basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY

GUIDELINES FOR PRACTICAL ASSESSMENT TASKS

2015

These guidelines consist of 75 pages.

TABLE OF CONTENTS

1. INTRODUCTION

The 16 Curriculum and Assessment Policy Statement 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
- 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-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 uses a technological process to inform the learner what steps needs to be followed to derive a solution for the problem.

The 2015 PAT has three focus areas with projects and simulations in each of the following fields:

- Electrical
- Electronics
- Digital Electronics

The PAT task consists of four simulations and a practical project. The teacher may choose any of the practical projects and use a combination of the simulations available.

The teacher has to apply assessment on an on-going basis at the same time that the learner is developing the required skills. Four 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 from Grades 10, 11 and 12. The PAT ensures that all the different skills will be acquired by learners on completion of practical work, that is, electrical, analogue and digital electronics 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.
- Practical project with:
  - Enclosure
    - The file must include a design.
    - The enclosure and the design must match.
    - No cardboard boxes are allowed.
    - Plastic and metal enclosures are acceptable.
    - The enclosure should be accessible for scrutiny inside.
    - Lids that are secured with screws 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.
    - 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.
    - Logo and name must be prominent on the enclosure.

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

PAT components and other items must be acquired timely 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 progressing 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 in time for moderation.

2. TEACHER GUIDELINES

2.1 HOW TO ADMINISTER THE 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. All formal assessment is the teacher's responsibility.

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 it.

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 is externally set and moderated, but internally assessed. All formal assessment will be done by the teacher. The PAT must be moderated by the following persons:

The teacher is required to produce a **working model and model answer file** which sets the baseline for assessment at a Highly Competent Level for every choice/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 rubric has been completed by the teacher, assessment will be deemed to be complete. **No re-assessment will be done once the rubrics have been filled in** and captured by the teacher. Learners must ensure that the work is done to the standard required before the teacher finally assesses the PAT during each stage of completion.

2.3 PAT ASSESSMENT MANAGEMENT PLAN

The assessment plan for the PAT is as follows:

TIME FRAME	ACTIVITY	RESPONSIBILITY
October–December 2014	Preparation for PAT 2015	Teacher – Builds the models and works out the model answers for the simulations for 2015. Identify shortages in tools, equipment and consumable items for simulations which must be procured in 2015. SMT – Receive procurement requests from teachers and process payments for the acquisition of required items.
January–March 2015	Simulations 1 and 2	Teacher – Copies and hands out simulations. Learners – Completes simulations. Teacher – Assesses simulations. HOD – Checks if tasks have been completed and marked by the teacher before the holiday.
January 2015	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 up on teacher to see if the process is being adhered to.
February 2015	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 – Includes practical sessions for learners to complete PAT project every week. Learners – Commence with completion of the PAT project. HOD – Checks on teacher to ensure that practical workshop sessions take place on a weekly basis.
April–June 2015	Moderation of Simulations 1 and 2	District Subject Facilitator/Subject Specialist will visit the school and moderate Simulations 1 and 2. 10% of learners work is moderated.
April–June 2015	Simulations 3 and 4	Teacher – Copies and hands out simulations. Learners – Completes simulations. Teacher – Assesses simulations. HOD – Checks if tasks have been completed and marked by the teacher before the holiday.
April–June 2015	PAT project: Learners continue with project	Teacher – Ensures that there is secure storage for PAT projects. Teacher – Hands out and takes in PAT projects. Teacher – Includes practical sessions for learners to complete PAT project every week. Learners – Continue with completion of the PAT project. HOD – Checks on teacher to ensure that practical workshop sessions take place on a weekly basis.
July holiday 2015	PAT intervention	Learners that are behind on the PAT are required to complete the project during this holiday.
July–August 2015	Moderation of Simulations 3 and 4	District Subject Facilitator/Subject Specialist will visit the school and moderate Simulations 3 and 4. Different learners from the previous term. 10% of learners' work is moderated.

TIME FRAME	ACTIVITY	RESPONSIBILITY
July–August 2015	PAT project: completion	Teacher – Ensures that there is secure storage for PAT projects. Teacher – Hands out and takes in PAT projects. Teacher – Completes the PAT project with learners and compiles the PAT file. Learners – Completes the PAT project and file. HOD – Checks to see that 100% of PAT files and project are completed and assessed
September–October 2015	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 at random.

2.4 MODERATION OF THE PATs

Provincial moderation of each term's simulations will start as early as the following term. Simulations 1 and 2 should be moderated as soon as the second term starts. Similarly Simulations 3 and 4 will be moderated in July. The project, however, will only be moderated upon 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 for 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 a Level 4 (Highly Competent).**
- **Level 5 assessments must exceed the model of the teacher in skill and finishing.**
- Learners being moderated will have access to their file 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 select at random no less than **two projects** (not simulations), of which learners will have to come and explain how the project was manufactured.
- Where required the moderator should be able to call on the learner to come and explain the function, principles of operation and also 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 up or downwards, depending on the decision reached as a result 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

In the absence of a PAT mark in Electrical Technology without valid reason, the learner will be given three weeks before the commencement of the final end-of-year examination to submit the outstanding task9s). Should the learner fail to fulfill the outstanding PAT requirement such a learner will be awarded a zero for that PAT component. The final mark for the PAT will be adjusted for promotion purposes in terms of the completed tasks.

A learner's results are regarded as incomplete if he/she does not offer any component of the PAT. He/She will be given another opportunity based on the decision of the Head of the assessment body.

2.6 SIMULATIONS

Simulations are circuits, experiments and tests 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 use simulation programs on computer are welcome to use them for the learners to practice 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 herewith outlined 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 the provided examples.
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 with 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 portfolio.

Moderators will use of the teacher's model answers and artefact when moderating.

2.7 PROJECTS

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

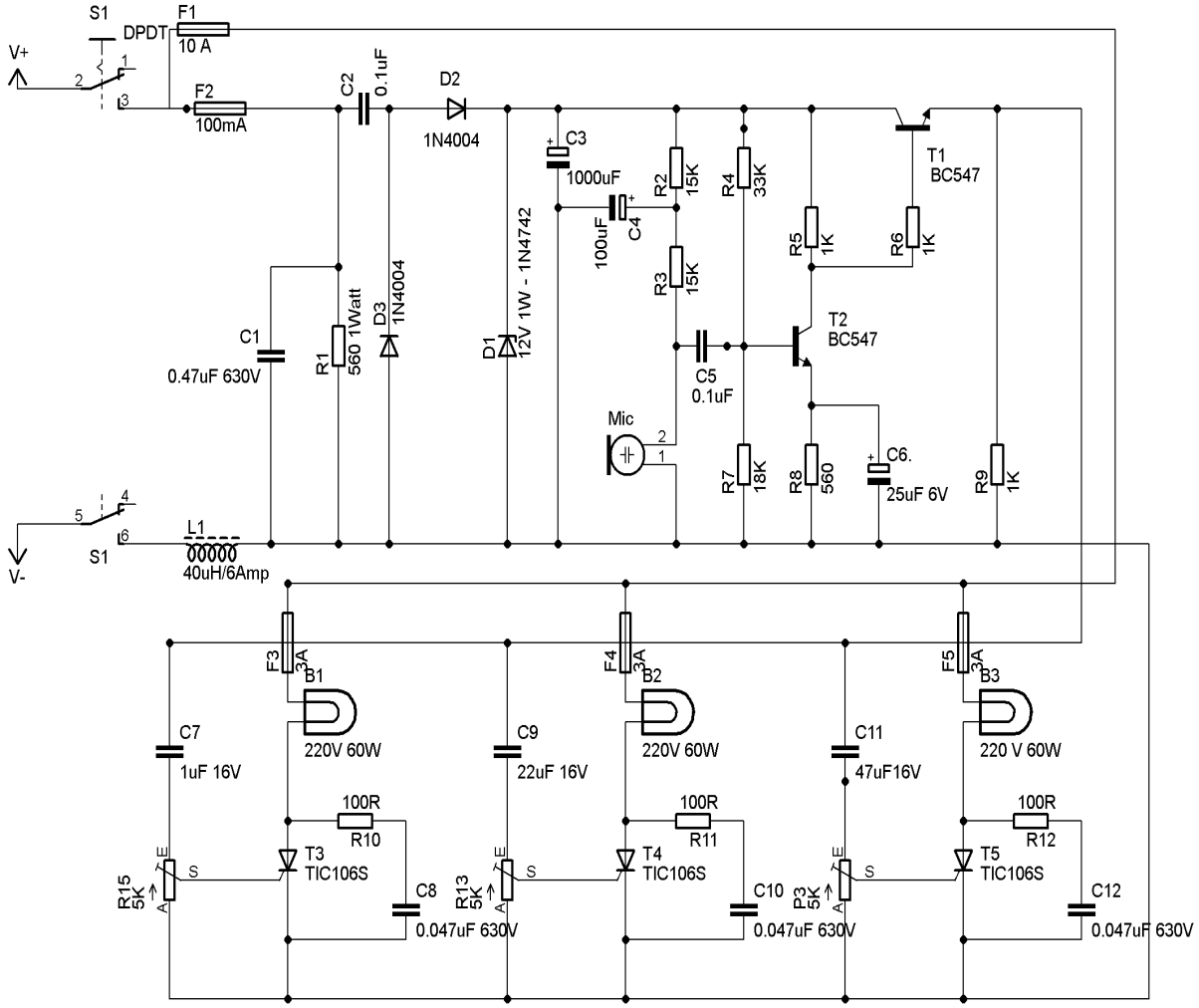
Projects vary in cost and teachers must ensure that the projects chosen fall within the scope of the school's budget.

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 portfolio correctly.

Description of the operation of the circuits is NOT complete. It is required of learners to interrogate the function of the components in the provided circuit. They 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/workshop reference books.

Electrical Project: Sound-to-light Controller (Option 1 of 6)

WARNING: Some parts in the circuit board are subjected to lethal potential because the device is connected to 230 V AC. When plugging in the project, place it in a plastic or wooden box to prevent the circuit from shocking you. Avoid connecting this circuit to other appliances (e.g. to the output of an amplifier by means of a cable) due to the absence of a mains transformer. Use only the microphone enclosed into the main case to pick-up the music.



COMPONENT LIST	
R1	560 kΩ 1 W
R2, □3	15 K ¼ W
R3	33 K ¼ W
R5, R6, R9	1 kΩ ¼ W
R7	18 K ¼ W
R8	560 Ω ¼ W
P1, P2, P3	5 K Pot
C1	0.47 uF 630 V
C2, C5	0.1 µF 220 V
C3	1 000 µF 16 V electrolytic
C4	100 µF 16 V
C6	25 µF 16 V
C7	1 µF 16 V

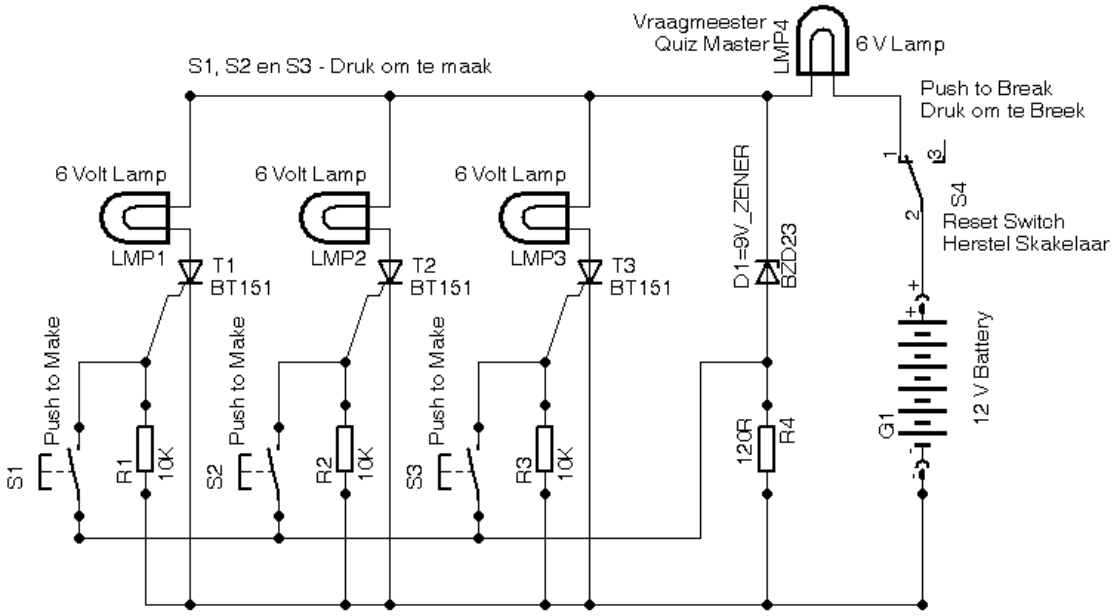
COMPONENT LIST	
C8, C10, C12	0.047 µF
C9	22 µF 16 V
C11	47 uF 16 V
D1, D2	1N4004
D3	1N4742 1 W
F1	10 A fuse 220 V
F2	100 mA fuse 220 V
F3, F4, F5	220 V 3 A fuse
L1	40 µH 6 A 10–15 turns on a ferrite core

COMPONENT LIST	
S1A & S1B	Double-pole switch
T1, T2	BC 547
T3, T4, T5	TIC 106 or BT 136
B1, B2, B3	60 W incandescent lamp
Mic	Low-impedance microphone

Electrical Project: Quiz Master (Option 2 of 6)

This circuit can be used to indicate: 'fastest finger first'. It has a globe for each contestant and one for the quiz master.

When a button is pressed the corresponding globe is illuminated. The quiz master globe is also illuminated and the cathode of the 9 V Zener diode sees approximately mid-rail voltage. The Zener diode comes out of conduction and no voltage appears across the 120 ohm resistor. No other globes can be lit until the circuit is reset.



COMPONENT LIST	
R1, R2, R3	10 kΩ ¼ W
R4	120 Ω ¼ W
T1, □2, T3	BT 151□SCR
LMP1, 2, 3, 4	6 volt lamp
S1, S2, S3, S4	Push-to-make switch
D1	9 V Zener diode
12 volt battery/supply	

Electronic Project: Automatic Battery Charger (Option 3 of 6)

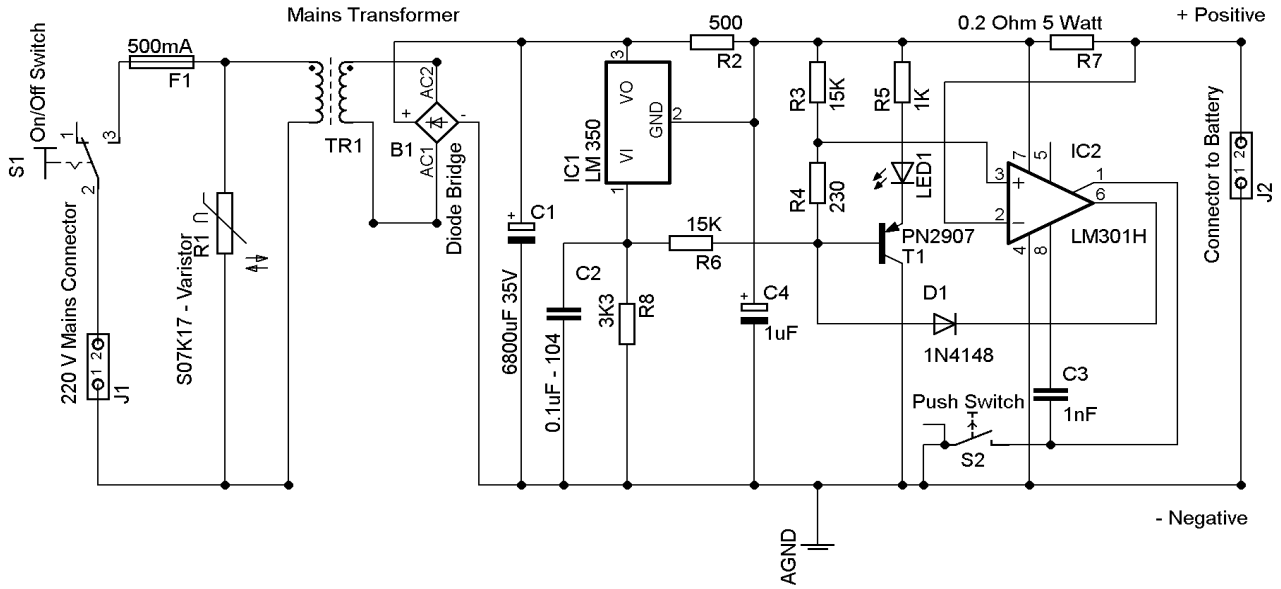
This automatic battery charger project is based on the national semiconductor LM350 3 A adjustable regulator. It is designed to charge 12 V lead-acid batteries. When the switch SW1 is pushed the output of the charger will go up to 14,5 V. The initial charging current is limited to 2 A.

