MOBILE ROBOTICS

NORMAL (TECHNICAL) EXAMINATION SYLLABUS

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A101 MOBILE ROBOTICS (2026)

I INTRODUCTION

This is a Normal (Technical) examination syllabus for a 2-year course in Mobile Robotics undertaken at upper secondary. The syllabus aims to provide students with the experience of developing their own mobile robots and at the same time provide a foundation to further their studies in mechatronics engineering or related fields.

The syllabus covers basic knowledge and skills in electricity, electronics, mechanical design and intelligent control that are relevant to technical courses at post-secondary level. It emphasises the application and integration of technical knowledge and skills to design and build mobile robots for the performance of specified tasks.

II AIMS OF SYLLABUS

The syllabus aims to:

1. Enable students to develop capabilities and skills for problem-solving and critical thinking through automation and robotics;
2. Provide opportunities for students to apply and refine design approaches in automation and robotics towards a viable solution;
3. Stimulate curiosity and interest in technology through design and build activities;
4. Promote an awareness of:
   - 4.1 the impact of technology on society, industry, business, home and leisure; as well as
   - 4.2 the changing and progressive nature of technology;
5. Enable students to acquire knowledge and skills in preparation for post-secondary technical courses; and
6. Inculcate in students safety consciousness and safe working habits.

III ASSESSMENT OBJECTIVES

The assessment objectives are classified into:

1. **Knowledge with Understanding**

Candidates should be able to demonstrate knowledge and understanding in relation to:

1.1 Technical definitions, laws, concept and theories;

1.2 Technical terminology and conventions including symbols, quantities and units; and

1.3 Technical equipment and tools including techniques of operation and safety aspect.

2. **Handling and applying information and problem solving**

Candidates should be able, by using words or symbolic and numerical forms of presentation, to:

2.1 Locate, select, organize and present relevant information from a variety of sources;

2.2 Plan and manage available resources leading to the completion of practical assessments within a time frame;

2.3 Analyse a need and develop ideas by considering relevant human, functional, aesthetic and technological factors through the use of appropriate thinking skills;

2.4 Apply appropriate knowledge of materials, processes and technological aspects in logic design and control; and

2.5 Refine ideas through ongoing testing, troubleshooting and evaluation prior to realisation.

3. **Integration and Realization**

Candidates should be able to:

3.1 Organise the work procedures involved in the realisation of a practical solution;

3.2 Realise a practical solution using appropriate equipment, materials and suitable fabrication techniques (mechanical and electronics); and

3.3 Apply their knowledge, skills, and trouble-shooting technique towards building a mobile robot.

IV SCHEME OF ASSESSMENT

Number of Examination Papers

1. Candidates will be required to take all three compulsory papers which will be examined in the second year of the course:

- Written Examination Paper 1
- Practical Examination
  - Paper 2: Interpret and apply schematic diagram in connecting a control circuit
  - Paper 3: Integrate and test a mobile robot with a given sub-system

Assessment Weighting

2. The assessment weighting for each paper is as shown in Table 1.

Table 1: Assessment Modes and Weightings

Paper	Mode	Duration	Marks	Weighting
1	Written Examination	1 hr	30	30%
2	Practical Examination	1 hr 30 mins	42	30%
3	Practical Examination	2 hrs	80	40%

Assessment Timeline

3. The timeline showing the recommended schedule for the conduct of the assessment is shown in Table 2.

Table 2: Assessment Timeline

Paper	Date
Paper 2 Practical Examination	September[1] of Year 2
Paper 3 Practical Examination	September[1] of Year 2
Paper 1 Written Examination	October of Year 2

[1] Paper 2 and Paper 3 will be on different dates in September, during the N-Level practical examinations period.

Written Examination

4. This paper will be examined towards the end of the examination year. This will be a formal, timed examination in which candidates will be assessed on their knowledge with understanding of the subject, their ability to handle and apply information and their problem-solving skills. The written examination consists of 30 compulsory multiple-choice questions and constitutes 30% of the total mark.

   The assessment grid for Paper 1 is shown in Table 3. The assessment objectives are weighted to give an indication of their relative importance. They are not intended to provide a precise statement of the marks allocated to each assessment objective.

