education

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NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

MECHATRONIC SYSTEMS

NQF Level 3

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MECHATRONIC SYSTEMS - LEVEL 3

CONTENTS

INTRODUCTION

A. What is Mechatronic Systems?

This subject covers the basics of practical analytical experience and is designed to develop students' analytical skills with respect to mechatronic sub-systems in control applications in the technical field. It will equip the student with analytical skills to understand operational functions of equipment, machines and design, producing skills for maintaining equipment related to the manufacturing industry.

B. Why is Mechatronic Systems important in the Mechatronics programme?

This subject contains trade specific skills, knowledge, attitudes and values to equip learners sufficiently to be able to assist in maintenance, repair and installation of mechatronic sub-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

- An 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 electronics as a form of control in mechatronic sub-systems.
- Analyse and connect electric drives as used in control technology.
- Analyse and connect basic hydraulic technical systems.
- Analyse and connect electro-hydraulic control systems.
- Apply trouble shooting techniques on electro-hydraulic 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 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 Mechatronic 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: Mechatronic Systems Level 3.*

4 WEIGHTED VALUES OF TOPICS

TOPICS	WEIGHTED VALUE
1 Analyse electronics as a form of control in mechatronic sub-systems	20%
2 Analyse and connect electric drives as used in control technology	20%
3 Analyse and connect basic hydraulic technical systems	20%
4 Analyse and connect electro-hydraulic control systems	20%
5 Apply trouble shooting techniques on electro-hydraulic 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 3, the student should have covered the following topics:

Topic 1: Analyse electronics as a form of control in mechatronic sub-systems
Topic 2: Analyse and connect electric drives as used in control technology
Topic 3: Analyse and connect basic hydraulic technical systems
Topic 4: Analyse and connect electro-hydraulic control systems
Topic 5: Apply trouble shooting techniques on electro-hydraulic control systems

7.1 Topic 1: Analyse electronics as a form of control in mechatronic sub-systems

7.1.1 Subject Outcome 1: Describe and apply electronic control technology

Range: Analogue, digital and microprocessor. Circuits: P, D and I control using op-amps, Linear resistive control, multi-vibrator control (A, BI and A stable). Timer/Counter using electronic circuits. Speed control, position control, thyristor control, phase control, cyclotronic control, RC servo control, PC control, choppers (flow, pressure, measurement, level, etc).

Learning Outcomes:

The student should be able to:

- List and explain
  - the differences between analogue, digital and microprocessor electronics.
  - basic operation of electronic control circuits using block diagrams and/or at component circuit level.
- Explain
  - how electronic control technology is used in mechatronic systems (temperature, pressure, level, flow measurement, final control, tele-metering, kinetic control).
  - what is meant by the terms positioning control, servo-mechanism, system response, dampening, overshoot, offset, reset, stabilising, feedback.
- Identify and select appropriate electronic control circuits to achieve function.
- Construct fundamental electronic control circuits.
- Test input and output of electronic control circuits to determine operation (black box approach) when troubleshooting.

7.2 Topic 2: Analyse and connect electric drives as used in control technology

7.2.1 Subject Outcome 1: Describe and apply electric drive control technology

Range: Drives: Permanent magnet DC drives, stepper motors, brushless AC and DC drives, tacho-generators. Control: speed, reversal of direction, position. Circuits: Resistive, electronic, digital.

Learning Outcomes:

The student should be able to:

- Explain
  - the fundamental operation of electric drive construction and operation.
  - the application of electric drive types.
  - how each drive type is controlled.
  - how the PC is used to control the stepper drive.
  - what is meant by the terms PWM, H bridge motor control, PIC based controller, motor control logic, phase control.
  - how a tacho-generator is used in an electronic control circuit.
- Select and identify correct electric drives for specified function.
- Construct control circuit using correct electric drive.
- Test and check for function.

7.3 Topic 3: Analyse and connect basic hydraulic technical systems

7.3.1 Subject Outcome 1: Describe and apply hydraulic technology

Range: Physical quantities and units used (force, mass, weight, pressure, acceleration, gravity, atmospheric pressure); Physical laws: hydrostatics (fluids at rest) hydraulic transmission of forces, hydraulic amplifiers (fluid in motion), law of volume control, hydraulic energy, friction and flow. Power pack: hydraulic gear pump, electric motor, reservoir, pressure relief valve, pipes and unions. Hydraulic circuit elements: Pressure relief valve (direct control), directional control valves (2/2, 3/2, 4/2, 5/2), check valve, cylinders (single/double), valves (pilot control, flow control, throttle control, 4/3 directional control).