As the charge of the battery continues to rise, the charging current decreases to 150 mA and the output voltage is reduced to 12,5 V. At this stage the charging is terminated and the light-emitting diode lights up to indicate that the charging process has been completed.

The schematic diagram below shows how the various components are connected. The first part of the diagram shows how the DC power supply to LM350 is achieved. The combined use of varistor V1 and fuse F1 is to protect the circuit from over-current and power surge of the mains supply.

Transformer TR1 is used to step down the input voltage from the mains to 16 V AC. Diode bridge B1 and electrolytic capacitor C1 are used to rectify the AC voltage to DC voltage.

This rectified DC power supply is fed into the input of the second circuit where LM350 and operational amplifier LM301A are used to control the charging current and voltage of the lead-acid battery. Once the charge is full, transistor T1 will turn ON and LED L1 will be ON to indicate that the charging has been completed. A heat sink is attached to LM350 to transfer the heat generated from the regulator to the ambient.



COMPONENT LIST – Automatic Battery Charger	
R1	Varistor 14 mm
R2	500 ohm, 5 W
R3, R6	15 K ¼ W
R4	230 ohm ¼ W
R5	1 K
R7	0,2 ohm 5 W
R8	3K3 ¼ W
J1	Mains supply
J2	12 V connector for battery/battery clamps
F1	500 mA fast-blow fuse
TR1	240 V–16 V transformer 3 A (+/-50 VA)
B1	5 A diode bridge
C1	6 800 uF 35 V electrolytic capacitor
C2	0.1 uF ceramic 104
C3	1 nF ceramic 102
C4	1 uF electrolytic 25 volt
D1	1N 4148 diode
IC1	LM350 16 volt positive voltage regulator
IC2	LM301 H operational amplifier
S1	On/Off switch for mains voltage
S2	Push-to-make switch
LED 1	Red LED 5 mm

Electronic Project: Battery-voltage Bar-graph Display (Option 4 of 6)

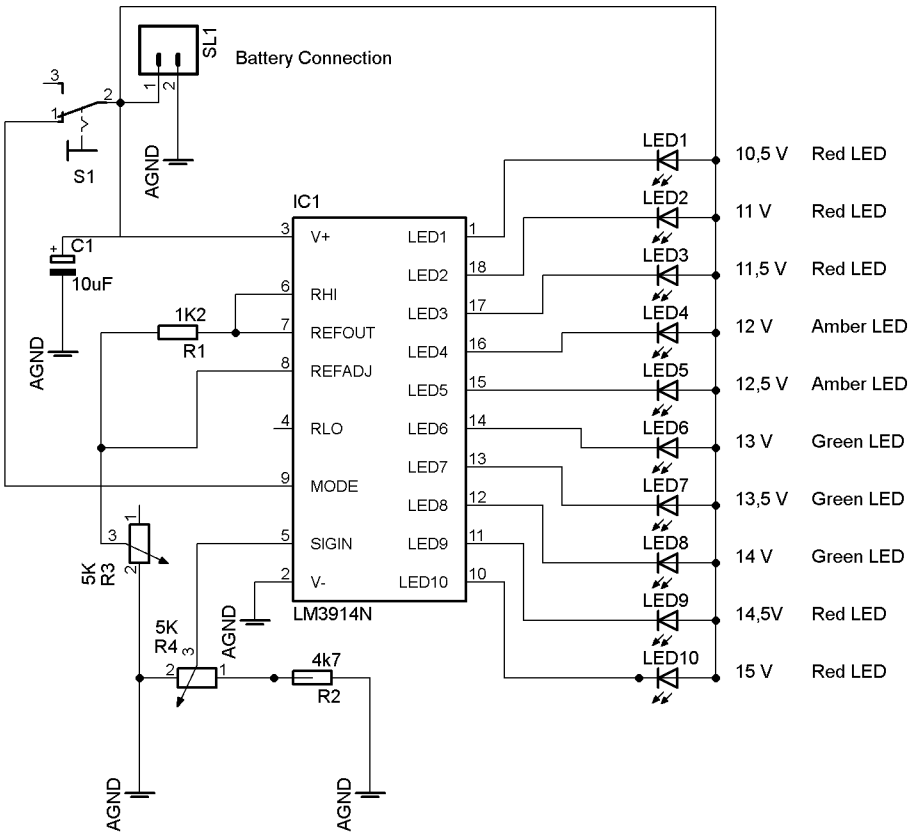
(This project can be used in conjunction with the automatic battery charger or with any battery charger circuit.)

This bar-graph LED-battery-level-indicator project is based on the LM3914 monolithic IC of the *National Semiconductor* that senses the voltage levels of the battery and drives the 10 light-emitting diodes based on the voltage level that is detected.

It provides a linear analogue display output and has a pin that can be configured to display the output in moving dot or bar graph. The current driving the LEDs is regulated and programmable hence limiting resistors are not required.

The schematic diagram below shows how the various components are connected. Switch S1 is used to change the display type from moving dot to bar graph type. When S1 is ON, the display type is bar graph but when it is OFF the display changes to moving dot type.

R3 is used to set the lower limit of the display. By using a variable DC power supply, set the VBAT to 10,5 V. Adjust VR1 until the LED L1 turns ON. Next, set the VBAT to 15 V; adjust VR2 until all the LEDs turn ON (when S1 is ON).



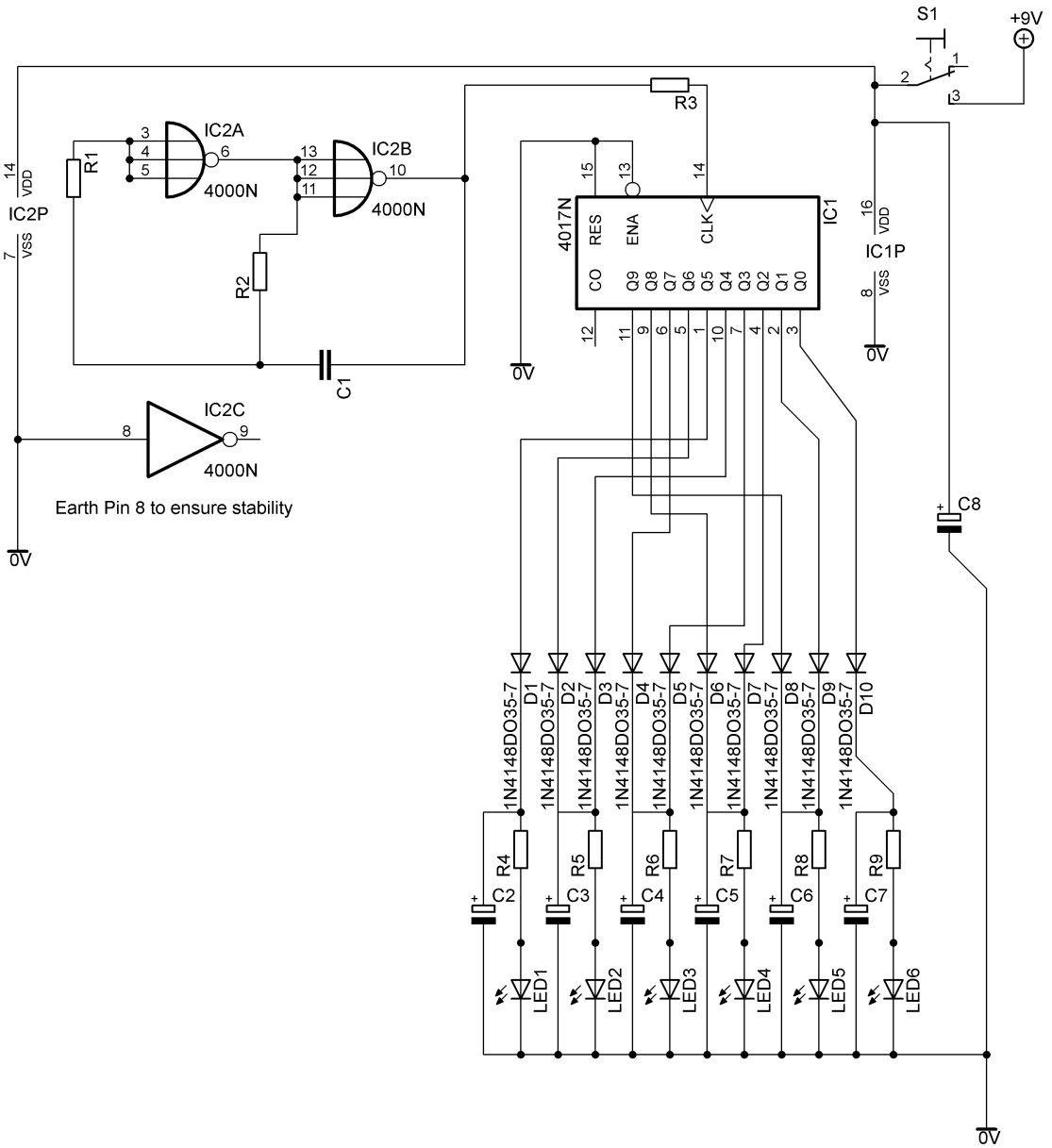
COMPONENT LIST	
R1	1K2 ¼ W 5%
R2	4K7 ¼ W 5%
R3	5 K potentiometer
LED 1–10	LED – Red, Amber, Green

COMPONENT LIST	
IC 1	LM 3914 N bar graph display driver
C1	10 µF 25 volt electrolytic capacitor
S1	SPST toggle switch

Digital Project: Light Rider (Option 5 of 6)

The circuit uses two NAND gates as an oscillator, feeding a clock pulse to the 4017 Johnson IC. The diodes assist in ensuring a forward- and backward-flashing pattern.

The capacitors are added to allow for a smooth effect, just like the 1980's hit TV series, *Knight Rider*.



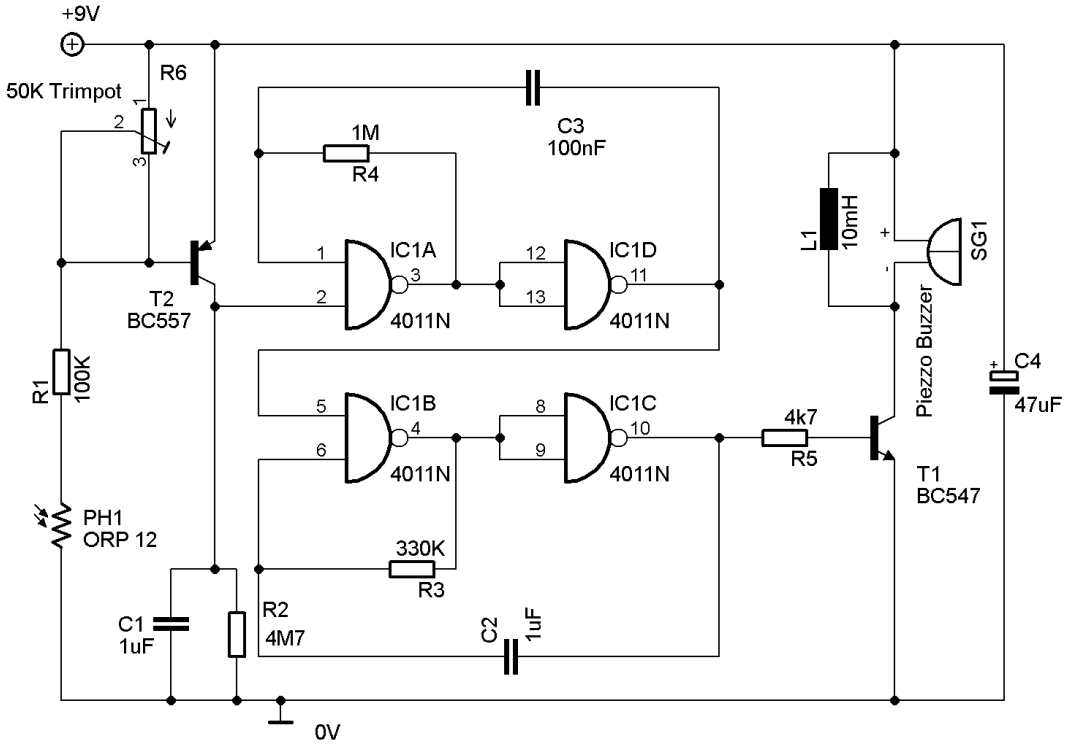
COMPONENT LIST	
IC 1	CD 4017 Johnson decade counter/ divider IC
IC 2	CD4000 – dual 3-input NAND gate IC plus inverter
R1, R2	470 K ¼ W (2 off)
R3	47 K ¼ W
R4–R9	1 K ¼ W (6 off)
C1	100 nF polyester cap(104)

COMPONENT LIST	
C2–C8	100 µF 1 V (or more) radial electrolytic (7 off)
D1–D10	1N4148 diode (10 off)
LED1–LED6	5 mm LED (colour of your choice) (6 off)
S1	SPST toggle switch
PP3 battery clip	
9 V PP3 battery	

Digital Project: Light Alarm (Option 6 of 6)

The light alarm utilises a light-dependant resistor (LDR) that triggers the BC557 PNP transistor. The logic circuit shown is a monostable multivibrator, which acts as a timer to switch on the driver transistor for the piezo buzzer.

When triggered the circuit should let out a loud buzzing sound for a predetermined time. You can alter the time period by experimenting with the values of the feedback resistors and the capacitors in the logic portion of the circuit diagram.



COMPONENT LIST	
IC 1	4011 quad 2-input NAND gate
R1	100 K ¼ W
R2	4M7 Ω ¼ W
R3	330 kΩ ¼ W
R4	1 MΩ ¼ W
R5	4k7 Ω ¼ W
R6	50 K trim pot

COMPONENT LIST	
C1, C2	1µF Mylar capacitor
C1	100 nF polyester cap (104)
C3	100 nF polyester cap
C4	47 µF electrolytic 16 V radial cap
T1	BC 547 NPN
T	BC 557 PNP
L1	10 mH inductor
PH 1	ORP 12 LDR
SG 1	9–12 V piezo buzzer
PP3 battery clip	
9V PP3 battery	

2.8 WORKING MARK SHEET

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

PAT mark sheet		Term 1		Term 2		Project			Total = 250 Term1 + Term 2 + Project	Mark out of 100	Moderated Mark
No.	Name of Learner (Alphabetical)	Simulation 1 50	Simulation 2 50	Simulation 3 50	Simulation 4 50	Design and Make Part 1–80	Design and Make Part 2–20	Design and Make Total = 50			
0	E.g. John Q Public	45	10	30	25	30	10	20	135	54%	54%
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
	Total										
	Average										

Teacher: _____ Moderator: _____ Principal: : _____

Signature: _____ Signature: _____ Signature: _____

Date: _____

School Stamp

3. LEARNER GUIDELINES

PAT 2015 Cover Page (Place this page at the front of the PAT.)

