basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY

GUIDELINES FOR PRACTICAL ASSESSMENT TASKS

2014

These guidelines consist of 64 pages.

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SECTION A (Teacher's Guide)

1. Structure of the PAT

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

The 2014 PAT has three focus areas with simulations in each of the following fields:

- **Electrical**
- **Electronics**
- **Digital Electronics**

The Practical Assessment Task consists of four simulations and a practical project. The teacher may choose any scenario for the practical project 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 hand 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 Grade 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.

A complete PAT will consist of 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 will be are allowed while plastic and metal enclosures will be deemed acceptable.
    - The enclosure should be accessible for scrutiny inside while lids that are secured with screws will be preferred.
  - Circuit board
    - The file should include the PCB design.
    - Mounted inside the enclosure in such a manner that it can be removed.
    - Switches, potentiometers, connectors and other items must be mounted.
    - Wiring must be neat and bound.
    - 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 ample 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.

2. Administration of the PAT

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

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 it to learners at the beginning of each term.

The PAT must not be allowed to leave the classroom 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.

3. Assessment and moderation of the PAT

The Practical Assessment Task for Grade 12 will be externally set and moderated, but internally assessed. All formal assessment will be done by the teacher. The PAT must be moderated by the following:

- The teacher is required to produce a working model which sets the baseline for assessment at a Highly Competent Level (Level 4). For the learner to achieve a Level 5, his work must exceed the standard set by the teacher in quality, finishing and content.
- When assessing the PAT, the teacher is required to compare the following items of the learner with his/her exemplars:
  1. PAT file with answers
  2. Simulations
  3. Project of the learner
- The Head of Department (HOD): It is the responsibility of the HOD to ensure that the teacher is progressing with the PAT from the start of the school year.
- The Provincial Moderator:
  1. The provincial moderator/s will moderate Simulations 1 and 2 in the 2nd and Simulations 3 and 4 in the 3rd term.
  2. Provincial moderator/s will moderate the final PAT during provincial moderation before the end of the third term and will effect changes on the mark sheets as is deemed necessary

3.1 Assessment

Frequent developmental feedback is required to guide and support learners in order to ensure that they understand what is expected of them.

Both formal and informal assessment should be conducted, taking the different tasks that constitute the PAT into account. Informal assessment may be done by the learners themselves, by a peer, group or by the teacher. Formal assessment always remains the responsibility of the teacher and must be recorded for progression purposes.

Teachers should ensure that assessment closely correlates with the assessment rubric and that the marks awarded comply with the level descriptor in that rubric. If it is found that a discrepancy exists during moderation, teachers will have to re-assess all the tasks as assessment was found to be inaccurate.

Once the rubric has been completed by the teacher, assessment will be deemed 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.

In cases where learners do not submit portions of the PAT, no marks will be awarded to those portions. Learners that fail to produce a complete PAT by the time moderation starts will receive zero for all sections not completed. Copies of supporting correspondence regarding this issue should be included in the portfolio.

Provincial departments are responsible for setting up moderation timetables and consequently PATs should be completed in time for moderation.

The assessment plan for the PAT is as follows:

TIME FRAME	ACTIVITY	RESPONSIBILITY
January–March 2014	Simulation 1 and 2	Teacher – Copy and hand out simulations Learners – Complete simulations Teacher – Assess simulations HOD – Check if tasks have been completed and marked by the teacher before the holiday.
January 2014	PAT Project: Procurement	Teacher – Obtain quotations for PAT projects Principal – Approve PAT procurement for PAT projects Teacher – Ensure that PAT projects are ordered and delivered. HOD – Checks up on teacher to see if the process is being adhered to.
February 2014	PAT Project: Learners commence with project.	Teacher – Ensure that there is secure storage for PAT projects. Teacher – Hands out and takes in PAT projects Teacher – Include practical sessions for learners to complete PAT project every week Learners – Commence with completion of the PAT project HOD – Check in on teacher to ensure that practical workshop sessions take place on a weekly basis

April–June 2014	Moderation of Simulation 1 and 2	District Subject Facilitator/Subject Specialist will visit the school and moderate Simulation 1 and 2. 10% of simulations are re-marked and moderated.
April–June 2014	Simulation 3 and 4	Teacher – Copy and hand out simulations Learners – Complete simulations Teacher – Assess simulations HOD – Check if tasks have been completed and marked by the teacher before the holiday.
April–June 2014	PAT project: Learners continue with project	Teacher – Ensure that there is secure storage for PAT projects. Teacher – Hands out and takes in PAT projects Teacher – Include practical sessions for learners to complete PAT project every week Learners – Continue with completion of the PAT project HOD – Check in on teacher to ensure that practical workshop sessions take place on a weekly basis
July holiday 2014	PAT intervention	Learners that are behind on PAT are required to complete the project during this holiday.
July–August 2014	Moderation of Simulation 3 and 4	District Subject Facilitator/Subject Specialist will visit the school and moderate Simulation 3 and 4. Different learners from the previous term. 10% of learners are re-marked and moderated.
July–August 2014	PAT project : Completion	Teacher – Ensure 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 – Complete the PAT project and file. HOD – Check to see that 100% of PAT files and project are completed and assessed
September–October 2014	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.

3.2 Moderation

During moderation of the PAT, the portfolio and the project will be presented to the moderator.

Moderation of each term's simulations will start as early as the following term. Simulation 1 and 2 can be moderated as soon as the second term starts, and similarly Simulation 3 and 4 will be moderated in July. The project, however, will only be moderated upon completion.

The moderation process is as follows:

- During moderation learners are randomly selected to demonstrate the different PAT 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.**
- Learners being moderated will have access to their completed simulations 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 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 explain how the project was manufactured.
- Where required, the moderator should be able to call on the learner to explain the function, principles of operation and also request the learner to exhibit the skills acquired through the simulations for moderation purposes.
- Upon 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.

SECTION B (Learner Tasks)

Department of Basic Education
Grade 12 National Senior Certificate 2014
Practical Assessment Task – Electrical Technology

Time Allowed: 1st – 3rd term 2014

Learner Name: _____

Examination Number: _____

School: _____

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 are not allowed.
- The PAT is completed over three quarters.
- The PAT consists of 4 simulations and a practical project.
- Calculations should be clear and include units. Calculations should be rounded off to TWO digits. 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 to use recycled components.
- This document must be placed inside your PAT file together with the other evidence.

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	

PAT COMPONENT	MAXIMUM MARK	LEARNER MARK
Project Design and Make: Circuit – 80 marks Design and Make: Enclosure – 20 marks ($Project = \frac{80+20}{2}$)	**50**	
Simulation 1 (Term 1)	**50**	
Simulation 2 (Term 1)	**50**	
Simulation 3 (Term 2)	**50**	
Simulation 4 (Term 2)	**50**	
Total	**250**	

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 filled in	☐	☐
6	Evidence of prototyping 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 on the enclosure	☐	☐
3	Logo designed and displayed 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 neatly tied and ready for inspection	☐	☐
7	File and project completed and ready for moderation at the workshop/room	☐	☐

Declaration by the learner

(This section is COMPULSORY)

Declaration: I _____(Name) herewith declare that the work represented in this Learner Portfolio is entirely my own work. 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

SECTION B: PROJECTS

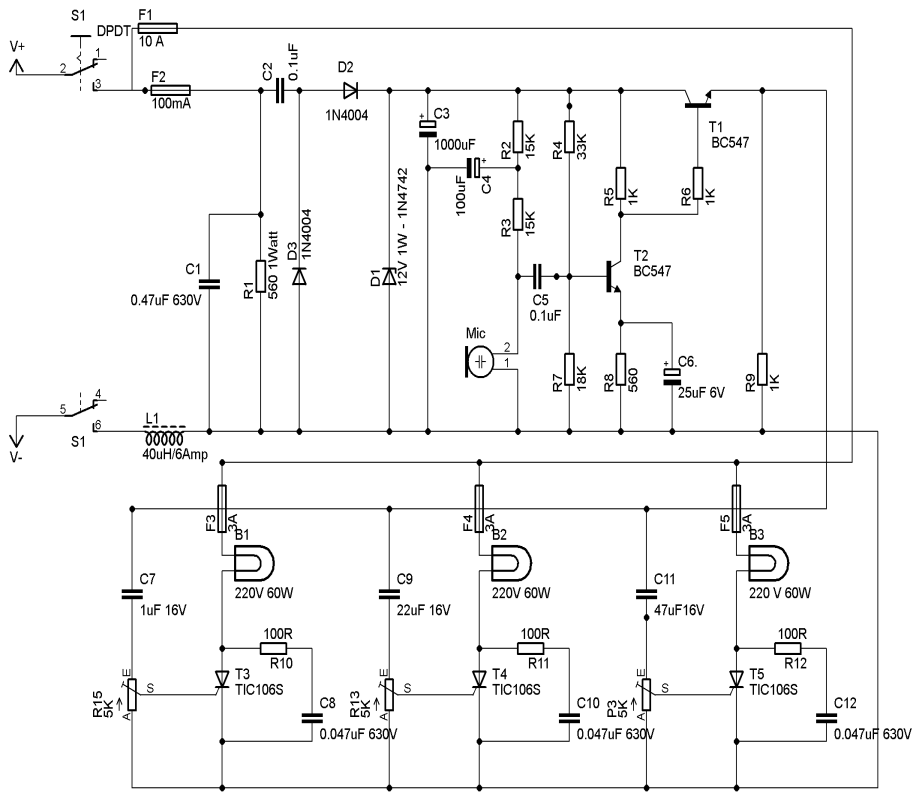
Below are examples of project circuits learners can choose from.

Teachers who have better circuits may use those instead. Teachers should not, however, choose simpler circuits as that would be a lowering of standards.

Once the teacher has chosen a design for his/her school, it is required of the teacher to construct a demonstration model of the chosen project which will set the standard for the project assessment.

ELECTRICAL PROJECT: SOUND-TO-LIGHT CONTROLLER (OPTION 1 OF 2)

WARNING: Some parts in the circuit board are subjected to lethal potential because the device is connected to 220 V AC. When plugged, enclose the circuit in a plastic or wooden box, to avoid being shocked. Do not connect this circuit to other appliances (for example to the output of an amplifier by means of a cable) as there is no mains transformer. Please use only the microphone enclosed into the main case to pick up sound.

