education

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SUBJECT GUIDELINES

COMPUTER-INTEGRATED MANUFACTURING

NQF Level 4

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COMPUTER-INTEGRATED MANUFACTURING - LEVEL 4

CONTENTS

INTRODUCTION

A. What is Computer-Integrated Manufacturing about?

This subject covers the basics of practical experience and is designed to be an introduction to the technical field of work. It will equip the student with CNC machining skills for the maintenance of mechatronic systems in the computer aided manufacturing (CAD/CAM) industry. Workshop and fieldwork procedures that conform to safety regulations and safe working practices will be learned.

B. Why is Machine Manufacturing important in the Mechatronics learning programme?

This subject contains trade specific skills, knowledge, attitudes and values so that students learn how to maintain, repair and construct basic mechatronic systems in practice.

C. The link between Machine Manufacturing Learning Outcomes and the Critical and Developmental Outcomes

The application of this subject is OBE orientated and relates to the following critical and developmental outcomes:

- Identify and solve problems in which responses display that responsible decisions using critical and creative thinking have been made.
- Work effectively with others as a member of a team, group organization, community.
- Organise and manage oneself and one's activities responsibly and effectively.
- Collect, analyse, organise and critically evaluate information.
- Communicate effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation.
- Use science and technology effectively and critically, showing responsibility towards the environment and the health of others.
- Demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.
- Contribute to the full personal development of the student.

D. Factors that contribute to achieving Computer-Integrated Manufacturing Learning Outcomes

- An understanding of technical (electro-mechanical) principles
- Analytical ability
- Ability to do mathematical calculations and manipulations
- Hand-skills
- Practical improvisation abilities
- Read and interpret working drawings
- Programming skills

1 DURATION AND TUITION TIME

This is a one-year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided the student meets all the assessment requirements.

Students with special education needs (LSEN) must be catered for in a way that eliminates barriers to learning.

2 SUBJECT LEVEL FOCUS

- Identify and explain the function and operation of mechatronic systems and accessories.
- Program and operate CNC machines to manufacture a simple mechatronic component.
- Program and operate a robot system in a manufacturing system application.
- Modify a mechatronic system programme to meet specifications.
- Produce a CAD drawing of a simple component, interface it with a CNC machine and robot system to produce the component in a CAD/CAM application.

3 ASSESSMENT REQUIREMENTS

3.1 Internal assessment (50 percent)

3.1.1 Theoretical component

The theoretical component forms 40 percent of the internal assessment mark.

Internal assessment of the theoretical component in Computer-Integrated Manufacturing Level 4 takes the form of observation, class questions, group work, informal group competitions with rewards, individual discussions with students, class, topic and semester tests and internal examinations. Lecturers can observe students when marking exercises from the previous day and asking class questions.

Assignments, case studies and tests can be completed at the end of a topic. Tests and internal examinations must form part of the internal assessment.

3.1.2 Practical component

The practical component forms 60 percent of the internal assessment mark.

Practical components include applications and exercises. All practical components must be indicated in a Portfolio of Evidence (PoE).

Internal assessment of the practical component in Computer-Integrated Manufacturing Level 4 takes the form of assignments, practical exercises, case studies and practical examinations in a simulated business environment.

Students may complete practical exercises daily. Assignments and case studies can be completed at the end of a topic. Practical examinations can form part of internal practical assessment.

- **Some examples of practical assessments include, but are not limited to:**
  - Presentations (lectures, demonstrations, group discussions and activities, practical work, observation, role-play, independent activity, synthesis and evaluation)
  - Exhibitions by students
  - Visits undertaken by students based on a structured assignment task
  - Research
  - Task performance in a “Structured Environment”

- **Definition of the term "Structured Environment"**

For the purposes of assessment, "Structured Environment" refers to a simulated workplace or workshop environment. Activities in the simulated workplace or environment must be documented in a logbook with a clear listing of the competencies to be assessed. The following information must be contained in the logbook:

- Nature of department or environment in which practical component was achieved
- Learning Outcomes
- Activities in the environment with which to achieve the Learning Outcomes
- Time spent on activities
- Signature of facilitator or supervisor and student

For the logbook to be regarded as valid evidence, it must be signed by an officially assigned supervisor.

