SMART ELECTRICAL TECHNOLOGY

NORMAL (TECHNICAL) EXAMINATION SYLLABUS

CONTENTS **PAGE**

The Common Last Topics highlighted in green will not be examined in 2020 N(T)-Level national examination for Secondary 3 candidates.

The Common Last Topics highlighted in yellow will not be examined in 2020 N(T)-Level national examination for Secondary 4 candidates.

A201 SMART ELECTRICAL TECHNOLOGY (2020)

I INTRODUCTION

Home automation technology and systems, with their ability to make everything that is used daily in homes, offices and buildings (e.g. electrical lighting, appliances, air-conditioning systems, security locks, curtains and blinds, even smartphones and tablets) work together, provide users with improved convenience, comfort, energy savings, security and an increased quality of life.

It is no wonder why home automation systems have seen rapidly increasing adoption and use worldwide, with many manufacturers getting into the market and a wide range of offerings.

This Smart Electrical Technology applied subject is a 120-hr Normal (Technical) examination syllabus for a two-year course at the upper secondary level that aims to provide students with training in the core, foundational concepts and principles of operation of all home automation systems, i.e. hardware and devices, software, combination and integration of the technologies involved, programming techniques, communication protocols and testing.

The inclusion of training in the use of smartphones to manage and control a home automation system by means of apps also serves to introduce the much talked about 'Internet of Things' today to students.

As the devices, loads and equipment controlled by home automation solutions are invariably electrical in nature, students will also be provided with foundational training in electrical circuits and technology in the applied subject. For home automation, students will learn, through a combination of theory lessons and hands-on practical training, the most commonly used basic and advanced control functions.

The training in electrical circuits and home automation systems will help prepare and enable students to take up further studies in electrical, control and computer engineering or related fields at post-secondary level.

II AIMS OF SYLLABUS

The syllabus aims to:

1. Equip students with a foundational knowledge of electrical circuits and systems and home automation systems in preparation for further engineering studies at post-secondary level;

2. Enable students to acquire skills and knowledge that are of immediate interest, relevance and use in daily life;

3. Enable students to develop their analytical abilities and problem- solving skills;

4. Inculcate in students safety consciousness and safe working habits;

5. Enable students to understand the applications of electrical technology and home automation technology in homes and built environments; and

6. Develop in students an interest in a post-secondary engineering-based education.

III ASSESSMENT OBJECTIVES

The assessment objectives are classified into**:**

1. **Practical Skills**

Candidates should be able to:

1.1 Follow a sequence of instructions or test procedures;

1.2 Draw and read instructions and circuit diagrams;

1.3 Use correct tools and systematic techniques;

1.4 Connect electrical and home automation system components and circuits with reference to instructions, diagrams and drawings;

1.5 Evaluate, set up, program and test operation of electrical and home automation components, devices, circuits and panel;

1.6 Obtain, record and/or interpret observations and test results; and

1.7 Adopt safe working habits and practices in the handling of equipment and tools and when working with electricity.

2. **Analytical and Problem-Solving Skills**

Candidates should be able to:

2.1 Apply knowledge acquired in the subject to analyse the requirements of a home automation solution or application; and

2.2 Design, implement and test home automation solutions for a given requirement or application.

3. **Knowledge with Understanding**

Candidates should be able to demonstrate knowledge and understanding of electrical and home automation systems, including:

3.1 Facts, natural laws and concepts, theories and principles of operation;

3.2 Terminology, conventions (including symbols, quantities, units of measurement); and

3.3 Programming principles and techniques, test instruments and tools (including their operation, safety aspects, and care).

IV SCHEME OF ASSESSMENT

Number of Examination Papers

1. Candidates will be required to attempt all three compulsory papers:

- Written Examination Paper 1
- Practical Examination
  - Paper 2: Electrical Principles & Conventional Lighting
  - Paper 3: Home Automation

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 - Electrical Principles & Conventional Lighting	1 hr 20 mins	132	30%
3	Practical Examination - Home Automation	1 hr 30 mins	84	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 - Electrical Principles & Conventional Lighting	Sept of Year 1
Paper 3 Practical Examination - Home Automation	Sept of Year 2
Paper 1 Written Examination	Oct of Year 2

Written Examination

4. 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. Candidates will be tested on their ability to perform a series of tasks by applying the appropriate skills and knowledge.

