasters
- Plastic and rubbers
- Metals
- Wipes

29.3.04T3 Pattern design
- Colours pattern making
- Allowances in pattern making

Practice

29.3.04P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) select materials for pattern making
b) design a pattern for a given casting

Content

29.3.04P1 Pattern making materials
- Wood
- Plasters
- Plastic and rubbers
- Metals
- Wipes
- Pattern allowance
- Colours pattern making

Suggested Learning Resources

- Models
- Pattern materials
- Wood working machines and tools

29.3.05 **MOULDING**

Theory

29.3.05T0 *Specific Objectives*

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

a) outline types of moulding sands and their preparation
b) describe various moulding process
c) explain factors influencing the selection of moulding process
d) describe the methods of testing moulds and moulding sand

29.3.05C *Competence*

The trainee should have the ability to:

i) prepare a mould and test it.
ii) Prepare moulding sand

Content

29.3.05T1 Types of moulding

29.3.05T2 Moulding processes

- types of moulding sand
- moulding sand preparation
- Floor moulding
- Bench moulding
- Shell

29.3.05T3 Factors in selecting a moulding process

- Size of casting
- Material
- Shape
- Complexity of design

29.3.05T4 Testing methods (sand and mould)

- Permeability – calculating permeability number
- Strength
- Moisture content
- Hardness
- Grain fineness test – calculating green fineness number GFN

Practice

29.3.05P0 *Specific Objectives*

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

a) prepare moulding sand
b) analyse the content of moisture in the moulding sand
c) mix moulding sand in good proportion

Content

29.3.05P1 Moulding sand
29.3.05P2 Moisture analyses
29.3.05P3 Sand mixing

Suggested Learning Resources

- Testing equipment

29.3.06 CORE MAKING

Theory

29.3.06T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) describe different types of cores
b) explain types of sand for cores making
c) identify tools and equipment used in core making
d) describe the process of core making and baking

29.3.06C *Competence*
The trainee should have the ability to make a given core and bake it

Content

29.3.06T1 Types of cores
- Balanced cores
- Cover core
- Hanging core

29.3.06T2 Types of sand
29.3.06T3 Tools and equipment
- Core boxes
- Core machine
- Blowing machine
- Core making and baking

29.3.06T4 Core making and baking process

Practice

29.3.06P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) identify tools and equipment used in core making
b) prepare core making
c) test core making sand
d) produce a core

Content

29.3.06P1 Tools and equipment
- Core boxes
- Core making machine
- Blowing machine

29.3.06P2 Core making and baking
29.3.06P3 Tests
29.3.06P4 Core

Suggested Learning Resources

- Tools and equipment for core making

29.3.07 **GATING SYSTEM**

Theory

29.3.07T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be to:
a) explain the elements of a gating system
b) outline the types of gates
c) explain the characteristics of gates

29.3.07C *Competence*
The trainee should have the ability to design a proper gating system for a given task

Content

29.3.07T1 Element of a gating system
- Riser
- Spruce
- Runner
- Chrorinov's rule of calculating solidification time

29.3.07T2 Types of gates
- Top gate
- parting gate
- bottom gates

29.3.07T3 Characteristics of gates
- Design of gating parameter
  - base diameter of gates, area of well depth

Practice

29.3.07P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be to:
a) design a gating system
b) produce a proper gating system for given cast design

Content

29.3.07P1 Design

29.3.07P2 Gating system

Suggested Learning Resources
- Models
- Patterns

29.3.08 MELTING AND POURING

Theory

29.3.08T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain the process of melting various casting metals
b) describe various types of furnaces
c) describe various pouring techniques
d) outline melt additives
e) describe various temperature measuring instruments

33.3.08C *Competence*

The trainee should have the ability to:

i) Melt molten material and pour into a mould
   Measure furnace temperature

Content

29.3.08T1 Melting process
- Charging
- Heating

29.3.08T2 Types of melting furnaces
- Open hearth
- Crucible
- Cupola
- Electric
- Melting of ferrous and non ferrous metals