Learning Outcomes:

The student should be able to:

- List
  - applications where hydraulics can be used
  - advantages and disadvantages of using hydraulics
  - and use fundamental physical quantities used in hydraulics
- Explain
  - what is meant by the term hydraulics
  - the energy conversion in hydraulic applications, using block diagrams
  - the construction of hydraulic systems using block diagrams
  - the basic physical laws related to hydraulics
  - the tasks of fluid, reservoir and filter pressure gauge
  - pump characteristics
  - the operation of hydraulic circuit elements and related symbols
- Identify and describe function, and draw the construction of a hydraulic pump and related elements and circuit diagram
- Apply formulae for fundamental physical quantities as used in hydraulics
- Identify and list the components that make up a hydraulic pump
- Read and interpret related power pack symbols

7.3.2 Subject Outcome 2: Connect basic hydraulic manual control systems

Range: Circuits: Directional control, check valves, pressure control, flow control, pressure compensated control, two-pump control, sequential control, regenerative control.

Learning Outcomes:

The student should be able to:

- Demonstrate a sound understanding of hydraulic symbols, and an ability to read hydraulic circuits
- Read and interpret hydraulic control circuit diagrams
- Connect hydraulic control circuits for functional operation in accordance with regulation
- Apply safety for self and others
- Use tools and equipment with care

7.4 Topic 4: Analyse and connect electro-hydraulic control systems

7.4.1 Subject Outcome 1: Describe and apply electro-hydraulic technology

Range: Electro-hydraulic systems (electric power supply/ amplifier, proportional solenoid, directional/ pressure/ flow control valve, hydraulic actuator (cylinder/ motor) block diagram of proportional hydraulics, related components (proportional valves directional/ pressure/ flow), electrics (amplifiers with and without feedback), fundamentals of open loop control, control loop, servo control technology.

Learning Outcomes

The student should be able to:

- Explain
  - what is meant by the term electro-hydraulics
  - what the term proportional control means
  - the construction of an electro-hydraulic system, using block diagrams
  - closed and open loop characteristics as used in proportional control
  - the operation of electro-hydraulic circuit elements and related symbols

- List
  - applications where electro-hydraulics can be used
  - Advantages and disadvantages of using electro-hydraulics
  - and use the fundamental physical quantities used in hydraulics
  - and explain the different control signals used in proportional control (digital, analogue V/A)(A/D, D/A converters
- Use basic formulae of proportional control
- Identify
  - and describe function, and draw the block diagram of a proportional control technical system
  - and list the components that make up an electro-hydraulic system
  - and select correct electronic controls (pilot, P, I, D, PID)
- Apply formulae for fundamental physical quantities as used in hydraulics (read flow, force and pressure wit respect to poppet diameter and spring force)
- Read and interpret electro-hydraulic control circuit symbology

7.4.2 Subject Outcome 2: Connect electro-hydraulic control systems

Range: Circuits: Clamping, flow control, pressure control, speed control, logic element control

Learning Outcomes:

The student should be able to:

- Describe electro-hydraulic symbols, and read electro-hydraulic circuits for control applications and connectivity
- Read and interpret electro-hydraulic control circuit diagrams
- Connect electro-hydraulic control circuits for functional operation in accordance with regulation
- Apply safety for self and others
- Use tools and equipment with care

7.5 Topic 5: Apply trouble shooting techniques on electro-hydraulic control systems

7.5.1 Subject Outcome 1: Name and apply trouble shooting on electro-hydraulic 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 occur in a drive section (cylinders/ motors)
  - that occur in energy control, energy supply, tubes and pipes, service unit and electrical control sections
- Safely eliminate faults in an electro hydraulic system

8 RESOURCE NEEDS FOR THE TEACHING OF MECHATRONIC 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 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	**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 LABORATORY**	
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
3g	**Basic and Advanced PLC**	
	Basic PLC	10
	Advanced PLC	2

3h	**Fieldbus and electric drives**	
	Fieldbus profibus-DP	2
	Electro-servo drives	2
	Electro-stepper drives	2
3i	**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.