Department of Basic Education
Grade 12 National Senior Certificate 2015
Practical Assessment Task – Electrical Technology

Time Allowed: Term 1–3 2015

Learner Name: _____

Examination Number: _____

School: _____

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Evidence of Moderation:

NOTE: When the learner evidence (LE) 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				
Provincial moderation			Re-moderation	

Mark Allocation

PAT Component	Maximum mark	Learner mark	Moderated mark
Simulation 1	50		
Simulation 2	50		
Simulation 3	50		
Simulation 4	50		
Design and Make Project – Circuit (80/2)	40		
Design and Make Project – Enclosure (20/2)	10		
Total	**250**		

3.1 INSTRUCTIONS TO THE LEARNER

- This PAT counts 25% of your final promotion mark.
- All work produced by you must be your own effort. Group work and co-operative work is not allowed.
- The PAT must be completed over three terms.
- The PAT must contain ANY 4 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 can be in colour or grey scale. Scanned photos and photocopies are allowed.
- You are allowed/encouraged to use recycled components.
- This document must be placed inside your PAT file together with the other evidence.

3.2 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 will be withheld.

_____ _____
Signature of learner Date

As far as I know, the above declaration by the learner is true and I accept that the work offered is his or her own.

_____ _____
Signature of teacher Date

_____ _____
Signature of principal Date

School Stamp

Design and Make Project

Time: January–August 2015

Learner Name: _____

School: _____

Examination Number: _____

Title/Type of Project: _____

Instructions

- This section is COMPULSORY for all learners.
- The teacher will choose a circuit for the project, which will be related to the simulations that will be completed.
- The checklist must be used to ensure all the required tasks for the PAT has been completed.

PAT Checklist

No.	Description	Tick (☑)	
		No	Yes
Design and Make: Part 1			
1	Circuit diagram drawn	☐	☐
2	Circuit description filled in.	☐	☐
3	Component list completed	☐	☐
4	Tools list for circuitry populated	☐	☐
5	Measuring instrument list completed	☐	☐
6	Evidence of prototype printed and pasted into the file	☐	☐
7	Learner's own Vero-board/PCB planning/design printed and included in file	☐	☐
Design and Make: Part 2			
1	Enclosure design in EGD completed and included in the file	☐	☐
2	Unique name written down and included on the enclosure	☐	☐
3	Logo designed and included on the enclosure	☐	☐
Miscellaneous			
1	Enclosure included in the project.	☐	☐
2	Enclosure prepared and drilled according to the design.	☐	☐
3	Enclosure finished off and completed with name and logo.	☐	☐
4	PCB securely mounted in the enclosure using acceptable techniques.	☐	☐
5	Is circuit inside the enclosure accessible?	☐	☐
6	Internal wiring neat and ready for inspection	☐	☐
7	File and project completed and ready for moderation at the workshop/room	☐	☐

Design and Make: Part 1

1. **Circuit diagram**
   Draw a circuit diagram of your project.

2. **Project: Description of operation**

Use the space provided below to provide an overview of how the project functions. Use your own words and do some research of your own.

3. **Component List**
Draw up a list of components you will need from the circuit diagram.

	Quantity	Description and value	Label on circuit diagram
E.g.	10	1 K ¼ W carbon-film resistor	R1
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

4. **Tools List**
Draw up a list of tools you will need to complete the PAT circuitry. You may add to the list as you proceed through the PAT.

	Description	Purpose/Use
E.g.	Long-nosed pliers	Used to bend wires and insert tips of stripped wire into board
1		
2		
3		
4		
5		

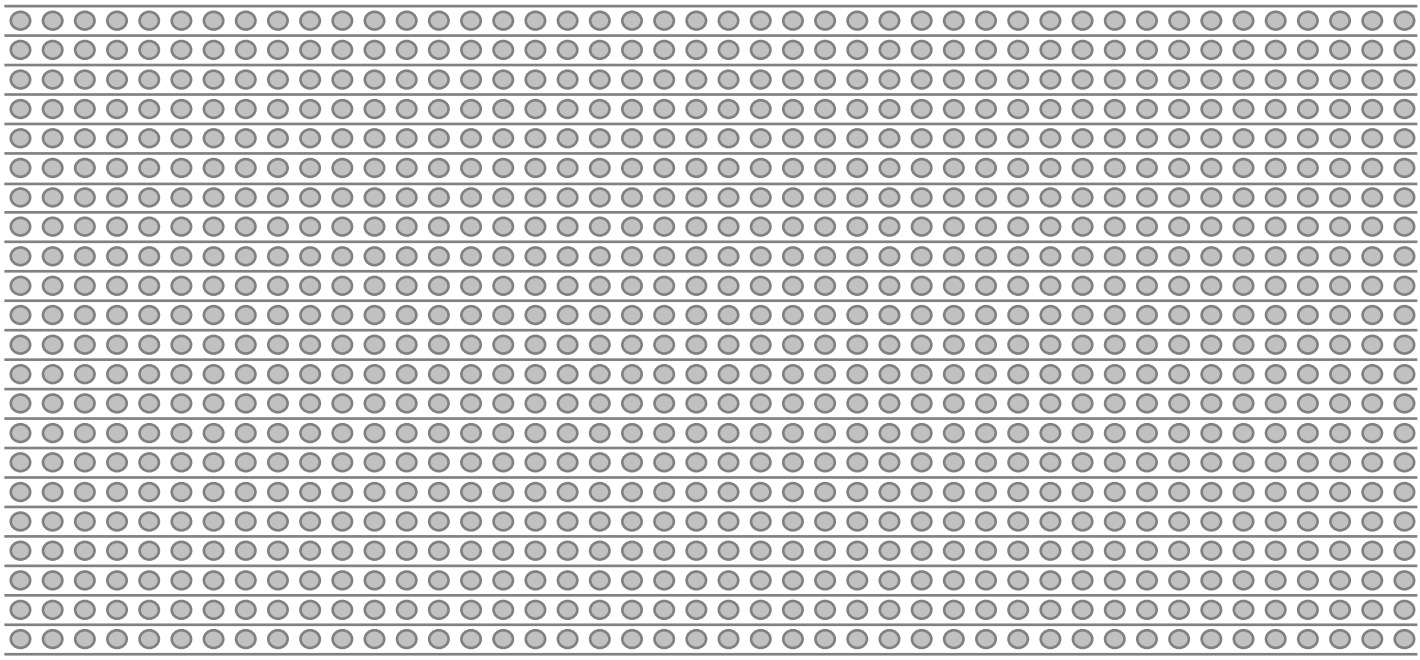
5. **Instruments List**
Draw up a list of instruments you will need to test your PAT. You will add to this list as you go along.

	Description	Purpose/Use
E.g.	Ammeter	Placed in series with the circuit to indicate the current flowing
1		
2		
3		

6. **Evidence of prototype**
Take photos of the working prototype on the breadboard using a digital camera or a cellphone and attach after this page. If measurements were taken, insert evidence thereof as well. Use labels to describe what is done in each photo.

7. **Vero-board Planning OR PCB Design**
If you do not use a Vero-board, add evidence of the PCB layout after this page.
Actual Vero-board hole spacing 0,1' (2,54 mm)
Use an **X** to show breaks made on the track

Final Design – Vero-board



Printed Circuit Board Planning

ASSESSMENT OF THE DESIGN AND MAKE PHASE: PART 1

(Items not submitted will not be awarded a mark (0).)

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)					
	0 Not submitted	**1 Not achieved**	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Circuit diagram	☐	☐ The learner was unable to draw a circuit diagram.	☐The learner was able to partially draw a circuit diagram, but drew more than half the symbols incorrectly.	☐The learner was able to correctly draw the circuit diagram and drew more than half the symbols incorrectly.	☐The learner was able to successfully draw the circuit diagram and drew all the symbols correctly, but did not label all the parts.	☐ The learner was able to successfully draw the circuit diagram correctly and drew the parts correctly. Everything is labelled according SI unit standards and the learner made special effort to ensure that the circuit diagram is neat.
Circuit description	☐	☐ The learner was unable to describe the circuit operation.	☐The learner was able to partially explain how the circuit operates.	☐The learner was able to describe the operation of the circuit diagram, but made mistakes on less than half the components.	☐The learner was able to successfully explain the operation of the circuit diagram and correctly identified all the symbols.	☐ The learner was able to successfully explain the operation of the circuit diagram correctly and identified the parts correctly. The learner was able to show evidence of how to alter the circuit to change its operating characteristics.
Prototype circuit is working on the breadboard.	☐ Not working **(0 marks)**	☐ Circuit was partly operational. No photos of prototyping are included. **(3 marks)**		☐ Circuit was fully operational, but the circuit in the photo is similar to other learners. **(5 marks)**	☐ Circuit was fully operational. The photo included does not resemble other learner's efforts, but no name is included. **(10 marks)**	☐ Circuit was fully operational. The photo included shows the circuit and name of the learner and it is unique. The photo is clear and components are distinguishable. **(15 marks)**
Trouble-shooting on the breadboard	☐	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes. If the learner's circuit worked first time, he/she was able to assist other learners in trouble-shooting.

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)					
	0 Not submitted	**1 Not achieved**	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Vero-board/ printed circuit board **Planning and layout stage only**	☐ Used a kit	☐ The learner was unable to plan the Vero-board/PCB layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or fewer components correctly on the Vero-board/PCB design.	☐The learner was able to correctly plan and place more than 4, but less than **8** components correctly on the Vero-board/PCB design. The learner copied the kit PCB with the help of the teacher.	☐The learner was able to successfully plan and place all the components correctly on the Vero-board/PCB design with links. The learner designed a new PCB layout with the help of the teacher.	☐ The learner was able to successfully plan and place all the components correctly on the PCB taking onto consideration space used, alignment of components and component types. The learner designed the new PCB layout without the help of the teacher.
Component selection and identification	☐	☐ The learner was unable to identify and select any components.	☐ The learner was able to identify and select fewer than 4 components.	☐ The learner was able to select more than 4, but fewer than 8 components.	☐ The learner was able to identify and select all components.	☐ The learner identified and selected components quickly and without the help of the teacher. The learner was also able to identify equivalent values using a variety of methods.
Instrument selection and use	☐	☐ The learner was unable to identify and select any instruments.	☐ The learner identified and selected the wrong instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/unsafely.	☐ The learner was able to identify and select all instruments correctly and used it correctly.	☐ The learner identified and selected instruments quickly and without the help of the teacher. The learner was also able to use instruments correctly in a safe ergonomic manner.
PCB manufacturing (Development and etching)	☐	☐ The learner is unable to make a PCB/Used a kit OR The learner used a Vero-board, but it does not work **(1 mark)**	☐ The learner over/under developed the board (over/under exposed to UV light) **(2 marks)**	☐ The learner over etched/under etched the PCB. Holes drilled pierced/broke the tracks & is not neatly finished/sanded down. OR The learner used a Vero-board, but it is only partially operational. **(5 marks)**	☐ The learner is able develop and etch the board neatly. All holes drilled are neatly finished/sanded down. There is no evidence of tinning. OR The learner used a Vero-board, and his circuit is operating correctly. **(10 marks)**	☐ The learner is able develop and etch the board neatly. All holes drilled are neatly finished/ sanded down. The learner tinned all tracks and the board is exceptionally neat. **(15 marks)**

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)					
	0 Not submitted	1 Not achieved	2 Not competent yet	3 Competent	4 Highly competent	5 Outstanding
Solder technique	☐	☐ Solder work is not neat, containing dry joints and loose joints. **(2 marks)**	☐ Solder work contains more than **5** but fewer than 10 dry or loose joints. **(4 marks)**	☐ Solder work contains fewer than **5** dry or loose joints. **(6 marks)**	☐ Solder work is neat, and there is no evidence of dry joints or loose connections. **(8 marks)**	☐Solder work is exceptionally neat. The solder work is smooth. The learner sealed the solder side against corrosion, using clear lacquer. (Plastic 70/Polyurethane etc.) **(10 marks)**
Component placement – neatness and aesthetics	☐	☐ Components are placed erratically and appear untidy.		☐ Most components are placed tidy. Fewer than **5** components appear untidy.	☐ All components are placed well. The board appears tidy and neat.	☐ Components are aligned exceptionally well. Component displacement from the board surface has been considered. All colour codes of resistors are aligned. Capacitors and other components are aligned and appear neat.
Housekeeping	☐	☐ The learner did no housekeeping.	☐ The learner did housekeeping under duress.	☐ The learner did housekeeping under the supervision of the teacher.	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
					Rubric (Maximum of 80)	

Design and Make: Part 2

1. **Enclosure design**
   Design an enclosure including the layout of the PCB and parts in the enclosure. Use colour to actuate your design. You are allowed to use hand-drawn designs and also the CAD programme.

Show the top, front and side views below.

2. Manufacture/Obtain an enclosure according to your design.

3. Choose a name for your device. Write down the name of the device below.

_____

4. Design a logo for your device below.

ASSESSMENT OF THE DESIGN AND MAKE PHASE: PART 2

(Items not submitted will not be awarded a mark (0).)

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)					
	0 Not submitted	**1 Not achieved**	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Enclosure design, planning and layout	☐	☐ The learner attempted a design but was unable to plan the enclosure layout.	☐The learner designed an enclosure using freehand sketches only. OR The learner was able to correctly plan and place fewer than 2 items according to the initial design.	☐The learner designed an enclosure using freehand concept sketches and then used an EGD approach to the final drawing with dimensions. No colour is used. OR The learner was able to correctly plan and place more than 2, but fewer than 4 parts correctly according to the planned design.	☐The learner designed an enclosure using an EGD approach to the final drawing with dimensions. Colour was used in concept sketches and models. OR The learner was able to successfully plan and place all the components correctly in the enclosure as planned in the design.	☐ The final design was in an EGD drawing and on CAD in colour with labels and dimensions. Colour was used in concept sketches and models. OR The learner was able to successfully plan and place all the parts correctly in the enclosure taking into consideration space used, alignment of components and component types and wire wrapping.
Name and logo design	☐	☐The name and logo design is on paper only, and not on the enclosure.	☐The learner applied a name or a logo, but the appearance was not neat.	☐The learner applied the name and logo of the device neatly, but used an existing logo from a company.	☐The learner applied the name and logo of the device neatly. The name and logo design is original.	☐The learner applied the logo and name neatly on different places on the project. The learner also included a specification plate/list.
Safety	☐	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner worked safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
Final product	☐	☐ The learner did not produce a finished product.	☐ Finished product gave a poor overall impression and did not work.	☐ The learner produced a final product that looked acceptable, but did not work.	☐ The learner produced a product that looked acceptable and it worked.	☐ The learner was able to finish the product and exhibited exceptional levels of competence in numerous areas. The project looked outstanding and worked very well.
					Rubric (Maximum of 20)	

Electrical – 1

Simulation 1 Time: 1 hour

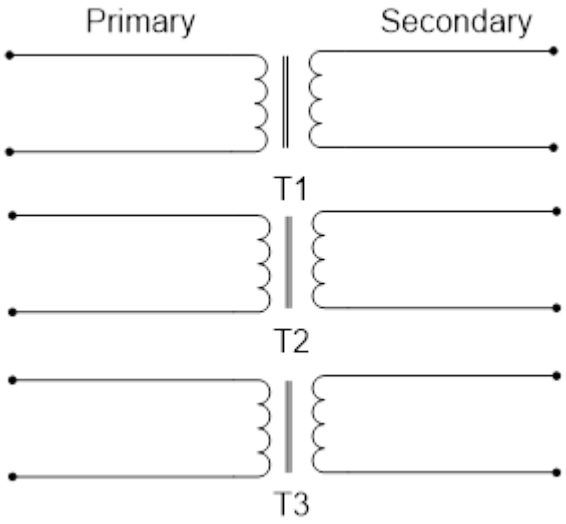
Learner: _____

School: _____

Examination Number: _____

Connecting three single-phase transformers to three-phase supply

1. **Purpose:**
To connect three identical single-phase transformers to a three-phase supply. The load of the transformer is three lamps.