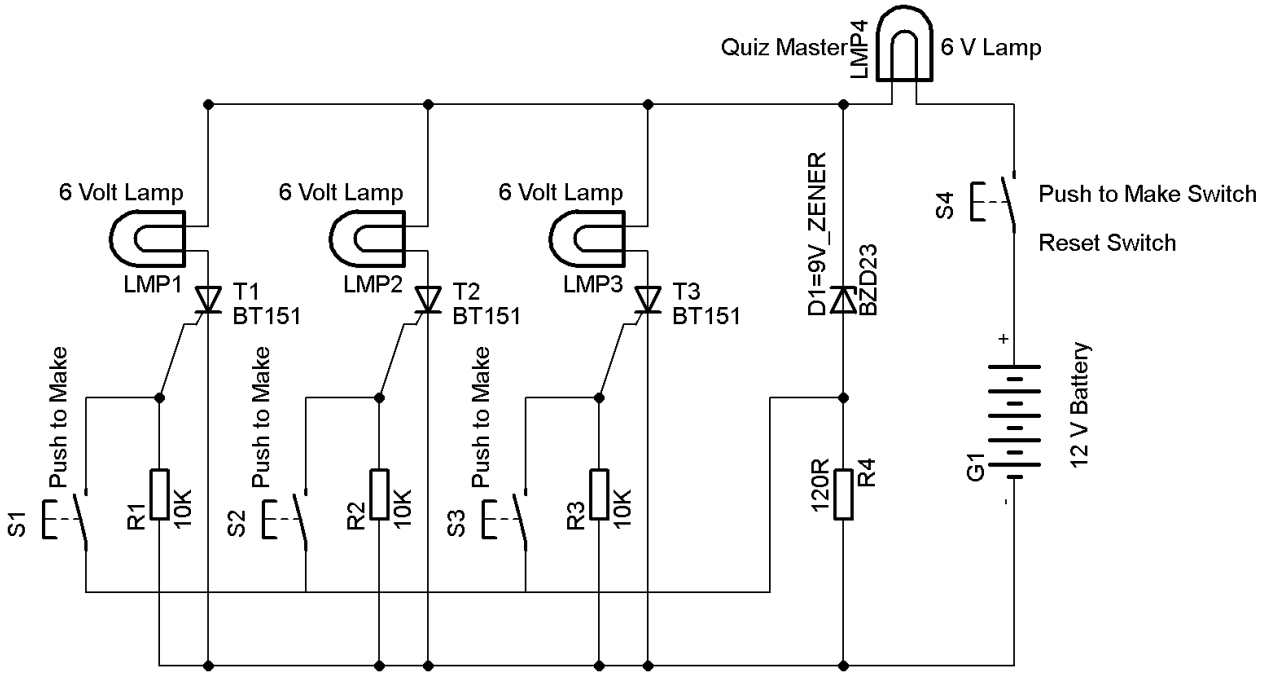


COMPONENT LIST	
R1	560 kΩ 1 W
R2, R3	15 kΩ ¼ W
R3	33 kΩ ¼ W
R5, R6, R9	1 kΩ ¼ W
R7	18 kΩ ¼ W
R8	560Ω ¼ W
P1, P2, P3	5 K Pot
C1	0.47 µF 630 V
C2, C5	0.1 µF 220 V
C3	1000 µF 16 V Electrolytic
C4	100 µF 16 V
C6	25 µF 16 V
C7	1 µF 16 V
C8, C10, C12	0.047 µF
C9	22 µF 16 V
C11	47 µF 16 v
D1, D2	1N4004
D3	1N4742 1 W
F1	10 A Fuse 220 V
F2	100 mA Fuse 220 V
F3, F4, F5	220 V 3A Fuse
L1	40 µH 6 A 10–15 Turns on a ferrite core
S1A & S1B	Double-pole switch
T1, T2	BC 547
T3, T4, T5	TIC 106 or BT 136
B1, B2, B3	60 Watt incandescent lamp
Mic	Low-impedance microphone

ELECTRICAL PROJECT: QUIZ MASTER CIRCUIT (OPTION 2 OF 2)

This circuit can be used to indicate which contestant in a quiz competition reacts the fastest by pushing a button. 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 Zener diode sees approx 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, T2, T3	BT 151 SCR
LMP1, 2, 3, 4	6 Volt Lamp
S1, S2, S3, S4	Push-To-Make Switch
D1	9V Zener Diode
12 Volt Battery/Supply	

ELECTRONIC PROJECT: AUTOMATIC BATTERY CHARGER (OPTION 1 OF 2)

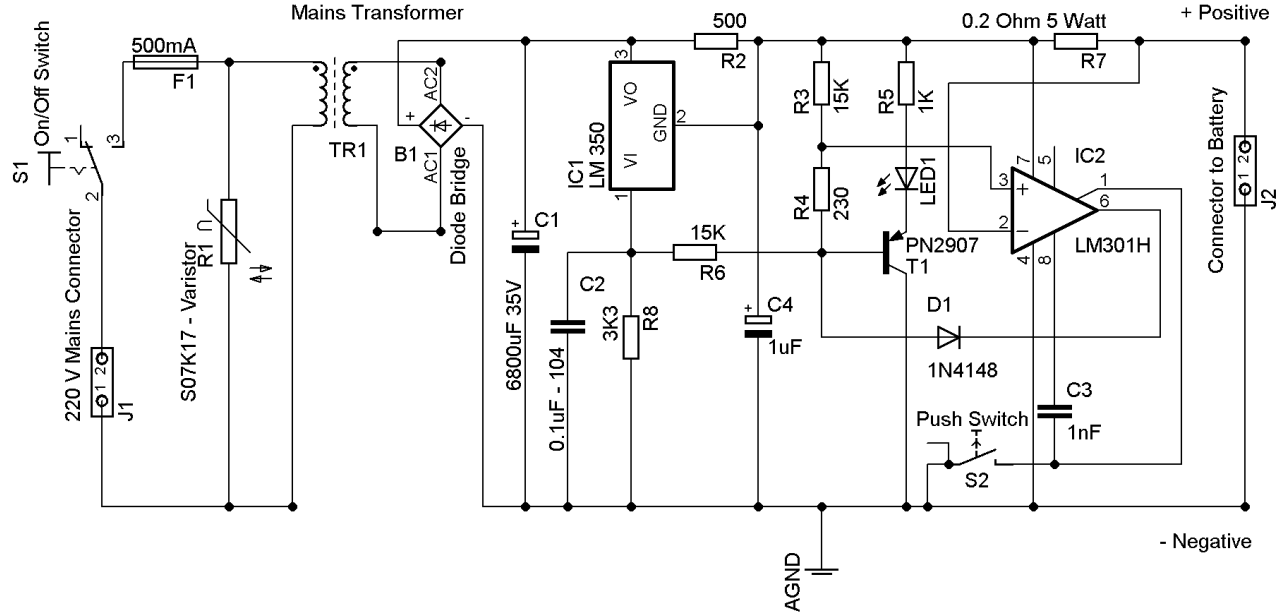
This automotive battery charger project is based on the National Semiconductor LM350 3A Adjustable Regulator. It is designed to charge 12 V lead-acid batteries. When the switch SW1 is pushed, the output of the charger will go up to 14,5 V. The initial charging current is limited to 2 A.

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 LED lights up to indicate that the charging process is completed.

The schematic diagram below shows how the various components are connected. The first part of the schematic diagram shows how the DC power supply to LM350 is achieved. The combination of varistor V1 and fuse F1 protects the circuit from a too high current and power surge of the mains supply.

Transformer TR1 is used to step down the input voltage from the mains to 16V AC. Diode bridge DB and electrolytic capacitor E1 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 Watt
R3, R6	15K ¼ Watt
R4	230 Ohm ¼ Watt
R5	1 kΩ
R7	0,2 Ohm 5 Watt
R8	3K3 ¼ Watt
J1	Mains Supply
J2	12V Connector for Battery/Battery Clamps
F1	500 mA Fast Blow Fuse
TR1	240V – 16 V Transformer 3 A (+/-50VA)
B1	5A Diode Bridge
C1	6800uF 35 V Electrolytic Capacitor
C2	0.1uF Ceramic 104
C3	1nF Ceramic 102
C4	1uF Electrolytic 25 Volt
D1	1N 4148 Diode
IC1	LM 350 16 Volt Positive Voltage Regulator
IC2	LM 301 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 2 OF 2)

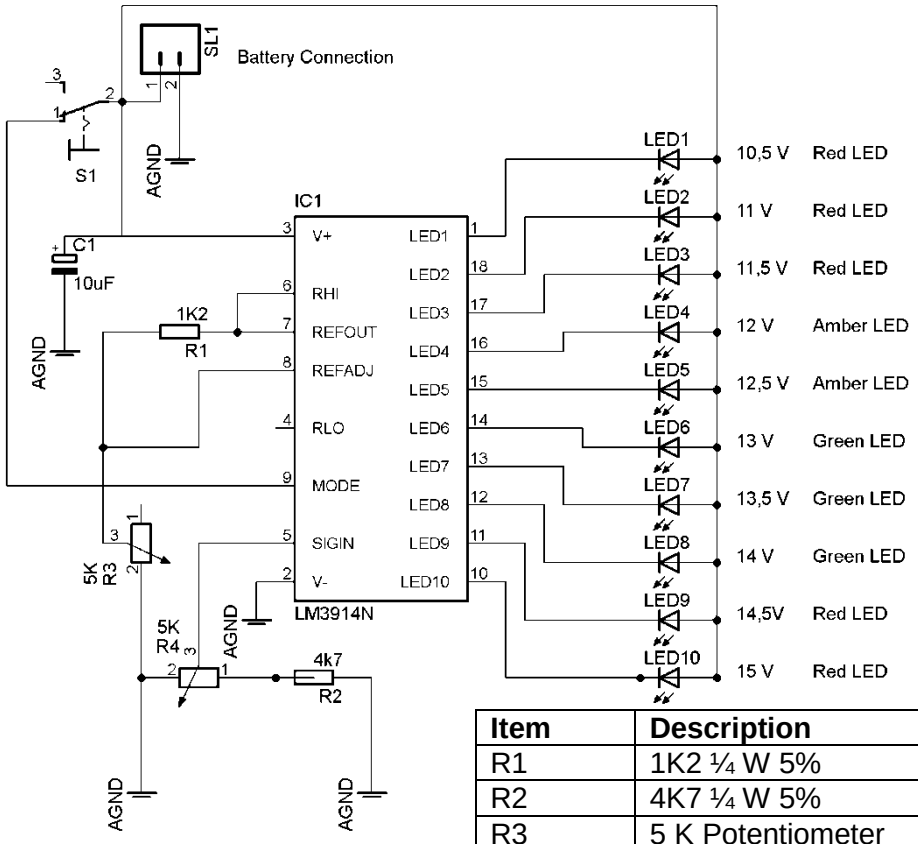
(This project can be used in conjunction with the automatic battery charger, or with any battery charger circuit.)