- **Evidence in practical assessments**

All evidence pertaining to evaluation of practical work must be reflected in the student's Portfolio of Evidence. The tools and instruments used for the purpose of conducting these assessments must be clear from the evidence contained in the PoE.

3.1.3 Processing of internal assessment mark for the year

A year mark out of 100 is calculated by adding the marks of the theoretical component and the practical component of the internal continuous assessment (ICASS).

3.1.4 Moderation of internal assessment mark

Internal assessment is subject to internal and external moderation procedures as set out in the *National Examinations Policy for FET College Programmes*.

3.2 External assessment (50 percent)

A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. A practical component will also be assessed.

External assessment details and procedures are set out in the *Assessment Guidelines: Computer-Integrated Manufacturing Level 4.*

4 WEIGHTED VALUES OF TOPICS

	TOPICS	WEIGHTED VALUE
1	Identify and explain the function and operation of mechatronic systems and accessories	15%
2	Program and operate CNC machines to manufacture a simple mechatronic component	30%
3	Program and operate a robot system in a manufacturing system application	30%
4	Modify a mechatronic system programme to meet specification	10%
5	Produce a CAD drawing of a simple component, interface it with a CNC machine and robot system to produce the component in a CAD/CAM application	15%
	TOTAL	**100**

5 CALCULATION OF FINAL MARK

Internal assessment mark: Student's mark/100 x 50 = a mark out of 50 (a)

Examination mark: Student's mark/100 x 50 = a mark out of 50 (b)

Final mark: **(a) + (b) = a mark out of 100**

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, reporting, moderation and verification purposes.

6 PASS REQUIREMENTS

A student must obtain at least fifty percent in internal continuous assessment and fifty percent in the examination in order to achieve a pass in this subject.

7 SUBJECT AND LEARNING OUTCOMES

On completion of Computer-Integrated Manufacturing Level 4, the student should have covered the following topics:

Topic 1: Identify and explain the function and operation of mechatronic systems and accessories
Topic 2: Program and operate CNC machines to manufacture a simple mechatronic component
Topic 3: Program and operate a robot system in a manufacturing system application
Topic 4: Modify a mechatronic system programme to meet specifications
Topic 5: Produce a CAD drawing of a simple component, interface it with a CNC machine and robot system to produce the component in a CAD/CAM application

7.1 Topic 1: Identify and explain the function and operation of mechatronic systems and accessories

7.1.1 Subject Outcome 1: Provide an overview of CNC machines
Range: Types: CNC lathe and milling machine.
Components: Chuck, light, guard, bed, vice, cutting tool, motor, the computer, software, interfacing.
Process visualisation systems.

Learning Outcomes:

The student should be able to:

- Identify
  - the parts that make up the CNC machine and the functions thereof
  - CNC machine safety and personal equipment requirements
  - CNC machine controls
  - CNC machine tools and accessories
  - physical safety factors
- Explain
  - the function of a CNC machine in industry
  - the CNC machine as a technical system
  - the operation of a CNC machine
  - and list the differences between a NC and CNC machine and a conventional machine
  - how interfacing is achieved between machine and computer
- Discuss the advantages and disadvantages of a CNC machine with respect to a conventional machine
- List the safety factors that must be considered before operation
- List some of the difficulties encountered when using a CNC machine

7.1.2 Subject Outcome 2: Provide an overview of robot systems

Learning Outcomes:

The student should be able to:

- Define a robot system
- Describe
  - degrees of freedom and robot axes
  - what is meant by the term “degrees of freedom”
  - what is meant by point to point programming
  - what is meant by a co-ordination system
  - what is meant by the term *Teach In*
  - various end effectors that are used on robot systems
- List
  - the main components that make up a robot system
  - the various applications for a robot system
- Select
  - the correct robot system to suit application.
  - the correct end effecter for application.

7.2 Topic 2: Program and operate CNC machines to manufacture a simple mechatronic component

7.2.1 Subject Outcome 1: Conduct Numerical Control programming

Range: CNC operations: Geometric and path instruction (straight line, circle, spline). Technology instructions (spindle speed, feed rate). Switching instructions (tool change, coolant, part change). Laws and principles: speeds, feeds, material properties, CNC machining principles, flow charts.

