NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

STORED PROGRAMME SYSTEMS

NQF Level 3

April 2008

STORED PROGRAMME SYSTEMS - LEVEL 3

CONTENTS

INTRODUCTION

A. What is Stored Programme Systems?

This subject covers the basics of connection of industrial standard stored program systems (SPS), solving PLC control problems, and is designed to be an introduction to the use of programmable logic controls in the automation of production of relevant documents used in the technical field. It will equip the student with fundamental information and technology related operational skills to use and maintain stored program systems and equipment, to use analytical and hand skills to program various control applications and make problem solving decisions in the maintenance of the mechatronic manufacturing arena.

B. Why is Stored Programme Systems important in the Mechatronics programme?

This subject contains enough trade specific skills, knowledge, attitudes and values to equip learners sufficiently to enable them to assist in maintenance, repair and installation of basic stored programme mechatronic systems in practice.

C. The link between the Learning Outcomes for Stored Programe Systems 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 Stored Programme Systems Learning Outcomes

- An understanding of the PC being an essential part of future mechatronic systems
- Ability to connect and troubleshoot on a PC
- Ability to use the computer to gather, process and communicate information
- Analytical ability
- Ability to do mathematical calculations and manipulations
- Hand-skills (specifically assembly work)
- Practical improvisation abilities.

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

- Describe stored programme systems used in automation control
- Select, apply and adjust sensor technology in industrial control applications
- Identify, select and install related PLC elements in accordance with safety regulations
- Create, test, debug and up/download PLC source control programmes to an industrial system
- Maintain and commission PLC stored programme industrial control systems.

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 Stored Programme Systems Level 3 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 Stored Programme Systems Level 3 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 part of 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. The practical component will also be assessed.

External assessment details and procedures are set out in the *Assessment Guidelines: Stored Programme Systems Level 3.*

4 WEIGHTED VALUES OF TOPICS

	TOPICS	WEIGHTED VALUE
1	Describe stored programme systems used in automation control	15%
2	Select, apply and adjust sensor technology in industrial control applications	20%
3	Identify, select and install related PLC elements in accordance with related safety regulations	20%
4	Create, test, debug and up/ download PLC source control programmes to an industrial system	30%
5	Maintain and commission PLC stored programme industrial control systems	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 to achieve a pass in this subject.

7 SUBJECT AND LEARNING OUTCOMES

On completion of Stored Programme Systems Level 3, the student should have covered the following topics:

Topic 1: Describe stored programme systems used in automation control
Topic 2: Select, apply and adjust sensor technology in industrial control applications
Topic 3: Identify, select and install related PLC elements in accordance with safety regulations
Topic 4: Create, test, debug and up/download PLC source control programmes to an industrial system
Topic 5: Maintain and commission PLC stored programme industrial control systems

7.1 Topic 1: Describe stored programme systems used in automation control

7.1.1 Subject Outcome 1: Explain stored programme systems

Range: SPS types: PLC systems (automation, processing); Robotic systems; SCADA systems; Intelligent Devices (controllers, micro-processors)

Learning Outcomes:
The student should be able to:

- Explain
  - what stored program systems are.
  - the make-up and function of the various stored program devices.
  - the applications of stored program devices.
  - the function of a Human- Machine-Interface System such as keypad controls, monitors, displays and supervisory-control and data acquisition (SCADA) systems employed in a manufacturing system.
- Describe the differences between industrial automation and process control
- Identify and explain the purpose of the various elements that make up a stored program system

7.1.2 Subject Outcome 2: Explain and apply PLC Technology

Range: Design elements: Input devices, processing devices and output devices (central control unit, memory, input module, output memory, programming device, software, programming languages. Fundamentals: Decimal system, binary system, BDC code, hexa-decimal, signed binary numbers, real numbers, binary and digital signal generation. Boolean operations: Basic logic functions, Further logic functions, Establishing switching functions, simplification of logic functions, Karnaugh diagrams, switching algebra systems; SCADA systems; Intelligent Devices (controllers, micro-processors).

Learning Outcomes:

The student should be able to:

- List and describe
  - the fundamental design elements of the PLC system.
  - the purpose and function of the PLC elements.
- Describe
  - basic fundamental operations of memory elements.
  - Boolean operations.
- Explain
  - the difference between binary, analogue and digital signals.
  - what is meant by output devices
  - what is meant by signal conditioning.
  - and draw basic logic switching operations using switches and electro-magnetic switches.
  - what is meant by scan rate in a PLC system.
  - the fundamental principles of A/D and D/A convertors.