This bar graph LED battery level indicator project is based on LM3914 monolithic IC from National Semiconductor that senses the voltage levels of the battery and drives the 10 LEDs 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 as a 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).

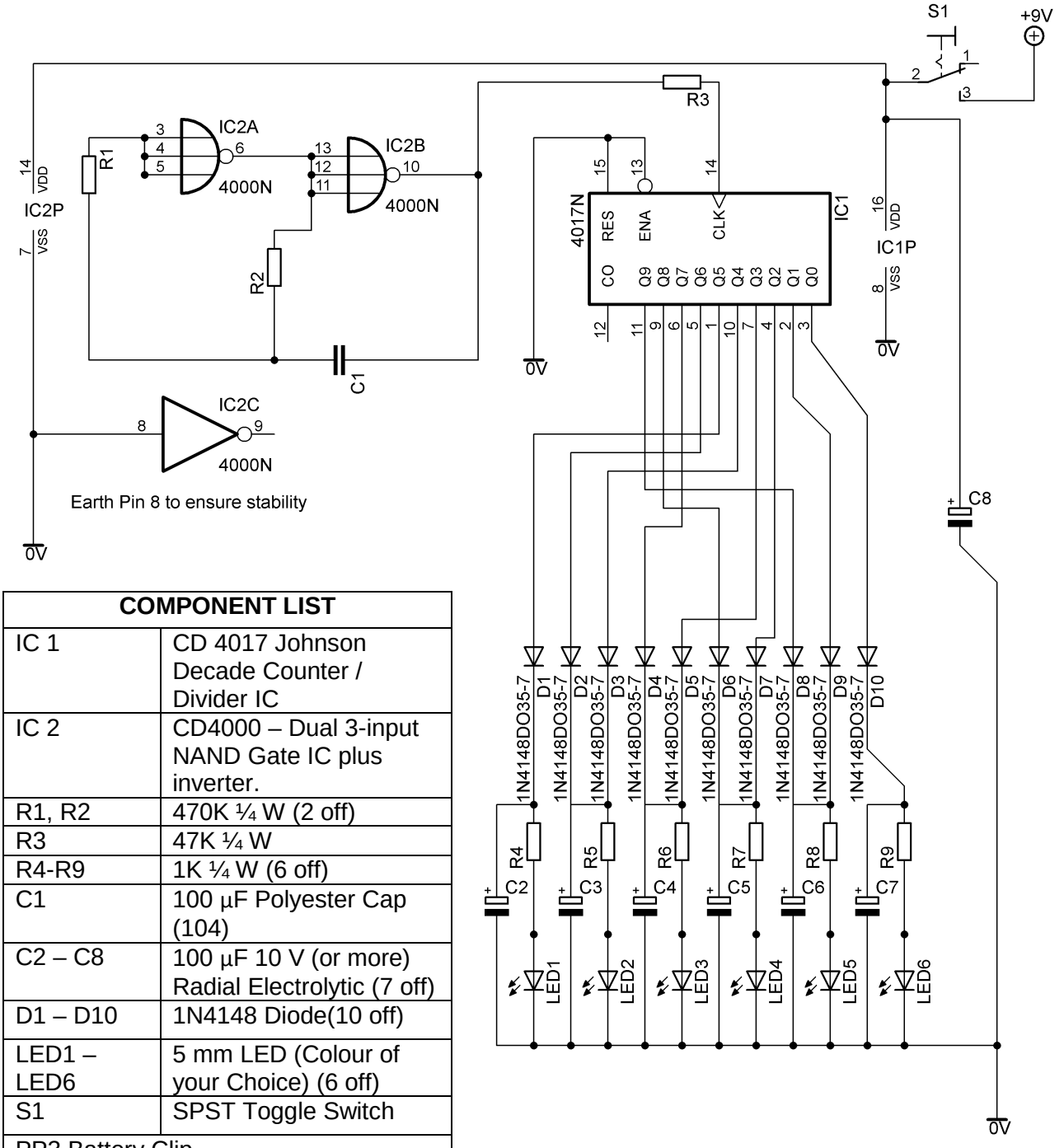


Item	Description	Quantity
R1	1K2 ¼ W 5%	1
R2	4K7 ¼ W 5%	1
R3	5 K Potentiometer	1
LED 1–10	LED – Red, AMBER, GREEN	10
IC 1	LM 3914 N Bar graph Display Driver	1
C1	10 µF 25 Volt Electrolytic Capacitor	1
S1	SPST Toggle Switch	2

DIGITAL PROJECT: LIGHT RIDER (OPTION 1 OF 2)

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

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

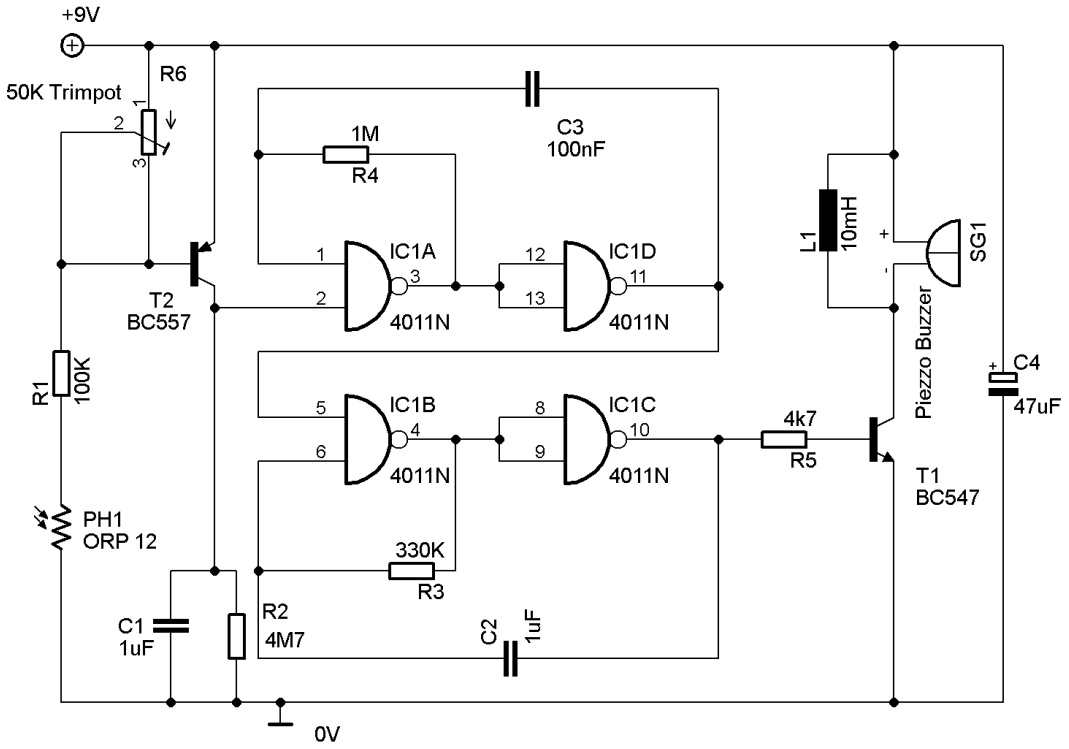


COMPONENT LIST	
IC 1	CD 4017 Johnson Decade Counter / Divider IC
IC 2	CD4000 – Dual 3-input NAND Gate IC plus inverter.
R1, R2	470K ¼ W (2 off)
R3	47K ¼ W
R4-R9	1K ¼ W (6 off)
C1	100 µF Polyester Cap (104)
C2 – C8	100 µF 10 V (or more) Radial Electrolytic (7 off)
D1 – D10	1N4148 Diode(10 off)
LED1 – LED6	5 mm LED (Colour of your Choice) (6 off)
S1	SPST Toggle Switch
PP3 Battery Clip	
9V PP3 Battery	

DIGITAL PROJECT: LIGHT ALARM (OPTION 2 OF 2)

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 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,	100K ¼ W
R2	4M7 Ω ¼ W
R3	330K Ω ¼ W
R4	1M Ω ¼ W
R5	4k7 Ω ¼ W
R6	50 K Trim pot
C1, C2	1µF Mylar Capacitor
C1	100 µF Polyester Cap(104)
C3	100 µF Polyester CAP
C4	47 µF Electrolytic 16 V Radial Cap
T1	BC 547 NPN
T2	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	

Design and Make Project

Time: January–August 2014

Learner Name: _____

School: _____

Examination Number: _____

Title/Type of Project: _____

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.

