



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY (ELECTRONICS)

GUIDELINES FOR PRACTICAL ASSESSMENT TASKS

GRADE 12

2025

These guidelines consist of 48 pages.

TABLE OF CONTENTS

	PAGE
1. INTRODUCTION	3
2. TEACHER GUIDELINES	5
2.1 How to administer PATs	5
2.2 How to mark/assess PATs	5
2.3 PAT Programme of Assessment (PAT PoA)	6
2.4 Moderation of PATs	8
2.5 Absence/Non-submission of tasks	8
2.6 Simulations	9
2.7 Projects	9
2.8 Working mark sheet	10
3. LEARNER GUIDELINES	11
3.1 PAT 2025 cover page	11
3.2 Instructions to the learner	12
3.3 Declaration of Authenticity (COMPULSORY)	12
4. SIMULATIONS	13
4.1 Simulation 1: Darlington transistor amplifier	13
4.2 Simulation 2: Non-inverting op amp	18
4.3 Simulation 3A: Switching circuits using 555 IC	23
Simulation 3B: Op-amp comparator using 741 IC	29
4.4 Simulation 4: Common emitter amplifier	33
5. SECTION B: DESIGN AND MAKE	38
5.1 Design and Make: Part 1	39
5.2 Assessment of the Design and Make Phase: Part 1	41
5.3 Design and Make: Part 2	43
5.4 Assessment of the Design and Make Phase: Part 2	44
6. PROJECTS	45
6.1 Practical Project: Dual voltage power supply	45
Alternative project: 0-30 V Variable Dual Voltage Power Supply	46
6.2 Practical Project: Line following buggy	47
6.3 Practical Project: Function generator	48
7. CONCLUSION	48

1. INTRODUCTION

The 18 Curriculum and Assessment Policy Statements subjects which contain a practical component all include a practical assessment task (PAT). These subjects are:

- **AGRICULTURE:** Agricultural Management Practices, Agricultural Technology
- **ARTS:** Dance Studies, Design, Dramatic Arts, Music, Visual Arts
- **SCIENCES:** Computer Applications Technology, Information Technology, Technical Sciences; Technical Mathematics
- **SERVICES:** Consumer Studies, Hospitality Studies, Tourism
- **TECHNOLOGY:** Civil Technology, Electrical Technology, Mechanical Technology and Engineering Graphics and Design

A practical assessment task (PAT) mark is a compulsory component of the final promotion mark for all candidates offering subjects that have a practical component and counts 25% (100 marks) of the end-of-the-year examination mark. The PAT is implemented across the first three terms of the school year. This is broken down into different phases or a series of smaller activities that make up the PAT. The PAT allows for learners to be assessed on a regular basis during the school year and it also allows for the assessment of skills that cannot be assessed in a written format, e.g. test or examination. It is therefore important that schools ensure that all learners complete the practical assessment tasks within the stipulated period to ensure that learners are resulted at the end of the school year. The planning and execution of the PAT differs from subject to subject.

Practical assessment tasks are designed to develop and demonstrate a learner's ability to integrate a variety of skills in order to solve a problem. The PAT also makes use of a technological process to inform the learner what steps need to be followed to derive a solution for the problem.

The PAT consists of four simulations and a practical project. The teacher may choose any ONE of the practical projects and TWO simulations available for ELECTRONICS. For the first simulation to be completed in term 1, the teacher must choose between Simulation 1 and Simulation 2. For Simulation 2 to be completed in term 2, the teacher must choose between Simulation 3 and Simulation 4.

The teacher must apply assessment on an ongoing basis at the same time that the learner is developing the required skills. TWO simulations should be completed by the learners, in addition to the manufacturing of a practical project.

The PAT incorporates all the skills the learner has developed throughout the year. The PAT ensures that all the different skills will be acquired by learners on completion of practical work, as well as the correct use of tools and instruments.

Requirements for presentation

A learner must present the following:

- PAT file with all the evidence of simulations, design and prototyping. A copy of the PAT 2025 cover page. The relevant simulations and assessment sheets should be copied and handed to each learner to include in the file.
- Practical project with:
 - Enclosure:
 - The file must include a design.
 - The enclosure and the design must match.
 - No cardboard boxes are allowed.
 - Plastic wooden and metal enclosures are acceptable.
 - Enclosures that are manufactured and/or assembled by the learners are preferred.
 - The enclosure should be accessible for scrutiny inside.
 - Lids that are secured are preferred.
 - Circuit board:
 - The file should include the PCB design.
 - The PCB must be mounted inside the enclosure in such a manner that it can be removed for scrutiny. Alternatively, inspection can be made from the bottom in cases where translucent (see-through) enclosures are used.
 - Switches, potentiometers, connectors and other items must be mounted.
 - Wiring must be neat and bound/wrapped.
 - Wiring must be long enough to allow for the PCB to be removed and inspected with ease.
 - Logo and name:
 - The file should contain the logo and name design and specification plate.
 - Logo, specification plate and name must be prominent on the enclosure.
 - The logo/specification plate must be affixed in a permanent manner – painted, glued or stuck on with vinyl.

The PAT will have a financial impact on the school's budget and school management teams are required to make provision for accommodating this particular expense.

PAT components and other items must be acquired timeously, for use by the learners, before the end of the first term at the start of the academic year.

It is the responsibility of the HOD to ensure that the teacher is making progress with the PAT from the start of the school year.

Provincial departments are responsible for setting up moderation timetables and consequently PATs should be completed by **31 August 2025**, in time for moderation.

2. TEACHER GUIDELINES

2.1 How to administer PATs

Teachers must ensure that learners complete the simulations required for each term. The project should be started in January in order to ensure its completion by August. In instances where formal assessments take place, the teacher has to assume the responsibility thereof.

The PAT should be completed during the FIRST THREE TERMS and must be ready at the start of PAT moderation. Teachers must make copies of the relevant simulations and hand them to learners at the beginning of each term.

The PAT must NOT be allowed to leave the workshop and must be kept in a safe place at all times when learners are not working on them.

The weightings of the PAT must be adhered to and teachers are not allowed to change weightings for the different sections.

2.2 How to mark/assess the PATs

The PAT for Grade 12 will be set and assessed internally, but moderated externally. All formal assessment will be done by the teacher.

The teacher is required to produce a working model and model answer file that sets the baseline for assessment at a Highly Competent Level for every project choice exercised by the learners. This file must include all the simulations with answers the teacher has done him/herself. The teacher will use the model answers and project to assess the simulations and projects of the learners.

Once a facet sheet has been completed by the teacher, assessment will be deemed to be complete. No reassessment will be done once the facet sheets have been completed and captured by the teacher. Learners must ensure that the work is done to the required standard before the teacher finally assesses the PAT during each stage of completion.

2.3 PAT Programme of Assessment (PAT PoA)

The programme of assessment (PoA) of the PAT is as follows:

TIME FRAME	ACTIVITY	RESPONSIBILITY
	Preparation for PAT 2025	Teacher – Builds the models and works out the model answers for the simulations. Identifies shortages in tools, equipment and consumable items for simulations that must be procured. SMT – Receives procurement requests from teachers and processes payments for the acquisition of required items
January–March 2025	Simulation 1	Teacher – Copies and hands out simulations Learners – Complete simulations Teacher – Assesses simulations HOD – Checks if tasks have been completed and marked by the teacher before the holidays
January 2025	PAT project – procurement	Teacher – Obtains quotations for PAT projects Principal – Approves PAT procurement for PAT projects Teacher – Ensures that PAT projects are ordered and delivered HOD – Checks that all tasks are completed and marked by the teacher before the holidays
February- March 2025	PAT project – learners commence with project	Teacher – Ensures that there is secure storage for PAT projects Teacher – Hands out and takes in PAT projects Teacher – Hands out copies of Section B, Design and Make: Part 1 Teacher – Includes practical sessions for learners to complete the PAT project every week Learners - Insert copies of Section B, Design and Make: Part 1 in the PAT file. Complete Section B, Design and Make: Part 1 (Circuit diagram, component list, Description of operation). Teacher – Assesses Section B, Design and Make: Part 1 HOD – Checks in on teacher to ensure that practical workshop sessions take place on a weekly basis
April–June 2025	Simulation 2	Teacher – Copies and hands out simulations Learners – Complete simulations Teacher – Assesses simulations Learners – Complete Section B, Design and Make: Part 1 (Circuit Board Manufacturing) Teacher – Assesses Section B, Design and Make: Part 1 HOD – Checks if tasks have been completed and marked by the teacher before the holidays
April–June 2025	Moderation of Simulation 1	District subject facilitator/subject specialist will visit the school and moderate Simulation 1 10% of learners' work is moderated
April–June 2025	PAT project – learners continue with project	Teacher – Includes practical sessions every week for learners to complete the PAT project Learners – Continue with completion of the PAT project HOD – Checks in on teacher to ensure that practical workshop sessions take place on a weekly basis
July holidays 2025	PAT intervention	Learners that are behind on the PAT are required to complete the project during these holidays
July–August 2025	Moderation of Simulation 2	District subject facilitator/subject specialist will visit the school and moderate Simulation 2 – different learners from the previous term 10% of learners' work is moderated

TIME FRAME	ACTIVITY	RESPONSIBILITY
July–August 2025	PAT project – completion	Teacher – Ensures that there is secure storage for PAT projects Teacher – Hands out Section B, Design and Make: Part 2 Learners – Insert copies of Section B, Design and Make: Part 2 in the PAT file; complete Section B, Design and Make: Part 2 Teacher – Assesses Section B, Design and Make: Part 2. Transfer marks onto working marksheet HOD – Checks to see that 100% of the PAT files and projects are completed and assessed
September 2025	PAT moderation	PAT projects are moderated by subject facilitators/subject specialists from the province and learners are available to demonstrate skills 10% of learners are moderated randomly
October 2025	PAT moderation	PAT projects and simulations are moderated by subject specialists from DBE and learners are available to demonstrate skills Learners are moderated randomly

2.4 Moderation of PATs

Provincial moderation of each term's simulations will start as early as the following term. Simulation 1 should be moderated as soon as the second term starts. Similarly, Simulation 2 will be moderated in July. The project will, however, only be moderated on completion.

During moderation of the PAT, the learner's file and project must be presented to the moderator.

The moderation process is as follows:

- During moderation, learners are randomly selected to demonstrate the different simulations. All four simulations will be moderated.
- The teacher is required to build an exemplar model of each project type chosen for the school.
- This model must be on display during moderation.
- The teacher's model forms the standard of the moderation at Level 4 (Highly Competent).
- Level 5 assessments must exceed the model of the teacher in skill and finishing.
- Learners who are moderated will have access to their files during moderation and may refer to the simulations they completed earlier in the year.
- Learners may NOT ask assistance from other learners during moderation.
- All projects and files must be on display for the moderator.
- If a learner is unable to repeat the simulation or cannot produce a working circuit during moderation, marks will be deducted and circuits assessed as not being operational.
- The moderator will randomly select no fewer than two projects (not simulations) and the learners involved will have to explain how the project was manufactured.
- Where required, the moderator should be able to call on the learner to explain the function and principles of operation, and request the learner to exhibit the skills acquired through the simulations for moderation purposes.
- On completion the moderator will, if needed, adjust the marks of the group upwards or downwards, depending on the outcome of moderation.
- Normal examination protocols for appeals will be adhered to, if a dispute arises from adjustments made.

2.5 Absence/Non-submission of tasks

The absence of a PAT mark in Electrical Technology without a valid reason: The learner will be given three weeks before the commencement of the final end-of-year examination to submit the outstanding task. Should the learner fail to fulfil the outstanding PAT requirement, such a learner will be awarded a zero (0) for that PAT component.

2.6 Simulations

Simulations are circuits, experiments and tests/tasks which the learner will have to build, test and measure and practically do as part of the development of practical skills. These skills have to be illustrated to the external moderator that visits the school at intervals during the school year.

Teachers who make use of simulation programs on a computer may use them for the learners to practise on. However, it is required that the circuit be built using real components and that measurements be made with actual instruments for the purposes of assessment and moderation.

The correct procedure for completing simulations is outlined below for teachers and school management teams who are responsible for the implementation of the PAT in Electrical Technology.