29.3.08T3 Pouring techniques
- Left hand pouring
- Right hand pouring
- Up pouring
- Bottom pouring
- Tea pot
- Melt additives
- Fluxes
- Alloying Elements

29.3.08T4 Melt additives

29.3.08T5 Pyrometers
- Thermocouple pyrometer
- Optical pyrometer
- Radiation pyrometer

Practice

29.3.08P0 *Specific Objectives*

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

a) identify correct charges for a given metal
b) light and operate melting furnaces
c) measure furnace temperature

Content

29.3.08P1 Melting process
- Charging
- Heating

29.3.08P2 Types of melting furnaces
- Open hearth
- Crucible
- Cupola
- Electric
- Melting of ferrous and non ferrous metals

29.3.08P3 Pyrometers
- Thermocouple pyrometer
- Optical pyrometer
- Radiation pyrometer

Suggested Learning Resources
- Model
- Furnace

29.3.09 CLEANING AND INSPECTION

Theory

29.3.09T0 *Specific Objectives*

	By the end of the sub-module unit, the trainee should be able to: a) identify various casting defects b) describe methods of inspection and testing castings c) explain various cleaning processes		**Practice**
29.3.09C	*Competence* The trainee should have the ability to: i) Identify casting defects Carry out tests and inspection on casting	29.3.09P0	*Specific Objectives* By the end of the sub-module unit, the trainee should be able to: a) perform non destructive test on a casting b) perform a visual examination to establish cast defect c) clean the casting of unwanted portions
	Content		*Content*
29.3.09T1	Casting defects - Slag inclusion - Shift - Cold shut and misrun o cleaning/fettling o knocking out of dry sand cores o removing gates and risers o removal of fins and unwanted projections o cleaning and smoothening of castings	29.3.09P1 29.3.09P2 29.3.09P3	Non destructive tests Visual Examination Cleaning and smoothening
			Suggested Learning Resources - Castings - Inspection tools - Cleaning tools
29.3.09T2	Testing and inspection - Visual inspection - Dimensional inspection	**29.3.10**	**DIE CASTING**
29.3.09T3	Cleaning processes		**Theory**
		29.3.10T0	*Specific Objectives* By the end of the sub-module unit, the trainee should be able to: a) outline the various types of die casting processes b) identify various types of die design

29.3.10C *Competence*
The trainee should have the ability to:
i) To produce a casting using die casting operation
ii) Design a die

Content

29.3.10T1 Types of die casting processes
- Gravity die casting process
- Pressure die casting
  - hot chamber
  - cold chamber

29.3.10T2 Types of die design
- Single impression die
- Multi impression die
- Combination die

Practice

29.3.10P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) operate die casting machines
b) design die for moulding a given casting

Content

29.3.10P1 Die casting machines
- Gravity die casting process
- Pressure die casting
  - hot chamber
  - cold chamber

29.3.10P2 Types of die design
- Single impression die
- Multi impression die
- Combination die

Suggested Learning Resources
- Charts

29.3.11 CENTRIFUGAL CASTING

Theory

29.3.11T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) describe the centrifugal casting process
b) explain various types of centrifugal casting process

29.3.11C *Competence*
The trainee should have the ability to produce a casting using centrifugal process

Content

29.3.11T2 Centrifugal casting process

29.3.11T3 Types of centrifugal casting
- True centrifugal casting
- Semi-centrifuging
- Centrifuging

Practice

29.3.11P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) identify the type of centrifugal casting machines
b) operate centrifugal casting machines

Content
29.3.11P1 Centrifugal casting process
29.3.11P2 Types of centrifugal casting
- True centrifugal casting
- Semi-centrifuging
- Centrifuging