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 watt 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 and use to test the 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		

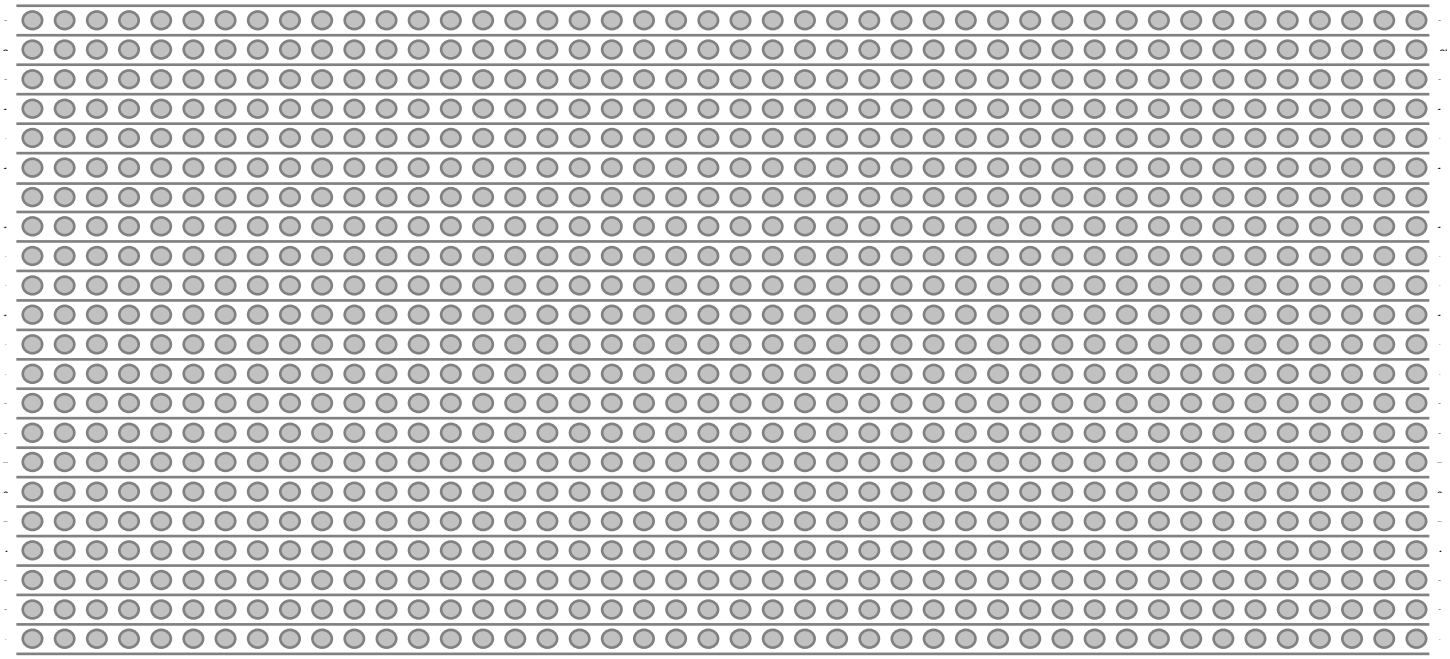
6. Evidence of prototyping

Take photos of the working prototype on the protoboard using a digital camera or a cellphone and attach it 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 is 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 any marks.)

Task Description	Mark Allocation (Tick the appropriate level next to the Task Indicated)					
	0 Not Submitted	1 Not Achieved	2 Not yet competent	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 less 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 all the parts correctly. The learner was able to show evidence on how to alter the circuit to change its operating characteristics.
Prototype circuit is working on the protoboard.	Not working **(0 marks)**	Circuit was partly operational. No photos of prototyping are included. **(3 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 protoboard.		The learner's circuit was not complete and she/he was unable to conduct troubleshooting.	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 yet competent	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 less 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 less than 4 components.	The learner was able to select more than 4, but less 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 it 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 yet competent**	**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 five but less than ten dry or loose joints. **(4 marks)**	Solder work contains less than five 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 it appears untidy.	Components are placed erratically and it appears untidy	Most components are placed tidily. Less than five 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)	

9. Enclosure design, planning and manufacture

Design an enclosure including the layout of the PCB and parts in the enclosure. Make use of colour to actuate your design. You are allowed to use not only hand-drawn designs but also the CAD programme.

1. Show the top, front and side view 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 any marks.)

Task Description	Mark Allocation (Tick the appropriate level next to the Task Indicated)					
	0 Not submitted	1 Not Achieved	2 Not yet competent	3 Competent	4 Highly Competent	5 Outstanding
Enclosure design, planning and layout		The learner attempted a design 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 less than two 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 less 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)	

SECTION C: SIMULATIONS

Simulations are circuits, experiments and tests which the learner will have to build, test and measure and practically demonstrate as part of the development of hands-on skills. These simulations represent real-world circuits and situations on a reduced scale and within a controlled environment. Furthermore, these skills have to be demonstrated to the external moderator that visits the school at intervals during the school year.

Teachers who make use of simulation programs on computer are welcome to use it 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 outlined below for teachers and school management teams who are responsible for the implementation of the PAT in Electrical Technology.

- **Step 1:** The teacher will choose simulations from 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 get lost/damaged very easily when learners are working with it.
- **Step 3:** Contact 3 different electronics component suppliers for comparative quotations.
- **Step 4:** Submit the quotations to the school management team 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 for the teacher's portfolio. Moderators will make use of the teacher's model answers and artefact when moderating.

Electrical – 1

Simulation 1 **Time: 1 hour**

Learner Name: _____

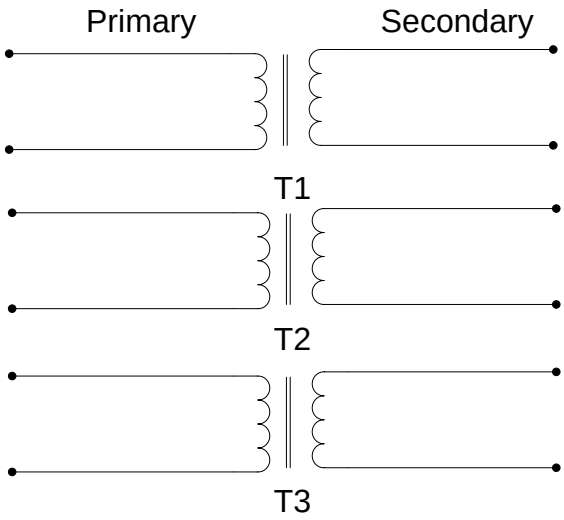
School: _____

Examination Number: _____

Connecting three single-phase transformers to three-phase supply

1. Purpose

To examine how star- and delta-connected transformers react in respect of voltage and current.



2. What you are going to do

Connect and test three single-phase transformers using a three-phase supply.

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.

NOTE: Mains supply can be lethal. Be extremely careful.

4. What you must do

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

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 school with no clamp meters should measure the primary line and phase voltages instead of voltage and currents

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

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 each lamp**	
	Voltage	**Current**	**Voltage**	**Current**
Phase 1				
Phase 2				
Phase 3				

5. In your own words describe what happened with the readings between the two different configurations (star/star vs. star/delta). Motivate your answer using a proven mathematical method. (4)

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

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

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

TOTAL: 50

Electrical – 2

Simulation 2 **Time: 1 hour**

Learner Name: _____

School: _____

Examination Number: _____

Inspecting and Testing the AC Motor

Purpose

When conducting an inspection and test of an AC motor it is advisable to make use of a checklist or report as is shown below.

Make use of the list below to conduct an inspection and test on an electrical motor. Your teacher will supply you with a motor to test.

Details of the motor under test: **(3)**

Phase: _____ **Supply voltage:** _____

Pole pares: _____ **Speed:** _____

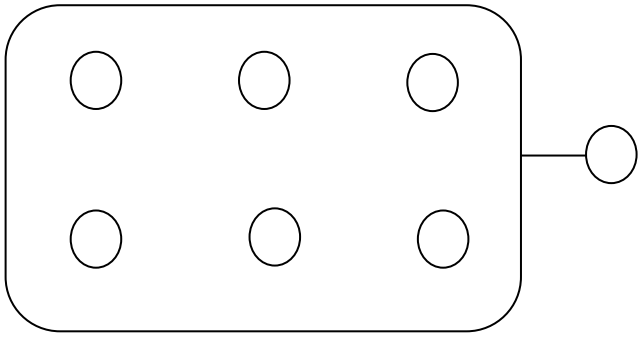
Efficiency: _____ **Current:** _____

DESCRIPTION	VISUAL INSPECTION AND 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 provided drawing below.

(3=Coils)
(2=Labels)



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

List the recommended repairs that should be affected on the electrical motor under test. (1)

TOTAL: 30

RUBRIC FOR SIMULATION 2: TESTING AN ELECTRIC MOTOR

Task Description	Mark Allocation				
	1 Not Achieved	2 Not yet competent	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 insulation resistance. .		The learner was able to test insulation resistance, but did not know why this was done.	The learner was able to correctly test insulation resistance and had a basic idea of the reason for this.	The learner was able to correctly insulation resistance and had a solid knowledge of the meters and the reasons for their use.
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 20)	
Written Task (Maximum of 30)	
Total (Maximum of 50)	