- STEP 1: The teacher will choose simulations from simulations that are provided.
- STEP 2: Compile a list of the components needed for every simulation. Add extra components as these items are very small and you will need extras, as these items get lost/damaged very easily when learners work on them.
- STEP 3: Contact three different electronics component suppliers for comparative quotations.
- STEP 4: Submit the quotations to the SMT for approval and procurement of the items.
- STEP 5: Place the components in storage. Collate items for each simulation, thus making it easier to distribute and use during practical sessions. Ensure that different values of components do not mix, as this would lead to components being used incorrectly and this could damage the component and in extreme cases, the equipment used.
- STEP 6: Copy the relevant simulations and hand them out to learners at the start of the term.

Teachers are allowed to adjust circuits and component values to suit their environment/resource availability.

Teachers are required to develop a set of model answers in the teacher's file. Moderators will use the teacher's model answers and artefacts when moderating.

2.7 Projects

The projects are construction projects teachers can choose for their learners. These projects are based on proven circuits provided by schools and subject advisors. The projects are based on working prototypes and require careful construction in order for it to operate correctly.

Projects vary in cost and teachers must ensure that the projects chosen to fall within the scope of the school's budget.

Once the teacher has decided on a circuit, he/she must construct the prototype. Thereafter, copies of the provided circuit can be made and distributed to learners. They MUST redraw these circuits in their files correctly.

The description of the operation of the circuits is NOT complete. Learners are required to interrogate the function of the components in the circuit provided. Learners should elaborate on the purpose of components in the circuit. It is recommended that learners investigate similar circuits available on the internet and in the school library or workshop reference books.

2.8 Working mark sheet

(A working Excel file is provided with this PAT.)

PAT mark sheet		Term 1	Term 2	Project		Total = Term 1 + Term 2 + Project	Mark out of 100	Moderated Mark
No.	Name of Learner	Simulation 1 or 2 50	Simulation 3 or 4 50	Design and Make Part 1 120	Design and Make Part 2 30			
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								
15.								
	Total							
	Average							

Teacher Name: _____

Principal Name: _____

Moderator Name: _____

Signature: _____

Signature: _____

Signature: _____

Date: _____

Date: _____

Date: _____

3. LEARNER GUIDELINES**3.1 PAT 2025 COVER PAGE**

(Place this page at the front of the PAT.)

Department of Basic Education Grade 12				
CAPS for Technical High Schools Practical Assessment Task – Electrical Technology				
Time allowed: Terms 1–3 (2025)				
Learner Name:	_____			
Class:	_____			
School:	_____			
Specialisation: ELECTRONICS				
Complete simulation 1 or 2 in the FIRST TERM and Simulation 3 or 4 in the SECOND TERM.				
Project (Write the name of the project): _____				
Evidence of moderation:				
NOTE:				
When the learner evidence selected has been moderated at school level, the table will contain evidence of moderation. Provincial moderators will sign the provincial moderation and only sign if re-moderation is needed.				
Moderation	Signature	Date	Signature	Date
School-based				
District moderation				
Provincial moderation			Re-moderation	
Mark allocation				
PAT Component	Maximum Mark	Learner Mark	Moderated Mark	
Simulation for Term 1	50			
Simulation for Term 2	50			
Design and Make Project – Circuit	120			
Design and Make Project – Enclosure	30			
Total	250			

3.2 Instructions to the learner

- The practical assessment task counts 25% of your final promotion mark.
- All work produced by you must be your own effort. Group work and co-operative work are NOT allowed.
- The practical assessment task must be completed over three terms.
- The PAT file must contain TWO simulations and a practical project.
- Calculations should be clear and include units. Calculations should be rounded off to TWO decimals. SI units should be used.
- Circuit diagrams can be hand-drawn or drawn on CAD. NO photocopies or scanned files are allowed.
- Photos are allowed and may be in colour or greyscale. Scanned photos and photocopies are allowed.
- This document must be placed inside your PAT file together with the other evidence.
- Learners with identical photos will be penalised and receive zero for that section.

3.3 Declaration of Authenticity (COMPULSORY)

Declaration:

I _____ (name) herewith declare that the work represented in this evidence is entirely my own effort. I understand that if proven otherwise, my final results may be withheld.

Signature of learner

Date

4. SIMULATIONS**4.1 Simulation 1: Darlington transistor amplifier**

Name of learner: _____	Mark	_____
Class: _____	Date completed: _____	50
Date Assessed: _____	Assessor Signature: _____	
Date Moderated: _____	Moderator Signature: _____	

4.1.1 Purpose:

- To construct a Darlington transistor amplifier circuit using discrete components
- To investigate the voltages, currents and current amplification of the Darlington transistor

U Required resources:

COMPONENTS	TOOLS AND EQUIPMENT
2x BC107 Darlington transistor	Multimeter
1 x 6 kΩ resistor ¼ W	Function generator
1 x 10 kΩ resistor ¼ W	Leads
1 X 15 kΩ resistor ¼ W	Breadboard
1 X 4,7 kΩ resistor ¼ W	Side cutters
1 x 100 nf capacitor	Pair of pliers
1 x 0,1 µf capacitor	Dual oscilloscope

4.1.3 Procedure:

Construct the circuit on the breadboard or the digital trainer as shown in FIGURE 4.1.4 on the next page.

Connect the Darlington transistor amplifier as shown in FIGURE 4.1.4 on the next page.

4.1.4 Circuit diagram:

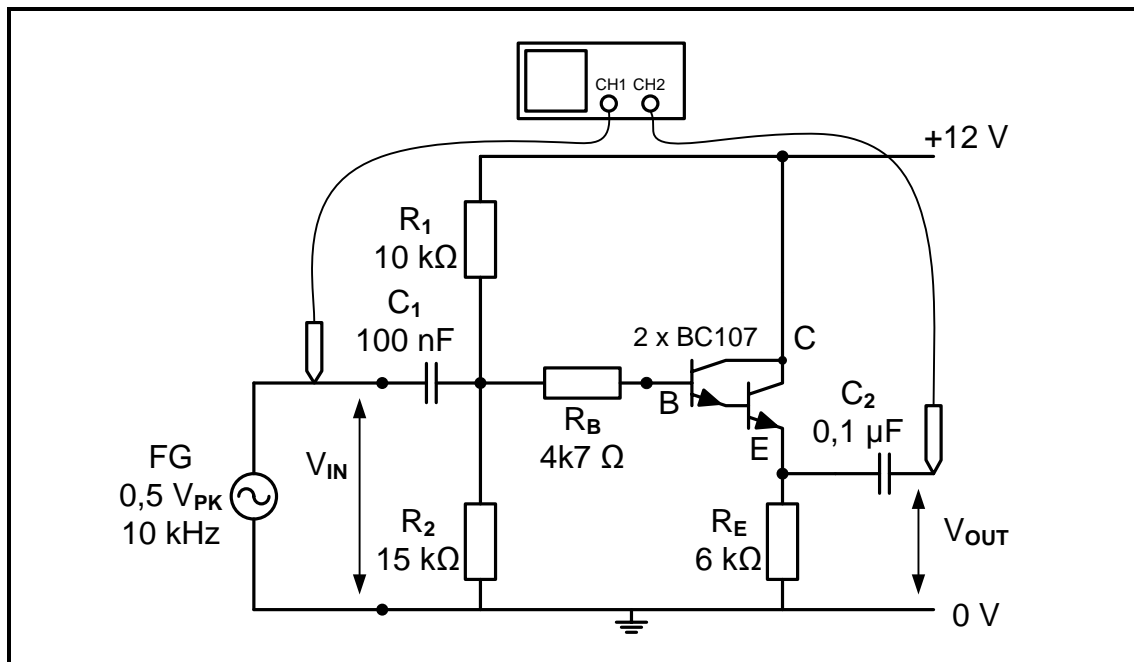


FIGURE 4.1.4: DARLINGTON TRANSISTOR AMPLIFIER

4.1.5 Identify pins/terminals 1, 2 and 3 in FIGURE 4.1.5 below.

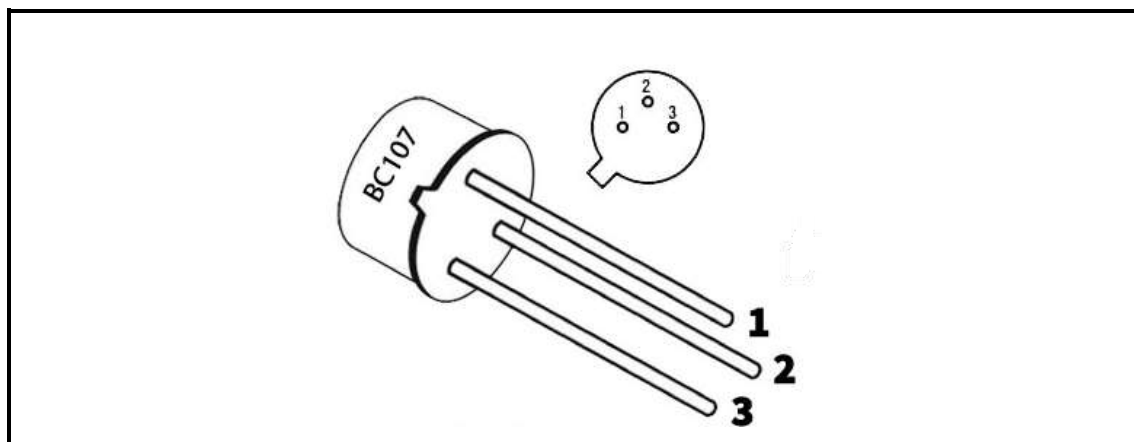


FIGURE 4.1.5: TRANSISTOR

Pin 1 = _____
 Pin 2 = _____
 Pin 3 = _____

(3)

4.1.6 Measure the voltage drop across R_1 , R_2 , R_E and BE .

V_{R1} : _____

(1)

V_{R2} : _____

(1)

V_{RE} : _____

(1)

V_{BE} : _____

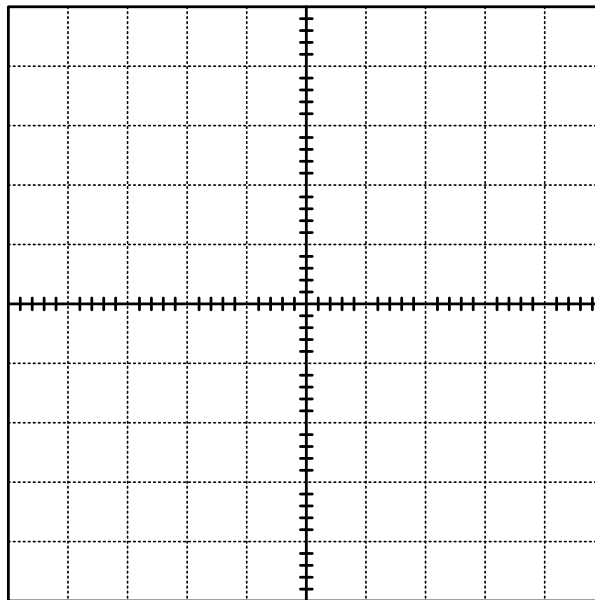
(1)

4.1.7 Use a multimeter to measure the emitter current (I_E), collector current (I_C) and base current (I_B) of the Darlington transistor amplifier circuit.

- Emitter current (I_E): _____ (1)
- Collector current (I_C): _____ (1)
- Base current (I_B): _____ (1)

4.1.8. Set up the oscilloscope to display at least TWO complete cycles for CH1 and CH2 with the voltage settings to display 2/3rd of the screen.

(a) Draw and label both the input (from CH1) and output (from CH2) waveforms for two complete cycles on the grid below.



CH 1 V/div: _____

CH 2 V/div: _____

Time/div: _____

V_{IN} : _____

V_{OUT} : _____

FIGURE:4.1.8 (a): GRID

NOTE: 3 marks for correctly labelled and drawn input waveform
4 marks for correctly labelled and drawn output waveform (7)

(b) State the relationship between the input and output waveform.

(1)

- (c) Calculate the capacitive reactances of the following capacitors when the function generator is set at 100 kHz.
- (i) C₁: _____

_____ (3)
- (ii) C₂: _____

_____ (3)
- (d) Calculate the current gain.
- A_I = _____
= _____
= _____ (3)
- (e) Refer to the waveform on the oscilloscope and determine the peak-to-peak value of the output voltage: _____ (2)
- (f) State THREE advantages of a Darlington transistor.
- (a) _____
(b) _____
(c) _____ (3)
- (g) Name an application of a Darlington transistor, besides being used in amplifier circuits.
_____ (1)
- (h) Is the BC107BP transistor shown in FIGURE 4.1.4 a current or a voltage amplifier component? Motivate your answer.