Table 3: Assessment Grid

Paper 1	Assessment Objectives			Marks
	Knowledge	Comprehension	Application	
	30% - 40%	30% - 40%	20% - 30%	30

Practical Examination Details

5. There are two practical papers to focus on the skill sets involved in (1) connecting a control circuit and (2) integration & testing of a mobile robot:

Practical Paper 2	**Duration:** 1 hour and 30 minutes
Candidates are to interpret a given schematic diagram and connect a control circuit, with a given set of components. At the end of the practical paper, the examiners will collect and keep candidates' work securely for subsequent marking. The practical paper 2 constitutes 30% of the total mark.	

Practical Paper 3	**Duration:** 2 hours
Candidates are to integrate and test a mobile robot with a given sub-system to perform a desired task. The mobile robot could be a wheeled robot or a robot with moving parts. At the end of the practical paper, the examiners will collect and keep candidates' work securely for subsequent marking. The practical paper 3 constitutes 40% of the total mark.	

6. The criteria upon which the marking scheme shall be built include the ability to:

- Understand/analyse the expected specifications/requirements and connect a control circuit accordingly;
- Troubleshoot and rectify faults;
- Integrate electronic cards, sensors and mechanical support;
- Use correct colour codes of wires for circuit connections; and
- Construct a firm mechanical support and perform good electrical jointing.

V USE OF CALCULATOR

An approved calculator may be used for all written and practical examinations.

VI SYLLABUS CONTENT

1. Mobile Robots

Overview

Automation plays an increasingly important role in the global economy and in daily experience. Students will learn about various forms of automation through robotic systems and the overview of a typical autonomous robotic system in functional blocks.

Content

- Evolution of robot systems
- Roles of robots and intelligent machines
- Overview of an autonomous robotic system

Learning Outcomes

Students should be able to:

1.1. Understand the evolution of robot systems

1.2. Explain the roles of robots and intelligent machines

1.3. Explain the overview of an autonomous robotic system by:
- Drawing the functional blocks
- Describing the operation of each block

2. Basic Electricity

Overview

Students will learn about the electrical theories and circuit operations. Students apply their knowledge and skills in the design of electronic projects.

Content

- Voltage, current and resistance and their relationships
- Series and parallel circuits
- Current rating
- Types of battery
- Use of multimeter
- Safety precautions when using measuring instruments

Learning Outcomes

Students should be able to:

2.1. State that current is a rate of flow of charge and that it is measured in amperes

2.2. State the unit for resistance and potential difference (p.d.)

2.3. State the relationships among current, resistance, p.d. and power

2.4. Apply the relationship of current, resistance and p.d. to solve related problems in a direct current (DC) circuit

2.5. State that the same current flows through the resistors connected in series

2.6. Determine the effective resistance of resistors connected in series

2.7. Determine the p.d. across each resistor connected in series

2.8. State that the p.d. across resistors connected in parallel is the same

2.9. Determine the effective resistance of resistors connected in parallel

2.10. Determine the current flowing through each of the two resistors connected in parallel

2.11. Explain the current rating of a device

2.12. Apply current rating knowledge in choosing suitable devices in a DC circuit

2.13. State the various types of batteries and where they are used

2.14. Draw the schematic symbol of:
- Battery
- DC supply
- Fixed resistor

2.15. Use a multimeter to measure the following quantities in a DC circuit:
- Voltage
- Current
- Resistance

2.16. Exercise safety precautions when handling and using measuring instruments

2.17. Explain the precautions and procedures for safe electrical work such as:
- Switching off supply when connecting/wiring up circuits
- Reporting defective items, including plugs and leads at once to the teacher
- Ensuring that all wiring, whether permanent or temporary, must be

neat, orderly, safe and sited so that it will not cause a tripping hazard or itself suffer unnecessary mechanical damage or wear
- Ensuring that terminals at voltages capable of electrocution are not exposed
- Ensuring correct polarity is observed

2.18. Explain the effects of short-circuit in a circuit such as:
- Damage to components in a circuit
- Overheating which could pose a fire hazard and damage insulation
- Tripping of circuit breakers

3. Basic Electronics

Overview

Students will learn about the basic electronic components and their uses and apply their knowledge and skills in designing and building electronic projects.