- List
  - the various PLC programming languages.
  - the various control applications employing a PLC.
  - the various input devices.
  - the various actuator devices.
  - the final drive devices.
- Identify, name and explain function of PLC design elements.
- Perform fundamental number system conversions.
- Perform Boolean operations.
- Apply switching algebra to solve problems.

7.2 Topic 2: Select, apply and adjust sensor technology in industrial control applications

7.2.1 Subject Outcome 1: Describe sensor technology - proximity sensors

Range: Sensor types: Magnetic (contact, contactless), inductive, optical (through beam, retro-reflective, diffused), capacitive, ultrasonic. Characteristics: Switching distance, material type influences, material thickness influences, response characteristics, signal types. Applications: Speed measurement, rotational speed, work-piece assembly, liquid level measurement, checking of threads, position detection

Learning Outcomes:

- Explain
  - what sensors are.
  - the importance of sensors as used in control applications.
  - the characteristics of the various sensor types.
- Name and draw the electrical symbols as used for the various proximity sensor types.
- Describe
  - various applications of the proximity sensor types.
  - the operating voltages and the related control signal types.
- Identify, select and adjust proximity sensors to perform function in a control application.

7.2.2 Subject Outcome 2: Describe sensor technology - distance and displacement

Range: Sensor types: Analogue inductive sensor, linear potentiometer, ultrasonic, optical. Characteristics: Voltage measurement, range and conductivity, sound propagation, photo-electric, capacitive, response curves, signal types. Applications: Position detection, measuring by means of deflection, determine eccentricity of a rotating disc, position detection of a spindle

Learning Outcomes:

The student should be able to:

- Explain
  - what sensors are.
  - the importance of sensors as used in control applications for distance and displacement.
  - the characteristics of the various sensor types.
- Name and draw the related electrical symbols as used for the various displacement and distance sensor types.
- Describe
  - various applications of the sensor types.
  - the operating voltages and the related control signal types.
- Identify, select and adjust distance and displacement sensor to perform function in a control application.

7.2.3 Subject Outcome 3: Describe sensor technology - force and pressure

Range: Sensor types: Force measurement-Strain gauges, measuring bridge amplifier, Pressure measurement- analogue pressure sensor, mechanical pressure switch, electronic pressure switch. Characteristics: Force, counter force elastic and plastic deformation, force measuring, pressure, torque, acceleration.

Learning Outcomes:

The student should be able to:

- Explain
  - what sensors are.
  - the importance of sensors as used in control applications for force and pressure.
  - the characteristics of the various sensor types.
- Name and draw the related electrical symbols as used for the various force and pressure sensor types.
- Describe
  - various applications of the sensor types.
  - the operating voltages and the related control signal types
  - signal and energy transmission
- Identify, select and adjust force and pressure sensors to perform function in a control application.

7.3 Topic 3: Identify, select and install related PLC elements in accordance with safety regulations

7.3.1 Subject Outcome 1: Install a PLC system in accordance with instruction, perception drawing and wiring diagram

Range: Design procedure: Description of control task (verbal, written, perception drawing), analyse to produce installation/ process, plan the installation, draw the electrical wiring diagram, assembly of the installation PLC program, draw up a solution - functional table, logic control, sequence control system, realisation of the solution.

Learning Outcomes:

The student should be able to:

- Design the procedure to determine electrical wiring diagram and related PLC control program.
- Explain the procedure for safely installing PLC related elements.
- List the elements that make the PLC installation safe.
- Identify and select the correct PLC equipment elements to ensure that PLC function is in accordance with task instruction.
- Install PLC elements in accordance to relevant safety procedures.
- Test installation for correctness.

7.4 Topic 4: Create, test, debug and up/download PLC source control programmes to an industrial system

7.4.1 Subject Outcome 1: Analyse the control instruction to produce a PLC control programme

Range: Control instructions: not limited to AND/NOT/OR control, branching, timer-sequence starting, conveyor belt control, counting control, sorting/checking/measuring, safety circuit). PLC terminology: configuration of a PLC, line number, operand, address, scan rate, program element, program line, debugging. Programming languages: (LD, FBD, IL, ST, SFC)

Learning Outcomes

- Explain
  - the procedure to analyse the task control instruction.
  - the fundamental differences between the PLC programming languages.
  - what is meant by related PLC terminology.
  - what is meant by simulating a program.
  - what is meant by transferring a program.
  - what is meant by functional check of a control system.