_____ (2)
- (35)**

**NOTE: Learner competency in this context will mean the following:
(This is done for easy assessment when using a rubric.)**

Not yet competent	Have not met the requirements and will be given another opportunity for re-assessment. <ul style="list-style-type: none">• Be precise about what they did wrong, or the areas they need to improve in.• Clearly explain the level of skill they need to achieve to be assessed as 'competent'.• Indicate whether part or all of the assessment events will need to be repeated.
Competent	<ul style="list-style-type: none">• Having the necessary ability, knowledge, or skill to complete the task successfully.• Acceptable and satisfactory, though not outstanding.
Outstanding	Went beyond expectation (neatness, proficiency – high degree of skills, expertise)

FACET SHEET FOR SIMULATION 1

Task description	Mark allocation (tick the appropriate level next to the task indicated)				Allocation of marks
	Competent after reassessment of certain/all parts of the task	Not yet competent after reassessment of certain/all parts of the task	Competent	Outstanding (Highly competent)	
Building the amplifier circuit	The learner was given opportunities to rebuild the circuit after the teacher intervened in identifying and rectifying more mistakes. (1)	The learner was given an opportunity to rebuild part of the circuit after the teacher intervened in identifying and rectifying a few mistakes. (2-3)	The learner correctly built the circuit without the guidance of the teacher. (4-5)	The learner correctly built the circuit without the guidance of the teacher and went beyond expectations and with high proficiency. (6)	<u>6</u>
Setting of the oscilloscope	The learner was given a third opportunity to set the oscilloscope to display 2/3 of the input and output waveforms on the screen. (1)	The learner was given a second opportunity to set the oscilloscope to display 2/3 of the input and output waveforms on the screen. (2-3)	The learner was able to correctly set the oscilloscope so that 2/3 of both the input and output waveforms can be displayed on the screen. (4-5)		<u>5</u>
Safety aspects	The learner was timeously reminded to apply safety rules, regulation and correct procedure when using tools and instruments. (0)	The learner was sometimes reminded to apply safety rules, regulation and correct procedure when using tools and instruments. (1)	The learner applied safety rules, regulation and correct procedure when using tools and instruments to wire the circuits without being reminded by the teacher. (2)		<u>2</u>
Attitude/ Behaviour/ Conduct	The learner was reluctant to work, cooperate, take responsibility of their own conduct and follow instructional, regulation and workshop practice even after being cautioned/reprimanded. (0)	The learner was reluctant to a certain degree to work, cooperate, take responsibility of their own conduct and follow instructional, regulation and workshop practice. (1)	The learner demonstrated willingness to work, cooperate, take responsibility of their own conduct and follow instructional, regulation and workshop practice. (2)		<u>2</u>
				Rubric Theory	<u>15</u>
				Total Simulation 1	+ <u>35</u>
					= <u>50</u>

4.2 Simulation 2: Non-inverting op amp

Name of learner: _____	Mark	50
Class: _____	Date completed: _____	
Date Assessed: _____	Assessor Signature: _____	
Date Moderated: _____	Moderator Signature: _____	

4.2.1 Purpose:

- To build a non-inverting operational amplifier circuit using a 741 IC
- To display the input and output waveforms on an oscilloscope
- To observe how a change in the value of R_F affects the gain and output voltage of the circuit by either increasing or decreasing the value of R_1

4.2.2 Required resources:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer	1 x LM 741 op amp
Analogue/Digital oscilloscope (dual trace)	2 x 10 k Ω for R_2 and R_1
Function generator	1 x 100 k Ω , 1 M Ω , for R_1
Multimeter	Connecting wires
Variable DC power supply (split supply)	
Side cutters	
Wire strippers	
Long-nose pliers	
Breadboard	

4.2.3 Procedure:

Construct the circuit on the breadboard as shown in FIGURE 4.2.3 on the next page. Adjust the function generator to 1 kHz at a voltage of 0,6 peak to peak. Set the oscilloscope. Channel 1 at 0,2 V/div, channel 2 at 0,2 V/div and Time at 0,2 msec /div.

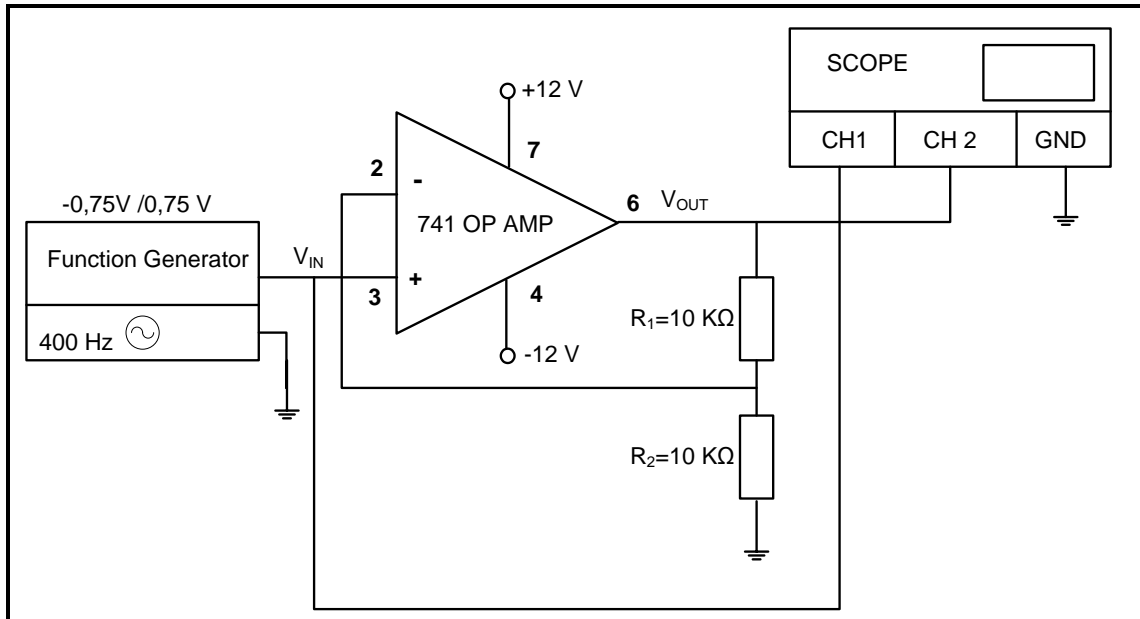
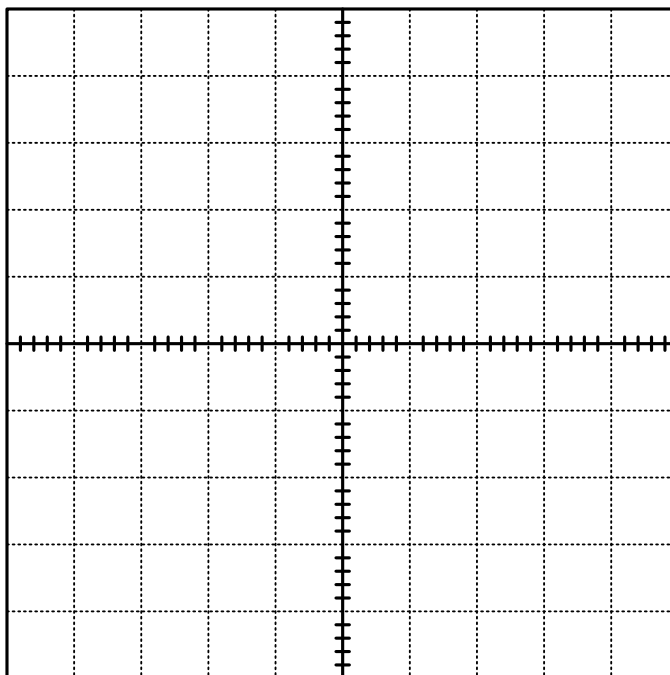


FIGURE 4.2.3: NON-INVERTING OP AMP

- 4.2.4 Set the oscilloscope up to display at least TWO complete cycles for CH1 and CH2 with the voltage settings to display 2/3rd of the screen.
- 4.2.5 Draw and label both the input (from CH1) and output (from CH2) waveforms for two complete cycles on the table below.
- 4.2.6 Write down the peak values of the input and output voltage readings from CH1 and CH2 with $R_2 = 10\text{ k}\Omega$



CH 1 V/div: _____

CH 2 V/div: _____

Time/div: _____

V_{IN} : _____

V_{OUT} : _____

TABLE 4.2.6

NOTE: 1 mark for each correct waveform = 2
 1 mark for each oscilloscope setting = 3
 1 mark for each voltage measurement = 2

(7)

4.2.7 Name and explain the type of feedback used in the circuit diagram.

(3)

4.2.8 Calculate the value of the gain using the values of the resistors in FIGURE 4.2.3.

$$A_V = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

(3)

4.2.9 Calculate the voltage gain of the circuit using the values of the voltages in 4.2.6.

$$A_V = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

(3)

4.2.10 Measure and record the voltages across V_{OUT} in the table below. Also calculate the voltage gain values in the table below as you change the value of R_F in the circuit. Use

$$A_V = 1 + \left(\frac{R_f}{R_1}\right)$$

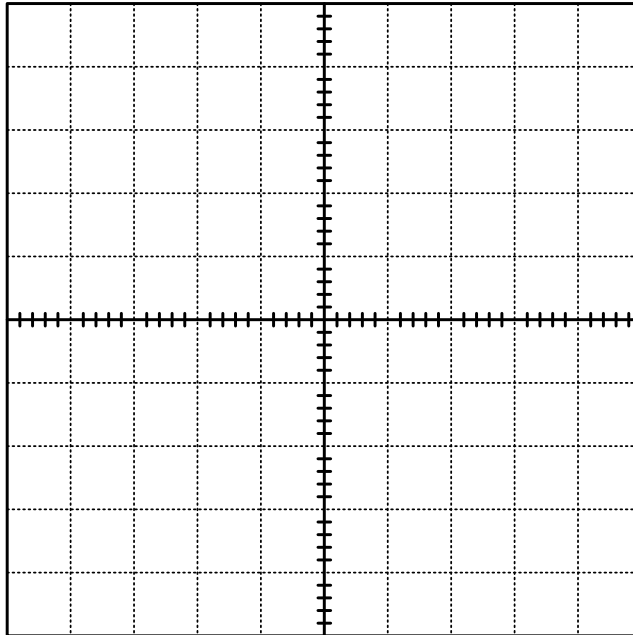
RESISTOR R_F	V_{IN}	V_{OUT}	VOLTAGE GAIN (A_V)
(a) 10 k Ω	0,6 V p-p	<hr/>	
(c) 100 k Ω	0,6 V p-p	<hr/>	
(d) 1 M Ω	0,6 V p-p	<hr/>	

TABLE 4.2.10

NOTE: 1 mark for each correct voltage value = 3
2 marks for each correct gain calculation = 6

(9)

4.2.11 Draw and label the input and output waveforms for at least TWO complete cycles in the table below. Indicate the voltage settings for CH 1 and CH 2 with $R_F = 1\text{ M}\Omega$.



CH 1 V/div: _____

CH 2 V/div: _____

Time/div: _____

V_{IN} : _____

V_{OUT} : _____

TABLE :4.2.11

NOTE: 1 mark for each correct waveform = 2
 1 mark for each oscilloscope setting = 3
 1 mark for each voltage measurement = 2

(7)

4.2.12 Calculate the gain of the amplifier by using resistance values when $R_F = 1\text{ M}\Omega$.

$A_V =$ _____
 = _____
 = _____

(3)

4.2.13 Refer to TABLE 4.2.10, your waveforms on the oscilloscope for 4.2.6 and 4.2.11, as well as your calculations in QUESTIONS 4.2.8 and 4.2.9.

Compare the gain in TABLE 4.2.10 to the gain in QUESTION 4.2.12 above and write a conclusion on your findings.