Suggested Learning Resources
- Models
- Centrifugal casting machine

29.3.12 INVESTMENT CASTING

Theory

29.3.12T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) outline various processes in investment casting
b) design investment die
c) explain types of investment casting

29.3.12C *Competence*
The trainee should have the ability to design simple pattern for investment casting

Content
29.3.12T1 Investment process
29.3.12T2 Design of investment die
29.3.12T3 Types of investment casting
- Lost wax
- Mercast

Practice

29.3.12P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) prepare materials for investment casting
b) design investment die

Content
29.3.12P1 Investment casting process
- Types of investment casting
- Lost wax
- Mercast

Suggested Learning Resources
- Models

29.3.13	**SHELL MOULDING**	
	Theory	
29.3.13T0	*Specific Objectives* By the end of the sub-module unit, the trainee should be able to: a) Explain the process of shell moulding b) Describe equipment used in shell moulding c) Outline casting material for shell moulding	
29.3.13C	*Competence* The trainee should have the ability to produce a casting using shell moulding process	
	Content	
29.3.13T1	Process of shell moulding	
29.3.13T2	Equipment in shell moulding	
29.3.13T3	Material used in shell moulding	
	Practice	
29.3.13P0	*Specific Objectives* By the end of the sub-module, trainee should be able to: a) Prepare material for shell moulding b) Design a shell mould	
	Content	
29.3.13P1	Material for shell moulding - Process of shell moulding - Equipment in shell moulding - Material used in shell moulding	
29.3.13P2	Design	
	Suggested Learning Resources - Shell mould models - Tool and equipment for shell moulding	
29.3.13	**PLASTIC PROCESSING METHODS**	
	Theory	
29.3.13T0	*Specific Objectives:* By the end of the sub-module unit, the trainee should be able to: a) explain various types of plastics b) outline the types of plastics processing methods	
29.3.11C	*Competence* The trainee should have the ability to ability to produce plastic articles using	

	various plastic moulding processes	produce a component b) operate a given plastic processing plant
	*Content***s**	*Content***s**
29.3.13T1	Types of plastics - Thermosetting - Thermoplastics	29.3.13P1 Types of plastics - Thermosetting - Thermoplastics
29.3.13T2	Processing methods - Compression moulding - Transfer moulding - Injection moulding - Extrusion - Blow moulding - Calendering - Vacuum moulding	29.3.13P2 Processing methods - Compression moulding - Transfer moulding - Injection moulding - Extrusion - Blow moulding - Calendering - Vacuum moulding
	Practice	*Suggested /learning /resources* - Injection moulding machine - Assorted moulded products
29.3.13P0	*Specific Objective***s:** By the end of the sub-module unit, the trainee should be able to: a) select a given plastic material to	

30.3.0 ENGINEEERING MATHEMATICS III

30.3.1 Introduction

This module unit is designed with knowledge, skills, techniques and attitudes necessary to enhance the understanding other analytical areas of study in this course. The module unit will also be very useful to trainees who aspire to further their training in this course.

This module is a build up of Engineering Mathematics I and II of this course. Trainees undertaking this module unit require to have successfully completed Engineering Mathematics I and II of this course or its equivalent. Timed tests, assignment, end of Module examinations and any other suitable method are the recommended mode of evaluation for this Module unit.

30.3.2 General Objectives

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

a) apply mathematics concepts in fabrication design and data analysis
b) organize, draw simple deductions and conclusions from the given data
c) apply probability Mensurations in structural fabrication