- List
  - the documentation that would be produced when designing a control program and explain the importance thereof.
  - the advantages and disadvantages of using PLC.
- Compare hardwired and software programming.
- Produce a source program in accordance with functional requirements in one LD or SL.
- Debug the control program.
- Simulate the source program.
- Produce the necessary design documentation.

7.5 Topic 5: Maintain and commission PLC stored programme industrial control systems

7.5.1 Subject Outcome 1: Commission faults in PLC systems

Range: Hardware faults: Incorrect input/output circuits; Input voltage type at input; Incorrect supply voltage or not available; No transmission between programming terminal and PLC- no interface cable; Wiring between PLC and actuators/sensors because mechanical damage to cables; Insulation stripped; Incorrect assembly/ not fastened properly. Software faults: Program created problem; Program input fault; Program transmission fault. Troubleshooting tools: Program flow charts; Sequential function chart; Function chart; Circuit diagrams with the PLC.

Learning Outcomes:

The student should be able to:

- List and explain
  - possible hardware faults in programmable logic controllers.
  - possible software faults in programmable logic controllers.
  - the various tools that can assist in troubleshooting programming faults.
- Apply various troubleshooting tools to perform commissioning of PLC application control programs.

8 RESOURCE NEEDS FOR THE TEACHING OF STORED PROGRAMME SYSTEMS - LEVEL 3

8.1 Physical resources

- **Infrastructure (building infrastructure, fixtures, networks)**
  - 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 lab/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	**MECHANICAL FUNDAMENTALS LAB/WORKSHOP**	for 20 learners
1a	**Classroom Facilities**	
	Workplaces	20
	Teaching	20
	General facilities	20
1b	**Hand Tools**	
	Workbenches, double	10
	Technical drawing	20
	Basic handtools	20
	Safety and house keeping	20
	Measurement and marking	10
	Sheet metal work	10
1c	**Power Tools**	
	Work benches, double	10
	Cutting and forming	10
	Drilling and tapping	10
	Welding and joining	10
	Electrical soldering	10
1d	**Machining**	
	Drilling	1
	Turning	1
	Milling	1
1e	**Training of facilitator**	
	Mechanical	1
2	**ELECTRICAL INSTALLATION AND MACHINE LAB**	
2a	**Electrical installation**	
	Safety and protection	2
	Industrial installation and control	2
	Domestic circuit installation and testing	2

2b	**Electrical Machines**	
	DC machines	2
	AC machines	2
2c	**Commissioning and training**	
	Teacher training - electrical	1
3	**MOTION AND CONTROL LAB**	
3a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	General	1
	Computer hardware	10
3b	**Pneumatics**	
	Advanced pneumatics	5
	Workstation pneumatics	2
	Software pneumatics	20
3c	**Electro-pneumatics**	
	Basic electro-pneumatics	5
	Advanced electro-pneumatics	5
	Measurement in pneumatics	2
	Workstation – electro-pneumatics	2
3d	**Hydraulics**	
	Basic hydraulics	5
	Workstation hydraulics	1
	Software hydraulics	20
3e	**Electro-Hydraulics**	
	Basic electro-hydraulics	2
	Advanced electro-hydraulics	2
	Workstation electro-hydraulics	1
3f	**Sensor Technology**	
	Proximity sensors	2
	Distance and displacement sensors	2
	Force and pressure sensors	2
	Workstation sensor technology	2
3f	**Basic and Advanced PLC**	
	Basic PLC	10
	Advanced PLC	2

3g	**Fieldbus and electric drives**	
	Fieldbus profibus-DP	2
	Electro-servo drives	2
	Electro-stepper drives	2
3h	**Commissioning and training**	
	Teacher training – Motion and control	1
4	**ELECTRONIC AND SOFTWARE LAB**	
4a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	Computer hardware	20
4b	**Courses**	
	Desktop laboratory	20
	Electrical engineering	20
	Electronics	20
	Project work	20
4c	**Advanced Courses**	
	Digital Electronics	3
	Microcomputer	3
	Power Electronics	3
	Electrical Machines	3
	Communication Technology	3
4d	**E-learning**	
	Electronics	3
	Mechatronics	20
4e	**Commissioning and Training**	
	Teacher training	1
5	**CNC AND CIM/ FMS LABORATORY**	
5a	**Classroom facilities**	
	Workplace	20
	General	20
	Computer hardware	1
5b	**CNC Manufacturing**	
	CNC trainers and CAD/ CAM	1
6	**COMPUTER LABORATORY**	
6a	**Classroom facilities**	
	Workstations	20
	Computer hardware	20
	Software (Microsoft Office)	20
	Internet access	20

7	**CENTRAL TOOL STORE**
8	**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.