(5)

Theory: (40)

FACET SHEET FOR SIMULATION 2

Task description	Mark allocation (tick the appropriate level next to the task indicated)				Allocation of marks
	Not yet competent after re-assessment of certain/all part of the task	Competent after re-assessment of certain part of the task	Competent	Outstanding (Highly competent)	
Building the non-inverting op-amp using LM 741 IC	The learner was given opportunities to rebuild the circuit after the teacher intervened in identifying and rectifying more mistakes. (1)	The learner was given an opportunity to rebuild part of the circuit after the teacher intervened in identifying and rectifying few mistakes. (2–3)	The learner correctly built the circuit without the guidance of the teacher. (4–5)	The learner correctly built the circuit without the guidance of the teacher and went beyond expectations and with high proficiency. (6)	$\frac{6}{6}$
Safety aspects	The learner was timeously reminded to apply safety rules, regulation and correct procedure when using tools and instruments (0)	The learner was sometimes reminded to apply safety rules, regulation and correct procedure when using tools and instruments. (1)	The learners applied safety rules, regulation, and correct procedure when using tools and instruments to wire the circuits without been reminded by the teacher. (2)		$\frac{2}{2}$
Attitude/ Behaviour/ Conduct	The learner was completely reluctant to work, cooperate, take responsibility of their own conduct, and follow instructional, regulation and workshop practice even after being cautioned/reprimanded. (0)	The learner was reluctant to a certain degree to work, cooperate, take responsibility of their own conduct, and follow instructional, regulation and workshop practice. (1)	The learner demonstrated willingness to work, cooperate, take responsibility of their own conduct, and follow instructions, regulation and workshop practice. (2)		$\frac{2}{2}$
				Rubric	$\frac{10}{10}$
				Theory	$+$ $\frac{40}{40}$
				Total	$=$ $\frac{50}{50}$

4.3 Simulation 3A: Switching circuits using 555 IC

Name of learner: _____	Mark	<div style="border: 1px solid black; padding: 5px; width: 80px; margin: 0 auto;">50</div>
Class: _____	Date completed: _____	
Date Assessed: _____	Assessor Signature: _____	
Date Moderated: _____	Moderator Signature: _____	

4.3.1 Purpose:

- To build an electronic piano (astable multivibrator) circuit using a 555 IC, on a breadboard as shown in FIGURE 4.3.3
- To display the output waveforms on an oscilloscope
- To calculate the output frequency
- To investigate how a change in R_F and C_1 affects the frequency and tone of the output

4.3.2 Required resources:

TOOLS/INSTRUMENTS	MATERIAL
Analogue/Digital trainer	1 x 555 IC
Analogue/Digital oscilloscope	2 x 0,1 μ F
Dual rail DC power supply (-5 V - 0 - +5 V)	1 x 10 μ F (25 V capacitor)
Side cutter	7 x 1 k Ω resistor
Wire stripper	1 x 10 k Ω resistor
Long-nose plier	1 x 5,6 k Ω speaker
Breadboard	6 x push to make switches
	Connecting wires

4.3.3 Procedure:

- (a) Build the circuit in FIGURE 4.3.3 (see next page) on the breadboard.
 - Connect channel 1 of the oscilloscope across capacitor C_1 .
 - Connect channel 2 of the oscilloscope to pin 3 of the IC.
 - Switch the circuit ON.
 - Press and hold S_1 and observe the output on the oscilloscope. Pay attention to the sound from the speaker.
 - Repeat this step for all switches.
 - Answer the questions that follow.

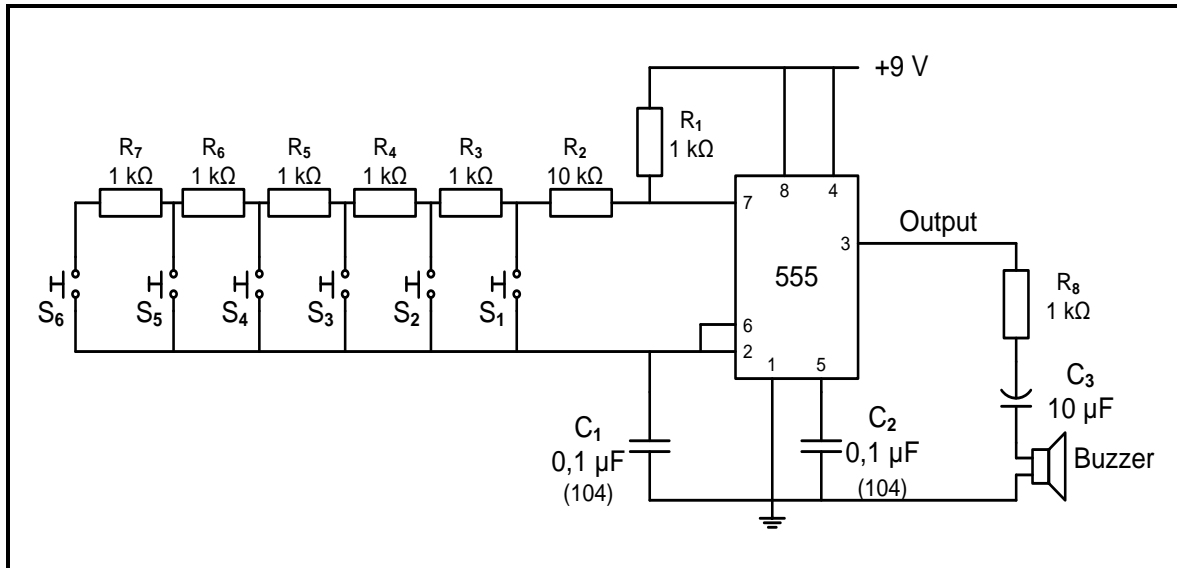
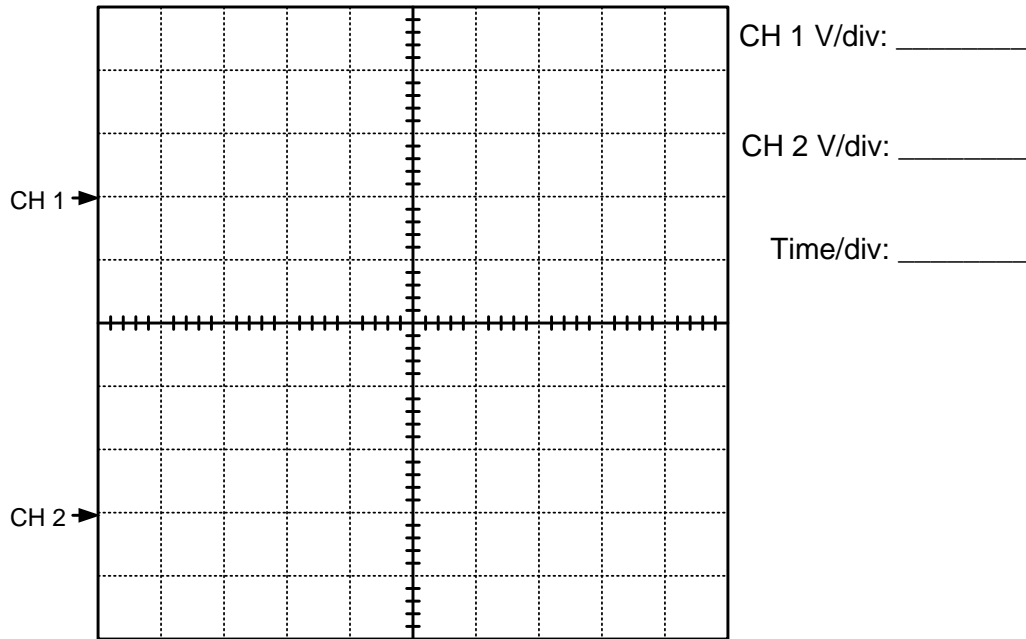


FIGURE 4.3.3: ASTABLE MULTIVIBRATOR CIRCUIT DIAGRAM

PARAMETER	FORMULAE	UNIT
Time high (T_1)	$0,693 \times (R_1+R_2) \times C_1$	Second (s)
Time low (T_2)	$0,693 \times R_2 \times C_1$	Second (s)
Time period (T)	$0,693 \times (R_1+(2 \times R_2+R_N)) \times C_1$	Second (s)
Frequency (F)	$1,44 / (R_1+(2 \times R_2+R_N)) \times C_1$	Hertz (Hz)
Duty cycle	$(T_1/T) \times 100$	Percentage (%)

- (b) Set the oscilloscope to display at least FOUR complete cycles of the output waveform with the amplitudes not smaller than two divisions peak-to-peak. Draw the output waveform, when S_1 is pressed, on the oscillogram on the next page.



NOTE: 1 mark for each correct waveform (o/p) (2)
1 mark for correct oscilloscope settings (1)

(3)

Calculate the following when S_1 is pressed:

- (c) The time that the output is high for each half cycle (Time high T_1) with:
 $T_1 = 0,693 \times (R_1 + R_2) \times C$

(2)

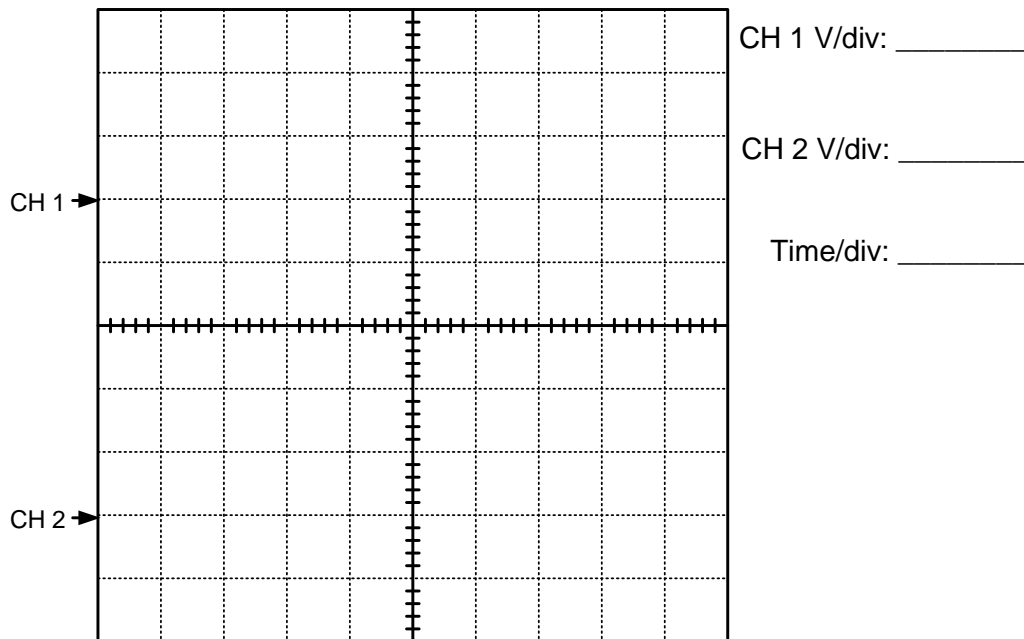
- (d) The time that the output is low for each half cycle (Time low T_2) with:
 $T_2 = 0,693 \times R_2 \times C_1$

(2)

- (e) The frequency of the output with $f = 1,44 / (R_1 + (2 \times R_2 + R_N)) \times C_1$

(2)

- (f) Set the oscilloscope to display at least FOUR complete cycles of the output waveform with the amplitudes not smaller than two divisions peak-to-peak. Draw the output waveform when S_6 is pressed on the oscillogram below.



NOTE: 1 mark for each correct waveform (o/p) (2)
1 mark for correct oscilloscope settings (1)

(3)

- (i) The time that the output is high for each half cycle (Time high T_1) with:
 $T_1 = 0,693 \times (R_1 + (2 \times R_2 + R_N)) \times C_1$

(2)

- (ii) The time that the output is high for each half cycle (Time high T_1) with:
 $T_1 = 0,693 \times (R_1 + (2 \times R_2 + R_N)) \times C_1$

(2)

(iii) The frequency of the output with $f = 1,44 / (R_1 + (2 \times R_2 + R_N)) \times C_1$

(2)

(g) Press each of the switches/push buttons while keeping the oscilloscope connected on the same setting as in (b).
Study the output waveform on the oscilloscope and compare it to the sound when each of the switches/push buttons is pressed.
Record your findings and motivate why this happens.