Electrical – 3

Simulation 3 **Time: 3 hours**

Learner Name: _____

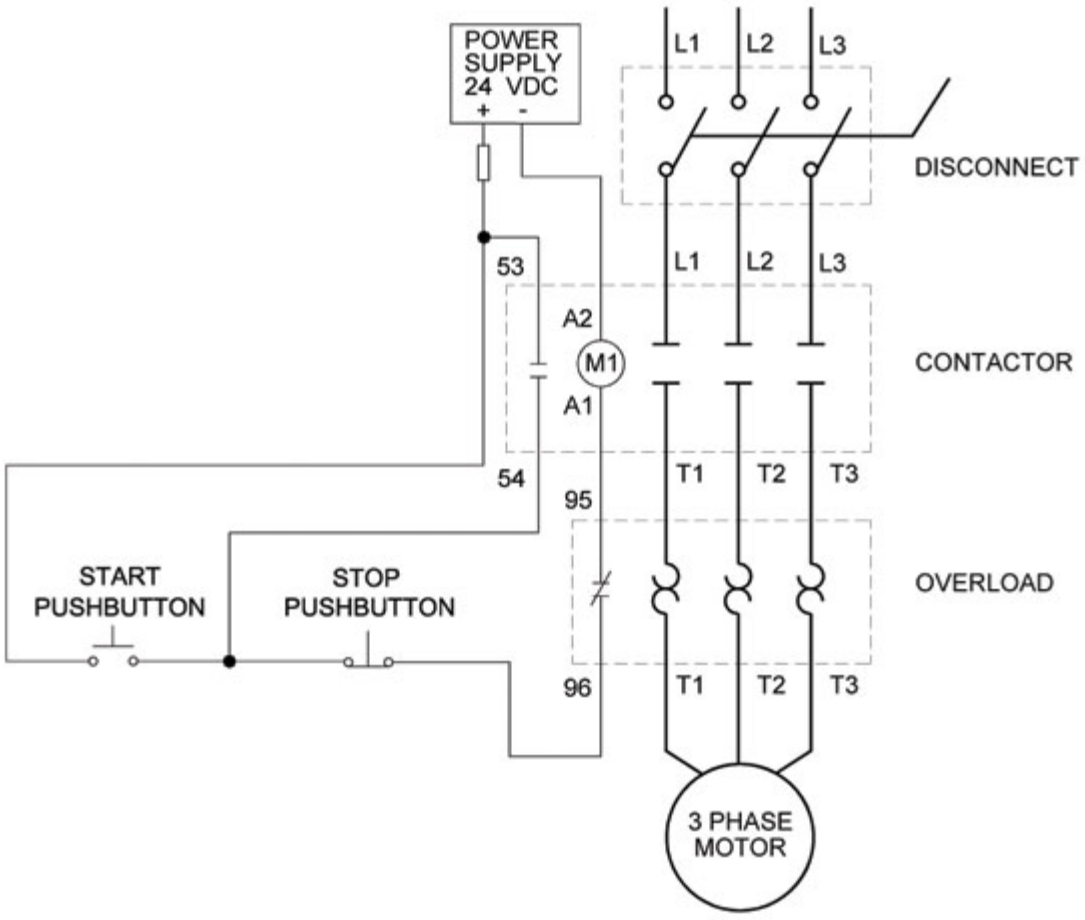
School: _____

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

Build (Assemble) 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

1. One, three-phase contactor with auxiliary contacts
2. One three-phase overload relay
3. One stop button (press-button type)
4. One start button (press-button)
5. One three-phase circuit-breaker
6. One fuse for the control circuit
7. One 380 V delta induction motor (squirrel-cage)
8. Correct wire size or plug in leads
9. Multimeter or continuity tester
10. Power supply – three-phase

4. What you must do

1. Consult the control and power circuit.
2. Construct/Wire the power and control circuit on the given panel.
3. Connect the motor to the power circuit and set the overload.
4. Now ask the teacher to check the circuits. If they are incorrect repair the fault.
5. When the circuits are correct switch the supply on and start the motor.
6. Stop the motor and switch the supply off.
7. 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 FOR SIMULATION 3: THREE-PHASE-DIRECT-ON-LINE-STARTER

Task Description	Mark Allocation				
	0 Not Achieved	1 Not yet competent	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
Control circuit working	The circuit did not work.	The circuit did not work.	The circuit did not work.	The circuit worked.	The circuit worked. This must correlate with the circuit wiring marks.
Main circuit wiring	The learner was unable 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
Main circuit working	The circuit did not work.			The circuit worked.	
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.
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, 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.
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)	

Electrical – 4

Simulation 4 **Time: 3 hours**

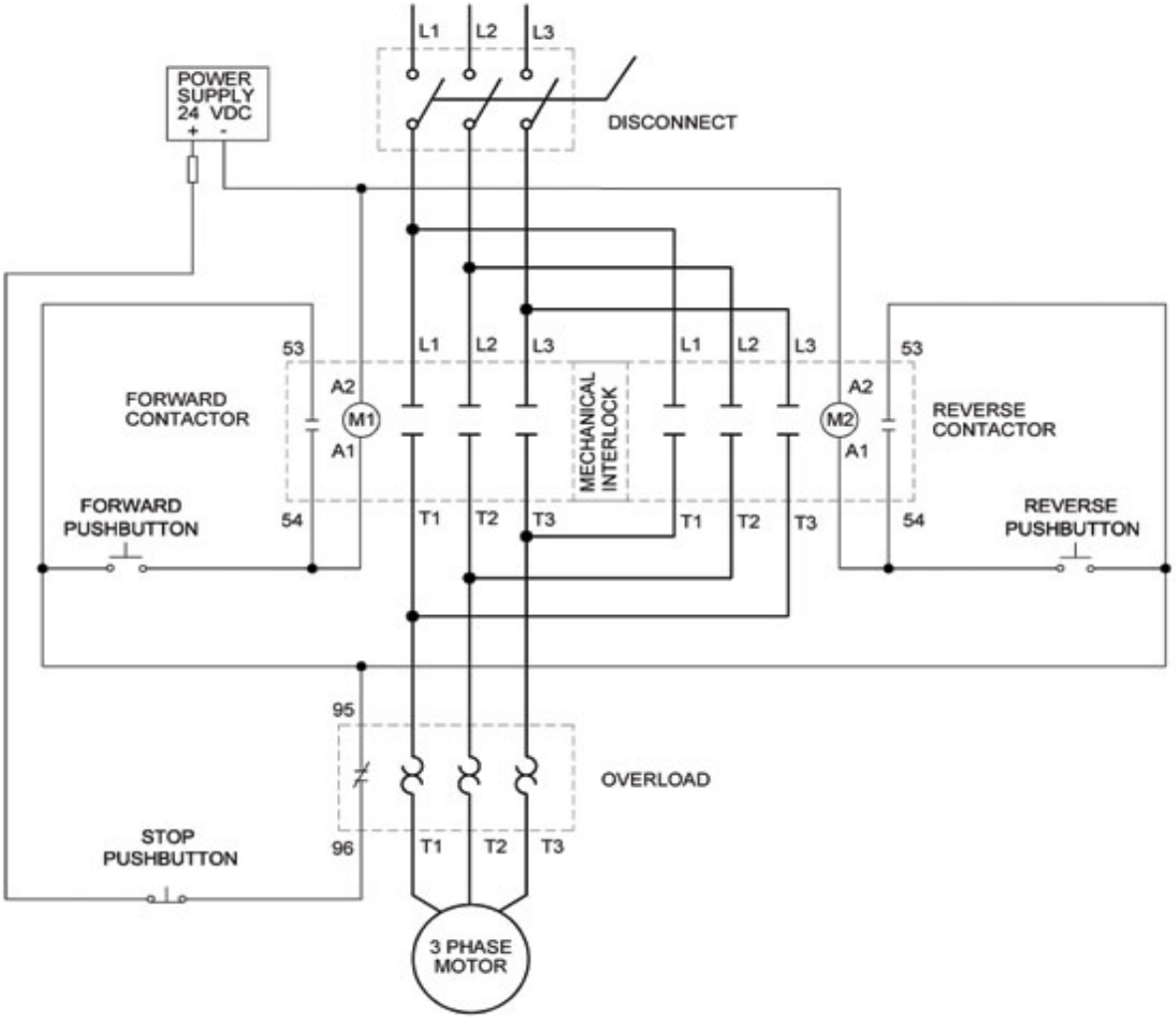
Learner Name: _____

School: _____

Examination Number: _____

Three-Phase Forward and 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
Build (Assemble) the power and control circuits of a three-phase forward and 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

1. Two, three-phase contactors with auxiliary contacts
2. One timer with normally open and closed contacts
3. Two stops, one for the emergency stop (press button type)
4. One start button (press button)
5. One three-phase circuit-breaker
6. One overload relay
7. Two fuses for the control circuit
8. One 380 V delta induction motor (squirrel-cage)
9. Correct wire size or plug in leads
10. Multimeter or continuity tester
11. Power supply

4. What you must do

1. Consult the control and power circuit.
2. Construct/Wire the power and control circuit on the given panel.
3. Connect the motor to the power circuit and set the overload.
4. Now ask the teacher to check the circuits. If they are incorrect repair the fault.
5. When the circuits are correct, switch the supply on and start the motor.
6. Stop the motor and switch the supply off.
7. 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 FOR SIMULATION 4: FORWARD REVERSE MOTOR STARTER

Task Description	Mark Allocation				
	1 Not Achieved	2 Not yet competent	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 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 the forward part of the circuit only.	The learner was able to wire both the forward and the reverse, but did not utilise interlocking.	The learner was able to successfully wire the control circuit for forward and reverse utilising interlocking.	The learner was able to successfully wire the control circuit for forward and reverse utilising 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.	
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.	
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.
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.
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 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**