Content

- Common electronic components and their uses, e.g. resistors, capacitors, diodes and transistors
- Breadboarding technique
- Soldering/desoldering technique and its related safety precautions

Learning Outcomes

Students should be able to:

3.1. Explain how resistors are used in current limiting and voltage divider circuits

3.2. Explain how a potentiometer is used as a voltage divider

3.3. Connect DC circuits using potentiometer and other components

3.4. Determine the value of resistor from its colour codes

3.5. State the basic function of a capacitor

3.6. Identify ceramic and electrolyte capacitors

3.7. State the capacitance value of a capacitor from its label, which may include an IEC code.

3.8. State the maximum voltage of an electrolyte capacitor from its label

3.9. State the basic function of a diode

3.10. Explain the function of a diode in a DC circuit

3.11. Identify the emitter, collector and base leads of a transistor

3.12. Explain how a transistor operates as a switch

3.13. Draw the schematic symbol of:
- Variable resistor
- Potentiometer
- Capacitor
- Diode
- NPN and PNP transistors

3.14. Describe the internal connection of a breadboard

3.15. Choose the correct type and colour of wires when connecting a circuit on a breadboard

3.16. Perform proper stripping of insulated wire for connection on a breadboard

3.17. Connect, test and troubleshoot a circuit on a breadboard based on a schematic diagram involving:
- Resistors (fixed and variable)
- Capacitors
- Diodes
- NPN and PNP transistors

3.18. Perform proper soldering technique on stripboards and donut boards safely

3.19. Distinguish between good and bad soldered joints

3.20. Perform proper desoldering using desoldering tools

4. Digital Electronics

Overview

The heart of an application robot is the control circuit. Students will learn to design and implement control circuits using digital logic gates in a mobile robot.

Content

- Common logic gates, e.g. AND, OR and NOT
- Truth Table with a maximum of 3 inputs
- Karnaugh Map techniques with a maximum of 3 inputs
- Boolean expressions
- Draw and implement logic circuit

Learning Outcomes

Students should be able to:

4.1. State the basic operations of AND, OR and NOT gates using a truth table

4.2. Draw the symbol of AND, OR and NOT gates

4.3. Form a Boolean expression from a simple combination logic circuit

4.4. Apply the knowledge of AND, OR, NOT gates to draw a simple combination logic circuit from a simple Boolean expression

4.5. Complete a truth table based on an application or a simple combination logic circuit (with a maximum of 3 inputs)

4.6. Apply Karnaugh Mapping to obtain a simplified Boolean expression from a truth table (with a maximum of 3 inputs):
- Complete a Karnaugh map from the given truth table
- Perform grouping activities in the Karnaugh map
- Form Boolean expressions from the Karnaugh map groupings
- Draw combination logic circuits based on the derived Boolean expressions

4.7. Identify the pin configuration of an DIL (dual in-line) IC package

4.8. State the voltage supply of a typical TTL (Transistor-Transistor Logic) IC

4.9. Connect, test and troubleshoot a circuit on a breadboard based on a schematic diagram involving logic gate ICs

5. Design

Overview

Design is a broad area that focuses on planning, exploring, practising and performing. Students will learn about each design phase and draw up a project schedule to manage the design process.

Content

- Design methods such as planning, exploring, practising and performing
- Project scheduling
- Realisation plans such as schematic and assembly drawings

Learning Outcomes

Students should be able to:

5.1. Explain the design method by:
- Drawing block diagrams to illustrate the design process
- Describing each phase of the design process

5.2. Produce a project schedule by using a simple Gantt Chart to show various stages of work (knowledge of critical path is not needed)

5.3. Identify and interpret schematic and assembly drawings, including:
- Electronics schematic diagrams
- Component lists
- Wiring diagrams
- Mechanical assembly drawings

6. Input and Output Devices

Overview

In any automation machines/systems, input and output devices are used to allow these machines to communicate with the outside world. Input devices feed information from the outside world to the machines while output devices send information from the machines to the outside world. In this topic, students will learn about these input and output devices and apply their knowledge and skills to build projects.

