education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

MECHATRONIC SYSTEMS

NQF Level 2

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MECHATRONIC SYSTEMS - LEVEL 2

CONTENTS

INTRODUCTION

A. What is Mechatronic Systems?

This subject covers the basics of practical analytical experience and is designed to be an introduction to the analysis of mechatronic systems in the technical field. It will equip the student with fundamental analytical skills to determine operational functions of equipment, machines and design, producing skills for maintaining the manufacturing industry equipment and related fields.

B. Why is Mechatronic 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 mechatronic systems in practice.

C. The link between the Learning Outcomes for Mechatronic 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 learner.

D. Factors that contribute to achieving Mechatronic Systems Learning Outcomes

- Understanding of energy flow, signal flow, block diagrams, manuals, system parameters and requirements profile.
- 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

- Analyse and apply basic technical systems
- Analyse and connect basic control circuits for technical systems
- Analyse and connect basic pneumatic technical systems
- Analyse and connect basic electro-pneumatic hybrid control systems
- Apply troubleshooting techniques to electro-pneumatic 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 Mechatronic Systems Level 2 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 Mechatronic Systems Level 2 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: Mechatronic Systems Level 2.*

4 WEIGHTED VALUES OF TOPICS

	TOPICS	WEIGHTED VALUE
1	Analyse and apply basic technical systems.	20%
2	Analyse and connect basic control circuits for technical systems.	20%
3	Analyse and connect basic pneumatic technical systems.	20%
4	Analyse and connect basic electro-pneumatic hybrid control systems.	20%
5	Apply troubleshooting techniques on electro-pneumatic control systems.	20%
	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 Mechatronic Systems Level 2, the student should have covered the following topics:

Topic 1: Analyse and apply basic technical systems
Topic 2: Analyse and connect basic control circuits for technical systems
Topic 3: Analyse and connect basic pneumatic technical systems
Topic 4: Analyse and connect basic electro-pneumatic hybrid control systems
Topic 5: Apply troubleshooting techniques on electro-pneumatic control systems

7.1 Topic 1: Analyse and apply basic technical systems.

7.1.1 Subject Outcome 1: Define, analyse and apply technical systems (energy, information and matter).

Range: Energy types: Relationships between kinetic, potential, electrical, chemical, mechanical, thermal and nuclear energy types.

Range: Coupling types: Electro-technical, electro-mechanical, mechanical.

Range: Process types and matter as used in the manufacturing industry.

Range: Technical systems: Simple torch, hand held fan, hand held vacuum, portable hand held, automatic kettle, electrical toaster, automatic iron, drill machine, pedestal press drill, welding machine, gas welder, conveyor belt system, pneumatic compressor, battery charger, hydraulic pump.

Learning Outcomes:
The student should be able to:

- Explain
  - what a technical system is with reference to energy, information and matter flow (input, process and output).
  - the principle of energy conversion.
  - the process stages to convert different energy types into electrical energy and vice versa.
  - the fundamental composition of a mechatronic technical system.
- Describe
  - different energy types.
  - various basic coupling systems that may be found in a technical system.
  - the types of information that can be found in technical systems.
  - the purpose and colour of information lamps on technical systems.
  - the types of matter and related processes that can be found in technical systems.
- Demonstrate an ability to apply understanding to the analysis of basic technical systems in accordance with energy conversion, information and matter flow using block diagrams.
- Apply mathematics to determine speed with respect to gear trains and belt drives.

7.1.2 Subject Outcome 2: Define, analyse and apply technical systems (simple-, component-, sub-systems and complex systems)

Range: Simple technical systems: Torch, hand held fan, hand held drill, toaster, automatic kettle, pneumatic compressor etc.

Range: Hybrid technical systems: Electrical–pneumatic; Electrical-hydraulic; Electrical–processor; *Electrical–pneumatic–processor.*

Applications can include: Packaging, feeding, metering, door/chute control, transfer of materials, turning/inverting parts, sorting of parts, stacking of components, stamping, embossing components.

Learning Outcomes:

The student should be able to:

- Explain
  - the differences between a component, a simple system, a sub-system and a complex system.

  - why it is necessary to be able to break down a simple technical system into component level or sub-system level.
  - how to break down and analyse a simple technical system into component lists, functional block diagrams and energy flow diagrams.
  - what is meant by hybrid technical systems.
  - what computer integrated manufacturing is, in relation to flexible manufacturing systems.
- List and explain general application of technical systems in industry.
- Demonstrate the ability to break down a technical system to component level sub-system level so as to determine component lists, function and operation thereof.

7.2 Topic 2: Analyse and connect basic control circuits for technical systems.

7.2.1 Subject Outcome 1: Explain and demonstrate fundamentals of basic control.

Range: Open Loop Control: Discontinuous (electric automatic kettle, electric pop-up toaster). Continuous (automatic iron, electric oven, electric geyser system) or any other related systems.