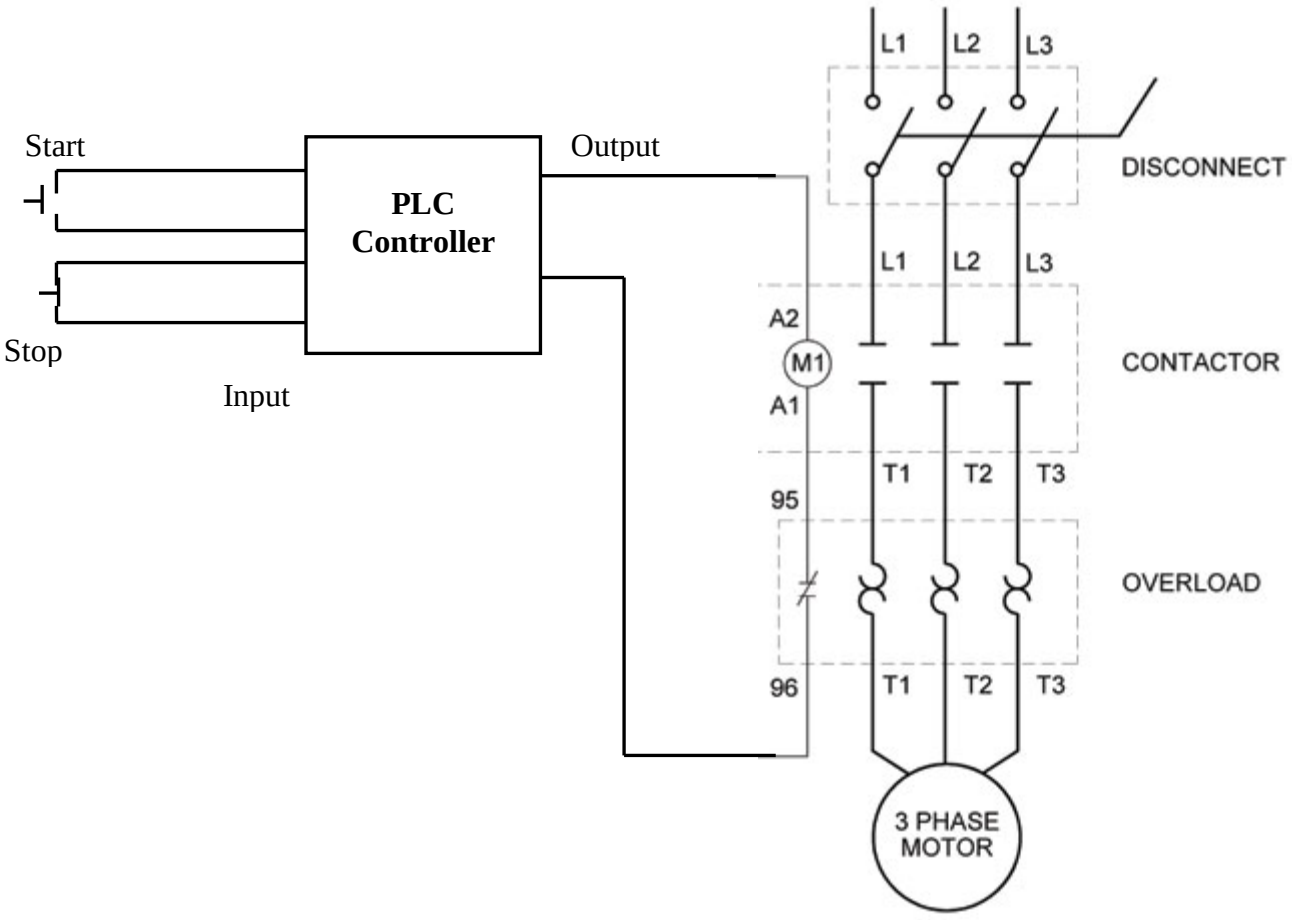
Learner Name: _____

School: _____

Examination Number: _____

Three-Phase-Direct-On-line-Starter using PLC

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



NOTE: Teachers may use alternative DoL circuits.

1. Materials and Equipment needed

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

2. What you are going to do

- Convert the control circuit of a three-phase-direct-on-line starter into 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 not switch 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.

3. Conclusion:

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

TOTAL: 50

RUBRIC FOR 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 yet competent	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.
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 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 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 1 **Time: 3 hours**

Learner Name: _____

School: _____

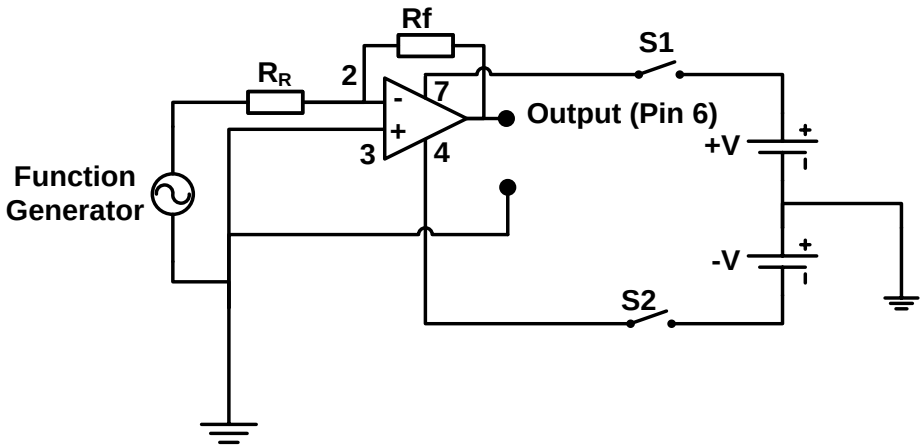
Examination Number: _____

Gain of an Op Amp

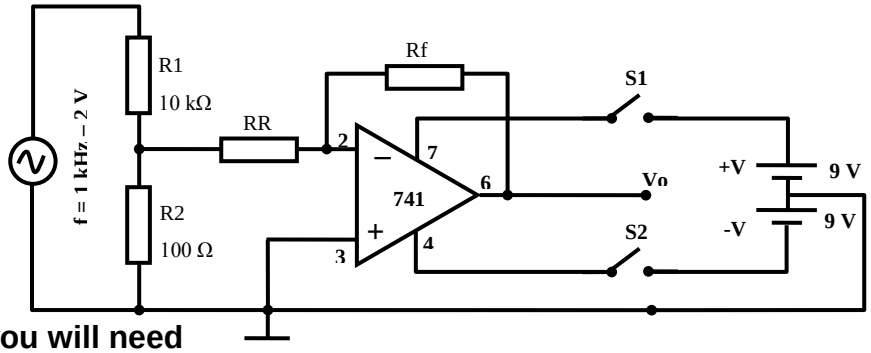
1. Purpose

To determine the gain of an operational amplifier mathematically and practically.

2. Circuit diagram



(Alternative Circuit Below[1])



3. What you will need

- Breadboard/Protoboard
- Hook-up wire
- 741 op amp and components
- Oscilloscope – dual trace
- Function generator
- Tools to prototype
- Split power supply (or two 9 V batteries) (+9v/0v/-9v)

[1] Circuit provided by Charl Marais HTS John Vorster

4. Procedure

- Connect the circuit shown above with Rf= R_R =100 kΩ on a protoboard.
- S1 and S2 are open.
- Set each of the two voltage supplies to 9 volt.
- 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 & 0V)
- 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 signal 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 our out of phase with each other (0º or 180º).
- Reduce the output of the function generator to zero.
- Repeat the experiment, each time replacing **R_R** with the values shown in the table[2].

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. After completion place all instruments and tools back and apply housekeeping.

7. Conclusion

There is a strong correlation between calculated and measured values. Discrepancies can be attributed to component tolerances.

TOTAL: 20

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

RUBRIC FOR SIMULATION 1: GAIN OF AN OP AMP

Task Description	Mark Allocation				
	1 Not Achieved	2 Not yet competent	3 Competent	4 Highly Competent	5 Outstanding
Protoboard 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 less components correctly on the board.	The learner was able to correctly plan and place more than 4, but less 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.
Component selection and identification	The learner was unable to identify and select any components.	The learner was able to identify and select less than 4 components.	The learner was able to select more than 4, but less 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.
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.
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 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)	
Measurements (20)	
Total (Maximum of 50)	

Electronic – 2

Simulation 2 **Time: 3 hours**

Learner Name: _____

School: _____

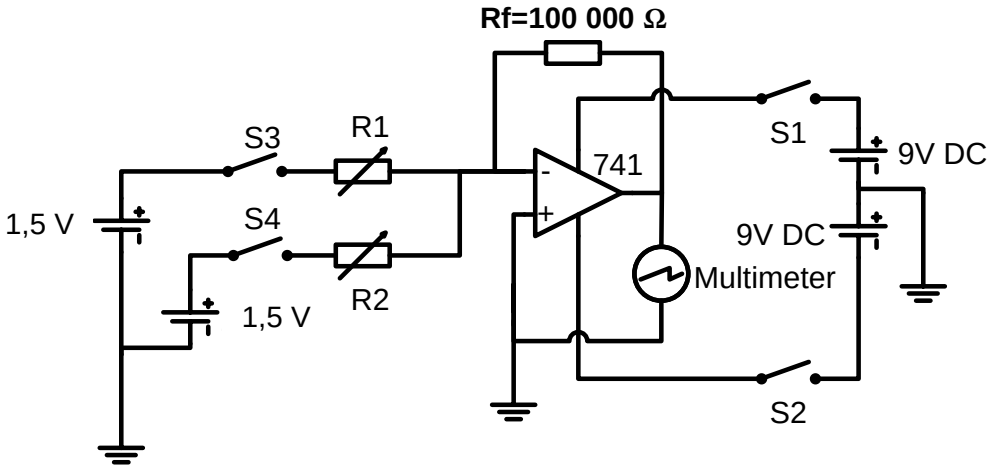
Examination Number: _____

Experimental Summer Circuit

1. Purpose

To examine the properties of a summer circuit

2. Circuit Diagram[1]



3. What you will need

- Protoboard
- Hook-up wire
- 741 op amp and components
- Multimeter
- Tools to prototype
- Split power supply (or two 9 V batteries)

4. Procedure

- Connect the circuit shown above.
- Make use of 1,5 V cells to supply S3 and S4.
- S1 and S2 are open.
- Set each of the two voltage supplies to 9 volts.
- Leave Switch S3 and S4 off (open).
- Switch S1 and S2 on.
- Switch on S_3.
- Adjust the value of R_1 (500 K Pot) so that the output voltage of the amplifier (Pin 6) is the same as the voltage at S_3. (V_{S3}= _____)

- Switch off S_3.

- Switch on S_4.
- Adjust the value of R_2 (500 K Pot) so that the output voltage of the amplifiers (Pin 6) is the same as the voltage at S_4. (V_{S4}= _____)
- Switch off S_4.

- Adjust these values separately. When S_3 is on S_4 must be off and vice versa.
- Switch S_1 and S_2 off. (The whole circuit is now switched off)
- Measure the resistance of R_1 and R_2 and record it in the table provided.

R_1		(1)
R_2		(1)

- Switch the circuit on (S_1 and S_2).
- Complete the table provided for all the possible positions for S_3 and S_4.

Condition		**Input Polarity**		**Vin**		**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	+	+				(2)
On	On	-	+				(2)

- Note the polarity of the input voltages in each case.
- After completion place all instruments and tools back and apply housekeeping.

