basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

ELECTRICAL TECHNOLOGY

PRACTICAL ASSESSMENT TASKS

2013

This PAT consists of 66 pages and a 2-page annexure.

TABLE OF CONTENTS

SECTION A (Teacher's Guide)

1. The 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 a technological process to inform the learner that steps need to be followed to derive a solution for the problem at hand.

The 2013 PAT has three scenarios and four 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. If teachers have a better circuit, they are welcome to use that for the practical circuit.

The teacher has to apply assessment on an ongoing 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 LO 4, 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 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 should make ample provision to accommodate this particular expense.

PAT components and other items must be acquired timeously, for use by the learners, before the start of each term.

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 the responsibility therefore.

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 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.
- Provincial Moderator: Provincial moderator/s will moderate the final PAT during provincial moderation at 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 learners understand what is expected of them.

Both formal and informal assessment should be conducted taking the different tasks that constitute the PAT, into account. The learners should be allowed to conduct informal assessment themselves, by a peer group or by the teacher. Formal assessment must always remain 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 must comply with the level descriptor in that rubric. If it is found that a discrepancy exists during moderation, teachers will have to re-assess 100% of the tasks that were found to be assessed inaccurately.

Once the rubric has been completed by the teacher, assessment will be deemed to be complete. No re-assessment will be done once the rubrics have been filled in and captured by the teacher. Learners must ensure that the work is done to the standard required before the teacher finally assesses the PAT during each stage of completion.

In cases where learners do not submit portions of the PAT, zero 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 2013	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 2013	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 2013	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 2013	Moderation of Simulation 1 and 2	District Subject Facilitator/Subject Specialist will visit the school and moderate Simulation 1 and 2. 10% of learners are re-marked and moderated.
April–June 2013	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 2013	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 2013	PAT intervention	Learners that are behind on PAT are required to complete the project during this holiday.
July–August 2013	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 2013	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 2013	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 can 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 on completion.

The final 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 have to 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.
- The moderator will select at random no less than two projects (not simulations), of which learners will have to come and explain how the project was manufactured.
- Where required, the moderator should be able to call on the learner to come and explain the function, principles of operation and also request the learner to exhibit the skills acquired through the simulations for moderation purposes.
- 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.

Department of Basic Education
Grade 12 National Senior Certificate 2013
Practical Assessment Task – Electrical Technology
SECTION B (The learner task)

Time Allowed: 1st–3rd term 2013

Learner Name: _____

Examination Number: _____

School: _____

Instructions to the learner:

- ✓ This practical assessment task counts 25% of your final promotion mark.
- ✓ All work produced by you must be your own effort. Group work and co-operative work are not allowed.
- ✓ The Practical Assessment Task is completed over three terms.
- ✓ 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 greyscale. Scanned photos and photocopies are allowed.
- ✓ You are allowed to use recycled components.
- ✓ You are allowed to use a kit.
- ✓ This document must be placed inside the 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**	

SECTION B: PROJECTS

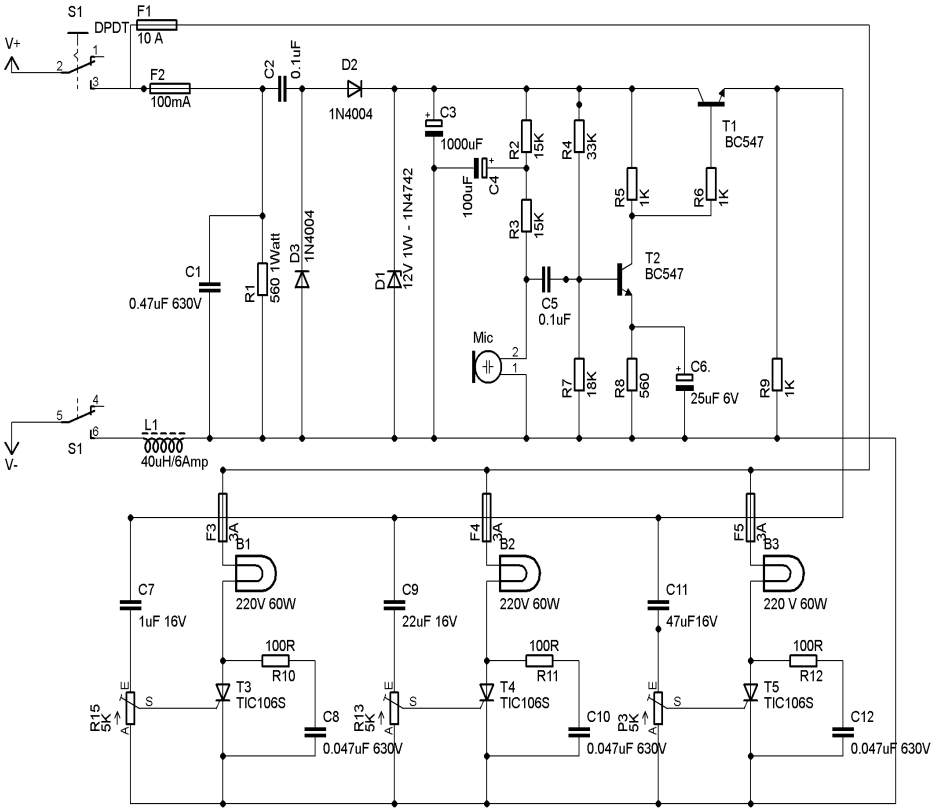
Below is one example of a project circuit for each of the possible options learners can choose from.

Teachers who have better circuits may use those instead of the following. 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. Six options are given from which the teacher can choose.

Electrical Project: Sound to Light Controller[1] (Option 1 of 2)

WARNING: Some parts in the circuit board are subjected to potentially lethal voltages because the device is connected to 230 V AC. When the project is plugged in the circuit must be enclosed in a plastic or wooden box to prevent it from shocking you. Due to the absence of a mains transformer do not connect this circuit to other appliances, e.g. to the output of an amplifier by means of a cable. Use only the microphone enclosed in the main case to pick-up the music.