Practical Paper 2 **Duration:** 1 hour and 20 minutes **Electrical Principles & Conventional Lighting**
This paper requires students to perform measurements using a multimeter, design a conventional lighting circuit, and then connect up the conventional lighting circuit using a pre-built training kit.

Practical Paper 3 **Home Automation**	**Duration:** 1 hour and 30 minutes
This paper requires students to: 1. Develop a mobile application for a home automation system using a laptop 2. Execute a mobile application on the Home Automation Training Kit using a laptop (including the conversion of the laptop version to the mobile version)	

6. The two practical papers shall be conducted under examination conditions. The weighting of Paper 2 (conducted in Sec 3) and Paper 3 (Sec 4) is 30% and 40% respectively. Students are not allowed to communicate with their classmates or to seek guidance and advice from their teachers, except for the control circuit design assessment. Marking will take the assistance provided into consideration.

7. The main criteria for assessment can be summarized as follows:

7.1 Electrical and home system components, devices, wiring drawn must be labelled correctly and in accordance with instructions;

7.2 Cables and circuit connections must comply with approved standards;

7.3 All connections must be correct as well as electrically and mechanically sound;

7.4 The ability to link, integrate and program home automation system including function tests;

7.5 The ability to apply knowledge to devise solutions for home automation applications; and

7.6 Observation and/or adherence to safety rules and precautions.

8. Task specific assessment rubrics will be used for awarding raw marks of practical examinations. A criticality value (1, 2, 3) will be factored on the raw score based on the relative importance of the element being assessed in terms of safety and risk of damage or loss of life, equipment or property in the event of a mishap caused as result of failure to meet requirement or standard of performance. Elements which would have a serious impact in all of these aspects are pegged at 3; those with little or no impact would be pegged at 1. Criticality factor 2 is assigned to elements that are rated between 1 and 3. A difficulty value (1, 2, 3) will be factored on the raw score based on how difficult the task or requirement is.

V USE OF CALCULATOR

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

VI SYLLABUS CONTENT

1. ELECTRICAL PRINCIPLES AND CIRCUITS

This section covers the basic principles of electricity, connection of simple electrical lighting circuits for residential premises and the use of multimeters for testing for electrical continuity.

1.1 Electrical Safety

Students should be able to:

1.1.1 Explain the 2 types of electric shock:
- Direct contact
- Indirect contact

1.1.2 Explain the potential dangers in electrical work

1.1.3 Understand the danger of hazardous work practices

1.1.4 Explain the precautions and procedures for safe electrical work

1.1.5 Explain the benefits of good housekeeping in electrical work

1.1.6 Recommend measures to protect against electrical hazards

1.2 Electric Circuits

Students should be able to:

1.2.1 Explain how an electric circuit works

1.2.2 State the 3 basic electrical quantities: voltage, current and resistance

1.2.3 State the units of measurement for voltage, current and resistance

1.2.4 Describe the use of a voltmeter for measuring voltage

1.2.5 Describe the use of an ammeter for measuring current

1.2.6 Describe the use of an ohmmeter for measuring resistance

1.2.7 State the different uses of a multimeter

1.2.8 Use the multimeter to measure current, voltage and resistance, and also check for continuity of an electrical installation

1.2.9 Exercise safety precautions when handling and using measuring instruments

1.3 Electric Circuit Laws

Students should be able to:

1.3.1 Understand the relationship between current, resistance and voltage (Ohm's Law): $V = I \times R$

1.3.2 Apply Ohm's Law to determine current, resistance or voltage in an electric circuit

1.3.3 Connect a simple electric circuit comprising ammeter, voltmeter, load and power supply to verify Ohm's Law

1.4 Electric Circuit Connections

Students should be able to:

1.4.1 Identify the 3 methods of connecting electrical loads:
- Series
- Parallel
- Series-parallel

1.4.2 State the characteristics of a series circuit:
- One path for current flow
- Supply voltage equals to sum of individual voltages
- Total resistance is the sum of individual resistances

1.4.3 State the characteristics of a parallel circuit
- Supply voltage is the same as all branch voltages
- Supply or total current is equal to the sum of individual branch currents
- Total resistance is smaller than the smallest individual resistance

1.4.4 Determine the total resistance of series circuit comprising 2 resistors using the formula: $R_T = R_1 + R_2$

1.4.5 Determine the total resistance of a parallel circuit comprising 2 resistors using the formula: $1/R_T = 1/R_1 + 1/R_2$

1.4.6 Connect a series circuit comprising 2 resistors, voltmeters and ammeters for the purpose of verifying the characteristics of series circuit

1.4.7 Connect a parallel circuit comprising 2 resistors, voltmeters and ammeters for the purpose of verifying the characteristics of parallel circuit

1.4.8 Recognise that a series-parallel circuit has a combination of series and parallel circuits

1.5 Power and Energy in an Electrical Circuit

Students should be able to:

1.5.1 Define the terms 'power' and 'energy' in electric circuits

1.5.2 State the units of measurement for power (watt) and energy (joule)

1.5.3 State and apply the formulae to determine power of an electric circuit comprising one electrical load: $P = V \times I$

1.5.4 State and apply the formulae to determine energy of an electric circuit comprising one electrical load: $E = P \times t$

1.5.5 State the practical unit of energy consumption in household (kilowatt-hour, kWh)

1.5.6 Calculate the energy consumption of an electrical load in kilowatt-hour

1.6 Electric Power Sources

Students should be able to:

1.6.1 State that supply sources can be alternating current (AC) or direct current (DC)

1.6.2 Distinguish the differences between AC and DC

1.6.3 Identify the common source of AC

1.6.4 State the sources for DC

1.6.5 Define the function of a cell

1.6.6 Draw the symbol for a cell

1.6.7 Explain the difference between a cell and a battery

1.7 Electrical Hazards and Protection

Students should be able to:

1.7.1 Explain the electrical hazards due to overcurrent and earth fault

1.7.2 Understand the need to protect people and properties against electrical hazards

1.7.3 Explain the importance of earthing to avoid the risk of electric shock

1.7.4 Describe the application and selection of different electrical protective devices for residential (fuses, circuit breakers, residual current operated circuit breakers)

1.7.5 Explain how protective devices can protect against electrical hazards

1.8 Electric Cables

Students should be able to:

1.8.1 State the function of a cable

1.8.2 State the 3 main parts of a cable

1.8.3 Describe the specific role of the three main parts of a cable

1.8.4 State the common materials used as conductor and insulator

1.8.5 Identify the common type of cable used in residential premises

1.9 Electrical Test Instruments

Students should be able to:

1.9.1 Explain the purpose of test instruments in electrical work (insulation-resistance tester, continuity tester, earth tester)

1.9.2 Explain the functions of a socket-outlet polarity tester

1.9.3 Explain the method to test for correct polarity of a socket outlet

1.10 Conventional Lighting Circuit

Students should be able to:

1.10.1 Define the term 'Final Circuit'

1.10.2 Analyse the design and characteristics of common final circuits:
- Lighting final circuit
- Power final circuit

1.10.3 Understand the 2 methods of wiring socket-outlet final circuit
- Radial final circuit
- Ring final circuit

1.10.4 State the cable sizes commonly used for lighting and power circuits

1.10.5 State the standard cable colour codes for a single-phase circuit

1.10.6 State the protective device sizes commonly used for lighting final circuits

1.10.7 State the application of the following electrical accessories:
- One-way switch
- Two-way switch
- Dimmer switch

1.10.8 Wire up and test conventional lighting final circuit with[1]:
- One-way control
- Two-way control
- Dimmer control

1.10.9 Wire up and test a 13A radial power circuit

1.10.10 Explain the method for testing wiring circuits for safe use

1.10.11 Analyse test results to identify the type of faults

1.11 Electrical Supply System

Students should be able to:

1.11.1 Explain how electricity is transmitted from power station to consumers

1.11.2 Explain how electricity is distributed in residential, commercial and industrial premises

1.11.3 Explain the function of transformers in transmission and distribution of electricity

1.11.4 State the voltages for generation, transmission and distribution of electricity in Singapore

[1] The Common Last Topic to be excluded in 1.10.8 comprises ONLY Practical 1.6.11 which has content application involving Florescent Lighting Circuit.