5. Conclusion

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

TOTAL: 10

RUBRIC FOR SIMULATION 2: EXPERIMENTAL SUMMER CIRCUIT

Task Description	Mark Allocation				
	1 Not Achieved	2 Not yet competent	3 Competent	4 Highly Competent	5 Outstanding
Protoboard 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 less components correctly on the protoboard.	The learner was able to correctly plan and place more than 4, but less than 8 components correctly on the protoboard.	The learner was able to successfully plan and place all the components correctly on the protoboard with links.	The learner was able to successfully plan and place all the components correctly on the protoboard 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.
Circuit operation	The circuit did not work at all. (0 marks)		The circuit worked after more than one try (5 marks)		The circuit worked first time (10 marks)
Component selection and identification	The learner was unable to identify and select any components.	The learner was able to identify and select less than 4 components.	The learner was able to select more than 4, but less 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 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 40)	
Measurements (10)	
Total (Maximum of 50)	

Digital – 1

Simulation 1 **Time: 3 hours**

Learner Name: _____

School: _____

Examination Number: _____

NAND Gate Applications

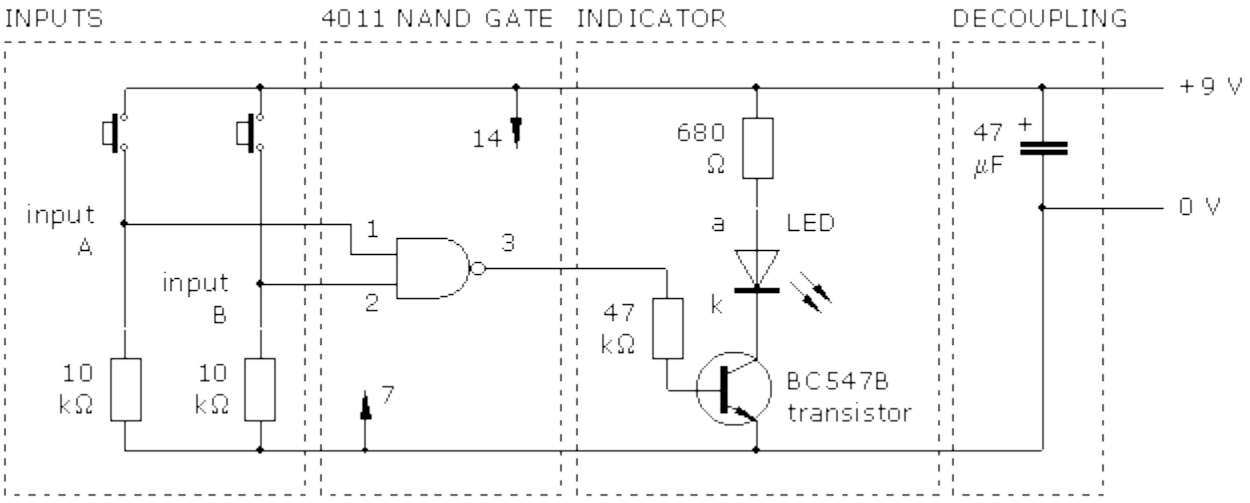
1. Purpose

To practise the use of NAND gates in logic circuits

2. What you will need

- Protoboard
- 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 Indicator

4. What you are going to do:

1. Investigate the behaviour of a single NAND gate using the 4011 Quad 2 input NAND Gate IC.
2. Investigate a universal property of a NAND gate.

5. Part A: Procedure

What you must do

1. Assemble the NAND gate indicator as shown below.
2. 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.)
3. Complete the truth table (1= Input Switch On and 0= Input Switch Off)

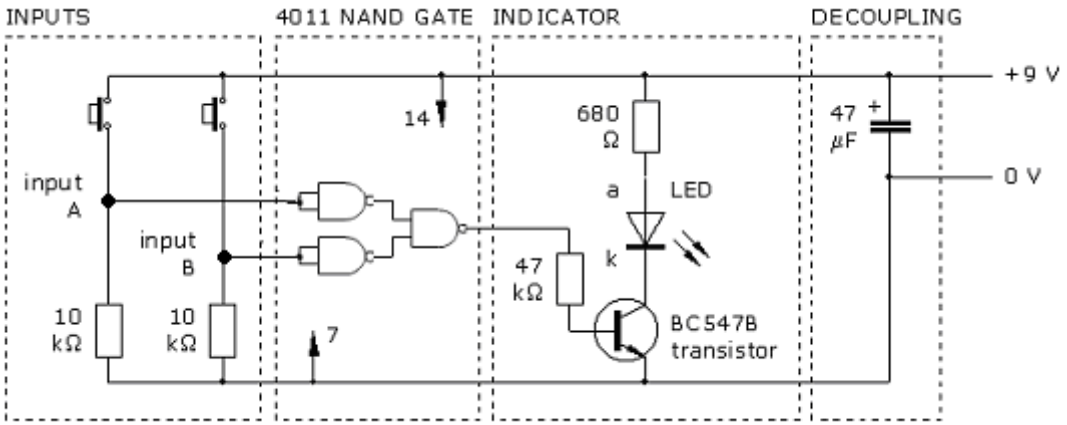
Input A	Input B	Output – LED
0	0	
0	1	
1	0	
1	1	

(4)

Part B: Procedure

What you must do

1. Modify your existing NAND gate circuit to the combinational NAND gate circuit as in the diagram shown below.
2. 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.

Ref: http://www.doctronics.co.uk/4011.htm

TOTAL: 10

RUBRIC FOR SIMULATION 1: NAND GATE APPLICATIONS

Task Description	Mark Allocation (Tick the appropriate level next to the Task Indicated)				
	1 Not Achieved	2 Not yet competent	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 less than 4 components.	The learner was able to select more than 4, but less 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.
Protoboard 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 less components correctly on the protoboard.	The learner was able to correctly plan and place more than 4, but less than 8 components correctly on the protoboard.	The learner was able to successfully plan and place all the components correctly on the protoboard with links.	The learner was able to successfully plan and place all the components correctly on the protoboard 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 troubleshooting.	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.
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 40)	
NAND Gates(Maximum of 10)	
Total (Maximum of 50)	

Digital – 2

Simulation 2 **Time: 3 hours**

Learner Name: _____

School: _____

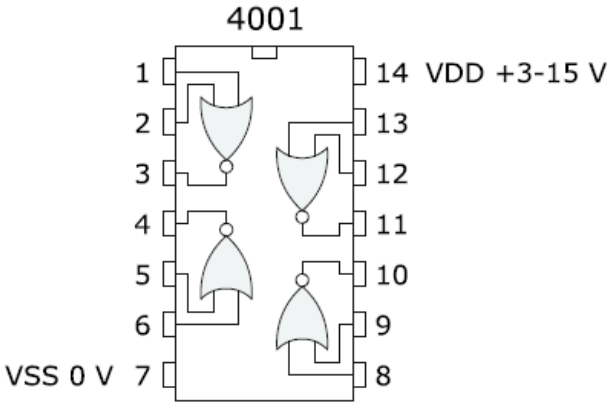
Examination Number: _____

NOR Gate Application

1. Purpose

To practise the application of NOR gates in logic circuits.

2. Thee 4001 Logic IC[3]

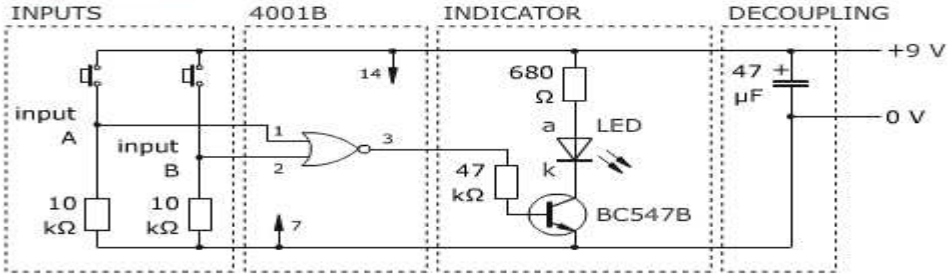


The truth table of each individual gate is:

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

NOR gate truth table
Where '0' represents a LOW voltage and '1' represents a HIGH voltage

You can investigate the behaviour of a single NOR gate using this circuit.



[3] Ref: www.doctronics.com

Step 1 – Build the NOR Gate Test Circuit (5 Marks)

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.)
Don't forget to connect pin 14 of the 4001 to +9 V and pin 7 to 0 V.

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 - Make use of the 4001 IC and build a logic circuit that will represent the following Boolean Function.

$$A.B = X$$

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)

(4 Marks)

Now build the circuit on a protoboard and check if the circuit operates correctly by filing the truth table below

A	B	X
0	0	
0	1	
1	0	
1	1	

(2 Marks for a filling the Truth Table)
(4 Marks for a working Circuit)

3. Conclusion

NOR gate combinations can be used to simulate any Boolean expression.

TOTAL: 20

RUBRIC FOR SIMULATION 2: NOR GATE APPLICATION

Task Description	Mark Allocation				
	1 Not Achieved	2 Not yet competent	3 Competent	4 Highly Competent	5 Outstanding
Protoboard 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 less components correctly on the board.	The learner was able to correctly plan and place more than 4, but less 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 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 less than 4 components.	The learner was able to select more than 4, but less 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 3 **Time: 3 hours**

Learner Name: _____

School: _____

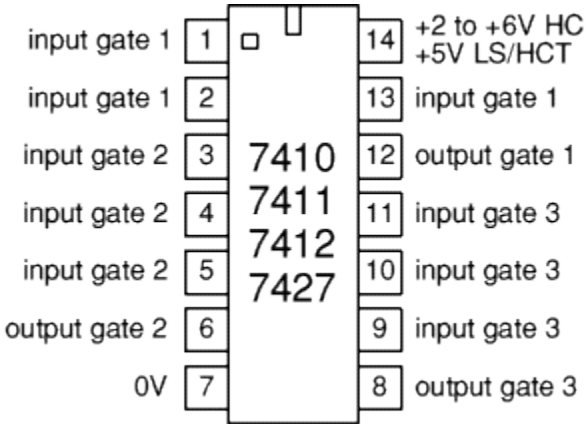
Examination Number: _____

NOR Gate Application using the 7427

1. Purpose

To illustrate that not all logic gates use 2 inputs only.