Content

- Input devices including sensors (e.g. thermistors, light-dependent resistors), mechanical switches, opto-switches, etc.
- Output devices including Light-Emitting Diodes (LED), buzzers, DC Motors, and effectors

Learning Outcomes

Students should be able to:

6.1. Describe the operation of the various types of input devices and their applications, including:
- Sensors [thermistor, light-dependent resistor (LDR), tilt, temperature and humidity, sound, colour (RGB), range (distance), reflective and slotted opto-switches]
- Switches (pushbutton, rocker, toggle, limit, slide)

6.2. Describe the operation of the various types of output devices and their applications, including:
- LEDs and 7-segment display
- Buzzers (magnetic and piezoelectric)
- DC motors
- OLED display
- Robotic arm
- Effectors (gripper, spray gun, vacuum cup)

6.3. Describe the common shapes, sizes and colours of LEDs

6.4. Compute the value of the current limiting resistor based on the supply voltage and current rating of an LED

6.5. Describe how a decimal digit can be shown on a 7-segment display (common cathode, common anode) using a truth table

6.6. Describe the configuration of switches including number of poles, throws, NO (normally open) operation mode and NC (normally closed) operation mode

6.7. Describe the application of a transistor and relay as load drivers

6.8. Describe the function of a free-wheeling diode in a relay driver circuit

6.9. Compare the advantages and disadvantages of using a transistor driver against using a relay driver

6.10. Draw the schematic symbol of:
- Thermistor
- Light-dependent resistor
- LED
- Magnetic buzzer
- DC motor
- Mechanical switch
- Opto-switch
- Relay
- Potentiometer

6.11. Connect, test and troubleshoot a circuit on a breadboard based on a schematic diagram involving:
- Thermistors
- Light-dependent resistors
- LEDs / 7-segment display
- Magnetic buzzers
- DC motors
- Mechanical switches
- Opto-switches
- Relays
- Potentiometers

7. Simple Mechanism

Overview

Students will learn about the working principles of common mechanisms found in machines and devices and apply them in the construction of mechanical support and moving parts.

Content

- Common mechanism e.g. leg levers, linkages, gears and spring loaded mechanism
- Common fasteners e.g. screws, rivets and pins

Learning Outcomes

Students should be able to:

7.1. Explain the applications of common mechanisms including:
- Levers
- Linkages
- Gears
- Spring loaded mechanisms
- Pulleys
- Cams

7.2. State the applications of the various fasteners including:
- Screws
- Rivets and pins

7.3. Demonstrate the proper use of screws in fabricating pieces for a robot

7.4. Describe the factors affecting the speed, mobility and stability of a wheeled robot including:
- Wheel diameters
- Gear ratio
- Robot speed
- Distance between wheels

8. Simple Robots

Overview

Students will learn to develop robots by integrating components to form simple robots that can complete a given task. They will also learn to identify and troubleshoot faults in simple robots.

Content

- Integration of input and output devices in simple robots
- Block-based coding (not assessed)

Learning Outcomes

Students should be able to:

8.1. Determine the function of components in simple robots, including:
- Thermistor
- Light Dependent Resistor (LDR)
- Tilt sensor
- Temperature and humidity sensor
- Sound sensor
- Colour sensor
- Range (distance) sensor
- Light-Emitting Diodes (LEDs)
- Buzzer
- DC motor
- OLED display
- Vacuum cup
- Gripper
- Robotic arm

8.2. Identify suitable component(s) for a simple robot to complete a given task.

8.3. Identify and troubleshoot faults in simple robots

9. Integration

Overview

Students will learn, apply and integrate their knowledge and skills in the designing and building of a mobile robot. The process of building a mobile robot will involve the construction of mechanical support, incorporation of factors affecting the mobility of the robot, designing of logic and control circuits, the assembling of the various components, and the testing and troubleshooting of faults.

Content

- Mechanical design of a mobile robot
- Integration of a mobile robot
- Troubleshooting technique

Learning Outcomes

Students should be able to:

9.1. Assemble and test a mobile wheeled robot to perform a specific set of actions

9.2. Interpret the schematic diagram for the interconnection of the sensing circuit, logic/ control circuit, and the motors driving circuit

9.3. Integrate, test and troubleshoot the wire connections between the microcontroller and input/output devices, as well as the mechanical hardware of a mobile robot that can perform specified tasks

VII REMARKS

The preclusion of N(T) Design and Technology (D&T) for students who offer Mobile Robotics (MR) has been lifted. Students have the option to offer both MR and D&T courses simultaneously.