30.3.3 Module Unit Summary and Time Allocation

ENGINEERING MATHEMATICS III

Code	Topic	Sub Topic	Time Hrs
30.3.01	Vector Field Theory	• Definition of dot and cross products of vectors • Solution of problems involving dot and cross products of vectors • Definition of operators • Definition of vector field • Solutions of problems involving F • Solutions of problems involving curl F • Definition of curl F	10
30.3.02	Matrices	• Matrix operation • Determinant of 3x3 matrix • Inverse of 3x3 matrix • Solution of linear simultaneous equations in 3 unknowns • Application of matrices	8
30.3.03	Numerical Methods	• Definition of interpolation and extrapolation • Application of interpolation and • Application of interactive methods to solve equations • Application of interactive methods to areas and volumes	6
30.3.04	Double And Triple Integrals	• Definition of double and triple integrals • Use of multiple integrals to	8

		find areas and volume • Consideration of double integrals in polar and cylindrical coordinates • Use of triple integrals in solving problems	
30.3.05	Differential Equations	• Types of first order differential equations • Formation of first order differential equations • Solutions of first order differential equations • Application of first order 8differential equations • Formation of the second order differential equations for various systems • Solution of second order differential equations • Application of second order differential equations	10
30.3.06	Laplace Transforms	• Definition of laplace transforms Deriving laplace transforms from first principles • State properties of laplace transform • Determination of inverse LT of simple transforms and partial fractions • Solution of differential equations by LT • Solution of simultaneous differential equations by given initial conditions	10
30.3.07	Fourier Series	• Determination of the fourier series as a periodic function of period 2 Π and extended to Π • Determination of fourier series of non-perodic functions over a given range • Determination of fourier	10

		series for even and odd functions and the half-range series for a given function	
30.3.08	Loci	• Definition of a point • Locus of a point in relation to a circle • Loci of points for given mechanism	4
Total Time			**66**

30.3.01 VECTOR FIELD THEORY

Theory

30.3.01T0 *Specific Objectives*
By the end of the sub-module unit, unit the trainee should be able to:

a) define dot and gross products of vectors
b) solve problems involving dot and cross products of vectors
c) define operators
d) define vector field f
e) define curl f
f) define div f
g) solve problems involving curl f
h) solve problems involving div F

30.3.01C *Competence*
The trainee should have the ability to apply knowledge of

vector field theory to engineering

Content

30.3.01T1 Definition of dot and cross products of vectors

30.3.01T2 Solution of problems involving dot and cross products of vectors

30.3.01T4 Definition of operators

30.3.01T5 Definition of vector field

30.3.01T6 Definition of curl F

30.3.01T7 Solutions of problems involving curl F

30.3.01T8 Solutions of problems involving F

30.3.02 MATRICES

Theory

30.3.02T0 *Specific Objectives*
By the end of the sub-module unit, unit the trainee should be able to:

a) carry out matrix operations
b) determine the determinant of a 3x3 matrix
c) determine the inverse of a 3x3 matrix
d) solve linear simultaneous equations in 3 unknowns
e) apply knowledge of matrices in solving problems in real life

30.3.02C *Competence*
The trainee should have the ability to apply knowledge of matrices to engineering

Content

30.3.01T1 Matrix operation

30.3.01T2 Determinant of 3x3 matrix

30.3.01T3 Inverse of 3x3 matrix

30.3.01T4 Solution of linear simultaneous equations in 3 unknowns

30.3.01T5 Application of matrices

Suggested Learning Resources

- Charts
- Square boards

30.3.03 NUMERICAL METHODS

Theory

30.3.03T0 *Specific Objectives*
By the end of the sub-module unit, unit the trainee should be able to:

a) define interpolation and extrapolation
b) apply interpolation extrapolation
c) apply interactive methods to solve problems

d) apply interactive methods to areas and volumes

30.3.03C *Competence*
The trainee should have the ability to apply knowledge of Numerical methods to engineering

Content

30.3.03T1 Definition of interpolation and extrapolation

30.3.03T2 Application of interpolation and extrapolation

30.3.03T3 Application of interactive methods to solve equations

30.3.03T4 Application of interactive methods to areas and volumes

Suggested Learning Resources
- Graphs
- Calculators

30.3.04 DOUBLE AND TRIPLE INTEGRALS

Theory

30.3.04T0 *Specific Objectives*
By the end of the topic, unit the trainee should be able to:
a) define double and triple integrals
b) use multiple integrals to find areas and volume
c) consider double integrals in polar and cylindrical coordinates
d) use triple integrals in solving problems