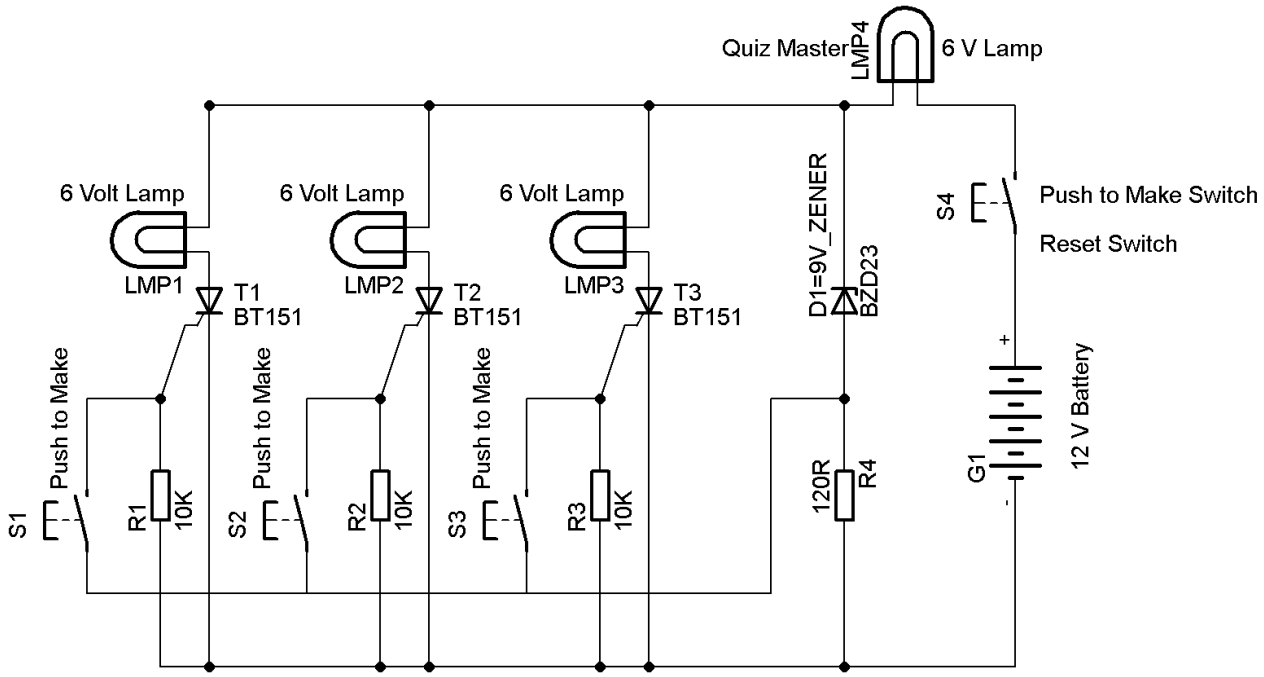
COMPONENT LIST	
R1	560 kΩ 1 W
R2, R3	15 K ¼ W
R3	33 K ¼ W
R5, R6, R9	1 kΩ ¼ W
R7	18 K ¼ W
R8	560 Ω ¼ W
P1, P2, P3	5 K Pot
C1	0,47 uF 630 V
C2, C5	0,1 µF 220 V
C3	1 000 µF 16 V electrolytic
C4	100 µF 16 V
C6	25 µF 16 V
C7	1 µF 16 V
C8, C10, C12	0,047 µF
C9	22 µF 16 V
C11	47 uF 16 V
D1, D2	1N4004
D3	1N4742 1 W
F1	10 A fuse 220 V
F2	100 mA fuse 220 V
F3, F4, F5	220 V 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 W incandescent lamp
Mic	Low-impedance microphone

[1] Circuit sent in by Trevor Adams – Western Cape Education Department

Electrical Project: Quiz Master[2] (Option 2 of 2)

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

When a button is pressed the corresponding globe is illuminated. The Quiz Master globe is also illuminated and the cathode of the 9V1 Zener sees approximately mid-rail voltage. The Zener comes out of conduction and no voltage appears across the 120 R resistor. No other globes can be lit until the circuit is reset.



COMPONENT LIST	
Rl, 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	9 V Zener diode
12 volt battery/Supply	

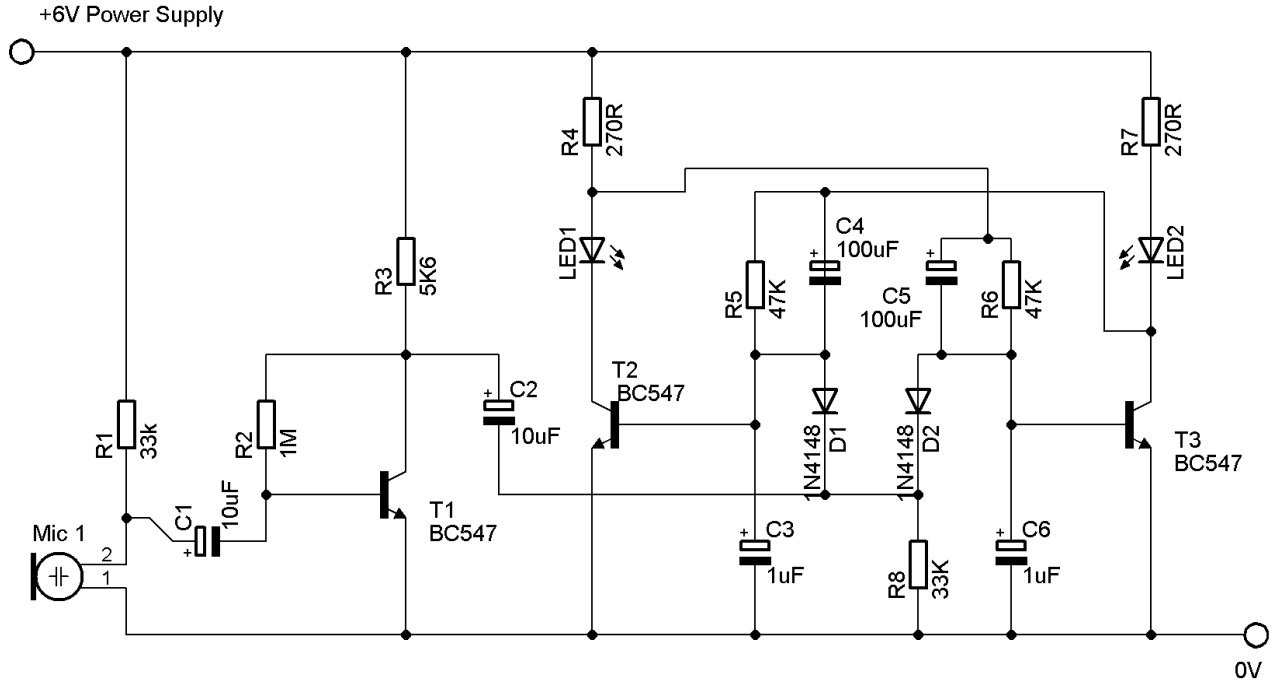
[2] Circuit provided by Trevor Adams WCED

Electronic Project: Clap Switch[3] (Option 1 of 2)

This circuit toggles the LEDs every time it detects a clap or tap or short whistle. The second 10 µF capacitor is charged via the 5 K 6 and 33 K and when a sound is detected, the negative excursion of the waveform takes the positive end of the 10 µF towards the 0 V rail. The negative end of the 10 µF will actually go below 0 V and this will pull the two 1N4148 diodes so the anode ends will have near to zero volt on them.

As the voltage drops, the transistor in the bi-stable circuit that is turned on, will have 0,6 V on the base while the transistor that is turned off, will have zero volt on the base. As the anodes of the two signal diode are brought lower, the transistor that is turned on will begin to turn off and the other transistor will begin to turn on via its 100 µF and 47 K.