(2)

Simulation 3A (20)

FACET SHEET FOR SIMULATION 3A

Task description	Mark allocation (tick the appropriate level next to the task indicated)				Allocation of marks
	Competent after re-assessment of certain part of the task	Not yet competent after re-assessment of certain/all part of the task	Competent	Outstanding (Highly competent)	
Building the astable multivibrator using 555 IC	The learner was given opportunities to rebuild the circuit after the teacher intervened in identifying and rectifying more mistakes (1)	The learner was given an opportunity to rebuild part of the circuit after the teacher intervened in identifying and rectifying few mistakes. (2-3)	The learner correctly built the circuit without the guidance of the teacher. (4-5)	The learner correctly built the circuit without the guidance of the teacher and went beyond expectations and with high proficiency (6)	<u>6</u>
Safety aspects	The learner was timeously reminded to apply safety rules, regulation, and correct procedure when using tools and instruments (0)	The learner was sometimes reminded to apply safety rules, regulation, and correct procedure when using tools and instruments. (1)	The learners applied safety rules, regulation, and correct procedure when using tools and instruments to wire the circuits without been reminded by the teacher. (2)		<u>2</u>
Attitude/ Behaviour/ Conduct	The learner was completely reluctant to work, cooperate, take responsibility of their own conduct, and follow instructional regulation and workshop practice even after being cautioned/reprimanded. (0)	The learner was reluctant to a certain degree to work, cooperate, take responsibility of their own conduct, and follow instructional, regulation and workshop practice. (1)	The learner demonstrated willingness to work, cooperate, take responsibility of their own conduct, and follow instructions, regulation and workshop practice. (2)		<u>2</u>
Rubic					<u>10</u>
Theory					+ <u>20</u>
Total Simulation 3 A					= <u>30</u>

Simulation 3B: Op-amp comparator using 741 IC**4.3.4 Purpose:**

- To investigate the characteristics of a 741-op-amp as a comparator with a sine wave input
- To display the input and output waveforms on an oscilloscope
- To investigate the effect of varying the reference voltage on the output

4.3.5 Required resources:

TOOLS/INSTRUMENTS	MATERIALS
Function generator	1 x LM741 op amp
Dual-trace oscilloscope	1 x 100 Ω resistor
Split DC power supply (+9 V/-9 V) or 2 x 9 V batteries	1 x 470 Ω resistor
Breadboard	1 x 10 k Ω potentiometer
Side cutters	1 x 1 k Ω resistor
Long-nose pliers	1 x LED
Wire stripper	Connecting wires

4.3.6 Procedure:

Set the dual voltage power supply to +9 V / -9 V.

Set the function generator to deliver 3 V_{P-P} 10 Hz sine wave.

Build the circuit in FIGURE 4.2.6 on your experiment board and connect it to the supply and input.

Use a multimeter and measure the voltage on pin 3.

Set the potentiometer until the voltage on pin 3 is 1 V.

Connect channel 1 of the oscilloscope across the input to display at least TWO complete cycles.

Connect channel 2 of the oscilloscope across the output to display at least TWO complete cycles.

Ensure that the V/div settings for channel 1 and channel 2 are set so that the waveforms are at least 2/3rd of the screen.

Set the T/div setting to display at least TWO complete cycles of the input and output.

Draw the input and output waveforms and answer the questions.

- (a) Build the circuit in FIGURE 4.2.6(a) on the experiment board.

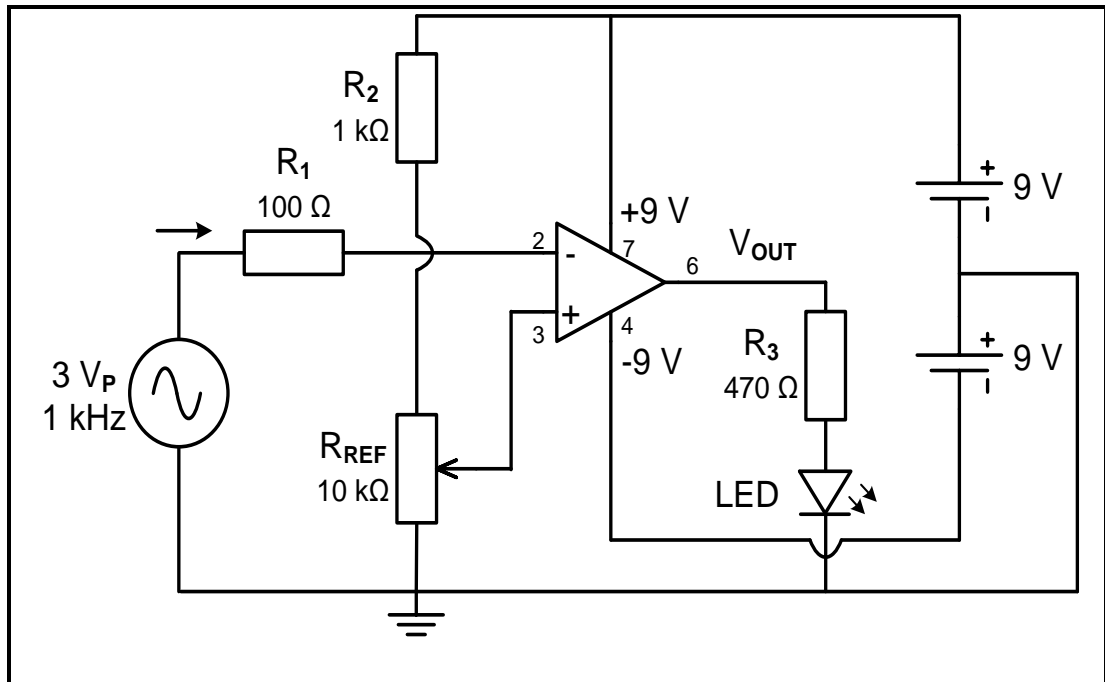
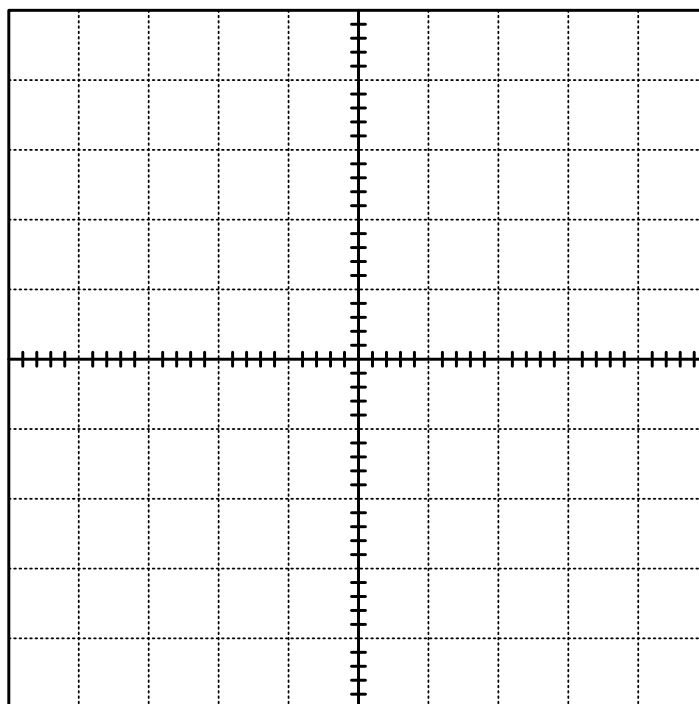


FIGURE 4.3.6: 741 OP-AMP COMPARATOR CIRCUIT

- (b) Draw and label the input waveforms from pin 2 and pin 6 on the oscilloscope below.
NOTE: Set the oscilloscope to display at least TWO complete cycles.



CH 1 V/div: _____

CH 2 V/div: _____

Time/div: _____

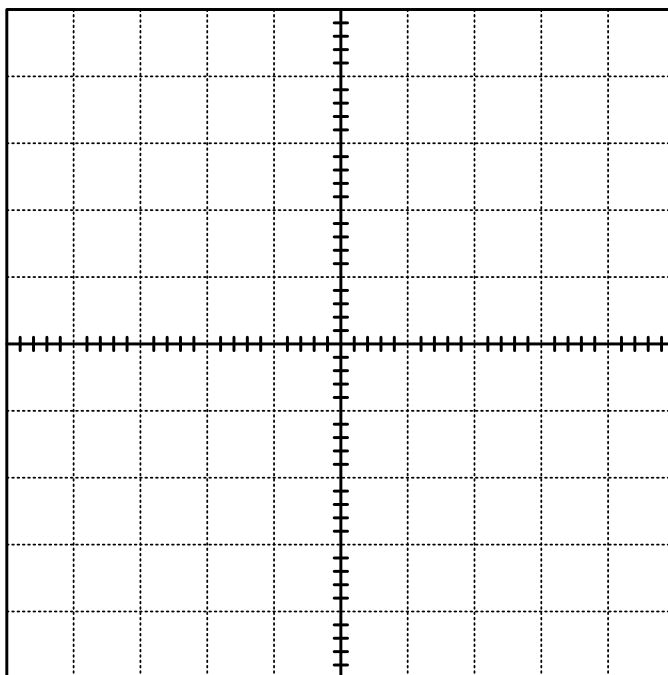
NOTE: 1 mark for each correct waveform = 2
1 mark for correct oscilloscope setting = 1

(3)

- (c) Explain the relationship between the input and the output waveforms with reference to the polarity and V_{REF} .

(2)

- (d) Adjust R_{REF} until the voltage on pin 3 is 2 V. Draw the input and output waveforms on the oscilloscope screen below.
NOTE: Keep the oscilloscope setting the same as in QUESTION 4.3.6(b).



CH 1 V/div: _____

CH 2 V/div: _____

Time/div: _____

NOTE: 1 mark for each correct waveform = 2
Oscilloscope settings remain the same (no marks awarded)

(2)

- (e) Compare the waveforms in QUESTION 4.3.6(b) to the waveforms in QUESTION 4.3.6(d) and explain the effect that adjusting R_{REF} has on the output.

(3)

Theory 3B

(10)

FACET SHEET FOR SIMULATION 3B

Task description	Mark allocation (tick the appropriate level next to the task indicated)				Allocation of marks
	Competent after re-assessment of certain parts of the task	Not yet competent after re-assessment of certain/all parts of the task	Competent	Outstanding (Highly competent)	
Building the comparator using a 741 IC	The learner was given opportunities to rebuild the circuit after the teacher intervened in identifying and rectifying more mistakes. (1)	The learner was given an opportunity to re-build part of the circuit after the teacher intervened in identifying and rectifying a few mistakes. (2-3)	The learner correctly built the circuit without the guidance of the teacher (4-5)	The learner correctly built the circuit without the guidance of the teacher and went beyond expectations and with high proficiency. (6)	<u>6</u>
Safety aspects	The learner was timeously reminded to apply safety rules, regulation, and correct procedure when using tools and instruments. (0)	The learner was sometimes reminded to apply safety rules, regulation, and correct procedure when using tools and instruments. (1)	The learners applied safety rules, regulation, and correct procedure when using tools and instruments to wire the circuits without been reminded by the teacher. (2)		<u>2</u>
Attitude/ Behaviour/ Conduct	The learner was completely reluctant to work, cooperate, take responsibility of their own conduct, and follow instructional, regulation and workshop practice even after being cautioned/reprimanded. (0)	The learner was reluctant to a certain degree to work, cooperate, take responsibility of their own conduct, and follow instructional, regulation and workshop practice. (1)	The learner demonstrated willingness to work, cooperate, take responsibility of their own conduct, and follow instructions, regulation and workshop practice. (2)		<u>2</u>
Rubric					/10
Theory					+ /10
Total Simulation 3B					= /20
Total Simulation 3A					+ /30
TOTAL:					= /50

4.4 Simulation 4: Common emitter amplifier

Name of learner: _____	Mark	<u>50</u>
Class: _____	Date completed: _____	
Date Assessed: _____	Assessor Signature: _____	
Date Moderated: _____	Moderator Signature: _____	

4.4.1 Purpose:

To construct a common emitter amplifier circuit using discrete components and displaying the input/output waveforms on an oscilloscope

4.4.2 Required resources:

TOOLS/INSTRUMENTS	MATERIALS
Analogue/Digital trainer (Breadboard) Analogue/Digital oscilloscope (Dual beam oscilloscope) Function generator Breadboard Multimeter Variable DC power supply (+10 V DC supply) Side cutters Pair of pliers Wire strippers	Transistor BC548/ BC182B/2N3904 R ₁ = 47 kΩ resistor R ₂ = 47 kΩ resistor R _C = 4k7 Ω R ₃ = 470 Ω resistor C ₁ =10 μF (input) C ₂ = 22 μF(output) C ₃ = 100 μF

4.4.3 Procedure:

Construct the circuit as shown below on your breadboard or digital trainer and switch on without connecting the signal generator.