Range: Relay logic control circuits: AND, OR, NOT, latching, simple control using timers, counters, input sensors, actuators, final drives, input devices

Range: Input devices: (pushbuttons (NO.NC), limit switches, float switches, thermostat, inductive proximity switch, capacitive proximity switch.

Range: Output devices: Indication lamps, actuators (relays, contactors, solenoid valves), final drives (electrical, pneumatic and hydraulic).

Learning Outcomes:

The student should be able to:

- Explain what is meant by
  - remote control.
  - automatic systems.
  - a main and control system.
  - an open loop control system.
  - a closed loop control system.
  - a control signal.
- Explain
  - the relationship between input, process and output in a control system.
  - the differences between an open loop continuous and discontinuous system.
  - relay logic control for simple applications.
  - technical control systems in relation to input, process, output.
- Identify
  - control components and explain their function.
  - and make minor adjustments to sensors for function.
  - and describe fundamental operation and use of control and switching elements.
- Describe the construction, symbols, terminal markings and specifications of fundamental control and switching elements.
- Demonstrate the ability to read and interpret relay logic control diagrams for construction purposes.
- Connect control circuit for analysis.
- Ensure all connections are made in accordance with regulations.

7.2.2 Subject Outcome 2: Explain and demonstrate the role of computers in industry.

Range: Intelligent devices (programmable sensors, robots, speed controllers); Programmable Logic Controllers (stand alone units, modular units); circuit diagrams (simple PLC electrical switching circuit connections).

Learning Outcomes:

The student should be able to:

- Describe what a flexible manufacturing system (FMS) is.
- Explain
  - advantages and disadvantages of computers being used in industry.
  - what is meant by a CAD system.
  - what is meant by a CAM/CIM system.
  - what is meant by an intelligent device in a technical system.
  - the construction and function of a programmable logic controller (PLC).
  - what is meant by a safety circuit.
- Identify, select and connect PLC control circuit elements from a circuit diagram.
- Ensure that connections are made in accordance with regulation.

7.3 Topic 3: Analyse and connect basic pneumatic technical systems.

7.3.1 Subject Outcome 1: Describe and apply pneumatic technology.

Range: Choice of working media: Electrics, hydraulics, pneumatics and/or a combination thereof.

Range: Working criteria selection: Force, stroke, type of motion, speed, size, service life, sensitivity, safety and reliability, energy costs, controllability, handling, storage.

Range: Choice of control media: Mechanical, electrical, electronic, pneumatic (low/high pressure), hydraulic.

Range: Selection criteria for control section: Reliability, sensitivity, ease of maintenance and repair, switching time, signal speed, space requirements, service life.

Range: System component: Actuating devices (pneumatic cylinders, rotary motors, indicators).

Range: Final control elements: direction control valves.

Range: Processing elements: directional control valves, logic elements, pressure control valves.

Range: Input elements: Sensors: directional control valves, limit switches, pushbuttons, proximity switches.

Range: Air supply system components: (air service unit – air filter, regulator, lubricator); directional control valves (signalling elements, processing elements, power, elements); non-return valves, flow control valves, pressure control valves, combinational valves.

Learning Outcomes:

The student should be able to:

- Define
  - what is meant by the term pneumatics.
  - and describe the terms preparation, compressibility, force requirements, noise levels and costs.
- State the four functions of compressed air applications (status of processes, information processing, switching final control elements, performing work function).
- List and explain
  - the three types of motion that can be performed by pneumatic components (linear, swivel and rotary).
  - general methods of material handling (clamping, shifting, positioning and orientation).
  - the factors that must be considered when selecting pneumatic technical systems (work/output requirements, preferred control methods, resource requirements, new/integrated into old system.
  - the operation of basic pneumatic system components.
- Explain the air generation and distribution in a pneumatic system (quality of air and possible malfunctions).
- Identify
  - and explain the function of components that make up the air supply system.
  - components that make up a pneumatic technical sub-system and draw up a materials list.

- Connect pneumatic components in accordance to a given circuit diagram.
- Connect flow lines in accordance to regulation.
- Use connecting elements, friction, clamping and crimping types.

7.3.2 Subject Outcome 2: Identify and apply pneumatic component symbols.

Range: Characteristics (function, actuation methods, connection number, switching positions, general operating principles, simplified flow representation); Non–characteristics (size, dimension of component, orientation of ports, physical details of elements, any connections)

Learning Outcomes:

The student should be able to:

- Draw and describe the symbol characteristics as used in pneumatic diagrams.
- List the information that is not represented by the symbols.
- Read and interpret pneumatic symbols for basic function purposes and connection.

7.3.3 Subject Outcome 3: Connect basic pneumatic manual control systems.

Range: Basic pneumatic design and connectivity tasks. Direct control, indirect control, logic AND, OR functions.

Learning Outcomes:

The student should be able to:

- Explain design procedure to determine task function (control problem analysis, solution design, implementation, evaluation and maintenance).
- Design and connect pneumatic task function.