2. **What you are going to do:**
Measure the primary and secondary line and phase voltages and currents.

3. **What you will need:**
- Three identical single-phase transformers, step down
- A three-phase supply
- Multimeter
- Connecting wires
- Three lamp holders
- Three 55–60 W lamps or smaller (12 V down lighters work well)

NOTE: The secondary voltage of the transformer is not critical. The only requirement is that the secondary voltage and the voltage of the lamps are compatible. It is the duty of the teacher to verify that the learners are connecting the transformers correctly, before connecting the mains supply. If you are not entirely sure of your connections do not switch on. Test for short circuits. Mains supply can be lethal. Be extremely careful.

4. **What you must do:**

4.1 Draw the circuit diagram in which the transformers are connected in a star/star connection. Number each phase. Now wire the circuit. (3=sketch) (5=wiring)

4.2 Complete the following table by measuring the primary and secondary voltages and current. (12)

Star/Star Connection

	Primary Supply to each Transformer		**Secondary Supply to each Lamp**	
	Voltage	**Current**	**Voltage**	**Current**
Phase 1				
Phase 2				
Phase 3				

NOTE: Schools using older panels which are closed up and schools with no clamp meters should measure the primary line and phase voltages instead of voltage and currents

4.3 Now change the secondary configuration to a star/delta configuration. (3=drawing)
Draw the circuit diagram to show the changes. (5=wiring)

4.4 Complete the following table by measuring the primary and secondary voltages and current. (12)

Star/Delta Connection

	Primary Supply to each Transformer		**Secondary Supply to every Lamp**	
	Voltage	**Current**	**Voltage**	**Current**
Phase 1				
Phase 2				
Phase 3				

4.5 Describe what happened to the readings between the two different configurations (star/star vs. star/delta). Motivate your answer using a proven mathematical method. (4)

4.6 What will happen to the secondary line voltage if you connect the transformers in delta/delta? (Calculate your answer.) (3)

4.7 What will the value of the secondary line current be if the transformer is connected in delta/delta? (Calculate your answer.) (3)

4.8 **Conclusion:**
Explain in your own words what you have learnt in this experiment.

[50]

Electrical – 2

Simulation 2 Time: 1 hour

Learner: _____

School: _____

Examination Number: _____

Inspecting and testing the AC motor

1. **Purpose:**
When inspecting and testing an AC motor it is advisable to use a checklist or report as shown below.
Use the list below to inspect and test an electrical motor. Your teacher will supply you with a motor to test.

Details of the motor being tested:

Phase: _____ **Supply voltage:** _____

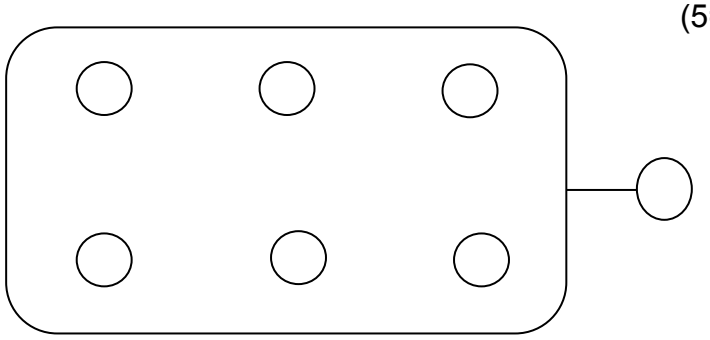
Pole pairs: _____ **Speed:** _____

Efficiency: _____ **Current:** _____ (3)

DESCRIPTION	VISUAL INSPECTION & READINGS TAKEN (Megger)	MARKS ALLOCATED
Condition of windings: Measurements taken		
Test 1: Continuity of the windings (3 marks)		
A1 – A2		
B1 – B2		
C1 – C2		
Test 2: Insulation resistance between windings (3 marks)		
A1 – B1		
A1 – C1		
B1 – C1		

Test 3 – Insulation resistance to earth (3 marks)		
A1 – Earth		
B1 – Earth		
C1 – Earth		
Test 4 – Mechanical inspection Note all errors (9 marks)		
Condition of rotor and shaft		
Key/Key way		
Front bearing		
Back bearing		
Condition of motor frame		
Condition of termination box		
Flange/Foot mount		
Front/Back-end shield		
Stator/Field housing		
Mounting bolts and nuts/screws		
Condition of cooling fan, fan cover and cooling fins		

Draw and label the correct connection of internal wiring on the drawing provided below:
(3=coils)
(5=labels)



Test	Finding (3 marks)
Is motor operational?	
Earth resistance	
Insulation resistance	

List the recommended repairs that should be effected on the electrical motor being tested. (1)

_____

_____

_____

(30)

RUBRIC SIMULATION 2: TESTING AN ELECTRIC MOTOR

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 Not Achieved	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Inspection points	☐ The learner did not identify any testing points.	☐The learner was unable to identify more than two testing points.	☐The learner was able to identify more than two testing points but could not motivate why these are used.	☐The learner was able to identify testing points on the motor and inside the motor. The learner was also able to motivate why these points have to be tested.	☐ The learner was able to successfully indicate all testing points in and on the motor. The learner was also to motivate why these points should be tested and was able to list symptoms that indicated certain errors.
Test continuity	☐The learner was unable to test continuity		☐ The learner was able to test continuity, but did not know why this was done.	☐ The learner was able to correctly test continuity and had a basic idea of the reason for this.	☐ The learner was able to correctly test continuity and had a solid knowledge of the meters and the reasons for their use.
Test earth resistance	☐The learner was unable to test earth resistance.	.	☐ The learner was able to test earth resistance, but did not know why this was done.	☐ The learner was able to correctly test earth resistance and had a basic idea of the reason for this.	☐ The learner was able to correctly earth resistance and had a solid knowledge of the meters and the reasons for their use.
House-keeping	☐ The learner did no house-keeping.	☐ The learner did house-keeping under duress.	☐ The learner did house-keeping under the super-vision of the teacher	☐ The learner did house-keeping after she/he was reminded by the teacher.	☐ The learner was able to do house-keeping without supervision or being reminded by the teacher. House-keeping was done excellently.
				Total of the Rubric (Maximum of 20)	
				Written Task (Maximum of 30)	
				Total (Maximum of 50)	

Electrical – 3

Simulation 3 Time: 3 hours

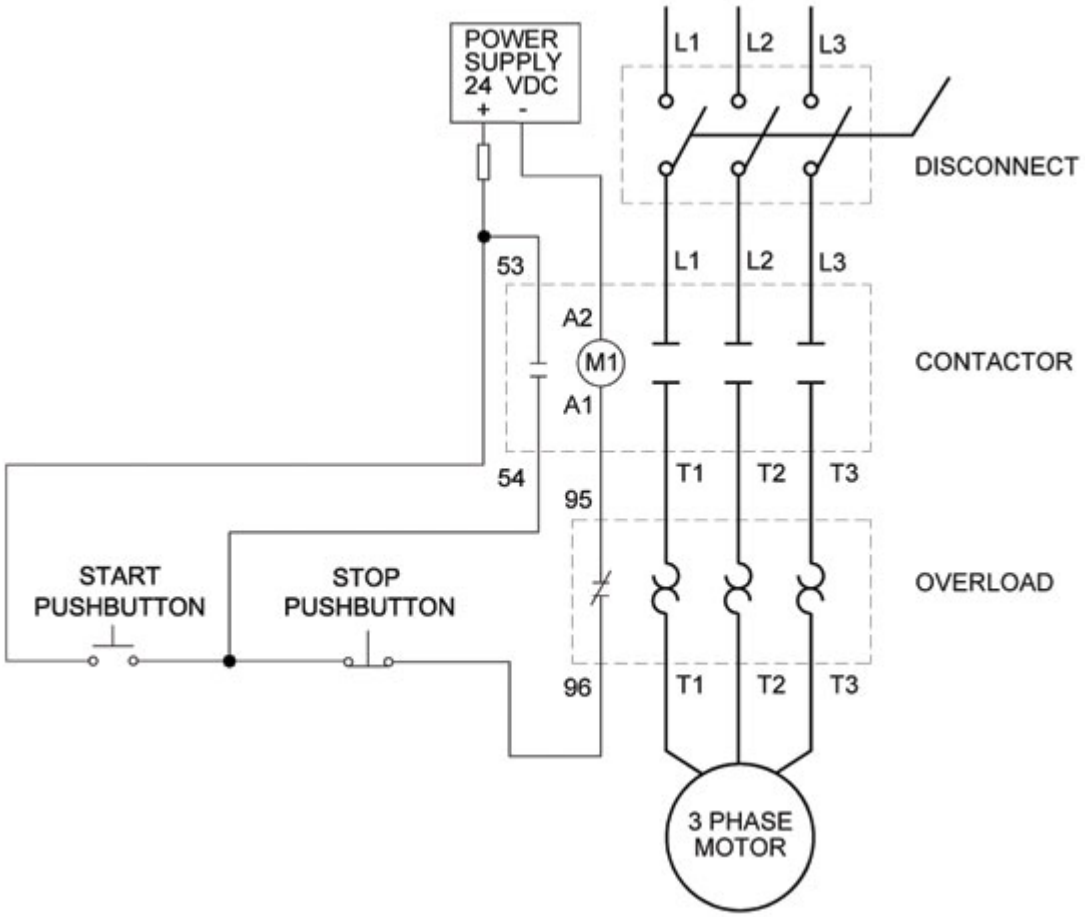
Learner: _____

School: _____

Examination Number: _____

Three-phase direct-on-line starter

1. **Purpose:**
Practical simulation of a three-phase direct-on-line starter.



NOTE: Teachers may use alternative DOL circuits.

2. **What you are going to do:**
Connect the power and control circuits of a three-phase direct-on-line starter. You will also set the overloads and use the correct wire size or plug in leads. The circuit will be checked, tested and the motor must be started.

3. **What you will need:**
   - One three-phase contactor with auxiliary contacts
   - One three-phase overload relay
   - One stop button, (press-button type)
   - One start button (press-button)
   - One three-phase circuit-breaker
   - One fuse for the control circuit
   - One three-phase squirrel cage
   - Correct wire size or plug in leads
   - Multimeter or continuity tester
   - Power supply – three phase

4. **What you must do:**
   - Connect the power and control circuit on the given panel.
   - Connect the motor to the power circuit and set the overload.
   - Now ask the teacher to check the circuits. If they are incorrect repair the fault.
   - When the circuits are correct switch the supply on and start the motor.
   - Stop the motor and switch the supply off.
   - On completion of the task switch the supply off and strip the circuits.

5. **Conclusion:**
   In which type of industrial application would DOL starters be used? Motivate your answer.

_____
_____
_____
_____
_____
_____
_____
_____
_____

TOTAL: 50

Ref: http://automationnotebook.com/2005_Issue_5/fyi_issue5_2005.html

RUBRIC SIMULATION 3: THREE-PHASE DIRECT-ON-LINE STARTER

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)				
	0 Not achieved	1 Not competent yet	2 Competent	4 Highly competent	5 Outstanding
Identification and purpose of parts	☐ The learner was unable to identify any parts.	☐The learner was able to identify less than three parts.	☐The learner was able to identify all parts, but did not know the function thereof.	☐The learner was able to successfully identify all parts and knew the purpose of most of the parts.	☐ The learner was able to successfully identify all parts and knew the purpose of all the parts.
Control circuit wiring	☐ The learner was unable to wire the control circuit.	☐The learner was able to wire part of the control circuit.	☐The learner was able to wire the control circuit, but could not establish retention at start.	☐The learner was able to successfully wire the control circuit.	☐ The learner was able to successfully wire the control circuit. The learner followed a step by step approach, testing along the way and included pilot lights
Trouble-shooting: Control circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete, but not functional and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes. The circuit is functional.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Control circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the circuit wiring marks.
Main circuit wiring	☐The learner was unable to wire the main circuit.	☐ The learner was able to wire the main circuit partly correct, but did not use overload protection.	☐ The learner was able to wire the main circuit including overload protection but did not know why it was used.	☐ The learner was able to wire the main circuit and test the overload protection and had a working knowledge of the circuit.	☐ The learner was able to correctly test the main circuit after assembly and had a well-founded knowledge of all the working parts. The learner was able to quickly re-assemble the circuit accurately without the aid of the circuit diagram
Trouble-shooting: Main circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete, but not functional and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes. The circuit is functional.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Main circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the main circuit wiring marks.
Tools selection and use	☐ The learner was unable to identify and select any tools.	☐ The learner identified and selected the incorrect tools.	☐ The learner was able to select the correct tools, but used them incorrectly/ unsafely.	☐ The learner was able to identify and select all tools correctly and used them correctly.	☐ The learner identified and selected tools quickly and without the help of the teacher. The learner was also able to use tools correctly in a safe ergonomic manner.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner worked safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
Housekeeping	☐ The learner did no house-keeping.	☐ The learner did house-keeping under duress.	☐ The learner did housekeeping under the supervision of the teacher.	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
				Total of the Rubric (Maximum of 50)	

Electrical – 4

Simulation 4 Time: 3 hours

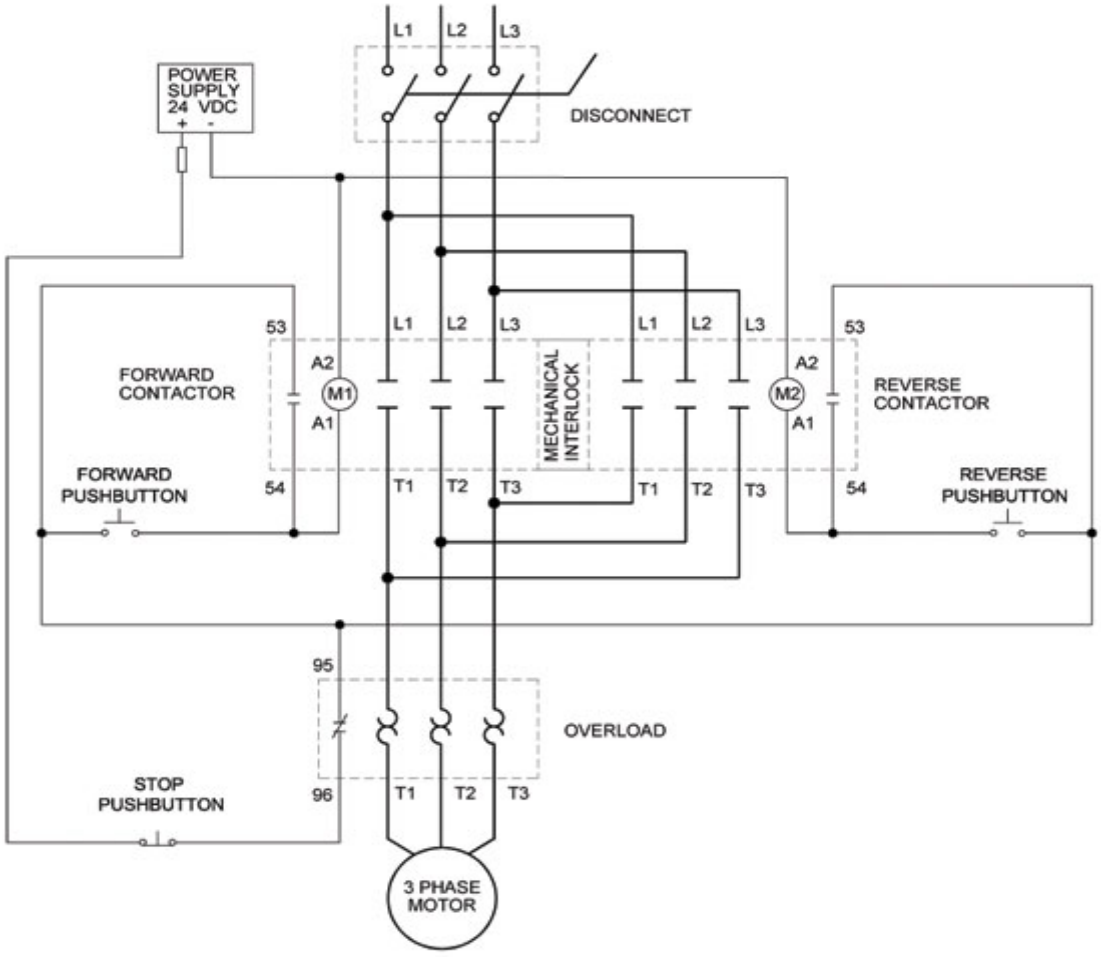
Learner: _____

School: _____

Examination Number: _____

Three-phase forward-reverse starter

1. **Purpose:**
Practical simulation of a three-phase forward-reverse starter.