As it begins to turn on, the transistor that was originally turned on will get less 'turn-on' from its 100 µF and 47 K and thus the two switch over very quickly. The collector of the third transistor can be taken to a buffer transistor to operate a relay or other device.



COMPONENT LIST	
R1, R8	33 kΩ ¼ W
R2	1 MΩ ¼ W
R3	5 K 6 Ω ¼ W
R4, R7	270 Ω ¼ W
R5, R6	47 kΩ ¼ W
T1, T2, T3	BC 547
C1, C2	10 µF 16 volt radial
C3, C6	1 µF 16 volt radial
C4, C5	100 µF 16 volt radial
D1, D2	1N4148 diode
LED 1, LED 2	5 mm LED red or green
Mic 1	Electret microphone
Power supply	6 V DC PSU

[3] Circuit provided by Trevor Adams WCED

Electronic Project: Cellphone Jammer [4](Option 2 of 2)

The 555 timer [8 pin] IC simply makes a noise. It is coupled via C4 [electrolytic] to modulate the MRF transistor oscillator.

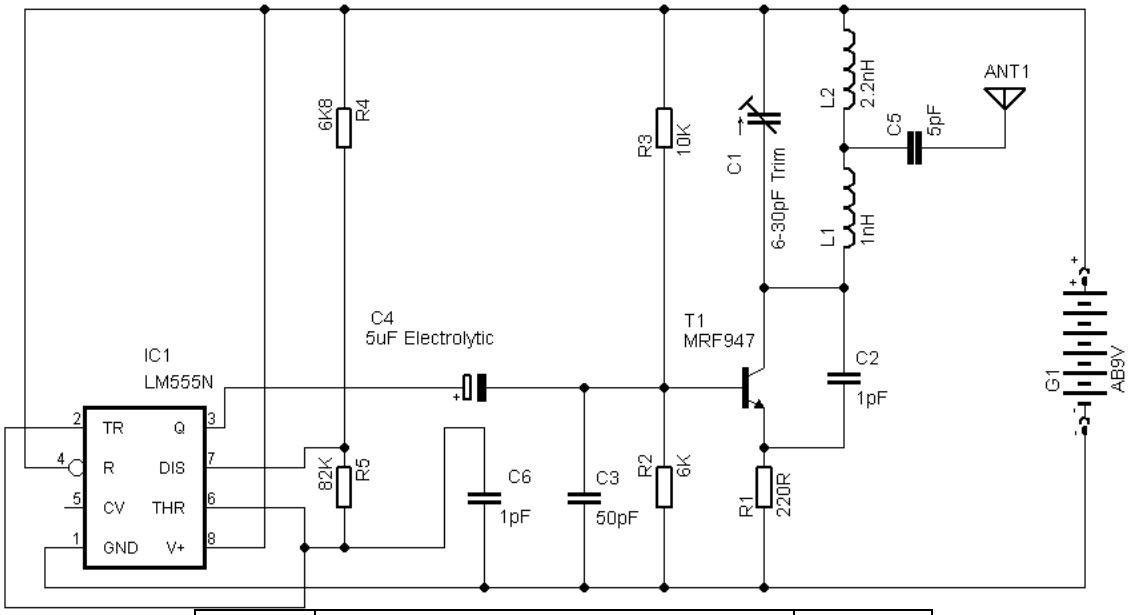
With C1 set at roughly one-third, you will be close to 900 MHz. By sweeping the C1 trimmer capacitor, you can swing the output frequency from 800 MHz to 2 GHz with the transistor and values shown.

Instead of a single-tapped coil, use two moulded inductors for ease of construction.
Values for C1, C2, L1, and L2 are critical for the frequency range.

You might want to build the unit into a metal box, add an on/off switch in the batteries and line, and maybe even add an LED.

Connect an old 800 MHz cellphone antenna to C5.
Output is reasonably good, although the current drain is a bit high, so a new 9 volt battery will only run about an hour, if you are lucky.

The 'cell kill distance' is around 3–5 metres, ample for most purposes. The components used in the component list are surface mount, but you can use through hole components.



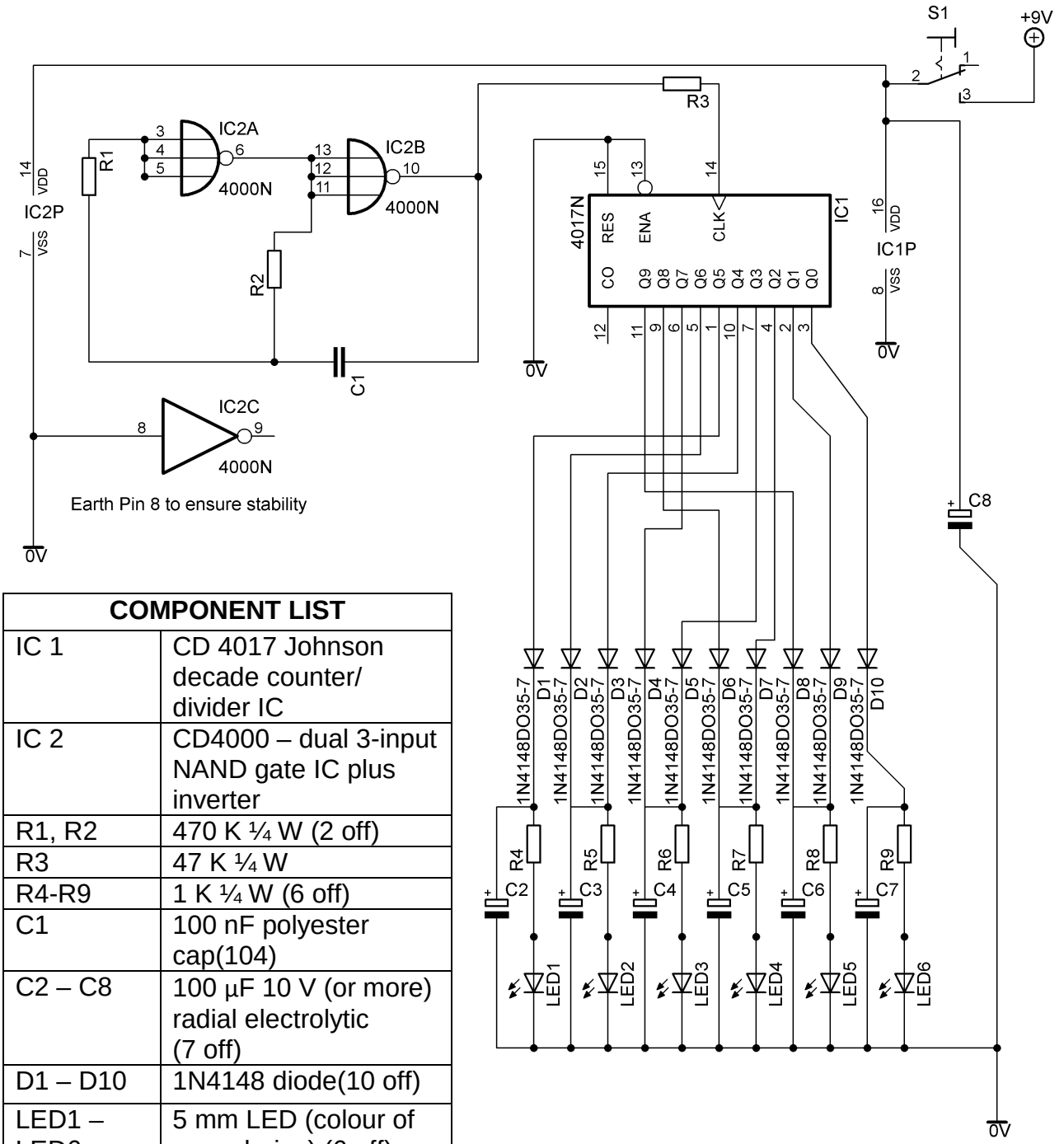
Item	Description	Quantity
R1	220 Ω 1% 0805 SMD	1
R2	6 kΩ 1% 0805 SMD	1
R3	10 K 1% 0805 SMD	1
R4	6 K 8 Ω 1% 0805 SMD	1
R5	82 kΩ 1% 0805 SMD	1
C1	6–30 pF trimmer cap	1
C2, C6	1 pF 2% 0805 CAP	2
C3	50 pF 2% 0805 CAP	1
C4	5 µF 2% electrolytic SMD/tantalum	1
C5	5 pF 2% 0805 CAP	1
T1	MRF947 RF Transistor	1
IC1	LM555 SMD	1
G1	9 V battery	1