7.4 Topic 4: Analyse and connect basic electro-pneumatic hybrid control systems.

7.4.1 Subject Outcome 1: Explain and demonstrate electro-pneumatic technology.

Range: Basic electrics, pneumatics and combinations thereof. Symbology and equipment (switches, indication lamps, timers, counters and sensors, power supplies), circuit diagrams (pneumatic and electrical, schematic, system, connection, internal wiring, assembly, layout), identification letters of parts and devices.

Learning Outcomes

The student should be able to:

- Explain
  - why electricity is used for the control signal for remote control applications.
  - how identification letters are used in electro-pneumatics applications.
  - what is meant by a delay on and/or delay off timer.
  - the purpose of using a step diagram in the design of an electro-pneumatic control circuit.
- List and explain
  - the fundamental principles used in electro-pneumatics.
  - the fundamental operation of parts and equipment used in electro pneumatics.
- Identify
  - and explain the different drawings used and their purposes.
  - applications in industry and explain why electro-pneumatics are used.
  - different electro-pneumatic circuit diagrams.
  - identify various electro- pneumatic parts.
- Describe application circuits that employ timers and counters in their control circuit.
- Redraw various electro-pneumatics circuit symbology.
- Use a step diagram to develop an electro-pneumatic control circuit.

7.4.2 Subject Outcome 2: Explain and perform electro-pneumatic co-ordinated motion control.

Range: Motion control (direct control, impulse valve, indirect control, self-holding circuits, alternating controls, logic functions).

Learning Outcomes:

The student should be able to:

- Explain
  - what is meant by the term “motion control”.
  - the various motion control types encountered in electro-pneumatics.
  - with the aid of a sketch what is meant by sequential timer and cascaded timer circuits.
  - the purpose and importance of sensors used in electro-pneumatic control.
  - how electric – pneumatic conversion control is achieved.
- List applications where
  - counters are used in electro-pneumatic control.
  - timers are used in electro-pneumatic control.
- Read and interpret electro-pneumatic symbols for basic function purposes and connection.
- Design and implement fundamental electro-pneumatic circuit diagrams using step diagrams.
- Perform fault finding on electro-pneumatic control circuits.

7.5 Topic 5: Apply troubleshooting techniques on electro-pneumatic control systems.

7.5.1 Subject Outcome 1: Apply trouble shooting electro-pneumatic sub-systems.

Range: drive section, energy control section, tubes and pipes, service unit, energy supply section.

Techniques: program flowchart, sequential function chart, function chart, circuit diagrams, measuring techniques, diagnostic programs, fault tree analysis.

Learning Outcomes:

The student should be able to:

- List common faults that
  - can normally occur in a drive section (cylinders and motors).
  - can occur in energy control, energy supply, tubes and pipes, service unit and electrical control sections.
- Safely eliminate faults in an electro pneumatic system.

8 RESOURCE NEEDS FOR THE TEACHING OF MECHATRONIC SYSTEMS - LEVEL 2.

8.1 Physical resources

	Mechatronics (Vocational Training) Level 2	
1	**MECHANICAL FUNDAMENTALS LAB/WORKSHOP**	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
1c	**Materials testing**	
	Material testing	1
2	**ELECTRICAL INSTALLATION AND MACHINE LAB**	
2a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	General	1
	Computer hardware	1
2b	**Electrical installation**	
	Safety and protection	2
	Industrial installation and control	2
	Domestic circuit installation and testing	2
2c	**Electrical Machines**	
	Transformers	2

3	**MOTION AND CONTROL LAB**	
3a	**Classroom Facilities**	
	Workplace	20
	Teaching	20
	General	1
	Computer hardware	10
3b	**Pneumatics**	
	Basic pneumatics	5
	Workstation pneumatics	2
	Software pneumatics	20
3c	**Electro-pneumatics**	
	Basic electro-pneumatics	5
	Workstation – electro-pneumatics	2
3d	**Hydraulics**	
3e	**Sensor Technology**	
	Proximity sensors	2
	Distance & displacement sensors	2
	Force and pressure sensors	2
	Workstation sensor technology	2
3f	**Basic and Advanced PLC**	
	Basic PLC	7
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
	Communication technology	3
4d	**E-learning**	
	Electronics	3
	Mechatronics	12

6	**COMPUTER LABORATORY**	
6a	**Classroom facilities**	
	Workstations	20
	Computer hardware	20
	Software (Microsoft office)	20
	Internet access	20

8.2 Equipment and machinery

The Mechatronic equipment as indicated above is the suggested minimum and other equipment can be used to obtain the same outcomes. Access by the learner and facilitator 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 Stationery

Files for Portfolio of Evidence and assessments, notes and learner materials are required.

8.4 Human resources

The lecturer should ideally be a registered educator on post level 1 or higher at an FET Institution, having relevant experience. The person needs to be an electrician or millwright having additional training or knowledge and experience in pneumatics, hydraulics, electro-pneumatics/hydraulics, A+, PLCs, industrial networking, field bus systems, robotics.

8.5 Financial resources

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