2. HOME AUTOMATION SYSTEM

This section covers the common technology used in home automation and installing and programming for smart control of lighting circuits in homes.

2.1 Home Automation Basics

Students should be able to:

2.1.1 List common functions of building automation systems (e.g. lifts, fire alarms and ventilation)

2.1.2 List common functions of home automation systems (e.g. lighting, blinds and security)

2.1.3 Explain the benefits and advantages of using a home automation system over a conventional system

2.1.4 List examples of common home automation standards and products, such as:
- KNX (used by Jung, ABB, Schneider, etc.)
- LonWorks
- C-Bus
- Z-Wave (used by MK Astral)
- ZigBee
- MODBUS

2.2 Basic Devices, Topology and Communication

Students should be able to:

2.2.1 Describe the key features of home automation systems and the relevant devices:
- Switching (e.g. switch)
- Dimming (e.g. dimmer)
- Timing (e.g. timer)
- Sensing (e.g. motion detector)
- Scene control (e.g. scene master)
- Central control (e.g. control panel)
- Visualisation (e.g. tablet)

2.3 Wireless Network and Radio Frequency

Students should be able to:

2.3.1 Describe the two methods by which devices can be linked:
- Twisted pair cables
- Radio frequency (RF) signals

2.3.2 State the benefits of RF control over twisted pair

2.3.3 Describe a topology as how devices are connected to each other

2.3.4 Identify the following common topologies for home automation:
- Bus
- Ring
- Mesh

2.3.5 State the advantages and disadvantages of common topologies for home automation

2.3.6 Describe a protocol as the rules used for communication between devices to send digital signals

2.3.7 Understand that signals are classified into command classes

2.4 Installing and Programming Devices

Students should be able to:

2.4.1 Install up to 5 common control devices such that they communicate through radio frequency correctly

2.4.2 Describe that every automation system device has a unique identity

2.5 Switching and Dimming

Students should be able to:

2.5.1 Describe the function of intelligent switches

2.5.2 Describe the differences between intelligent switches and conventional switches (e.g. one-way/two-way switches or dimmers)

2.5.3 Describe and program intelligent switches to control lighting and electrical devices

2.6 Timing and Sensing

Students should be able to:

2.6.1 Describe the function of timers

2.6.2 Describe the functions of sensors and give motion and light sensors as examples of common sensors used in home automation systems

2.6.3 State how timers and sensors can be used to switch devices on and off automatically to conserve energy

2.6.4 Describe and program timers as well as sensors to control lighting and electrical devices

2.7 Scene Control

Students should be able to:

2.7.1 Describe the function of the scene master of a home automation system

2.7.2 Describe and program the scene master for complex lighting scenes (switching, dimming)

2.7.3 Describe and program a button as a master-off scene

2.7.4 Describe the use of remote control for accessing complex scenes[2]

2.8 Central Control and Visualisation

Students should be able to:

2.8.1 Describe and program a central control device for switching, dimming and scene control

2.8.2 Convert control of a conventional lighting circuit to use a home automation system

2.9 Home Automation Controller

Students should be able to:

2.9.1 State how a controller communicates with the home automation system

2.9.2 State the purpose and benefits of using a home automation controller

2.9.3 List common hardware modules for a home automation controller, such as:
- Universal communication module
- I/O expansions
- Keypads
- Direct digital controller (DDC)

2.9.4 Install and configure a home automation controller to communicate with devices and loads correctly

2.9.5 Use a home automation controller to automate the activation of devices and loads correctly based on a given scenario

2.9.6 Send commands to control devices and loads (e.g. switches, dimmers, blinds, buzzers)

[2] The Common Last Topic to be excluded in 2.7.4 comprises ONLY Practical 2.17 which has content application involving the use of remote keys for the Home Automation Kit.