[4] Circuit provided by Madeleine Roodt H/S Dinamika

Digital Project: Light Rider[5] (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 forward and backward flashing pattern.

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

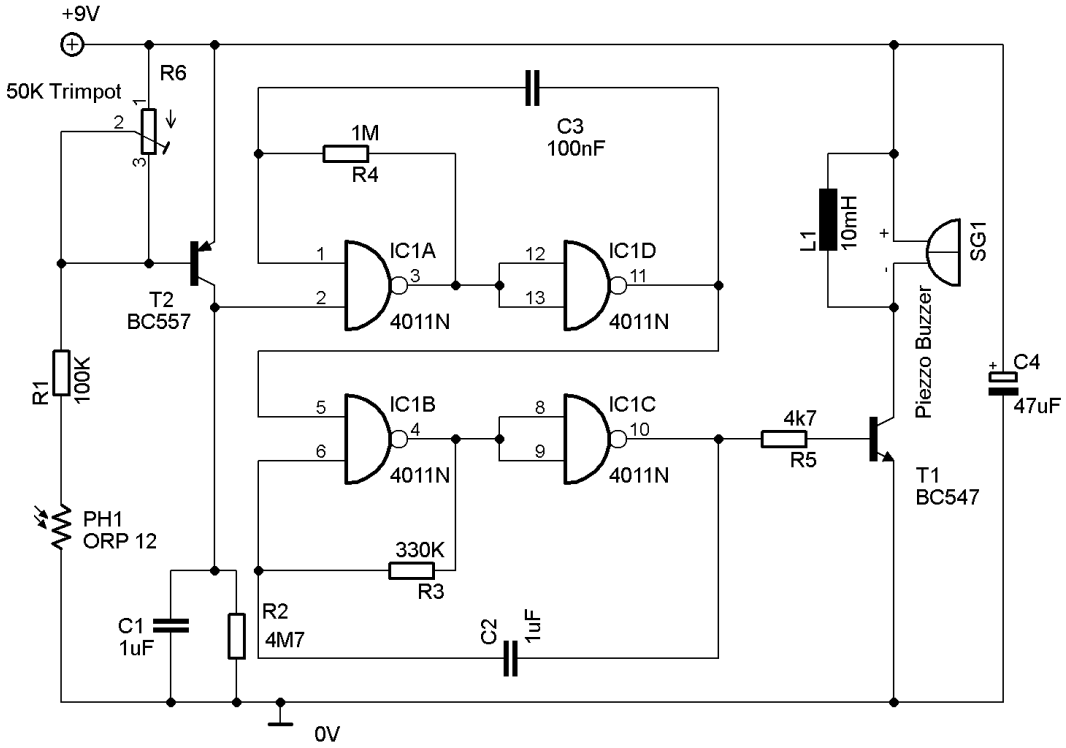


COMPONENT LIST	
IC 1	CD 4017 Johnson decade counter/ divider IC
IC 2	CD4000 – dual 3-input NAND gate IC plus inverter
R1, R2	470 K ¼ W (2 off)
R3	47 K ¼ W
R4-R9	1 K ¼ W (6 off)
C1	100 nF polyester cap(104)
C2 – C8	100 µF 10 V (or more) radial electrolytic (7 off)
D1 – D10	1N4148 diode(10 off)
LED1 – LED6	5 mm LED (colour of your choice) (6 off)
S1	SPST toggle switch
PP3 battery clip	
9 V PP3 battery	

[5] Circuit provided by Trevor Adams WCED

Digital Project: Light Alarm[6] (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	
IC1	4011 Quad 2 input NAND gate
R1	100 K ¼ W
R2	4M7 Ω ¼ W
R3	330 kΩ ¼ W
R4	1 M Ω ¼ W
R5	4 K 7 Ω ¼ W
R6	50 K trim pot
C1, C2	1 µF Mylar capacitor
C1	100 nF polyester cap (104)
C3	100 nF polyester cap
C4	47 µF electrolytic 16 V radial cap
T1	BC 547 NPN
T2	BC 557 PNP
L1	10 mH inductor
PH 1	ORP 12 LDR
SG 1	9–12 V piezo buzzer
PP3 battery clip	
9 V PP3 battery	

[6] Circuit provided by Johan Prinsloo H/S Centurion

Design and Make Project

Time: January–August 2013

Learner Name: _____

School: _____

Examination Number: _____

Title/Type of Project: _____

Design and Make 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.