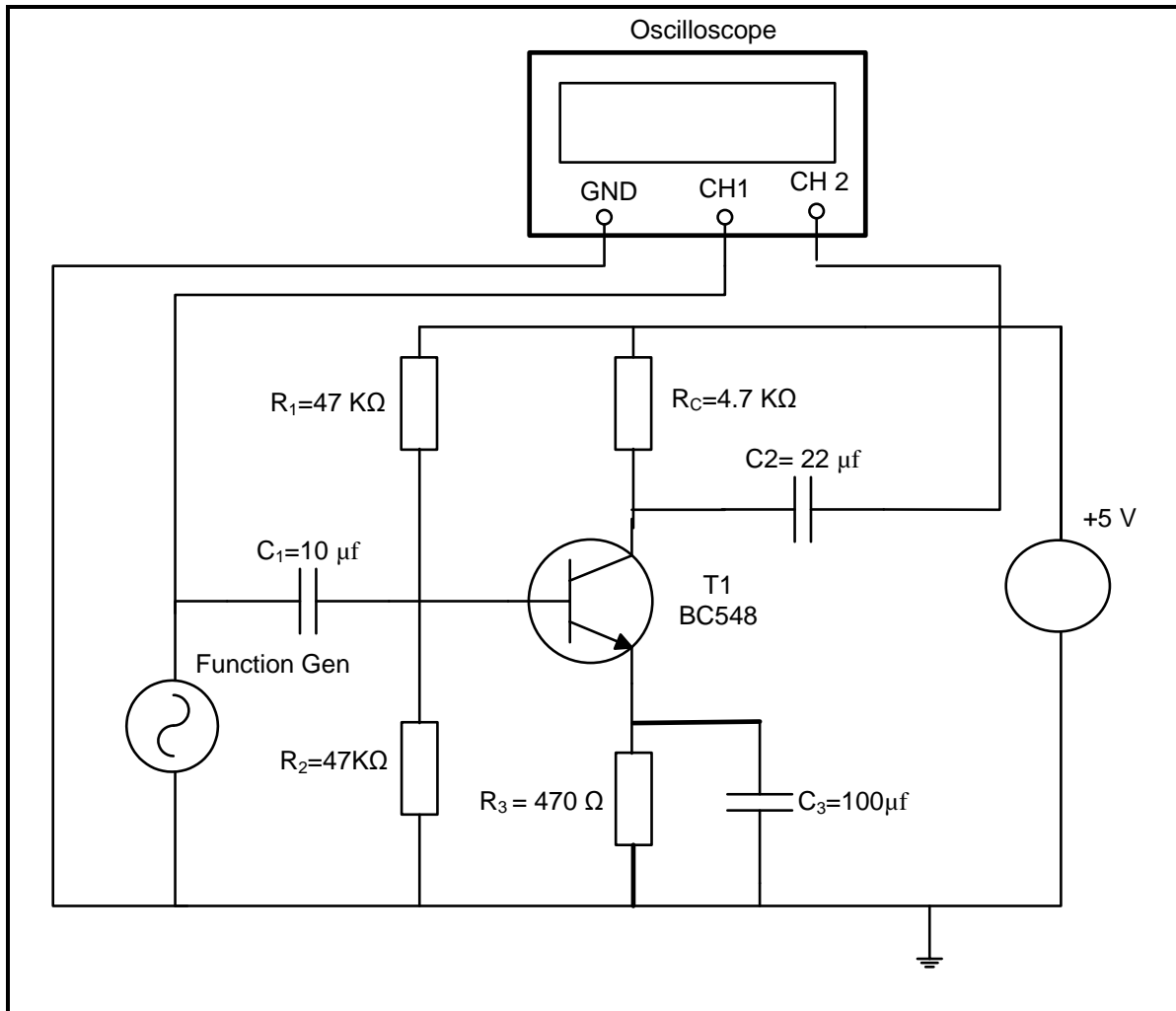


FIGURE 4.4.3: COMMON EMITTER AMPLIFIER

4.4.4 Measure the following without the function generator and the capacitors connected to the circuit.

4.4.4(a) Measure the DC voltage between the base of the transistor and the ground. $V_{BG} =$ _____ (1)

4.4.4 b) Measure the DC voltage between the emitter and the ground. $V_{EG} =$ _____ (1)

4.4.4(c) Measure the voltage across the collector and the emitter. V_{CE} _____ (1)

4.4.4(d) Measure the voltage drop across R_1 and R_2 . V_{R1} _____ and V_{R2} . _____ (2)

4.4.4(e) Measure the voltage drop across R_c and R_3 .
 V_{RC} _____ and V_{R3} _____ (2)

4.4.4(f) Explain why the circuit in FIGURE 4.4.3 is called a common emitter amplifier.

 _____ (2)

4.4.5 Use a multimeter to measure the following currents:

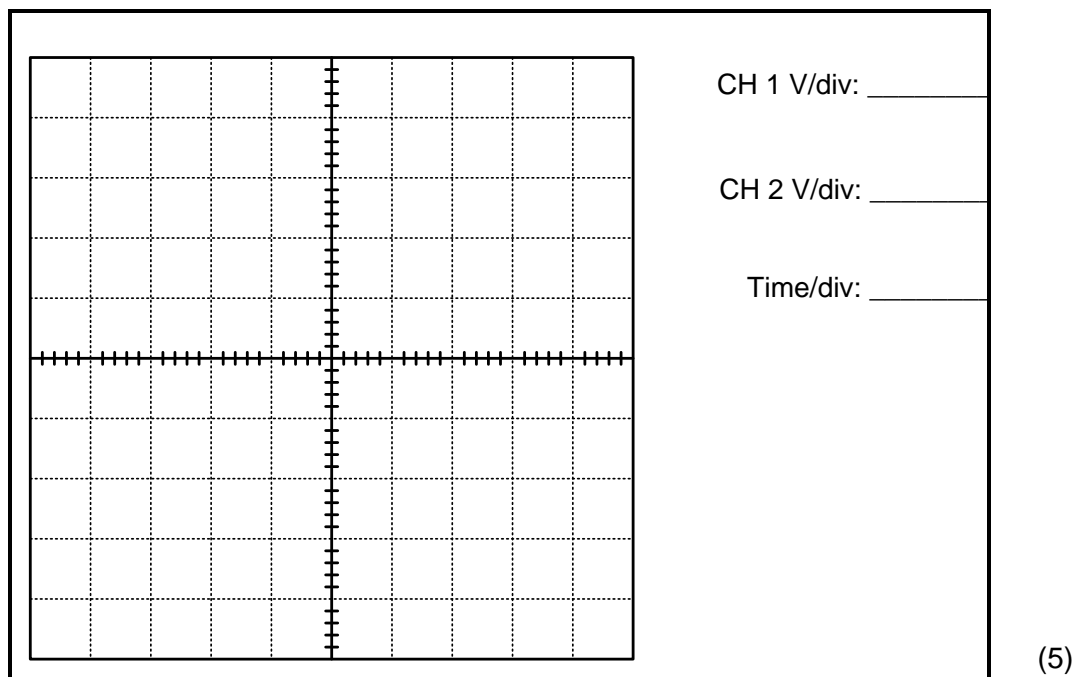
4.4.5(a) Base current (I_B) _____ (1)

4.4.5(b) Collector current (I_C) _____ (1)

4.4.5(c) Emitter current (I_E) _____ (1)

- 4.4.6
- Set the function generator to 1 kHz and adjust the level of the signal for an undistorted signal at the output (Channel 2 of the oscilloscope AC 0,5 V/ division, time base of 0,1 ms /division).
 - Connect Channel 1 across the terminals of the function generator with AC at 10 mV/Division.

4.4.6(a) Draw the input and output waveforms on the graticule provided below.



4.4.6(b) Determine the voltage gain by referring to QUESTION 4.4.6 (a).

$A_V =$ _____
 = _____
 = _____ (3)

4.4.6(c) Calculate the capacitive reactance of the capacitor C_3 when the function generator is set at 1 kHz.

$$X_C = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

(3)

4.4.6(d) Calculate the capacitive reactance of the capacitor C_1 when the function generator is set at 1 kHz.

$$X_C = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

(3)

4.4.7 Complete TABLE 4.4.7 below by writing the characteristics of the transistor connected in common emitter, base and collector configurations.

TRANSISTOR CONFIGURATIONS	VOLTAGE GAIN	CURRENT GAIN	PHASE SHIFT
1. Common emitter			
2. Common base			
3. Common collector			

TABLE 4.4.7


(9)

TOTAL SIMULATION 4

(35)

Task description	Mark allocation (tick the appropriate level next to the task indicated)				Allocation of marks
	Competent after reassessment of certain part of the task	Not yet competent after reassessment of certain/all part of the task	Competent	Outstanding (Highly competent)	
Building the common emitter amplifier	The learner was given opportunities to rebuild the circuit after the teacher intervened in identifying and rectifying more mistakes. (1)	The learner was given an opportunity to rebuild part of the circuit after the teacher intervened in identifying and rectifying few mistakes. (2–5)	The learner correctly built the circuit without the guidance of the teacher. (6–8)	The learner correctly built the circuit without the guidance of the teacher and went beyond expectations and with high proficiency. (9)	$\overline{9}$
Safety aspects	The learner was timeously reminded to apply safety rules, regulation and correct procedure when using tools and instruments. (0)	The learner was sometimes reminded to apply safety rules, regulation and correct procedure when using tools and instruments. (1)	The learners applied safety rules, regulation, and correct procedure when using tools and instruments to wire the circuits without been reminded by the teacher. (2–3)		$\overline{3}$
Attitude/ Behaviour/ Conduct	The learner was completely reluctant at all to work, cooperate, take responsibility of their own conduct, and follow instructional, regulation and workshop practice even after being cautioned/reprimanded. (0)	The learner was reluctant to a certain degree to work, cooperate, take responsibility of their own conduct and follow instructional, regulation and workshop practice. (1)	The learner demonstrated willingness to work, cooperate, take responsibility of their own conduct and follow instructions, regulation and workshop practice. (2–3)		$\overline{3}$
Rubric					$= \overline{15}$
Total Simulation 4					$+ \overline{35}$
TOTAL:					$= \overline{50}$

5. SECTION B: DESIGN AND MAKE

Design and Make Project		
Time: January to August 2025		
Learner Name:	_____	
School:	_____	
Class:	_____	
Title/Type of Project:	_____	

INSTRUCTIONS

- This section is **COMPULSORY** for all learners.
- The teacher will choose a circuit for the project.
- Any project constructed must include at least (but is not limited to):
 - Seven components
 - A variety of components (both active and passive)
 - PCB making in some form
 - Soldering
 - An enclosure with a switch and protection
- The checklist below must be used to ensure that all the required tasks for the PAT have been completed.

PAT CHECKLIST

The learner **MUST** fill in this checklist **BEFORE** marking of the section takes place.

NO.	DESCRIPTION	TICK (□)	
		NO	YES
Design and Make: Part 1			
1.	Circuit diagram drawn	<input type="checkbox"/>	<input type="checkbox"/>
2.	Circuit description filled in	<input type="checkbox"/>	<input type="checkbox"/>
3.	Component list completed	<input type="checkbox"/>	<input type="checkbox"/>
4.	Tools list for circuitry populated	<input type="checkbox"/>	<input type="checkbox"/>
5.	Measuring instrument list filled in	<input type="checkbox"/>	<input type="checkbox"/>
Design and Make: Part 2			
1.	Enclosure design completed and included in the file	<input type="checkbox"/>	<input type="checkbox"/>
2.	Unique name written down and on the enclosure	<input type="checkbox"/>	<input type="checkbox"/>
3.	Logo designed and on the enclosure	<input type="checkbox"/>	<input type="checkbox"/>
Miscellaneous			
1.	Enclosure included in the project	<input type="checkbox"/>	<input type="checkbox"/>
2.	Enclosure prepared and drilled according to the design	<input type="checkbox"/>	<input type="checkbox"/>
3.	Enclosure finished off and completed with name and logo	<input type="checkbox"/>	<input type="checkbox"/>
4.	PCB securely mounted in the enclosure using acceptable techniques	<input type="checkbox"/>	<input type="checkbox"/>
5.	Circuit inside the enclosure accessible	<input type="checkbox"/>	<input type="checkbox"/>
6.	Internal wiring neat and ready for inspection	<input type="checkbox"/>	<input type="checkbox"/>
7.	File and project completed and ready for moderation at the workshop/room	<input type="checkbox"/>	<input type="checkbox"/>

5.1.3 **Component list**

List the components you will need for the circuit diagram.