2. The 7427 logic IC



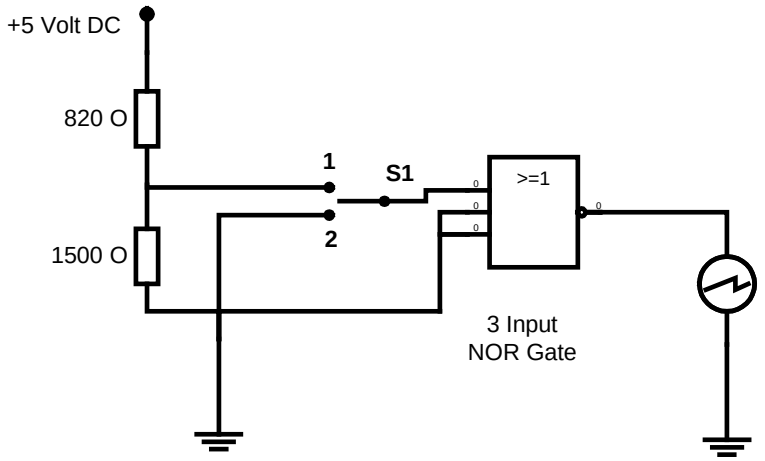
NOTE: This IC can only handle up to 6 V DC.

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
- Protoboard
- Hook-up wire

4. What you must do: Simple NOR gate: Circuit 1

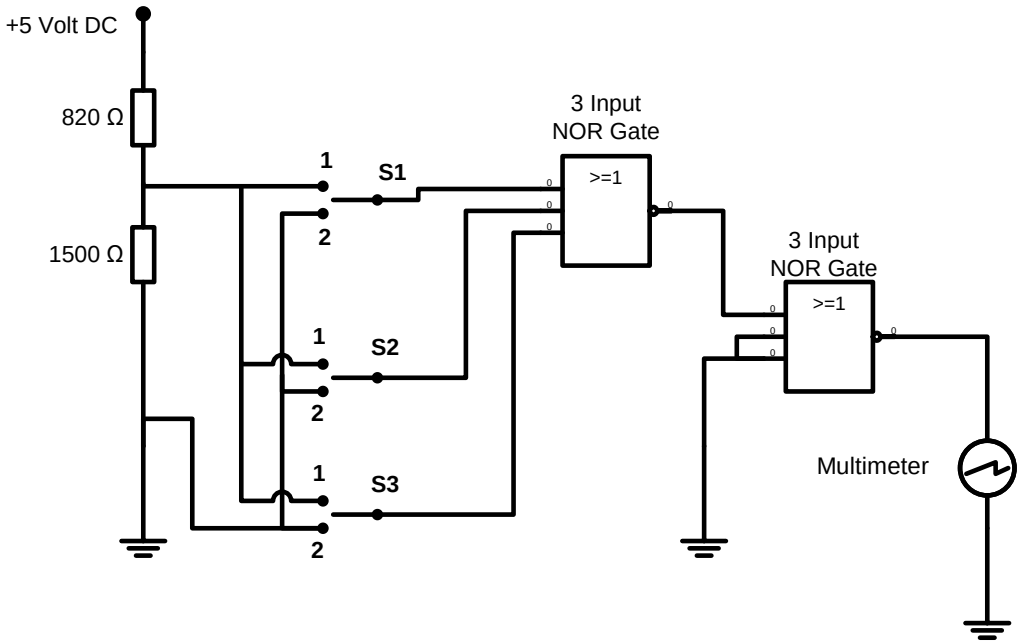
- Connect one of the NOR gates of the 7427 as shown below. The voltage divider provides the proper DC levels for the IC.
- Positive Logic 1 = 2,4–5 volts
- Positive Logic 0 = 0–0,5 volts
- S1 provides between 0–3,2 volts to the IC depending on its state.
- Complete the Truth Table.



S1	Multi-meter	
		(1)
		(1)

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

- 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	Multi-meter = 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)

6. Conclusion

Logic gates can be adapted to have more than just 2 inputs. There are devices with multiple inputs to a logic gate.

TOTAL: 15

RUBRIC FOR DIGITAL SIMULATION 3: NOR GATE APPLICATION USING THE 7427

Task Description	Mark Allocation (Tick the appropriate level next to the Task Indicated)				
	1 Not Achieved	2 Not yet competent	3 Competent	4 Highly Competent	5 Outstanding
Protoboard 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 less components correctly on the board.	The learner was able to correctly plan and place more than 4 but less 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 into 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.
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 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 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 35)	
				Truth Tables and Boolean Expression (Maximum of 15)	
				Total (Maximum of 50)	

Digital – 4

Simulation 4 **Time: 3 hours**

Learner Name: _____

School: _____

Examination Number: _____

Boolean algebra

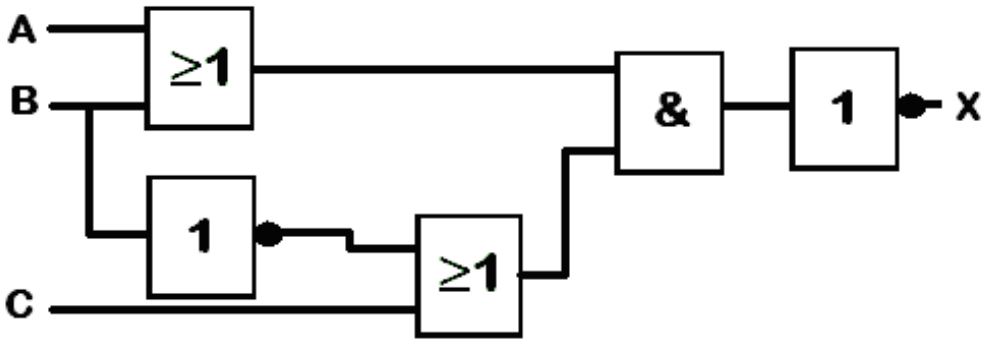
1. Purpose

To test Boolean algebra and construct an electronic circuit that simulates a Boolean expression.

In the year 1847, English mathematician George Boole (1815–1864) published, *The Mathematical Analysis of Logic*. This book showed how using a specific set of logic can help one to wade through piles of data to find the required information. The importance of Boole's work was his approach to logic. By incorporating logic into mathematics, Boole was able to determine what formed the base of Boolean logic or algebra. It was the analogy which algebraic symbols had with those that represented logical forms. This basic analogy gave birth to what is known as the Boolean Logic or Boolean algebra. As we know, the working of computers are based on the binary number system (1 or 0), where 1 means 'ON' and 0 signifies 'OFF'. These two states are represented by a difference in voltage. During the time when Boole was defining his Boolean logic, Charles Babbage was developing his 'analytical engine' – today's computer. Therefore the Boolean logic has been in use with the ancestor of the digital computer.

In order to work with and construct digital circuits we will first have to assess your knowledge and understanding of Boolean algebra.

2. Determine the Boolean equation for the following logic gate circuit: (7)



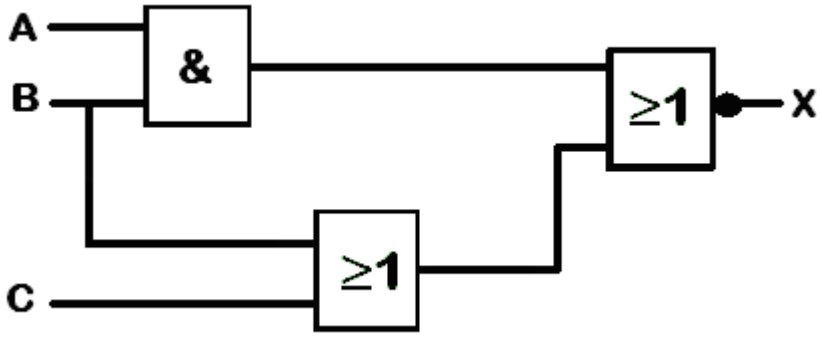
3. Draw the logic gate circuit for the Boolean Equation $X = \overline{(A+B)}\ \overline{C}$ (4)

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

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 =

5. Redraw the following circuit by making use of NAND gate combinations: (6)



6. Making use of De Morgan's Theorem, prove that the LHS = RHS.
(Show all steps.) (5)

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

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

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

8. Making use of a Karnaugh Map, simplify the following truth table and give the final Boolean expression. (9)

A	B	C	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. **Construct, on a protoboard**, a logic circuit using a logic IC, a logic gate network that will satisfy the Boolean expression shown below. X must be represented by a LED which will light up when X = 1 and when X = 0 the LED will not light up. (Schools with PLC's may opt to simulate this question on PLC) (10)

$$A.B + C.D = X$$

10. Conclusion

Boole Algebra equations can be constructed and applied electronically.

TOTAL: 50

Working Mark sheet

(A working Excel file is available from the national co-ordinator**)**

PAT Mark sheet		Term 1		Term 2		Project			Total = 250 Term 1 + Term 2 + Project	Mark out of 100	Moderated Mark
No.	Name of Learner	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 Citizen	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 Name: _____
Signature: _____
Date: _____

Moderator Name: _____
Signature: _____

Principal Name: _____
Signature: _____

School Stamp

Annexure: Component List for Electronic/Digital Simulations

Component List - Gain of an Op Amp	
IC	741 Op Amp
Rf	10 K 1/4W 5%
Rr1	10 K 1/4W 5%
Rr2	5 K 1/4W 5%
Rr3	3k3 1/4W 5%
Rr4	2k4 1/4W 5%
Rr5	20k1/4W 5%
Rr6	30k 1/4W 5%
S1, S2	SPST Toggle Switch

Component List - Experimental Summer Circuit	
Rf	10 K 1/4W 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
R 1	680 Ohm 1/4W 5%
R 2	47K 1/4W 5%
R3, R4	10 K 1/4W 5%
C1	47 uF 16 V
IC 1	4011 NAND Gate IC DIP Package
D1	Red LED

Component List - NOR Gate Application	
IC 1	4001 NOR Gate IC DIP Package
T1	BC 547
S1, S2	Tactile Push to Make N/O Switch
R 1	680 Ohm 1/4W 5%
R 2	47K 1/4W 5%
R3, R4	10 K 1/4W 5%
C1	47 uF 16 V
D1	Red LED

Component List - NOR Gate Using the 7427	
IC 1	7427 Quad 3 Input Nor Gate - DIP Package
R 1	820 Ohm 1/4W 5%
R 2	1k5 1/4W 5%
S1, S2, S3	SPST Toggle Switch