NOTE: The teacher can use an alternative forward-reverse starter circuit.

2. **What you are going to do:**
Connect the power and control circuits of a three-phase forward-reverse starter. You will also set the overloads and use the correct wire size or plug-in leads. The circuit will be checked, tested and the motor must be started.

3. **What you will need:**
- Two three-phase contactors with auxiliary contacts
- One timer with normally open and closed contacts
- Two stops, one for the emergency stop (press button type)
- One start (press button)
- One three-phase circuit breaker
- One overload relay
- Two fuses for the control circuit
- One three-phase squirrel-cage induction motor
- Correct wire size or plug-in leads
- Multimeter or continuity tester
- Power supply

4. **What you must do:**
- Consult the control and power circuit.
- Construct/Wire the power and control circuit on the given panel.
- Connect the motor to the power circuit and set the overload.
- Now ask the teacher to check the circuits. If they are incorrect repair the fault.
- When the circuits are correct, switch the supply on and start the motor.
- Stop the motor and switch the supply off.
- On completion of the task switch the supply off and strip the circuits.

5. **Conclusion:**
Give TWO examples where this circuit can be used effectively.

_____

_____

TOTAL: 50

Ref: http://automationnotebook.com/2005_Issue_5/fyi_issue5_2005.html

RUBRIC SIMULATION 4: FORWARD-REVERSE MOTOR STARTER

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)				
	1 Not achieved	2 Not competent yet	3 Competent	4 Highly competent	5 Outstanding
Identification and purpose of parts	☐ The learner was unable to identify any parts.	☐The learner was able to identify fewer than three parts.	☐The learner was able to identify all parts, but did not know the function thereof.	☐The learner was able to successfully identify all parts and knew the purpose of most of the parts.	☐ The learner was able to successfully identify all parts and knew the purpose of all the parts.
Control circuit wiring	☐ The learner was unable to wire the control circuit.	☐The learner was able to wire the forward part of the circuit only.	☐The learner was able to wire both the forward and the reverse, but did not use interlocking.	☐The learner was able to successfully wire the control circuit for forward and reverse using interlocking.	☐ The learner was able to successfully wire the control circuit for forward and reverse using interlocking. The learner followed a step by step approach, testing along the way and included pilot lights
Control circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the circuit wiring marks.
Troubleshooting : Control circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Main circuit wiring	☐The learner was unable to wire the main circuit.	☐ The learner was able to wire the main circuit partly correct, but did not use overload protection.	☐ The learner was able to wire the main circuit including overload protection, but did not know why it was used.	☐ The learner was able to wire the main circuit and test the overload protection and has a working knowledge of the circuit.	☐ The learner was able to correctly test the main circuit after assembly and had a well-founded knowledge of all the working parts. The learner was able to quickly re-assemble the circuit accurately without the aid of the circuit diagram.
Main circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the main circuit wiring marks.
Troubleshooting : Main circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Tool selection and use	☐ The learner was unable to identify and select any tools.	☐ The learner identified and selected the incorrect tools.	☐ The learner was able to select the correct tools, but used them incorrectly/ unsafely.	☐ The learner was able to identify and select all tools correctly and used them correctly.	☐ The learner identified and selected tools quickly and without the help of the teacher. The learner was also able to use tools correctly in a safe ergonomic manner.
Housekeeping	☐ The learner did no house-keeping.	☐ The learner did house-keeping under duress.	☐ The learner did housekeeping under the supervision of the teacher	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher	☐ The learner worked safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
				Total of the Rubric (Maximum of 50)	

Electrical – 5

Simulation 5 Time: 3 hours

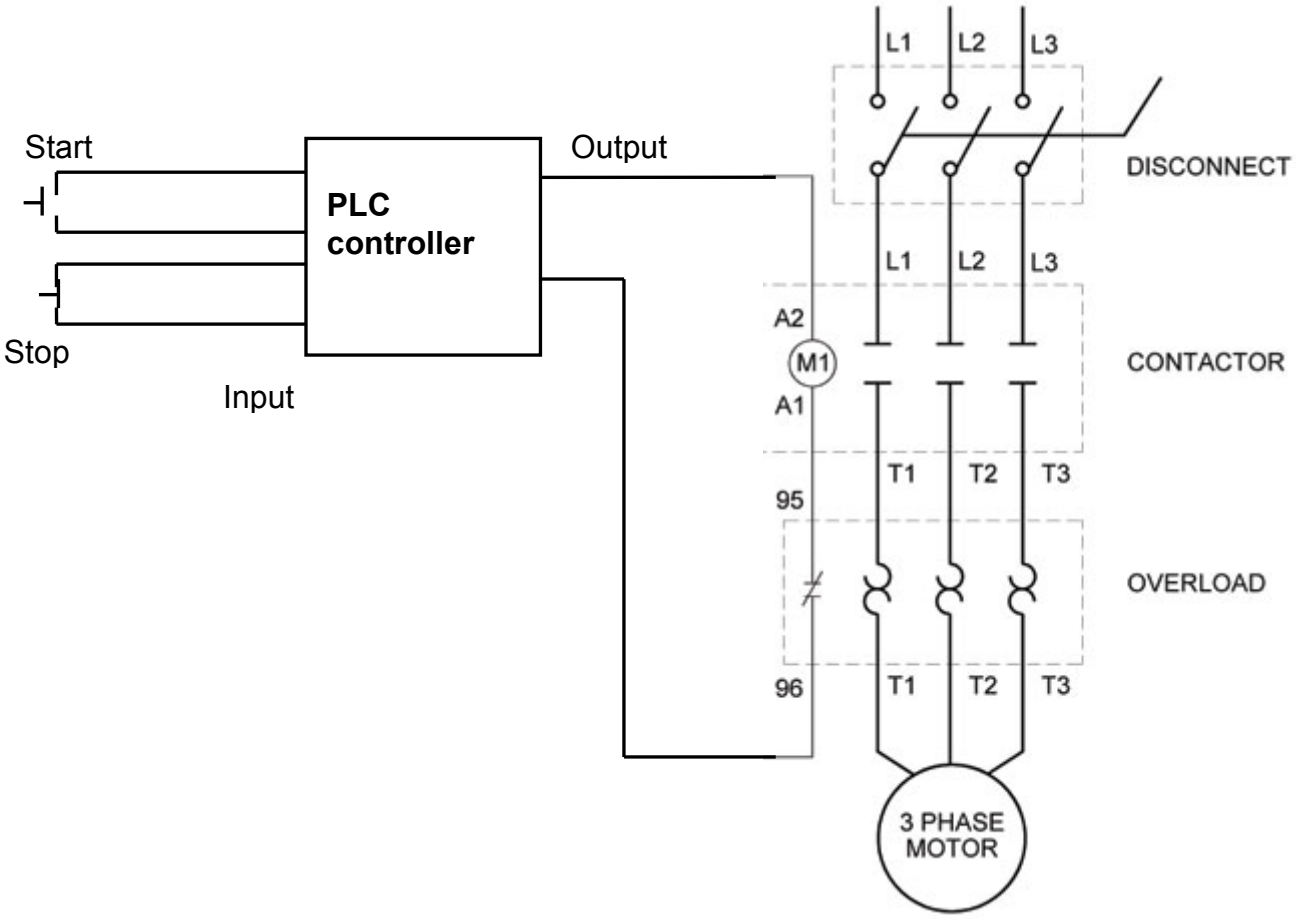
Learner: _____

School: _____

Examination Number: _____

Three-phase direct-on-line starter using PLC

1. **Purpose:**
   Practical simulation of a three-phase DOL starter using PLC.



NOTE: Teachers may use alternative DOL circuits.

2. **Materials and equipment needed:**

- One, three-phase contactor with auxiliary contacts
- One three-phase overload relay
- One three-phase circuit breaker
- Three-phase squirrel-cage induction motor
- Correct wire size or plug-in leads
- Multimeter or continuity tester
    - Power supply – three phase
    - Desktop personal computer/Notebook/Laptop
    - PLC unit

3. **What you are going to do:**

- Convert the control circuit of a three-phase direct-on-line starter into a ladder logic diagram.
- Write a simple ladder logic program.
- Download the program to the PLC and run the program.
- Wire the main circuit to the PLC unit.
- Connect the motor to the main circuit.
- Do not switch on the supply before the teacher has checked the circuit.
- When the circuits are correct switch the supply on.
- Run the PLC program to start the motor.

4. **Conclusion:**

In which type of industrial application would DOL starters be used? Motivate your answer.

_____
_____
_____
_____
_____
_____
_____
_____
_____

TOTAL: 50

RUBRIC SIMULATION 5: THREE-PHASE DIRECT-ON-LINE STARTER USING PLC

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)				
	0 Not Achieved	**1 Not competent yet**	**2 Competent**	**4 Highly competent**	**5 Outstanding**
Identification and purpose of parts	☐ The learner was unable to identify any parts.	☐The learner was able to identify fewer than three parts.	☐The learner was able to identify all parts, but did not know the function thereof.	☐The learner was able to successfully identify all parts and knew the purpose of most of the parts.	☐ The learner was able to successfully identify all parts and knew the purpose of all the parts.
Conversion of the control circuit to ladder logic diagram	☐ The learner was unable to convert control circuit to ladder logic diagram.	☐The learner was able to convert only one part of the control circuit to ladder logic diagram.	☐The learner was able to convert two to three parts of the control circuit to ladder logic diagram.	☐The learner was able to convert four to five parts of the control circuit to ladder logic diagram.	☐ The learner was able to successfully convert all parts of the control circuit to ladder logic diagram.
Writing PLC program	☐ The learner was unable to write a PLC program.	☐The learner was able to write only one instruction of the program.	☐The learner was able to convert two to three instructions of the program.	☐The learner was able to convert four to five instructions of the program.	☐ The learner was able to successfully convert all instructions of the program
Downloading and running	☐ The learner was unable to download and run the program to the PLC. **(0 marks)**		☐ The learner was able to download and run the program on the PLC with some assistance from the teacher. **(2 marks)**		☐ The learner was able to download and run the program on the PLC without any assistance from the teacher. **(5 marks)**
Troubleshooting of the program (only if the program was not running)	☐The learner could not trouble shoot at all.	☐ The learner was able to trouble shoot after four attempts.	☐ The learner was able to trouble shoot after three attempts.	☐ The learner was able to trouble shoot after two attempts.	☐ The learner's program worked after the first attempt. **(5 marks)**
Main circuit wiring and running of the PLC	☐The learner was unable to wire the main circuit.	☐ The learner was able to wire the main circuit partly correct, but did not use overload protection.	☐ The learner was able to wire the main circuit including overload protection but did not know why it was used.	☐ The learner was able to wire the main circuit and test the overload protection and had a working knowledge of the circuit.	☐ The learner was able to correctly test the main circuit after assembly and had a well-founded knowledge of all the working parts. The learner was able to quickly re-assemble the circuit accurately without the aid of the circuit diagram
Running the motor using the PLC main circuit working	☐ The circuit did not work.	☐ The circuit worked after some troubleshooting. The main circuit had to be corrected OR the PLC programming had to be altered. **(4 marks)**			☐ The circuit worked. The main circuit was wired correctly and the PLC operated correctly. **(10 marks)**
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner worked safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
Housekeeping	☐ The learner did no housekeeping.	☐ The learner did housekeeping under duress.	☐ The learner did housekeeping under the supervision of the teacher.	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
				Total of the Rubric (Maximum of 50)	

Electronic – 1

Simulation 6 Time: 3 hours

Learner: _____

School: _____

Examination Number: _____

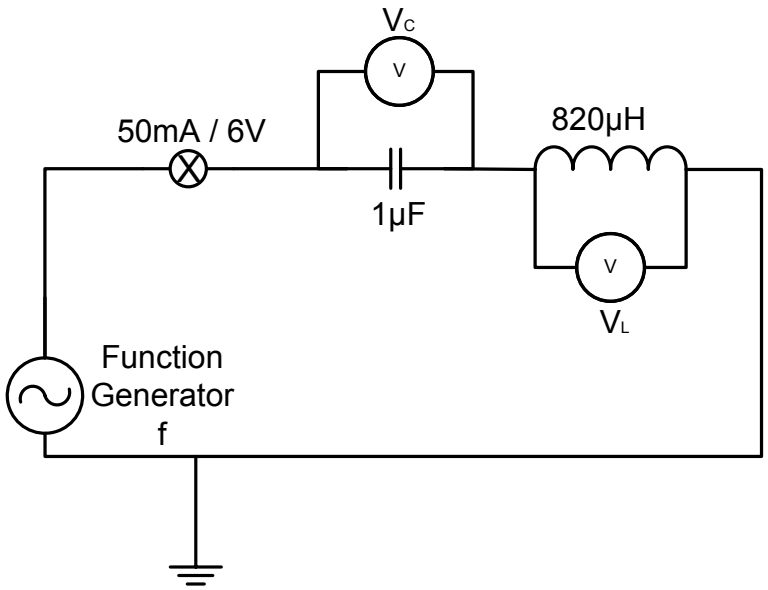
RLC

1. **Purpose:**
To investigate the voltages across a lamp, inductor and a capacitor at a specific voltage setting and a range of frequencies.

2. **Material and equipment needed:**

Description	**Quantity**
Breadboard/Prototype board	1
Function generator	1
Dual-channel oscilloscope	1
Multimeter	2
Connecting leads	
1 µF capacitor	1
50 mA/6 V lamp	1
820 µH coil	1

3. **Method:**
3.1 Construct the circuit shown below.



3.2 Set the function generator to sine wave and adjust the voltage to around 5 to 6 V. Once the voltage is set do not change the amplitude setting of the voltage.

3.3 Set the amplitude settings on the oscilloscope to the same for both channel 1 and channel 2.

Operation 1:
Connect a voltmeter across the coil and a voltmeter across the capacitor.

1. Adjust the frequency of the function generator until the reading on each meter is the same. Record the reading of the frequency and voltages across each component.

V_C	
V_L	
f	

(3)

2. State the value of the frequency at this setting. Explain why this is this value.

_____

_____

_____

(2)

3. Adjust the frequency above this value and record the values of the voltage across the capacitor and resistor. Describe the reason for the readings on the meters.