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		

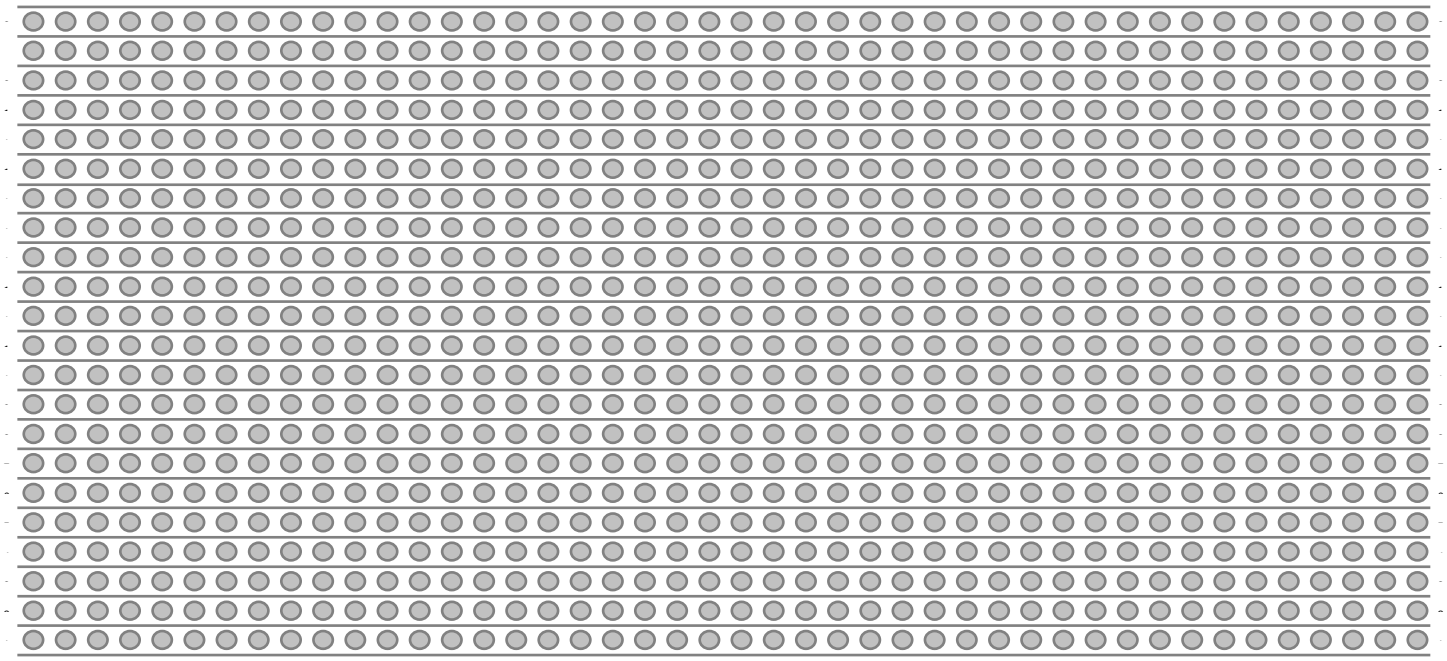
6. Evidence of prototyping

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

7. Vero-board Planning OR PCB Design

If you do not use a vero-board, add evidence of the PCB layout after this page.
Actual vero-board hole spacing 0,1' (2.54 mm).
Use an **X** to show breaks made on the track

Final Design – Vero-board



Printed Circuit-Board Planning

Assessment of the Project (*Items not submitted will be awarded a zero (0).)*

Task Description	**Mark Allocation** (Tick the appropriate level next to the Task Indicated)					
	0 **Not Submit-ted**	**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 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 breadboard	☐ Not working **(0 marks)**	☐ Circuit was partly operational. No photos of prototyping are included. **(3 marks)**		☐ Circuit was fully operational, but the circuit in the photo is similar to other learners. **(5 marks)**	☐ Circuit was fully operational. The photo included does not resemble other learner's efforts, but no name is included. **(10 marks)**	☐ Circuit was fully operational. The photo included shows the circuit and name of the learner and it is unique. The photo is clear and components are distinguishable. **(15 marks)**
Trouble-Shooting on the breadboard	☐	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes. If the learner's circuit worked first time, he/she was able to assist other learners in trouble-shooting.
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.

Task Description	Mark Allocation (Tick the appropriate level next to the Task Indicated)					
	0 Not Submit-ted	**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.
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)**
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		☐ Most components are placed tidy. 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)		

8. Enclosure design

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 hereunder.

2. Manufacture/Obtain an enclosure according to your design.
3. Choose a name for your device. Write down the name of the device hereunder.

_____

4. Design a logo for your device hereunder.

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 on the enclosure	☐	☐
Miscellaneous			
1	Enclosure included in the project	☐	☐
2	Enclosure prepared and drilled according to the design	☐	☐
3	Enclosure finished off and completed with name and logo	☐	☐
4	PCB securely mounted in the enclosure using acceptable techniques	☐	☐
5	Is circuit inside the enclosure accessible	☐	☐
6	Internal wiring neat up and ready for inspection	☐	☐
7	File and project completed and ready for moderation in the workshop/room	☐	☐

Assessment of the Design and Make Phase: Part 2 (*Items not submitted will be awarded a zero (0).)*

Task Description	**Mark Allocation** (Tick the appropriate level next to the Task Indicated)					
	0	**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

- The teacher will choose simulations from the three sections listed below.
- Copy the relevant simulations and hand them out to learners at the start of the term.
- Teachers are allowed to adjust circuits and component values to suit their environment/resource availability.
- Teachers are required to develop a set of model answers in the teacher's portfolio.

SECTION 1: ELECTRICAL	SECTION 2: ELECTRONICS	SECTION 3: DIGITAL
Simulation/ Experiment 1: Connecting three single-phase transformers to a three-phase supply	**Simulation/ Experiment 1:** The regulated power supply	**Simulation/ Experiment 1:** Boolean algebra
Simulation/ Experiment 2: Inspecting and testing an AC motor	**Simulation/ Experiment 2:** The multivibrator using a 555 timer	**Simulation/ Experiment 2:** NAND gate applications
Simulation/ Experiment 3: 3-phase direct-on-line-starter	**Simulation/ Experiment 3:** Gain of an Op Amp	**Simulation/ Experiment 3:** NOR gate application
Simulation/ Experiment 4: 3-phase forward and reverse	**Simulation/ Experiment 4:** Experimental summer circuit	**Simulation/ Experiment 4:** NOR gate application using the 7427

Electrical

Simulation 1 **Time: 1 hour**

Learner Name: _____

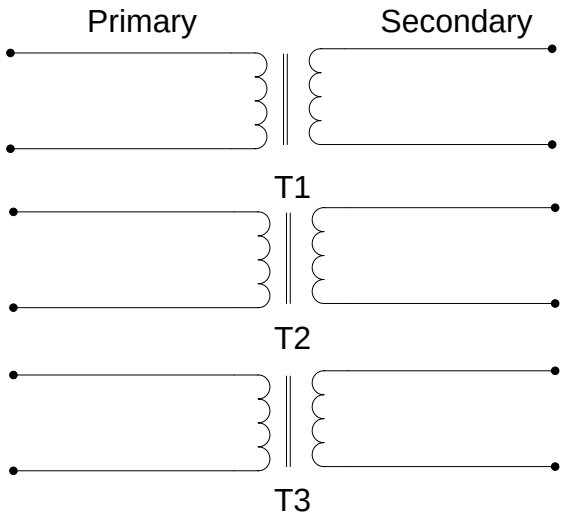
School: _____

Examination Number: _____

Connecting three single-phase transformers to a 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[7])

NOTE: The secondary voltage of the transformer is not critical. The only requirement is that the secondary voltage and the voltage of the lamps are compatible.