2.10 Basic Networking and Installing Relevant Mobile Apps

Students should be able to:

2.10.1 State the function of a router.

2.10.2 Determine the IP address of a router.

2.10.3 Write basic programs (with guided steps) to create a mobile app that controls electrical loads

2.10.4 Install and configure a mobile app to communicate with a home automation system correctly[3]

2.11 Controlling Electrical Loads/Security Features via Mobile Phone

Students should be able to:

2.11.1 Configure a PC, a mobile phone and a hardware router to be connected via the same wireless network

2.11.2 Test the control of electrical loads via a PC

2.11.3 Test the control of electrical loads via a mobile phone

2.11.4 State the security features that are possible using a mobile app and home automation controller

[3] The Common Last Topic to be excluded in 2.10.4 comprises ONLY Practical 2.18 which has content application involving mobile application for the Home Automation Kit.

VII GLOSSARY OF TERMS USED

This glossary is to provide candidates with a clear understanding of the meaning, intent and expectations relating to the requirements of learning outcomes and/or questions in test papers.

1 **Analyse** refers to the ability to consider, in detail, results, data and/or information available to deduce or discover essential features, the possible causes or the correct answer or solutions to a problem at hand.

2 **Apply** refers to the ability to put one's knowledge of natural laws, principles or formulae to some practical or specific use.

3 **Calculate** refers to the use of mathematical methods to determine a result.

4 **Compare** would require students to give the similarities and differences between items, concepts, ideas etc.

5 **Connect** refers to the joining or fastening together, physically or by wires, two or more circuit components and devices.

6 **Construct** means to draw and form, on a display screen, a circuit diagram comprising parts or elements in a systematic manner so as to meet specified requirements.

7 **Define** would require a formal statement or declaration of the meaning of a given term or phrase.

8 **Describe** would require students to state in words (with diagrams or drawings as appropriate) the component, condition, type of operation etc.

9 **Determine** means to establish or ascertain the value, answer or result by means of calculation, investigation, experiment, survey or study.

10 **Distinguish** refers to the ability to perceive or identify the differences between given systems and/or equipment.

11 **Download** refers to copy (data) from one computer system to another, typically over the Internet.

12 **Explain** would require an answer that which could include the definition of the term(s), some relevant comments and/or reference to theory.

13 **Identify** as applied to a component, device, drawing symbol etc refers to the recognition and giving the correct term, phrase and/or cause or reason.

14 **Interpret** refers to the ability to conceive the significance of a problem or event, offer an explanation and/or explain the meaning of the problem or event.

15 **Investigate** means to observe or inquire into in detail on the operation or operational performance of an equipment or system.

16 **List** means a series of words, items etc.

17 **Measure** refers to the use of a measuring or test instrument to determine the value of an electrical quantity in a circuit or equipment.

18 **Outline** refers to a listing or summary of the main points and/or differences between two or more devices or equipment items.

19 **Read** as applied to the use of measuring instruments refers to the ability to derive the true value of the electrical quantity being measured.

20 **Recognise** means to know, accept or remember something that is true of a concept, idea or fact.

21 **Recommend** refers to the ability to come up with a correct solution or solutions to solve a given problem or restore a circuit or equipment to its normal condition based on a understanding of the underlying causes of the problem.

22 **State** would require a straight forward and direct answer with little or no supporting comments or reference to theory or concepts.

23 **Test** refers to the process of verifying whether a component, circuit, appliance, equipment and/or system works or performs as per requirements and specifications

24 **Troubleshoot** calls for the ability to determine, by means of testing and observation, the causes and solutions to a problem. It also means the ability to restore an equipment or system to normal operation by means of replacement of a part(s) or removing the cause of the abnormal operation.

25 **Understand** means the ability to perceive and comprehend the meaning, nature and significance of a/an concept, equipment or system.

26 **Wire** is the act of connecting wires between circuit components and devices.