V_C	
V_L	

(2)

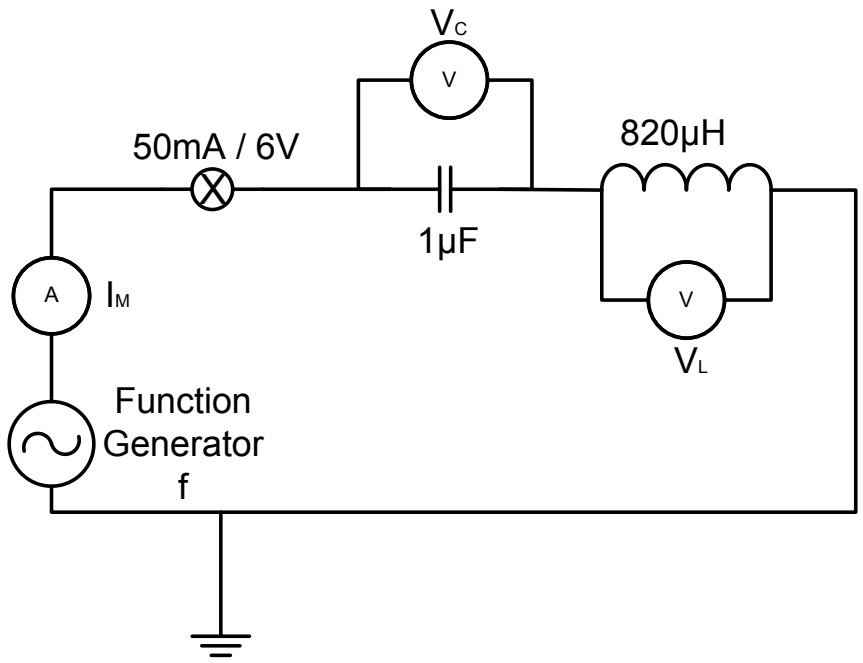
4. Adjust the frequency below this value and record the values of the voltage across the capacitor and resistor. Describe the reason for the readings on the meters.

V_C	
V_L	

(2)

Subtotal: (9)

Operation 2:
Connect an ammeter in the circuit to measure the current flow in the circuit as shown below:



1. Adjust the frequency of the function generator until the reading on the meter is at a maximum. Record the reading of the frequency and the current reading.

I_M	
f	

(2)

2. Describe the state of the frequency when the current is at a maximum.

_____

_____ (2)

3. Adjust the frequency above this value and record the value of the current. Describe the reason for the reading.

I	

(1)

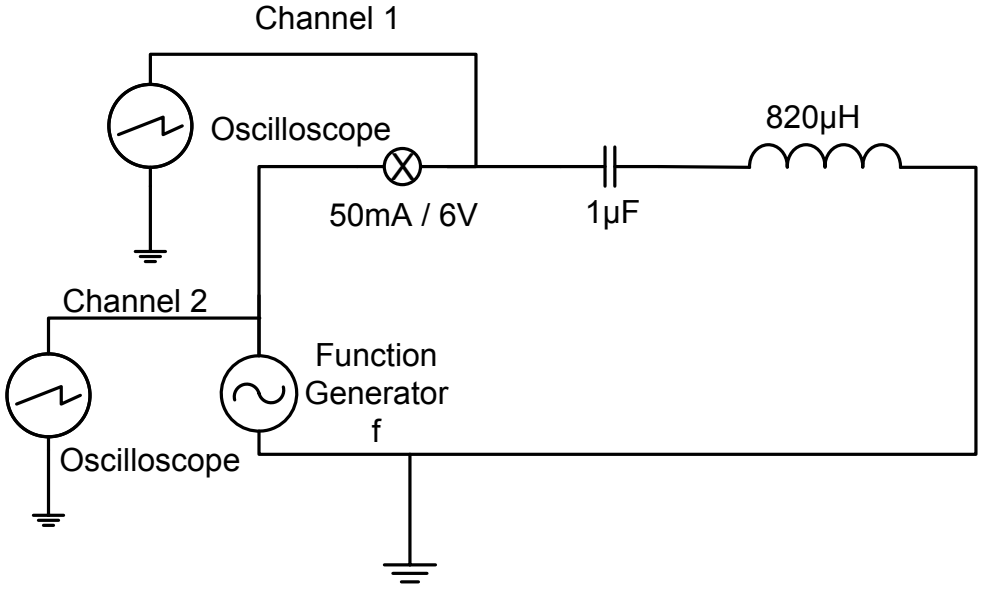
4. Adjust the frequency below this value and record the value of the current. Describe the reason for the reading.

I	

(1)

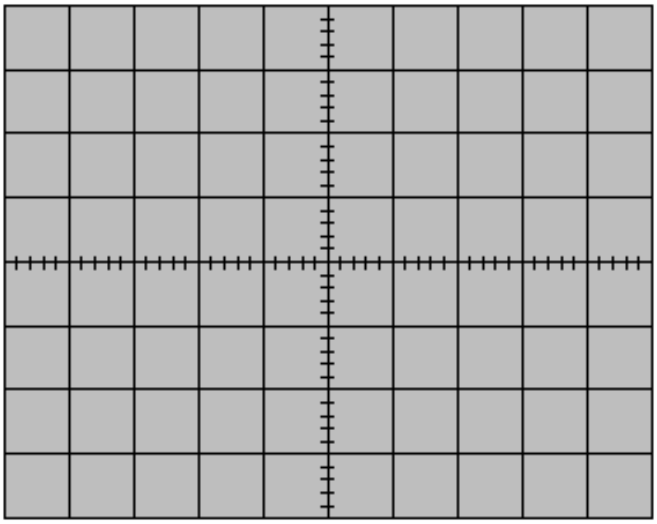
Subtotal: (6)

Operation 3:
Connect the oscilloscope to the circuit as shown below.
Connect channel 1 across the lamp and channel 2 across the supply.



1. Adjust the frequency of the function generator to obtain resonant frequency by observing the changing waveforms on the oscilloscope

2. Draw the shape the waveforms at resonant frequency. (4)



3. Describe why the waveforms are this shape. (3)

4. Adjust the frequency of the function generator and describe what happens to the shape of the waveforms. (3)

_____

_____

_____

Subtotal: (10)

ASSESSMENT SIMULATION 6: SERIES RLC CIRCUIT

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 Not Achieved	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Trouble-shooting	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Circuit operation	☐ The circuit did not work at all. **(0 marks)**		☐ The circuit worked after more than one try. **(2 marks)**		☐ The circuit worked first time. **(5 marks**)
Instrument selection and use: Multimeter	☐ The learner was unable to identify and select the multimeter.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/ unsafely.(Voltage and current selection incorrect)	☐The learner was able to identify and select all multimeters correctly and used them correctly.	☐ The learner identified and selected the multimeter quickly and without the help of the teacher. The learner was also able to use the multimeter correctly in a safe ergonomic manner.
Instrument selection and use: Function Generator(FG)	☐ The learner was unable to identify and select the function generator.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used it incorrectly/ unsafely. (Could not connect and adjust the FG)	☐The learner was able to identify and select the FG correctly and used it correctly with some assistance from the teacher or a learner.	☐ The learner identified and selected the FG quickly and without the help of the teacher. The learner was also able to use the FG correctly in a safe ergonomic manner.
Instrument selection and use: Oscilloscope	☐ The learner was unable to identify the oscilloscope.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/ unsafely. (Could not connect and adjust oscillo-scope correctly)	☐The learner was able to identify and select the oscilloscope correctly and used it correctly some assistance from the teacher or a learner.	☐ The learner identified and selected instruments quickly and without the help of the teacher. The learner was also able to use the oscilloscope correctly in a safe ergonomic manner.
				Rubric (25)	
				Operation 1 (10)	
				Operation 2 (6)	
				Operation 3 (9)	
				Total (50)	

Electronic – 2

Simulation 7 Time: 3 hours

Learner: _____

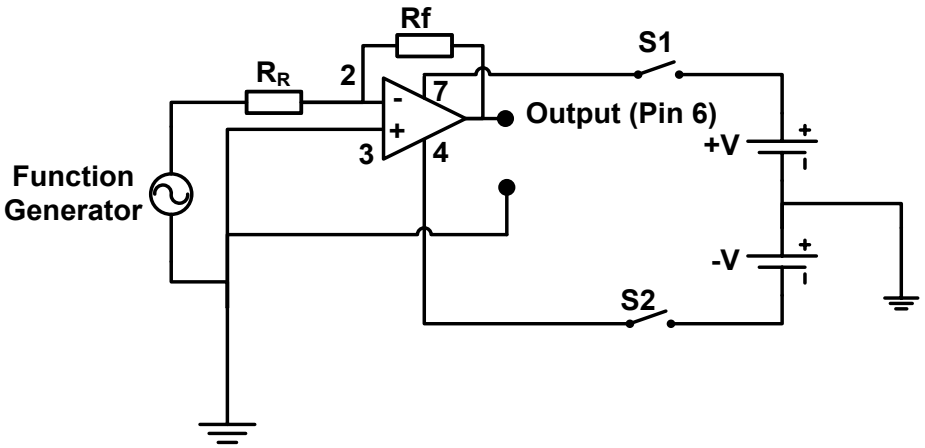
School: _____

Examination Number: _____

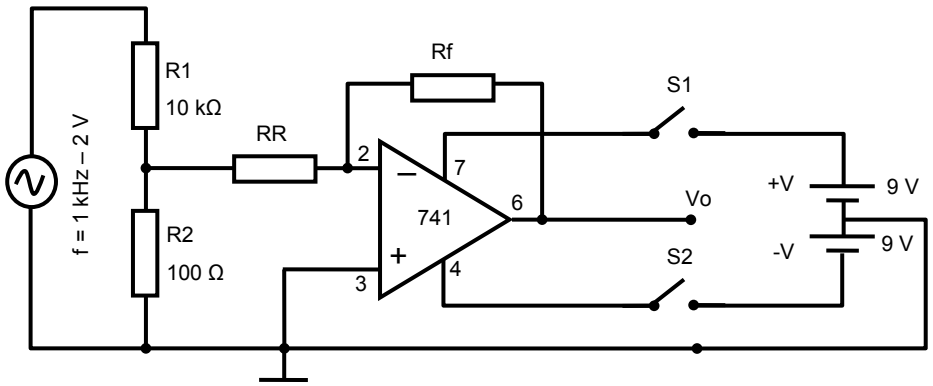
Gain of an Op Amp

1. **Purpose:**
To determine the gain of an operational amplifier mathematically and practically.

2. **Circuit diagram:**



(Alternative circuit below)



3. **What you will need:**
   - Breadboard/Protoboard
   - Hook-up wire
   - 741 op amp and components
   - Oscilloscope – dual trace
   - Function generator
   - Tools
   - Split power supply (or two 9 V batteries) (+9 V/0 V/-9 V)

4. **Procedure:**
   - Connect the circuit shown above with Rf = RR = 100 kΩ on a breadboard.
   - S1 and S2 are open.
   - Set each of the two voltage supplies to 9 volts.
   - Set the function generator to 1 000 Hz. Reduce the gain to zero output or as close as you can.
   - Connect trace/channel 2 of the oscilloscope to the output of the op amp. (Pin 6 & 0 V)
   - Trigger/Sync the oscilloscope to show the wave form.
   - Connect the input wave from the function generator to trace/channel 1 of the oscilloscope. (Function generator)
   - Close S1 and S2 applying power to the circuit.
   - Slowly increase the output of the function generator to just below the point where the output signal is being distorted. (Look at both the input and the output waveforms and compare the shape to see if the output is being distorted.)
   - With the oscilloscope measure and record the output voltage V_{out} from the amplifier (output pin 6) (peak-to-peak value).
   - With the oscilloscope measure and record the input voltage V_{in} to the amplifier (output of the function generator) (peak-to-peak value).
   - Calculate the gain of the amplifier and record it in the table.
   - Compare the input and output waveforms and determine whether or not they are in or out of phase with each other (0º or 180º).
   - Reduce the output of the function generator to zero.
   - Repeat the experiment, each time replacing RR with the values shown in the table.

5. **Measurements:**

Rf **Ω**	**R_R** **Ω**	**V_{P-P}**		**Gain** $A = \frac{Vout}{Vin}$	**In phase with input?**	
		Output	**Input**			
100 000	100 000					Control
	50 000					(4)
	33 000					(4)
	24 000					(4)
	200 000					(4)
	300 000					(4)

(The last two values will have to be made up using different resistors.)

6. **Housekeeping:**
On completion place all instruments and tools back and apply housekeeping.

7. **Conclusion:**
There is a strong correlation between calculated and measured values. Discrepancies in measurements and calculations can be attributed to component tolerances.

Subtotal: (20)

RUBRIC ELECTRONIC SIMULATION 7: GAIN OF AN OP AMP

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 **Not achieved**	**2** **Not competent yet**	**3** **Competent**	**4** **Highly competent**	**5** **Outstanding**
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or fewer components correctly on the board.	☐The learner was able to correctly plan and place more than 4, but fewer than 8 components correctly on the board.	☐The learner was able to successfully plan and place all the components correctly on board with links.	☐ The learner was able to successfully plan and place all the components correctly on the board taking onto consideration space used, alignment of components and component types.
Troubleshooting	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Component selection and identification	☐ The learner was unable to identify and select any components.	☐ The learner was able to identify and select fewer than 4 components.	☐ The learner was able to select more than 4, but fewer than 8 components.	☐ The learner was able to identify and select all components.	☐ The learner identified and selected components quickly and without the help of the teacher. The learner was also able to identify equivalent values using a variety of methods.
Instrument selection and use	☐ The learner was unable to identify and select any instruments.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/unsafely.	☐ The learner was able to identify and select all instruments correctly and used them correctly.	☐ The learner identified and selected instruments quickly and without the help of the teacher. The learner was also able to use instruments correctly in a safe ergonomic manner.
Housekeeping	☐ The learner did no housekeeping.	☐ The learner did housekeeping under duress.	☐ The learner did housekeeping under the supervision of the teacher	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner did work safely under supervision of the teacher	☐ The learner did work safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
				Rubric (Maximum of 30)	
				Measurements (20)	
				Total (Maximum of 50)	

Electronic – 3

Simulation 8 Time: 3 hours

Learner: _____

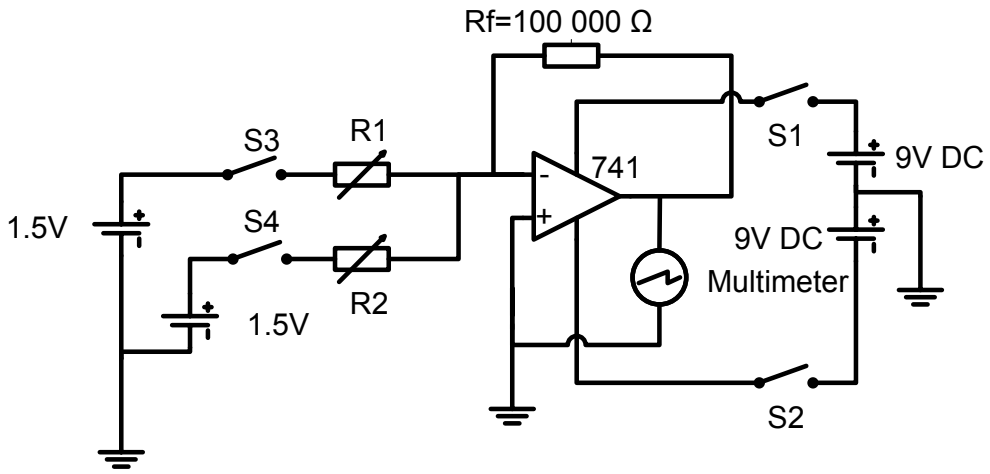
School: _____

Examination Number: _____

Experimental summer circuit

1. **Purpose:**
   To examine the properties of a summer circuit

2. **Circuit diagram[1]:**



3. **What you will need:**
   - Breadboard/Protoboard
   - Hook-up wire
   - 741 op amp and components
   - Multimeter
   - Tools
   - Split power supply (or two 9 V batteries)

[1] Ref: Basic Electronics: A Text Lab Manual: Paul B Zbar, Albert P Malvino, McGraw Hill

4. **Procedure:**

Step 1

- Connect the circuit shown above.
- Use 1,5 V cells to supply S3 and S4.
- S1 and S2 are open.