It is the duty of the teacher to verify that the learners are connecting the transformers correctly, before connecting the mains supply. If you are not entirely sure of your connections do not switch on. Test for short circuits.

Mains supply can be lethal. Be extremely careful.

[7] Tip received from Kobus van Dyk – www.pert.co.za

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 up the circuit. (3=Drawing) (5=Wiring)

2. Complete the table below by measuring the primary and secondary voltages and currents. (12)

Star/Star Connection

	Primary supply to each transformer		**Secondary supply to each lamp**	
	Voltage	**Current**	**Voltage**	**Current**
Phase 1				
Phase 2				
Phase 3				

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

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 table below by measuring the primary and secondary voltages and currents. (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

Simulation 2 **Time: 1 hour**

Learner Name: _____

School: _____

Examination Number: _____

Inspecting and Testing the AC Motor

Purpose

When inspecting and testing an AC motor it is advisable to use a checklist or report as shown below.

Use the list below to inspect and test an electrical motor. Your teacher will supply you with a motor to test.

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

Phase: _____ **Supply voltage:** _____

Pole pairs: _____ **Speed:** _____

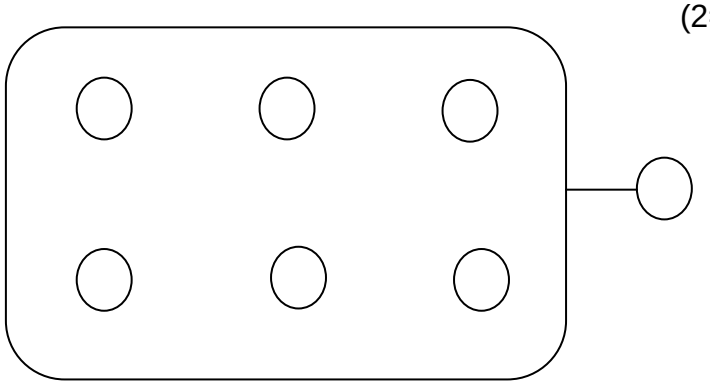
Efficiency: _____ **Current:** _____

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

Test 4: Mechanical inspection Note all errors (9 marks)		
Condition of rotor and shaft		
• Key/Key way		
• Front bearing		
• Back bearing		
Condition of motor frame		
• Condition of termination box		
• Flange/Foot mount		
• Front/Back-end shield		
• Stator/Field housing		
• Mounting bolts and nuts/ screws		
• Condition of cooling fan, fan cover and cooling fins		

Draw and label the correct connection of internal wiring on the drawing below:

(3=coils)
(2=labels)



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

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

_____

_____

_____

_____

TOTAL: 25

Rubric for Simulation 2: Testing an Electric Motor

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
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

Simulation 3 **Time: 3 hours**

Learner Name: _____

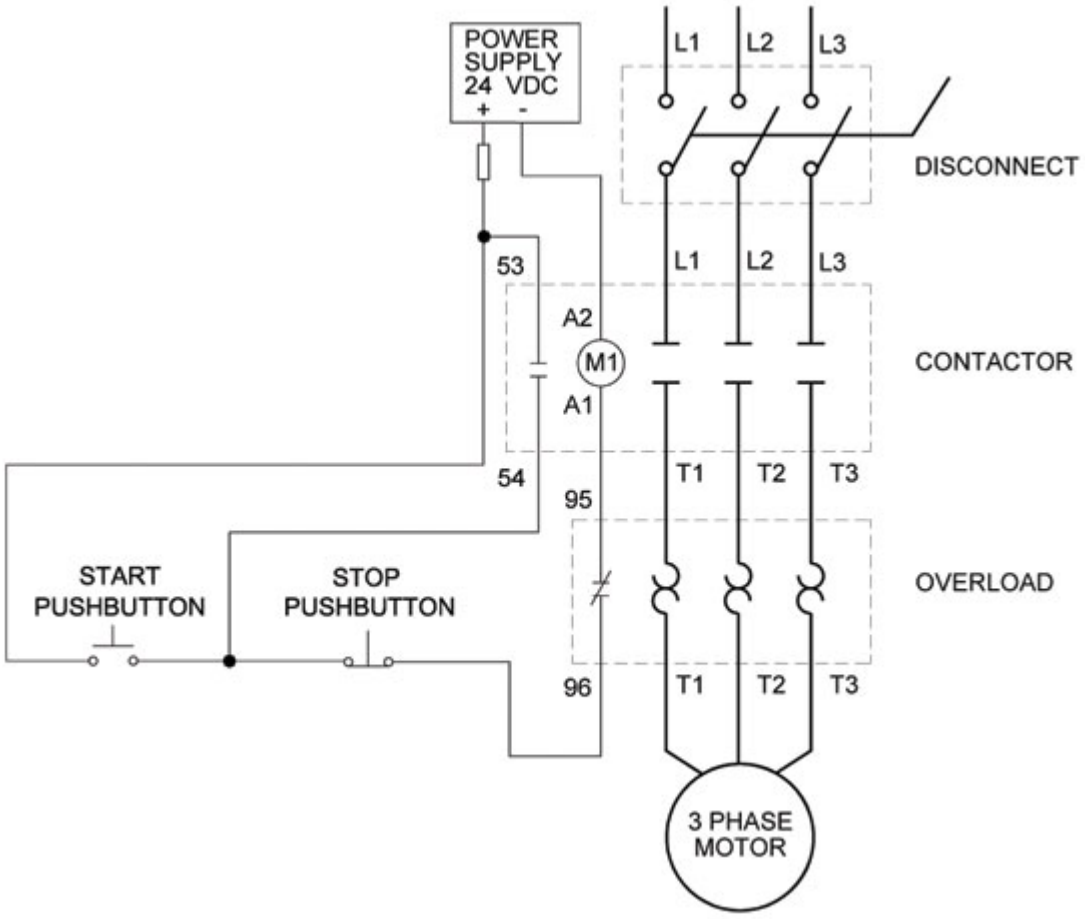
School: _____

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. Consider 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 Simulation 3: Three-Phase-Direct-On-line-Starter

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)				
	0 Not Achieved	1 Not 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
Troubleshooting: Control Circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete, but not functional and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes. The circuit is functional.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Control circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the circuit wiring marks.
Main circuit wiring	☐The learner was unable 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
Troubleshooting: Main Circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete, but not functional and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes. The circuit is functional.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Main circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the main circuit wiring marks.
Tools selection and use	☐ The learner was unable to identify and select any tools.	☐ The learner identified and selected the incorrect tools.	☐ The learner was able to select the correct tools, but used them incorrectly/unsafely.	☐ The learner was able to identify and select all tools correctly and used them correctly.	☐ The learner identified and selected tools quickly and without the help of the teacher. The learner was also able to use tools correctly in a safe ergonomic manner.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner worked safely under supervision of the teacher.	☐ The learner worked safely without being reminded by the teacher.	☐ The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
Housekeeping	☐ The learner did no 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