LABEL	DESCRIPTION AND VALUE	QUANTITY

5.1.4 **Tools/Instrument list**

List the tools needed to complete the project.

DESCRIPTION	PURPOSE

5.2 Assessment of the Design and Make Phase: Part 1

NO.	FACET DESCRIPTION	Mark	Achieved mark
Circuit diagram			
1.	The circuit diagram was drawn using: <ul style="list-style-type: none"> • Freehand sketches (2) • EGD equipment (5) • CAD/Any electronic design software (6) 	6	
2.	The circuit diagram was drawn using correct symbols.	3	
3.	The circuit diagram has all labels, e.g. R1, C1, Tr1	3	
4.	The circuit diagram has all component values, e.g., 100 Ω , 220 μF	4	
5.	The circuit diagram has a name/title.	2	
6.	The circuit diagram has a frame and title block.	2	
Circuit Diagram Subtotal:		20	
Component List			
7.	Labels correlate with circuit diagram.	2	
8.	Description and values correlate with circuit diagram.	2	
9.	Quantities are correct.	1	
Component List Subtotal:		5	
Description of Operation			
10.	Basic function of the circuit is described correctly. The purpose/role/function of each component is described.	11	
11.	All subcircuits in the circuit diagram and component list are included in the description.	4	
12.	Purposes of subcircuits in the circuit diagram are described correctly.	5	
13.	Learner used own interpretation and did not copy from another source verbatim.	3	
14.	Sources are acknowledged.	2	
Description of Operation Subtotal:		25	
Tools/Instrument List			
15.	The tools/instrument list has been completed.	4	
16.	The tools/instruments listed all have a purpose for being used.	1	
Tools/Instrument List Subtotal:		5	

NO.	FACET DESCRIPTION	Mark	Achieved mark
Circuit Board Manufacturing			
17.	Transfer of the PCB design onto the blank board is correct. Not over-exposed or under-exposed.	5	
18.	Circuit board is etched neatly according to the PCB design.	10	
19.	The learner's name is etched onto the circuit design.	4	
20.	All burrs are removed.	2	
21.	Axial and radial components are placed neatly and flush with the board.	5	
22.	Component orientations are aligned between similar components (e.g. the gold band of all resistors are placed on the same side).	2	
23.	Soldered components – leads are cut off, flush and neat on the solder side.	5	
24.	More than 60% of the solder joints are shiny (not dry joints).	5	
25.	Wire insulation is stripped to the correct length (no extra copper showing).	3	
26.	Wiring is long enough to allow for dismantling and inspection.	2	
27.	Wiring is wrapped neatly.	2	
28.	A power switch is included and fitted to the enclosure.	2	
29.	A fuse/protection is included and fitted correctly where applicable.	2	
30.	Wiring entering/exiting the enclosure is provided with a grommet/applicable fittings/socket where applicable.	2	
31.	Batteries/Transformer is mounted using a battery housing/mounting bracket and battery clip (NO double-sided tape).	2	
32.	The project has a pilot light/LED installed in the enclosure showing when the circuit is operational. LED is mounted with a grommet or applicable fitting. (Switch is on – must go out when fuse is blown.)	2	
33.	The project is fully operational and commissioned/installed in the enclosure.	10	
	Circuit Board Manufacturing Subtotal:	65	
	Circuit Diagram Subtotal:	20	
	Component List Subtotal:	5	
	Description of Operation Subtotal:	25	
	Tools/Instrument List Subtotal:	5	
	Circuit Board Manufacturing Subtotal:	65	

TOTAL (PART 1 = 120 marks)	
---	--

NOTE: If pre-etched and pre-manufactured PCBs are used, learners will not be able to receive any marks for facets 17–20.
In projects where facets are not applicable, e.g. projects without transformers/batteries, the projects should be marked and the totals adjusted accordingly.

5.3 Design and Make: Part 2

5.3.1 Enclosure design

- Design an enclosure for your project.
- NO FREEHAND DRAWINGS.
- Draw using EGD equipment **OR** use a CAD program.
- Draw in first-angle orthographic projection.
- Add your drawings after this page.
- Use colour to enhance your drawing.

5.3.2 Manufacture the enclosure neatly according to your design.

You may use pre-cut panels from metal, wood and/or Perspex/Plexiglas.

You must, however, construct/assemble these parts.

Injection moulded enclosures are also acceptable. It is important that your enclosure and the placement of the parts align with your design.

5.3.3 Choose a name for your device.

Write down the name of the device below.

5.3.4 Design a unique logo for your device, as well as a specification plate and attach it after this page.

Logo design	Specification plate design

5.4 Assessment of the Design and Make Phase: Part 2

NO.	FACET DESCRIPTION	Mark	Achieved mark
Enclosure Design			
1.	Enclosure design is included in first-angle orthographic projection.	2	
2.	Drawn design includes a title box and page border.	1	
3.	Isometric drawing included additionally.	2	
4.	Dimensions are included.	2	
5.	The name of the device is written in the PAT document.	1	
6.	The logo design and specification plate design are in the PAT document.	2	
Enclosure Design Subtotal:		10	
Enclosure Manufacturing			
7.	Enclosure matches the design. Dimensions and placement correlate.	1	
8.	Name of the device is attached on the enclosure.	1	
9.	The logo design is attached on the enclosure.	2	
10.	The logo design on the enclosure is durable and not merely a paper pasted on the enclosure (painted/used decoupage/screen printed/sublimation printed).	2	
11.	The enclosure is manufactured from scratch/pre-cut parts. Perfectly manufactured square, neat and sturdy enclosure (5) Injection moulded/pre-manufactured enclosures minimum alterations. (3) Enclosures may include sheet metal, Perspex, Plexiglas, Wood, Glass and other raw materials, injection-moulded plastic boxes Enclosures may NOT include cardboard, paper, margarine container.	5	
12.	Holes/Cut-outs in the enclosure are made with the appropriate tools and match the design.	3	
13.	Specification plate with the learner's name, operating voltage, fuse rating and additional information on the project.	2	
14.	Enclosure is neatly prepared, painted and aesthetically pleasing.	2	
15.	The circuit board is mounted using appropriate methods inside the enclosure. (NO double-sided tape, Prestik, glue, chewing gum, masking tape, etc.)	2	
Enclosure Manufacturing Subtotal:		20	

TOTAL (PART 2 = 30 marks)	
--------------------------------------	--

6. PROJECTS

6.1 Practical Project 6.1: Dual voltage power supply

This project uses a centre-tapped transformer. The recommended rating of the transformer is 240 V to 18-0-18 V transformer.

NOTE: Sometimes the transformer one purchases, outputs more than the specified value, so be careful when choosing the transformer.

Capacitors C1 and C2 act as smoothing capacitors. This is to even out any fluctuation in voltage. You can also add a bypass capacitor after the C1 and C2 to remove any AC noise, which is not shown in the circuit. Next the two voltage regulators: the 7812 gives positive 12 V and the 7912 gives negative 12 V. Other variants of voltage regulator ICs can also be used.

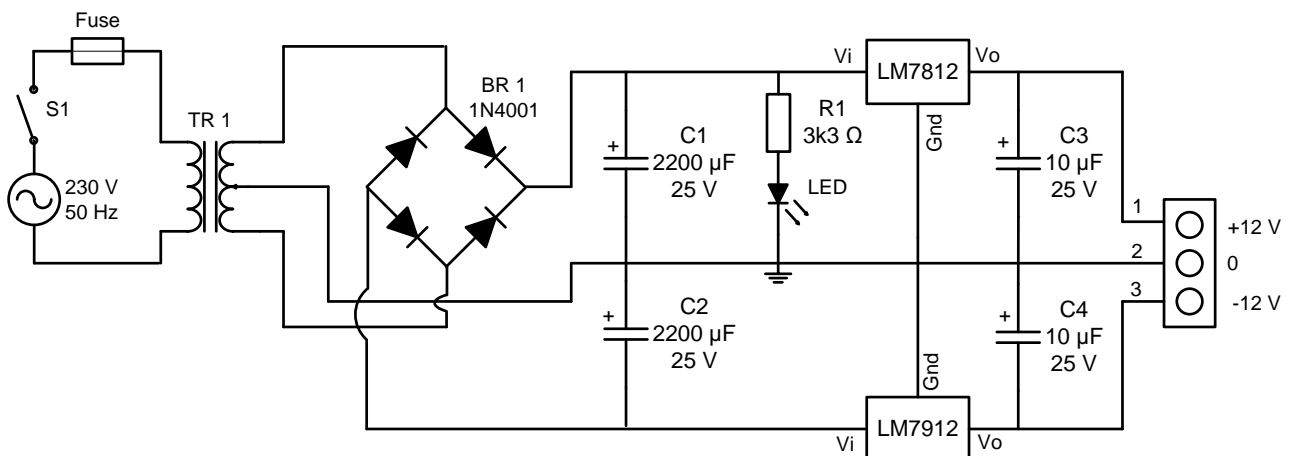
NOTE: 78xx gives the positive output and 79xx gives the negative output

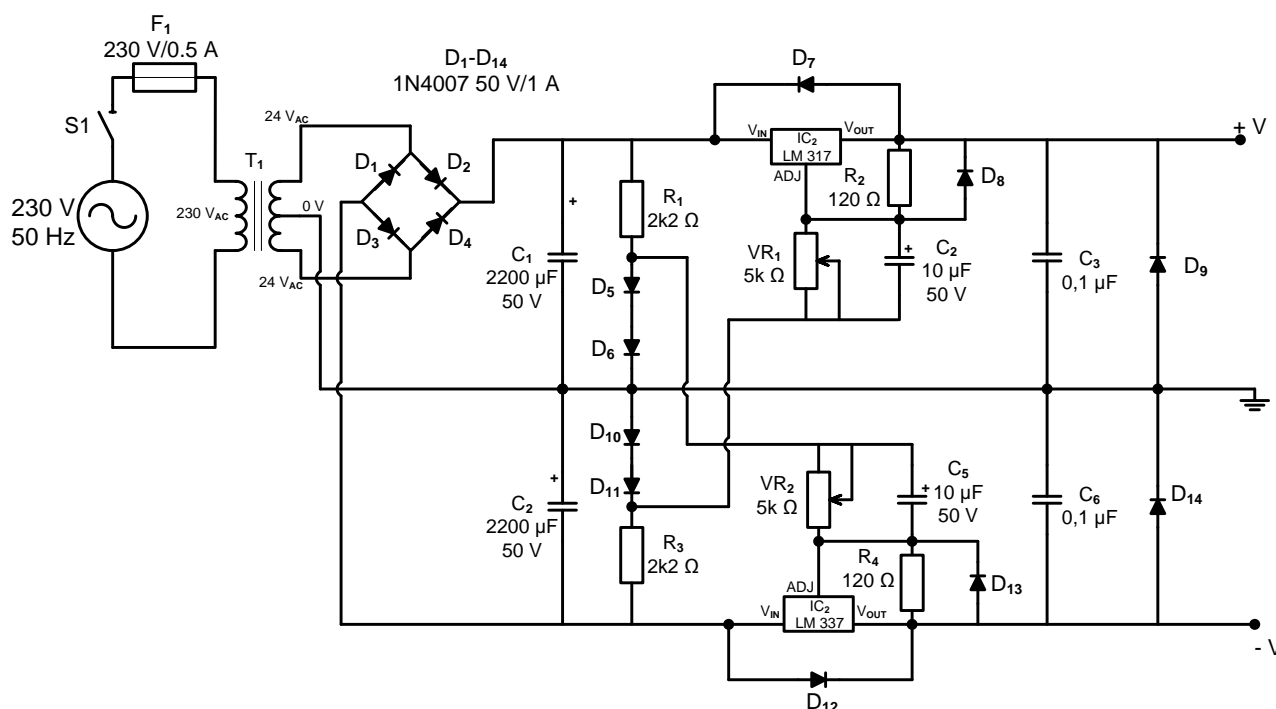
The capacitors C3 and C4 are used as the bypass capacitor to remove the AC noise and give a pure, cleaner DC signal.