30.3.04C *Competence*
The trainee should have the ability to apply knowledge of integrals to engineering

Content

30.3.04T1 Definition of double and triple integrals

30.3.04T2 Use of multiple integrals to find areas and volume

30.3.04T3 Consideration of double integrals in polar and cylindrical coordinates

30.3.04T4 Use of triple integrals in solving problems

Suggested Learning Resources
- Calculators

30.3.05 DIFFERENTIAL EQUATIONS

Theory

30.3.05T0 *Specific Objectives*
By the end of the topic, unit the trainee should be able to:
a) distinguish different types of first order

	differential equations b) form first order differential equation c) solve first order differential equations d) apply first order differential equations e) form the second order differential equations f) solve second order differential equations g) apply second order differential equations in different systems	
30.3.05C	*Competence* The trainee should have the ability to apply knowledge of differential equations to engineering	
	Content	
30.3.05T1	Types of first order differential equations	
30.3.05T2	Formation of first order differential equations	
30.3.05T3	Solutions of first order differential equations	
30.3.05T4	Application of first order differential equations	
30.3.05T5	Formation of the second order differential equations for various systems	
30.3.05T6	Solution of second order differential equations	
30.3.05T7	Application of second order differential equations	
	Suggested Learning Resources - Calculators	
30.3.06	**LAPLACE TRANSFORMS**	
	Theory	
30.3.06T0	*Specific Objectives* By the end of the topic, unit the trainee should be able to: a) define the laplace transforms b) derive the transforms of simple functions c) state the properties of laplace transforms d) determine the inverse of lt of simple forms and partial fractions e) solve differential equation by lt f) solve simultaneous differential equations by LT given initial conditions	

30.3.06C *Competence*
The trainee should have the ability to apply Laplace transforms to engineering

Content

30.3.06T1 Definition of laplace transforms

30.3.06T2 Deriving laplace transforms from first principles

30.3.06T3 State properties of laplace transform

30.3.06T4 Determination of inverse LT of simple transforms and partial fractions

30.3.06T5 Solution of differential equations by LT

30.3.06T6 Solution of simultaneous differential equations by given initial conditions

Suggested Learning Resources

- Laplace tables

30.3.07 FOURIER SERIES

Theory

30.3.07T0 *Specific Objectives*
By the end of the topic, unit the trainee should be able to:

a) Determine the fourier series of a periodic function of period 2π and extended to π
b) Determine the fourier series for a non-periodic function of the range of 2π to π
c) Determine fourier series for even and odd functions and half-range series for a given function

30.3.07C *Competence*
The trainee should have the ability to apply fourier series to engineering

Content

30.3.07T1 Determination of the fourier series as a periodic function of period2π and extended to π

30.3.07T2 Determination of fourier series of non-perodic functions over given range

30.3.07T3 Determination of fourier series for even and odd functions and the half-range series for a given function

30.3.08 LOCI

Theory

30.3.08T0 *Specific Objectives*
By the end of the topic, unit the trainee should be able to:

	a) define the locus of a point b) determine the locus of a point in relation to a circle c) calculate loci of parts for given mechanisms		*Content* 30.3.08T1 Definition of a point 30.3.08T2 Locus of a point in relation to a circle 30.3.08T3 Loci of points for given mechanism
30.3.08C	**Competence** The trainee should have the ability to apply loci to engineering		*Suggested Learning Resources* - Charts - Scientific calculators

31.3.0 TRADE PROJECT

31.3.1 Introduction

This module unit is intended to equip the trainee with knowledge, skills and attitudes to enable him/her research, design, develop, produce a component and write a report on the project.

31.3.2 General Objectives

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

a) state the scope of the project
b) outline the design procedure and provide possible solutions to the task