Simulation 4 **Time: 3 hours**

Learner Name: _____

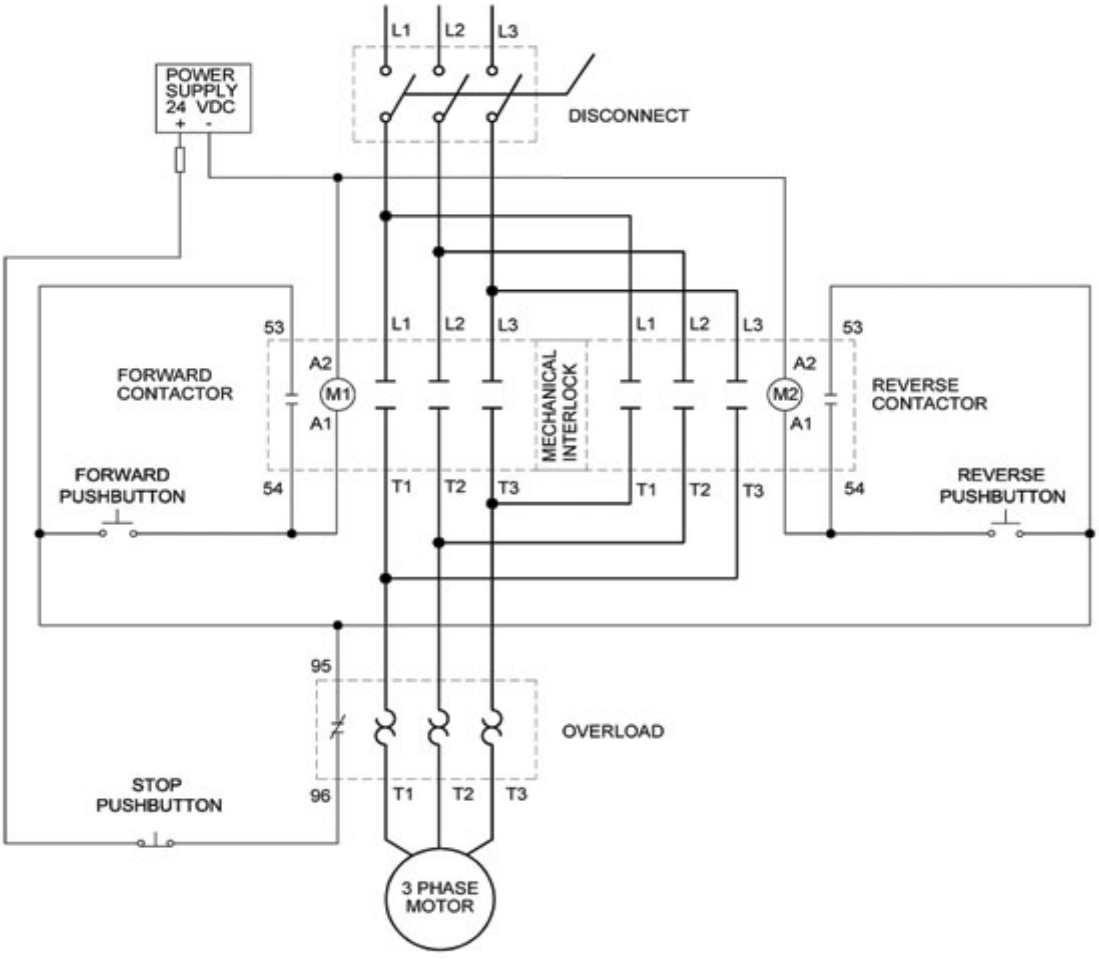
School: _____

Examination Number: _____

Three-phase forward and reverse starter

1. Purpose

Practical simulation of a three-phase forward and 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 (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. Study the control and power circuits.
2. Construct/Wire the power and control circuits 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: 10

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

Rubric Simulation 4: Forward-reverse-motor-starter

Task Description	Mark Allocation (Tick the appropriate level next to the task indicated)				
	1 Not Achieved	2 Not 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.
Troubleshooting: Control Circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
Main circuit wiring	☐The learner was unable to wire the main circuit.	☐ The learner was able to wire the main circuit partly correct, but did not use overload protection.	☐ The learner was able to wire the main circuit including overload protection, but did not know why it was used.	☐ The learner was able to wire the main circuit and test the overload protection and has a working knowledge of the circuit.	☐ The learner was able to correctly test the main circuit after assembly and had a well founded knowledge of all the working parts. The learner was able to quickly re-assemble the circuit accurately without the aid of the circuit diagram.
Main circuit working	☐ The circuit did not work.				☐ The circuit worked. This must correlate with the main circuit wiring marks.
Troubleshooting: Main Circuit	☐The learner's circuit was not complete and she/he was unable to conduct trouble-shooting.	☐ The circuit was complete, but was not functional. The learner was unable to identify the problem.	☐ The circuit was complete and the learner was able to identify and rectify one mistake.	☐ The circuit was complete and the learner was able to identify and rectify two mistakes.	☐ The circuit was complete and the learner was able to identify and rectify all mistakes.
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.
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)	

Electronic

Simulation 1 **Time: 3 hours**

Learner Name: _____

School: _____

Examination Number: _____

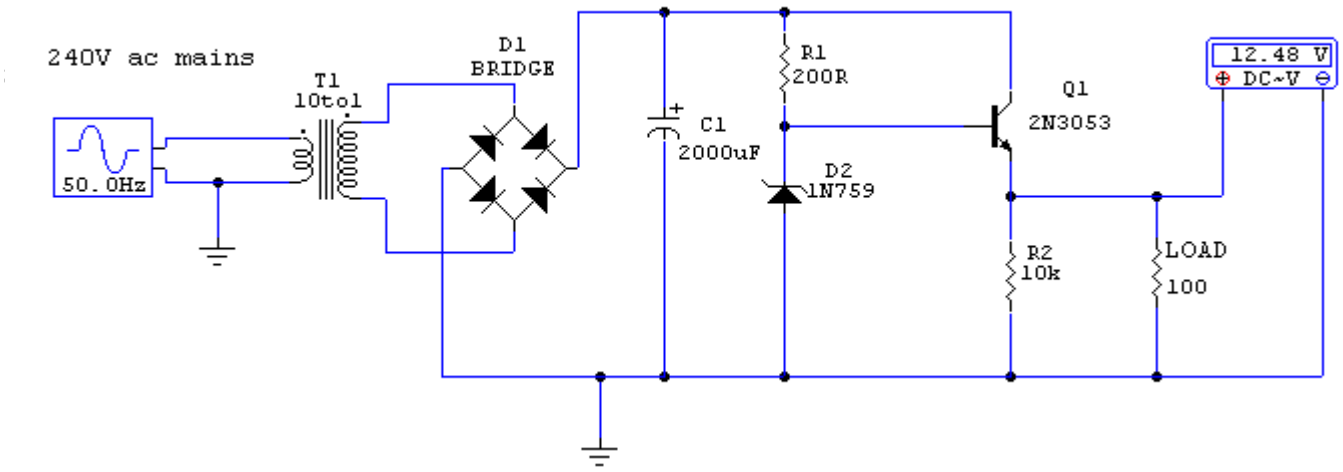
The Regulated Power Supply

1. Purpose

To show the working of the different stages in a regulated power supply and to demonstrate the waveforms present in each stage.