Learning Outcomes:

The student should be able to:

- Explain
  - the CNC programming methodology
  - and list the standard codes and formats
  - what is meant by tooling paths
  - what is meant by the common CNC operations
  - and utilise the fundamental underlying laws related to CNC Machines
  - relationships between CNC programme and final machined component
  - what is meant by programme sequencing
  - the importance of setting time limits
  - what is meant by co-ordination and XYZ
- Interpret drawing and documentation and define tool path geometry
- Calculate tool path co-ordinates
- Define programming elements
- Define machine code functions
- Write programme and operation sheet in required format for machine operation (speeds, feed, and depth of cut considered)
- Write a programme to produce a simple component that conforms to the correct format of machine using M and G codes

7.2.2 Subject Outcome 2: Operate a CNC machine

Range: Safety and operational procedures.

Learning Outcomes:

The student should be able to:

- List the
  - various CNC operations to produce CNC machined components
  - sequence of events to operate the CNC machine
  - safety requirements for safe operations
  - setting up and operation procedures
- Operate the CNC machine to produce a component safely using correct sequence of operations
- Adhere to related safety regulations (correct coolants, speeds and feed rate used)
- Set up time limits
- Write a programme in the required format

7.3 Topic 3: Programme and operate a robot system in a manufacturing system application

7.3.1 Subject Outcome 1: Conduct robot programming

Learning Outcomes:

The student should be able to:

- Describe
  - robot software
  - robot safety precautions
  - the function of the hand held programmer
- Set up industrial robots and manipulators
- Turn on the robot system
- Program the robot system to perform function

7.4 Topic 4: Modify a mechatronic system programme to meet specifications

7.4.1 Subject Outcome 1: Conduct mechatronic system programme conformance to specification

Learning Outcomes:

The student should be able to:

- Explain
  - the purpose of specification conformance
  - the implications of not meeting conformance
  - the purpose of tool conformance
- Edit and modify existing programme to meet conformance
- Produce documentation to meet conformance (machine accepts work piece without damage)

7.5 Topic 5: Produce a CAD drawing of a simple component, interface it with a CNC machine and robot system to produce the component in a CAD/CAM application

7.5.1 Subject Outcome 1: Set up a CAD/CAM/CNC/Robot mechatronic system

Learning Outcomes:

The student should be able to:

- Describe
  - the purpose of CAD/CAM in CNC manufacturing
  - the interfacing procedure between systems
- Identify and describe the function of the various system elements that make up a CAD/CAM system
- List
  - CAD/CAM applications in industry
  - the advantages and disadvantages of CAD/CAM applications
- Explain what is meant by a Distributed Control System (DCS) (SCADA)
- Set up a CAD/CAM system in a computer integrated manufacturing application

7.5.2 Subject Outcome 2: Produce a CAD engineering drawing and interface it

Learning Outcomes:

Range: Drawing types: Simple Mechanical

The student should be able to:

- Explain
  - the procedure to produce a CAD drawing
  - the purpose of CAD drawing symbols
  - how CAD/CAM interfacing can be achieved
- Use the tool box of a CAD application programme
- Produce
  - and modify a simple 2- and 3-D engineering drawing using CAD
  - a simple component drawing
- Interface the CAD system with that of CNC and robotic systems to produce a simple component

8 RESOURCE NEEDS FOR THE TEACHING OF COMPUTER-INTEGRATED MANUFACTURING - LEVEL 4

8.1 Physical resources

- **Infrastructure (building infrastructure, fixtures, networks)**

  Well equipped workshops are essential for this practically orientated subject. If possible, using the facilities of employers in the manufacturing field for training purposes is preferred.