Step 2

- Set each of the two voltage supplies to 9 volts.
- Leave Switch S3 and S4 off (open).
- Switch S1 and S2 on.

Step 3

- Switch on S4.
- Adjust the value of R2 (500 K Pot) so that the output voltage of the amplifiers (Pin 6) is the same as the input voltage at S4.

VS3		(Control)
VS4		(1)

- Switch off S4.

Step 4

- Adjust the values of R1 and R2 separately.
- When S3 is on S4 must be off and vice versa.
- Switch S1 and S2 off. (The whole circuit is now switched off.)
- Measure the resistance of R1 and R2 and record it in the table provided.

R1		(1)
R2		(1)

Explain why the circuit must be shut off when measuring the resistance of R1 and R2. (2)

Step 5

- Switch the circuit on (S1 and S2).
- Complete the table provided for all the possible positions for S3 and S4.

Condition		Input Polarity		V_{in}		V_{out} at pin 6	
S_3	S_4	V_{S3}	V_{S4}	V_{S3}	V_{S4}		
On	Off	+					(2)
Off	On		+				(2)
On	On	+	+				(3)
On	On	-	+				(3)

Note the polarity of the input voltages in each case.

5. **Housekeeping:**
On completion place all instruments and tools back and apply housekeeping.

6. **Conclusion:**
Electrical voltage values can be added or subtracted from each other, similar to the addition and subtraction of mathematical values.

Subtotal: (15)

RUBRIC ELECTRONIC SIMULATION 8: EXPERIMENTAL SUMMER CIRCUIT

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 Not achieved	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Breadboard planning and layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or fewer components correctly on the breadboard.	☐The learner was able to correctly plan and place more than 4, but fewer than 8 components correctly on the breadboard.	☐The learner was able to successfully plan and place all the components correctly on the breadboard with links.	☐ The learner was able to successfully plan and place all the components correctly on the breadboard taking onto consideration space used, alignment of components and component types.
Trouble-shooting	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Circuit operation	☐ The circuit did not work at all. **(0 marks)**		☐ The circuit worked after more than one try. **(3 marks)**		☐ The circuit worked first time. **(5 marks**)
Component selection and identification	☐ The learner was unable to identify and select any components.	☐ The learner was able to identify and select fewer than 4 components.	☐ The learner was able to select more than 4, but fewer than 8 components.	☐ The learner was able to identify and select all components.	☐ The learner identified and selected components quickly and without the help of the teacher. The learner was also able to identify equivalent values using a variety of methods.
Instrument selection and use	☐ The learner was unable to identify and select any instruments.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/unsafely.	☐ The learner was able to identify and select all instruments correctly and used them correctly.	☐ The learner identified and selected instruments quickly and without the help of the teacher. The learner was also able to use instruments correctly in a safe ergonomic manner.
House-keeping	☐ The learner did no house-keeping.	☐ The learner did house-keeping under duress.	☐ The learner did house-keeping under the supervision of the teacher.	☐ The learner did house-keeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner worked safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
				Rubric (Maximum of 35)	
				Measurements (15)	
				Total (Maximum of 50)	

Digital – 1

Simulation 9 Time: 3 hours

Learner: _____

School: _____

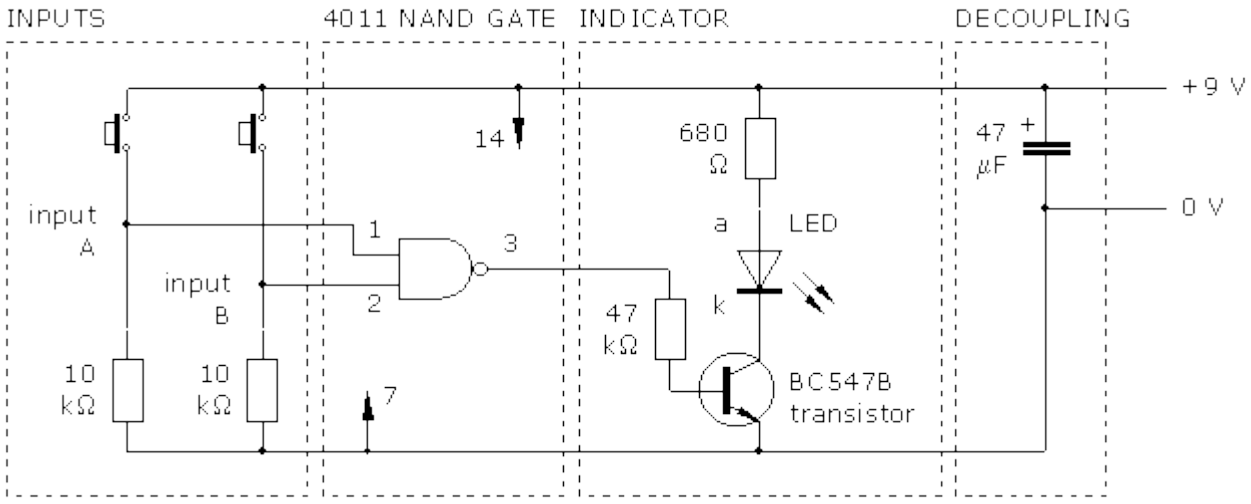
Examination Number: _____

NAND gate applications

1. **Purpose:**
   To practise the use of NAND gates in logic circuits.

2. **What you will need:**
   - Breadboard
   - 9 V power supply
   - Miniature tactile switch x2
   - BC547B NPN transistor
   - 680 Ω resistor
   - 47 kΩ resistor
   - 10 kΩ resistor x2
   - 47µF capacitor
   - 4011 IC

3. **The circuit: NAND gate indicator**



Circuit 1 – The NAND Gate Test Circuit

4. **What you are going to do:**
   - Investigate the behaviour of a single NAND gate using the 4011 Quad 2-input NAND gate IC.
   - Investigate a universal property of a NAND gate.

5. **Part A: Procedure**

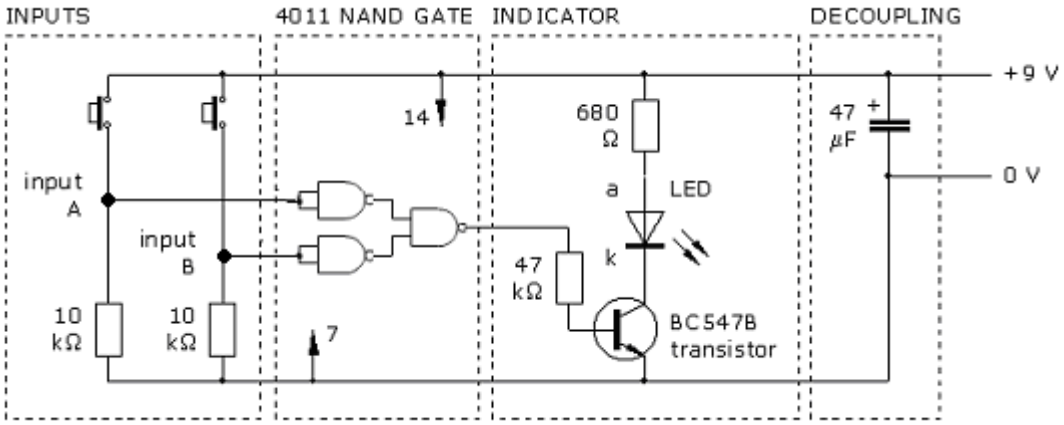
- Assemble the NAND gate indicator as shown below.
- The inputs of the gate must be connected, either to LOW or to HIGH, and must NOT be left open circuit. This is the function of the input switches with the pull-down resistors.
- To avoid overloading the output of the gate, a transistor switch indicator circuit should be used.
- It is good practice with CMOS circuits to insert a decoupling capacitor, 47 µF or 100 µF, across the power supply. (This helps to prevent the transfer of spikes along the power supply rails.)
- Complete the truth table (1 = Input Switch On and 0 = Input Switch Off)

Input A	Input B	Output – LED
0	0	
0	1	
1	0	
1	1	

(4)

6. **Part B: Procedure**

Modify your existing NAND gate circuit to the combinational NAND gate circuit as in the diagram shown below.



Operate the Input A and Input B switches to confirm the output action of the circuit.

Input A	Input B	Output – LED
0	0	
0	1	
1	0	
1	1	

(4)

This combination of NAND gates operates the same as a … gate. (2)

6. **Conclusion:**

NAND gates can be combined to simulate any Boolean expression.

Subtotal: (10)

RUBRIC DIGITAL SIMULATION 9: NAND GATE APPLICATIONS

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 Not achieved	**2 Not competent yet**	**3 Competent**	**4 Highly competent**	**5 Outstanding**
Component selection and identification	☐ The learner was unable to identify and select any components.	☐ The learner was able to identify and select fewer than 4 components.	☐ The learner was able to select more than 4, but fewer than 8 components.	☐ The learner was able to identify and select all components.	☐ The learner identified and selected components quickly and without the help of the teacher. The learner was also able to identify equivalent values using a variety of methods.
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or fewer components correctly on the breadboard.	☐The learner was able to correctly plan and place more than 4, but fewer than 8 components correctly on the breadboard.	☐The learner was able to successfully plan and place all the components correctly on the breadboard with links.	☐ The learner was able to successfully plan and place all the components correctly on the breadboard taking onto consideration space used, alignment of components and component types.
Trouble-shooting	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but is not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
PART A: Circuit operational	☐ Not operational **(0 marks)**				☐Operational **(5 marks)**
PART B: Circuit operational	☐ Not operational **(0 marks)**				☐Operational **(5 marks)**
Instrument selection and use	☐ The learner was unable to identify and select any instruments.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/ unsafely.	☐ The learner was able to identify and select all instruments correctly and uses it correctly.	☐ The learner identified and selected instruments quickly and without the help of the teacher. The learner was also able to use instruments correctly in a safe ergonomic manner.
Tool selection and use	☐ The learner was unable to identify and select any tools.	☐ The learner identified and selected the incorrect tools.	☐ The learner was able to select the correct tools, but used them incorrectly/ unsafely.	☐ The learner was able to identify and select all tools correctly and used them correctly.	☐ The learner identified and selected tools quickly and without the help of the teacher. The learner was also able to use tools correctly in a safe ergonomic manner.
House-keeping	☐ The learner did no house-keeping.	☐ The learner did house-keeping under duress.	☐ The learner did house-keeping under the supervision of the teacher.	☐ The learner did house-keeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
				Rubric (Maximum of 40)	
				NAND gates(Maximum of 10)	
				Total (Maximum of 50)	

Digital – 2

Simulation 10 Time: 3 hours

Learner: _____

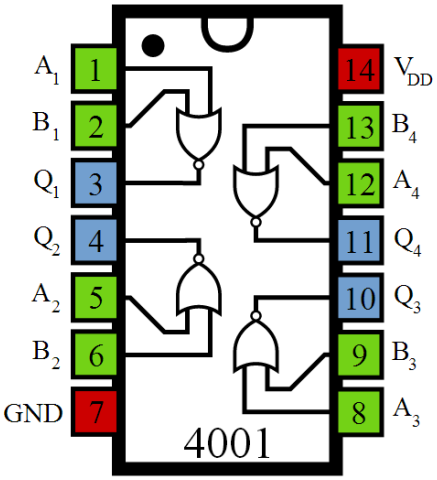
School: _____

Examination Number: _____

NOR gate application

1. **Purpose:**
To practise the application of NOR gates in logic circuits.

2. **The 4001 Logic IC[2]**



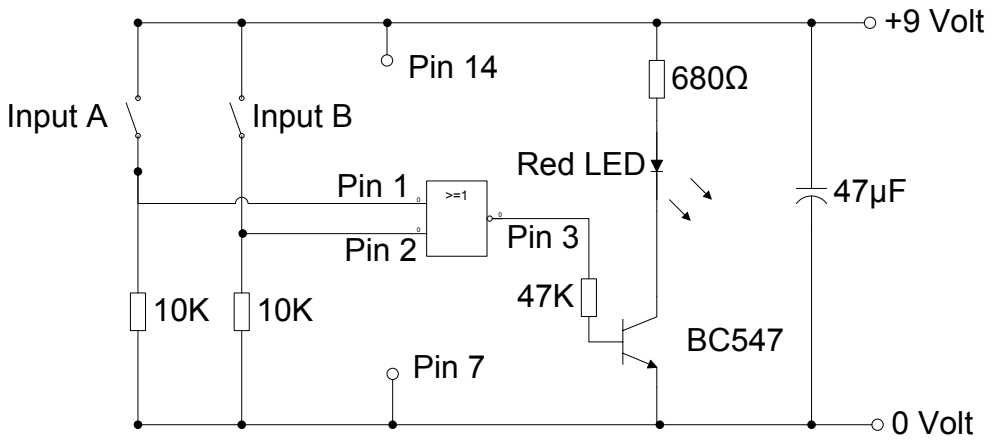
The truth table of each individual gate is that of a NOR gate truth table.

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

'0' represents a LOW voltage and '1' represents a HIGH voltage.

[2] Ref: www.doctronics.com

The circuit below uses the 4001 CMOS IC to investigate the behaviour of the NOR gate.



Step 1 – Build the NOR gate test circuit

- The inputs of the gate MUST be connected, either to LOW or to HIGH, and MUST NOT be left open circuit.
- This is the function of the input switches with their pull-down resistors.
- To avoid loading the output of the gate, a transistor switch indicator circuit should be used.
- It is good practice with CMOS circuits to insert a decoupling capacitor, 47 µF or 100 µF, across the power supply. (This helps to prevent the transfer of spikes along the power supply rails.)
- Do not forget to connect pin 14 of the 4001 to +9 V and pin 7 to 0 V.

Component connected correctly	Maximum Marks	☑/☒
Supply polarity	1	☐
Capacitor polarity	1	☐
Transistor	1	☐
Pin 14/Pin 7 correct	1	☐
NOR Gate Pin	1	☐

(5)

NOTE:
In the prototype circuit, it is not essential to make connections to the unused gates. However, in any final circuit, all unused CMOS inputs must be connected either to HIGH or to LOW.

Make it an absolute rule that CMOS inputs are NEVER left open circuit. There is no problem with CMOS outputs. Worry about the inputs and leave any unused outputs unconnected.

Step 2

- Use the 4001 IC and build a logic circuit that will represent the following Boolean function: (5 marks for a working circuit)

$$A + B = X$$

- Circuit design
  - Draw the logic gate circuit using NOR gates in the block provided below (Include the power connections to the IC and external components you will use)

Design drawn correctly	Maximum Marks	☑/☒
Supply polarity	1	☐
Capacitor polarity	1	☐
Transistor on output	1	☐
Pin 14/Pin 7 correct	1	☐
Circuit design correct (Will operate)	1	☐

(5)

- Now build the circuit on a breadboard and check if the circuit operates correctly.

Component connected correctly according to design	Maximum Marks	☑/☒
Supply polarity	1	☐
Capacitor polarity	1	☐
Transistor	1	☐
Pin 14/Pin 7 correct	1	☐
NOR Gate Pin	1	☐

(5)

- Now fill the truth table according to the functioning of the circuit you designed. Press the switches to simulate the inputs and use a LED ON as 1 and LED OFF as 0.