Resources required:

Tool	Materials	
Multimeter	1 x transformer 240 to 15-0-15 volt	1 x 7812 voltage regulator IC
Side cutters	4 x 1N4001	1 x 7912 voltage regulator IC
Wire strippers	2 x 2200uF/25V	1x toggle switch
Soldering iron	2 x 10uF/25V	1 x in line 2 A fuse and holder
Helping Hands	1 x 3.3 kΩ	1 m mains supply cable
PCB etching tank or similar	1 x red LED	1 x 3 pin plug
Solder sucker	2 x heat sink	1 x PCB
	1 x 3 pin terminal block	2 x digital panel voltmeter displays
	1 x grommet – power indicator	
	1 x grommet/PVC compression gland/ solder butt sleeve 3-2mm – power chord	
	1 x Cabtyre – ½ metre length	

Circuit diagram:



Alternative project: 0-30 V Variable Dual Voltage Power Supply

<https://www.eleccircuit.com/0-60-volt-dc-variable-power-supply-using-lm317lm337/>

Working explanation

The LM317T is an adjustable regulator IC that can adjust the output voltage from 1,25 V to 37 V. It can provide up to 1,5 A with an input voltage of 3 V to 40 V. Internally, the LM317 has full protection, e.g. short-circuit protection, input over voltage protection, overload protection. Another interesting feature is the elimination of the ripple.

The output voltage (V_o) is determined from the formula $V_o = 1,25\{1+(R_2/R_1)\}$ where R_1 is the resistance constant from 120 ohms to 240 ohms. We can adjust resistor R_2 from a minimum value (0 ohms) to any value we want. If R_2 is 0 ohms minimum output, the voltage is about 1,25 V. Related: LM317 calculator, making LM317 start at 0 volts.

Electronic circuits require a constant voltage. The output voltage of LM317T may not need to reduce to 0 V. However, in the experiments, it may be necessary to start the voltage at 0 V. Unfortunately, the minimum output voltage is 1,25 V.

The negative voltage regulated IC, LM337T is similar to LM317. If the Adj connects to ground, the lowest output voltage is -1,25V.

Diodes D1-D4 are rectifier ACV from 240 volts of the transformer into DCV of about 33 V, in both positive and negative voltage.

The capacitors C1 and C4 are a voltage filter from the bridge diodes to smooth the pulsating DCV.

The R1, D5 and D6 create the reference voltage of +1,25 volts to the LM337T to adjust the voltage to start at 0 V.

The R3, D10 and D11 make voltage -1,25 V to LM317T. It can also adjust the beginning voltage to 0 V.

The D7, D8, and D12 - D13 protects it against backward voltage from the output, which may cause damage to the IC. C2 and C5 are connected to reduce the noise signal from adjusting the potentiometer (VR1, VR2) and smooths the voltage at the output.

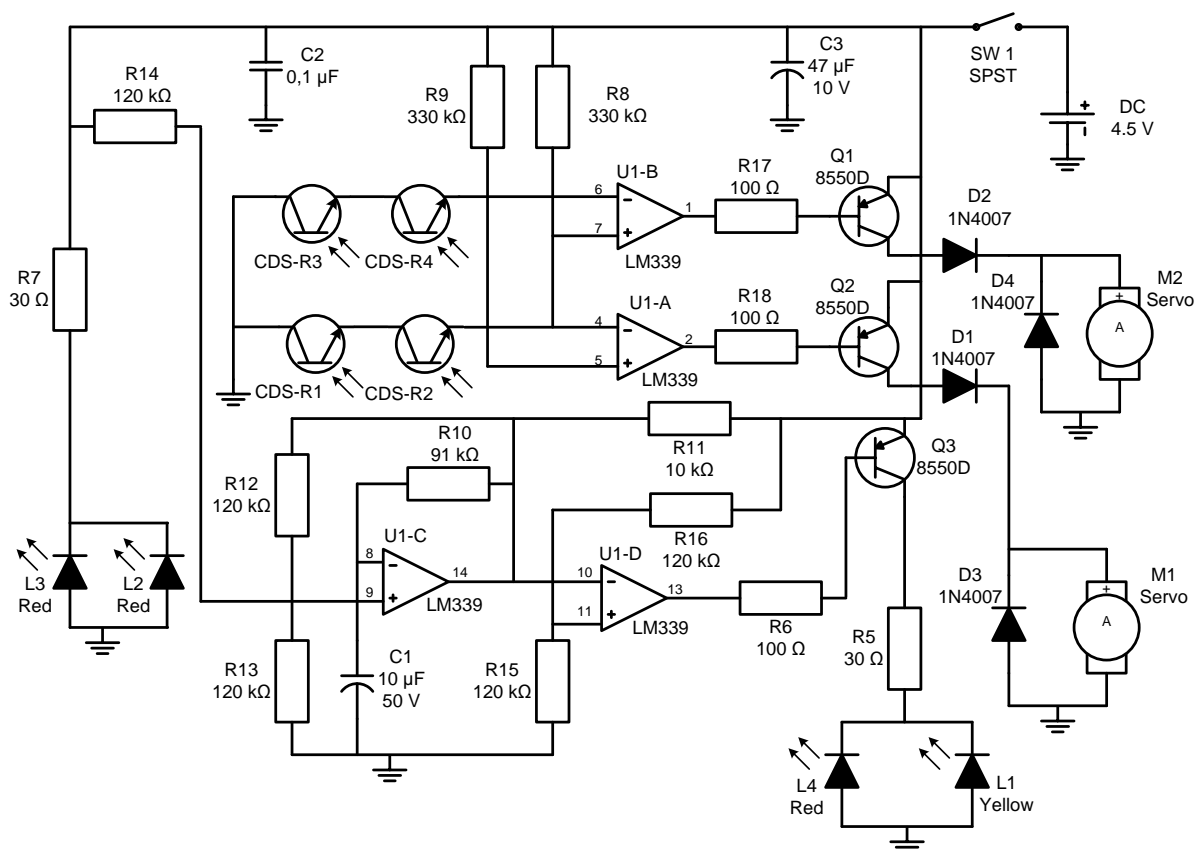
After examining and successfully assembling the device, apply AC power.

Hold the DC voltmeter to measure the positive output. Then rotate VR1; you can read the voltage from 0–30 volt. If everything is correct, then move the lead of the meter to measure the negative.

Next, adjust the VR2; you can read voltage from 0-30 volts. Alternatively, connect a digital panel voltmeter between ground and +V to display the positive output voltage and a digital panel voltmeter between ground and -V to display the negative output voltage.

6.2 Practical Project: Line following buggy

The line following buggy will follow a black line drawn on white paper by TWO photo interrupters. Create different routes with black electric tape or a black marker for your line-tracking robot. The buggy operates using an IR sensor. The IR diode transmits a signal when a black line is encountered. The signal is fed to the IC chip that stop or start each motor, alternatively switching ON and OFF motor 1 and 2 to alter the buggy's direction.



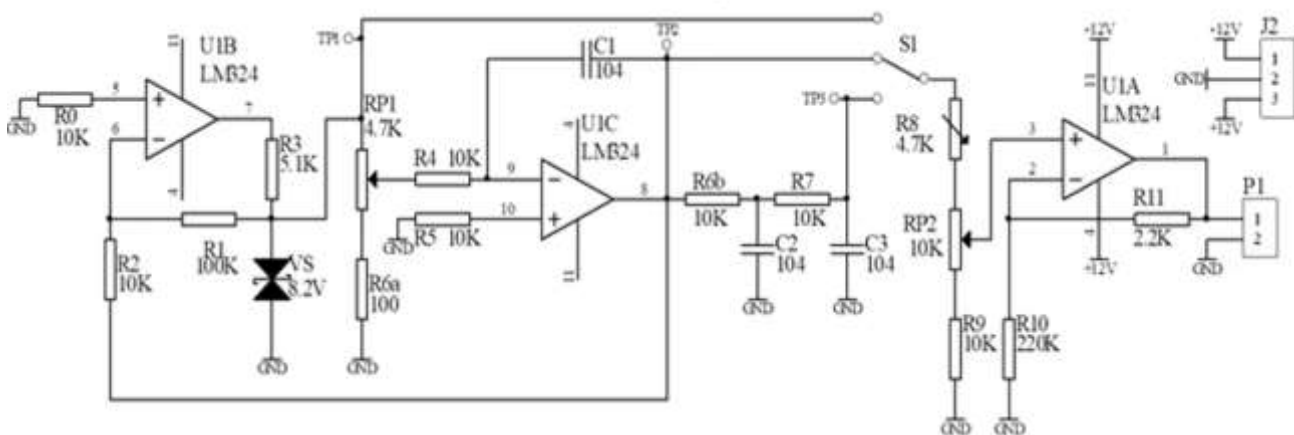
NO.	POSITION	ITEM	DESCRIPTION	QTY
1	R5, R7	Resistor	30 Ω 1/8 W 5%	2
2	R6, 17, 18	Resistor	100 Ω 1/8 W 5%	3
3	R8, R9	Resistor	330 kΩ 1/8 W 5%	2
4	R10	Resistor	91 kΩ 1/4 W 5%	1
5	R11	Resistor	10 kΩ 1/4 W 5%	1
6	R12, 13, 14, 15, 16	Resistor	120 kΩ 1/4 W 5%	5
7	R1/CDS, R2/CDS, R3/CDS, R4/CDS	Photo sensor	WJ5800D	4
8	C3	Electrolytic capacitor	47 μF/16 V	1
9	C1	Electrolytic capacitor	10 μF/16 V	1
10	C2	Ceramic capacitor	104/50V	1
11	D1, 2, 3, 4	Diode	1N4007 ¼ W	4
12	S1	Slide switch	SK-12f1406(1p2t) H=8 mm	1
13	BH-3V	Battery holder	AA x 2 : 58 x 34 mm.	1
14	L1	LED	5 mm yellow diffuse LED	1
15	L2, 3, 4,	LED	5 mm red diffuse LED	3
16	Q1, 2, 3	Transistor	S8550D TO-92	3
17	U1	IC	LM339N	4
18	Gear box	Gear box		1
19	Metal wheel	Metal wheel	4 Direction	2
20	Plastic wheel	Plastic wheel	R=37mm	1
21	M1, M2	Servo motor	Servo motor	2

6.3 Practical project: Function generator

In the circuit diagram, U1B, U1C, U1A are three independent operational amplifiers inside a LM324 IC. The circuit composed by U1B is a comparator; the circuit composed by U1C, C1 and related circuits is an integrating circuit; the circuit composed by R6b, C2 and R7, C3 is a filter, which is used to filter out high harmonics and convert triangular waves into nearly triangular waves. The circuit consisting of R6b, C2, R7 and C3 is a filter for filtering out high harmonics and converting triangular waves to approximate sine waves. Rp2 is used to adjust the output amplitude and R8 and R9 are used to limit the maximum and minimum output signal amplitude.

The output of U1B (pin 7) feeds the output signal through R2,R1 to the input (pin 6), forming a positive feedback circuit.

The output signal from the output of U1C (pin 8) is also fed to the input of U1B (pin 6) via R2 to control the working state of U1B. The circuit consisting of U1C, C1 and the associated resistor is an integral circuit. The output of U1C (pin 8) outputs a triangular wave signal, and adjusting RP1 can influence the charging and discharging time of this integral circuit, thus changing the frequency of the triangular wave. A high-pass filter consisting of R6b, C2, R7 and C3 is connected to the output of U1C (pin 8) to filter out the high frequency harmonics from the triangle wave and convert the triangle wave into an approximate sine wave.



7. CONCLUSION

On completion of the practical assessment task, learners should be able to demonstrate their understanding of the industry, enhance their knowledge, skills, values and reasoning abilities as well as establish connections to life outside the classroom and address real-world challenges. The PAT furthermore develops learners' life skills and provides opportunities for learners to engage in their own learning.