  - Building to be appropriately designed for workshop types and/or laboratory type presentations that comply with building regulations and safety standards.
  - The tables below show broadly the laboratory and work area requirements, related training equipment for allocated students and the relevant facilitator training that may be required for the delivery of this vocational training:

	Mechatronics (Vocational Training)	
1	**ELECTRICAL INSTALLATION AND MACHINE LABORATORY**	for 20 learners
1a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	General	1
	Computer hardware	1
1b	**Electrical installation**	
	Safety and protection	2
	Industrial installation and control	2
1c	**Electrical Machines**	
	DC machines	2
	AC machines	2
	Three phase machines	2
	Fault simulator three phase machines	2
	Frequency drives (three-phase machines)	2
1d	**Commissioning and training**	
	Teacher training - electrical	1

2	**MOTION AND CONTROL LABORATORY**	
2a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	General	1
	Computer hardware	10
2b	**Pneumatics**	
	Basic pneumatics	5
	Advanced pneumatics	5
	Workstation pneumatics	2
	Software pneumatics	20
2c	**Electro-pneumatics**	
	Basic electro-pneumatics	5
	Advanced electro-pneumatics	5
	Measurement in pneumatics	2
	Workstation – electro-pneumatics	2
2d	**Hydraulics**	
	Basic hydraulics	5
	Workstation hydraulics	1
	Software hydraulics	20
2e	**Electro-Hydraulics**	
	Basic electro-hydraulics	2
	Advanced electro-hydraulics	2
	Workstation electro-hydraulics	1
2f	**Sensor Technology**	
	Proximity sensors	2
	Distance and displacement sensors	2
	Force and pressure sensors	2
	Workstation sensor technology	2
2g	**Basic and Advanced PLC**	
	Advanced PLC	2
2h	**Fieldbus and electric drives**	
	Fieldbus profibus-DP	2
	Electro-servo drives	2
	Electro-stepper drives	2
	Workstation fieldbus and drives	1
2i	**Commissioning and training**	
	Teacher training – Motion and control	1

3	**ELECTRONIC AND SOFTWARE LABORATORY**	
4a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	Computer hardware	20
3b	**Courses**	
	Desktop laboratory	20
	Electrical engineering	20
	Electronics	20
	Project work	20
3c	**Advanced Courses**	
	Digital Electronics	3
	Microcomputer	3
	Power electronics	3
	Electrical machines	3
	Communication technology	3
3d	**E-learning**	
	Electronics	3
	Mechatronics	20
3e	**Commissioning and Training**	
	Teacher training	1
4	**CNC AND CIM/ FMS LABORATORY**	
4a	**Classroom facilities**	
	Workplace	20
	General	20
	Computer hardware	1
4b	**CNC Manufacturing**	
	CNC turning	1
	CNC milling	1
	CNC trainers and CAD/ CAM	1
4c	**FMS production modules**	
	FMS pallet transport	1
	FMS material input	1
	FMS material output	1
	FMS processing	1
	FMS processing	1
	FMS assembly	1
	FMS automated warehouse	1
	FMS quality assurance	1
	FMS control	1
	FMS programming	1

4d	**Commissioning and training**	
	Teacher training – CIM/FMS	1
5	**COMPUTER LABORATORY**	
5a	**Classroom facilities**	
	Workstations	20
	Computer hardware	20
	Software (Microsoft Office)	20
	Internet access	20
6	**CENTRAL TOOL STORE**	
7	**ABLUTIONS**	

8.2 Equipment and machinery

The equipment as indicated above is the suggested minimum although other equipment can be used to obtain the same outcomes. Access by the student and lecturer to the above listed equipment and machinery is essential. Machinery and laboratory equipment as listed above is essential in the delivery of vocational training for Mechatronics.

8.3 Human resources

- The minimum qualification requirements for educators who deal with the learning and teaching of this subject will be qualification as a mechatronic mechanician/ technician/ technologist, or in one or more of the following sub-fields: electrician, electrician (signals), millwright, IT specialist, etc.
- Lecturers should ideally be qualified as educators capable of teaching up to NQF level 6 at least. They should be creative and have a sound knowledge of learner centred education.
- It is essential that educators working in this environment attend seminars and upgrading workshops regularly in order to be updated and re-skilled in respect of the latest developments in technology.
- The recommended number of students for workshop practice is 20.

8.4 Financial resources

The institution should make provision for workshop practice consumables during practical training, maintenance of physical resources, purchasing of new equipment and finance to hire external providers.