A	B	X
0	0	
0	1	
1	0	
1	1	

(4)

3. **Conclusion:**

_____

_____ (1)

Subtotal: (20)

RUBRIC DIGITAL SIMULATION 10: NOR GATE APPLICATION

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 **Not achieved**	**2** **Not competent yet**	**3** **Competent**	**4** **Highly competent**	**5** **Outstanding**
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or fewer components correctly on the board.	☐The learner was able to correctly plan and place more than 4, but fewer than 8 components correctly on the board.	☐The learner was able to successfully plan and place all the components correctly on the board with links.	☐ The learner was able to successfully plan and place all the components correctly on the board taking onto consideration space used, alignment of components and component types.
Troubleshooting	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify 1 mistake.	☐ The circuit was complete and the learner was able to identify and rectify 2 mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Component selection and identification	☐ The learner was unable to identify and select any components.	☐ The learner was able to identify and select fewer than 4 components.	☐ The learner was able to select more than 4, but fewer than 8 components.	☐ The learner was able to identify and select all components.	☐ The learner identified and selected components quickly and without the help of the teacher. The learner was also able to identify equivalent values using a variety of methods.
Tool selection and use	☐ The learner was unable to identify and select any tools.	☐ The learner identified and selected the incorrect tools.	☐ The learner was able to select the correct tools, but used them incorrectly/ unsafely.	☐ The learner was able to identify and select all tools correctly and used them correctly.	☐ The learner identified and selected tools quickly and without the help of the teacher. The learner was also able to use tools correctly in a safe ergonomic manner.
Housekeeping	☐ The learner did no housekeeping.	☐ The learner did housekeeping under duress.	☐ The learner did housekeeping under the supervision of the teacher	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner did work safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
				Rubric (Maximum of 30)	
				Working Circuits (Maximum of 20)	
				Total (Maximum of 50)	

Digital – 3

Simulation 11 Time: 3 hours

Learner: _____

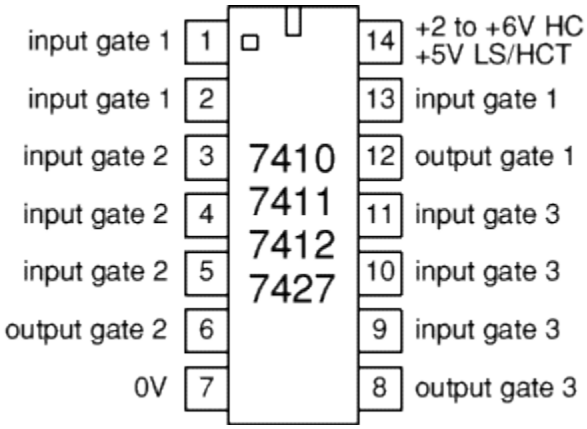
School: _____

Examination Number: _____

NOR gate applications using the 7427

1. **Purpose:**
   To illustrate that not all logic gates use two inputs only.

2. **The 7427 logic IC:**



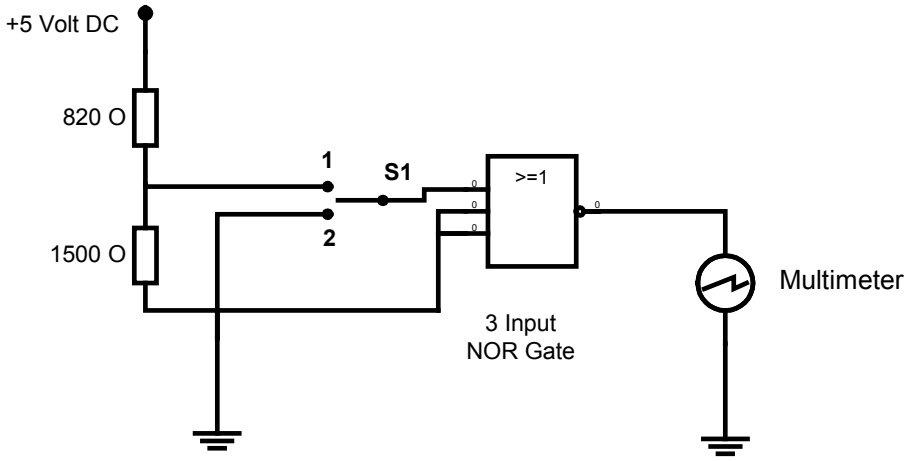
NOTE: This IC can only handle up to 6 V DC.

3. **What you will need:**
   - Regulated power supply
   - Multimeter
   - Components
     - 7427 triple, three-input NOR gate IC
     - 820 Ω resistor
     - 1 500 Ω resistor
     - 3 x SPDT switches
   - Breadboard
   - Hook-up wire

4. **What you must do:**

Circuit 1: Simple NOR gate

- Connect one of the NOR gates of the 7427 as shown below.
- The voltage divider provides the proper DC levels for the IC.
- Positive Logic 1 = 2,4–5 volts
- Positive Logic 0 = 0–0,5 volts
- S1 provides between 0–3,2 volts to the IC depending on its state.



Circuit Connected Correctly	Maximum Marks	☑/☒
Supply polarity	1	☐
Multimeter polarity	1	☐
Multimeter setting	1	☐
Pin identification	1	☐
Resistor placement	1	☐

(5)

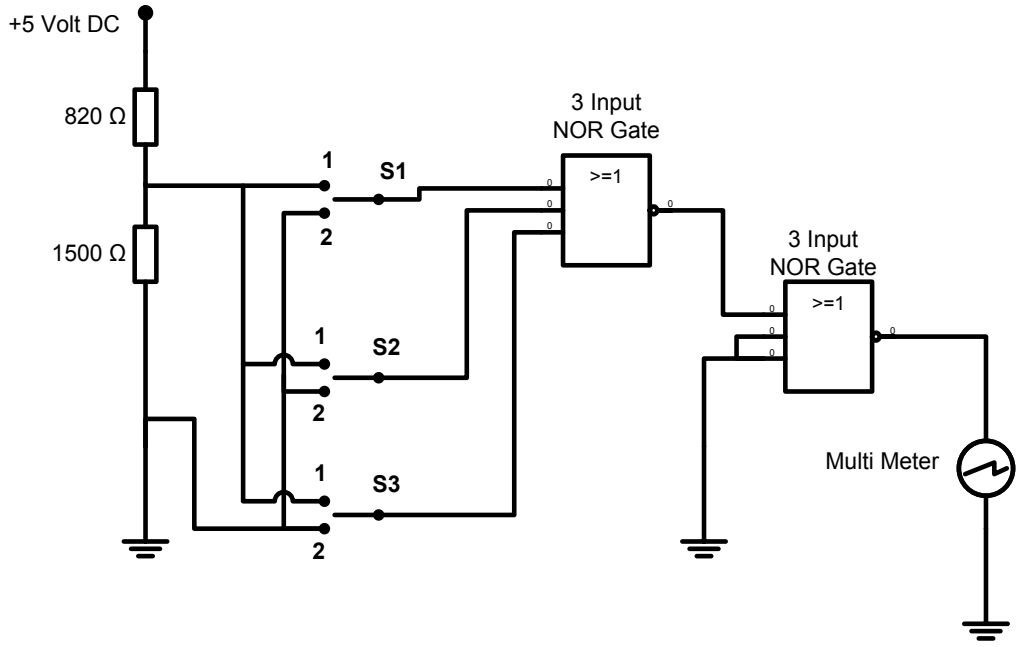
- Complete the truth table.

S1	Multimeter Reading
Position 1	
Position 2	

(2)

Circuit 2: 2-gate combination NOR gate
What you must do:

- Connect the NOR gates of the 7427 as shown below.
- The voltage divider provides the proper DC levels for the IC.
- Positive Logic 1 = 2,4–5 volts
- Positive Logic 0 = 0–0,5 volts
- S1, S2 and S3 provides between 0–3,2 volts to the IC depending on its state.
- Complete the truth table.
- Derive the Boolean expression from the circuit.



S1 = A	S2 = B	S3 = C	Multimeter = D	
0	0	0		(1)
0	0	1		(1)
0	1	0		(1)
0	1	1		(1)
1	0	0		(1)
1	0	1		(1)
1	1	0		(1)
1	1	1		(1)

Boolean expression = _____ (5)

5. **Conclusion:**
Logic gates can be adapted to have more than just two inputs. There are devices with multiple inputs to a logic gate.

Subtotal: (20)

RUBRIC DIGITAL SIMULATION 11: NOR GATE APPLICATION USING THE 7427

Task Description	**Mark Allocation** (Tick the appropriate level next to the task indicated)				
	1 **Not achieved**	**2** **Not competent yet**	**3** **Competent**	**4** **Highly competent**	**5** **Outstanding**
Troubleshooting	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Circuit 1: Operational	☐ The circuit did not work. **(0 marks)**				☐ The circuit worked. **(5 marks)**
Circuit 2: Operational	☐ The circuit did not work. **(0 marks)**				☐ The circuit worked. **(5 marks)**
Instrument use	☐ The learner was unable to identify or use any instruments correctly.	☐ The learner identified and used the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/unsafely.	☐ The learner was able to identify and use all instruments correctly.	☐ The learner identified all instruments quickly and without the help of the teacher. The learner was also able to use instruments correctly in a safe ergonomic manner.
Housekeeping	☐ The learner did no housekeeping.	☐ The learner did housekeeping under duress.	☐ The learner did housekeeping under the supervision of the teacher	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner did work safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
				Rubric (Maximum of 30)	
				Circuits Subtotal (Maximum of 20)	
				Total (Maximum of 50)	

Digital – 4

Simulation 12 Time: 3 hours

Learner: _____

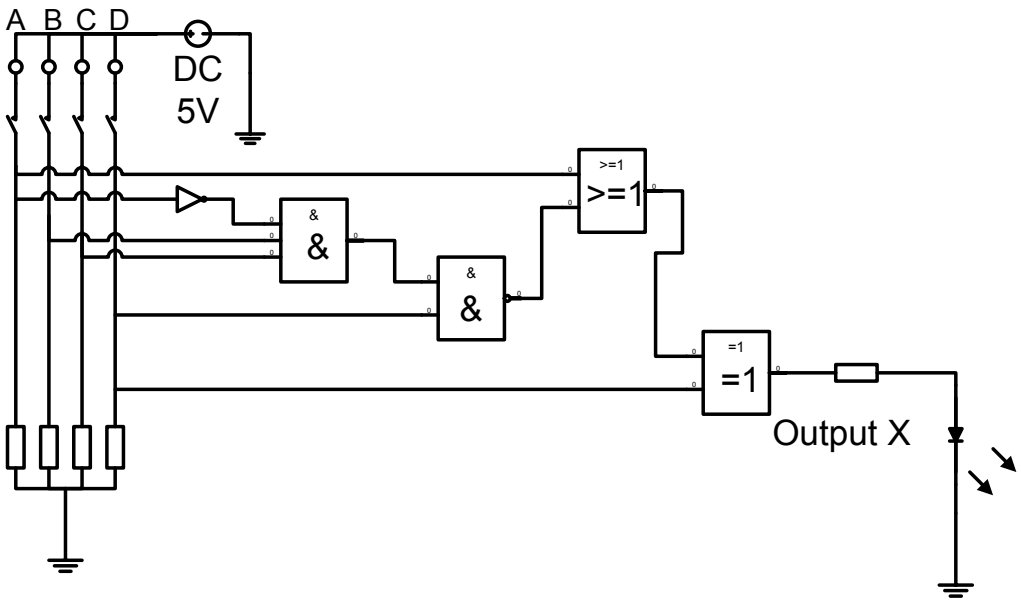
School: _____

Examination Number: _____

Boolean Algebra

1. **Purpose:**
To test Boolean algebra and construct an electronic circuit that simulates a Boolean expression.

2. **What you must do:**
Determine the Boolean equation for the following logic gate circuit: (7)



3. Draw the logic gate circuit for the Boolean equation $X = \overline{(A+B)}\ \overline{C}$

(5)

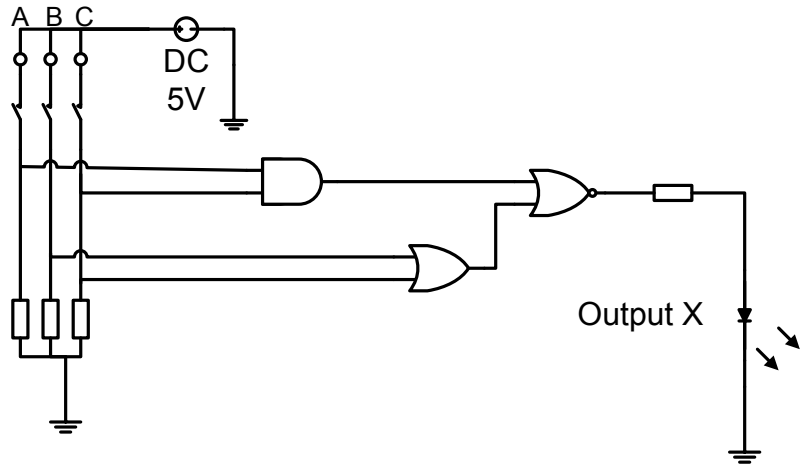
4. Determine the Boolean equation for the following truth table:

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

X=

(4)

5. Redraw the following circuit using NAND gate combinations:



(5)

6. Using De Morgan's Theorem, prove that the LHS = RHS. (Show ALL steps.)

$$\overline{\overline{A+B}.C} = \overline{\bar{A}.\bar{B}} + C$$

(5)

7. Simplify the following Boolean equation. (Show ALL steps.)

$$Z = (A + \bar{B} + \bar{C})(B.\bar{C})$$

(7)

8. Use a Karnaugh map. Simplify the following truth table and give the final Boolean expression.

A	B		X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

	00	01	11	10
0				
1				

X = _____

(9)

9. **Construct**, **on a breadboard**, a logic circuit using a logic IC to form a logic gate network that will satisfy the Boolean expression shown below.
X must be represented by an LED which will light up when X = 1 and when X = 0 the LED will not light up.
(Schools with PLCs may opt to simulate this question on PLC.)

$$(A + B) + C.\overline{D} = X$$

Circuit Design

(8)

10. **Conclusion:**
Boolean algebra equations can be constructed and applied electronically.

TOTAL: 50

ANNEXURE: COMPONENT LIST FOR ELECTRONIC/DIGITAL SIMULATIONS

Component List – Gain of an Op Amp	
IC	741 op amp
Rf	10 K ¼ W 5%
Rr1	10 K ¼ W 5%
Rr2	5 K ¼ W 5%
Rr3	3k3 ¼ W 5%
Rr4	2k4 ¼ W 5%
Rr5	20k1/4 W 5%
Rr6	30k ¼ W 5%
S1, S2	SPST toggle switch

Component List – Experimental Summer Circuit	
Rf	10 K ¼ W 5%
S1, S2, S3, S4	SPST toggle switch
1,5 V source	1,5 V battery
Bat. holder	1 x battery holder
R1, R2	50 K Pot

Component List – NAND Gate Applications	
T1	BC 547
S1, S2	Tactile push-to-make N/O switch
R1	680 ohm ¼ W 5%
R2	47 K ¼ W 5%
R3, R4	10 K ¼ W 5%
C1	47 uF 16 V
IC1	4011 NAND gate IC DIP package
D1	Red LED

Component List – NOR Gate Application	
IC1	4001 NOR gate IC DIP package
T1	BC 547
S1, S2	Tactile push-to-make N/O switch
R1	680 ohm ¼ W 5%
R2	47 K ¼ W 5%
R3, R4	10 K ¼ W 5%
C1	47 uF 16 V
D1	Red LED

Component List – NOR Gate using the 7427	
IC1	7427 Quad 3 input NOR gate – DIP package
R1	820 ohm ¼ W 5%
R2	1k5 ¼ W 5%
S1, S2, S3	SPST toggle switch