2. Circuit diagram

The circuit diagram showed below forms the basis of the design of your power supply.



NOTE: This circuit above uses a 13 volt Zener diode, D2, which provides the voltage regulation. Approximately 0,6–0,7 volts are dropped across the transistor's b-e junction, leaving a higher current 12,3 volt output supply. This circuit can supply loads of up to 500 mA.

3. What you are going to do

Build (Assemble) the power supply shown above using the values supplied. If these specific value components are not available, make use of the nearest available value (as close to the original as possible).

4. What you will need

1. A transformer 240 V–18 V (remember nearest possible value)
2. Components
3. Multimeter
4. Oscilloscope
5. Connecting wires
6. Breadboard
7. Tools

5. What you must do

1. Construct the prototype on the breadboard according to the supplied circuit. (Do not build the whole circuit at once. Build it step by step in accordance with the measurements taken below.)
2. Measure the following voltages using a multimeter and complete the table.

DESCRIPTION OF MEASUREMENTS TAKEN (8)	VALUE
Mains supply voltage	
Transformed AC/Secondary voltage (No diode bridge attached)	
Rectified DC (No circuit attached)	
Rectified DC – C1 = 100 μF smoothing capacitor	
Rectified DC – C1 = 2 000 μF smoothing capacitor	
Voltage across Zener D2	
Vbe of the transistor Q1	
Output voltage across the load resistor	

3. Connect the oscilloscope to show the following stages:
   a. Output voltage of the transformer (rest of the circuit removed)
   b. Output voltage of the diode bridge with no smoothing cap attached, and the rest of the circuit removed/disconnected (only the transformer and diode bridge connected)
   c. Output voltage of the diode bridge with the 100 μF capacitor attached as smoothing capacitor (do not use the large 200 uF capacitor at this stage)
   d. Output voltage over the load (R_{Load})

Oscillogram of output voltage of the transformer only (3 marks) **V/Div = _____** **T/Div = _____**		**Oscillogram of output voltage of the diode bridge with no smoothing cap attached, and the rest of the circuit removed/disconnected (3 marks)** **V/Div = _____** **T/Div = _____**	

Oscillogram of output voltage of the diode bridge with the 100 µF capacitor attached as smoothing capacitor (3 marks) **V/Div = _____** **T/Div = _____**		**Oscillogram of output voltage over the load (3 marks)** **V/Div = _____** **T/Div = _____**	

6. Conclusion

The oscillograms indicate how an alternating current/voltage can be changed to a direct current/voltage using a regulated power supply circuit.

TOTAL: 10

Rubric for Electronic Simulation 1: Regulated Power Supply

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
Breadboard planning layout **Component selection and identification**	☐ The learner was unable to plan the breadboard layout using the supplied circuit diagram. ☐ The learner was unable to identify and select any components. **(2 marks)**	☐The learner was able to correctly plan and place 4 or less components correctly on the vero-board. ☐ The learner was able to identify and select less than 4 components. **(4 marks)**	☐The learner was able to correctly plan and place more than 4 but less than 8 components correctly on the breadboard. ☐ The learner was able to select more than 4, but less than 8 components. **(6 marks)**	☐The learner was able to successfully plan and place all the components correctly on the breadboard with links. ☐ The learner was able to identify and select all components. **(8 marks)**	☐ The learner was able to successfully plan and place all the components correctly on the vero-board taking into consideration space used, alignment of components and component types. ☐ 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. **(10 marks)**
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.
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 **Safety**	☐ The learner did no housekeeping. The learner did not work safely.	☐ The learner did housekeeping under duress. The learner worked safely after being reprimanded.	☐ The learner did housekeeping under the supervision of the teacher. The learner worked safely under supervision of the teacher.	☐ The learner did housekeeping after she/he was reminded by the teacher. The learner did work safely without being reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently. The learner was able to do work safely without supervision or being reminded by the teacher. Safety was excellent.
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.

Rubric (Maximum of 30)	
Measurement and Oscillogram (Maximum of 20)	
Final Mark Out of 50	

Electronic

Simulation 2 **Time: 3 hours**

Learner Name: _____

School: _____

Examination Number: _____

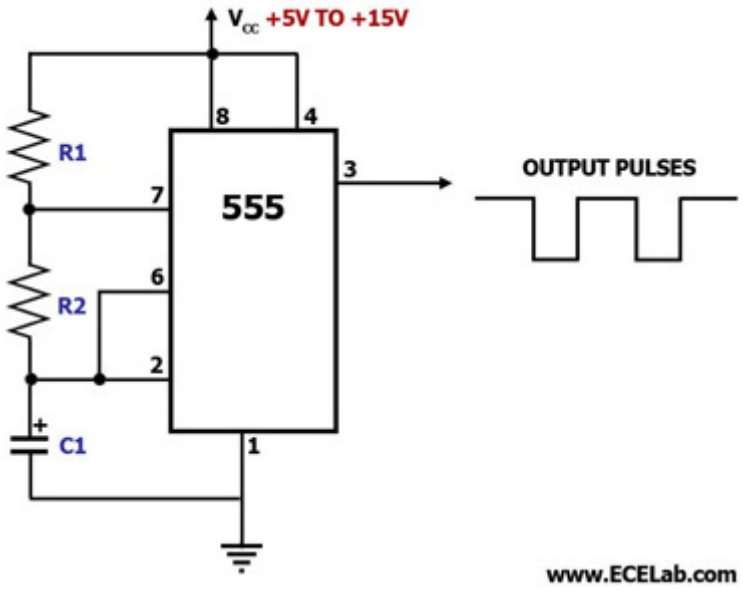
The Multivibrator using a 555 Timer

1. Purpose

Simulating a multivibrator circuit by using a 555 timer IC.

2. Circuit diagram

The circuit diagram shows a 555 timer configured as a multi-vibrator.



Component List

- R1 – 4 K 7 Ω
- R2 – 50 K or NAV (Nearest Available Value. Use a variable resistor to adjust the frequency)
- C1 – 0,1 µF
- 555 IC
- Connecting wires

3. What you are going to do

Build (Assemble) the timer shown above using the values supplied and if these specific value components are not available make use of the nearest available value (as close to the original as possible).

4. What you will need

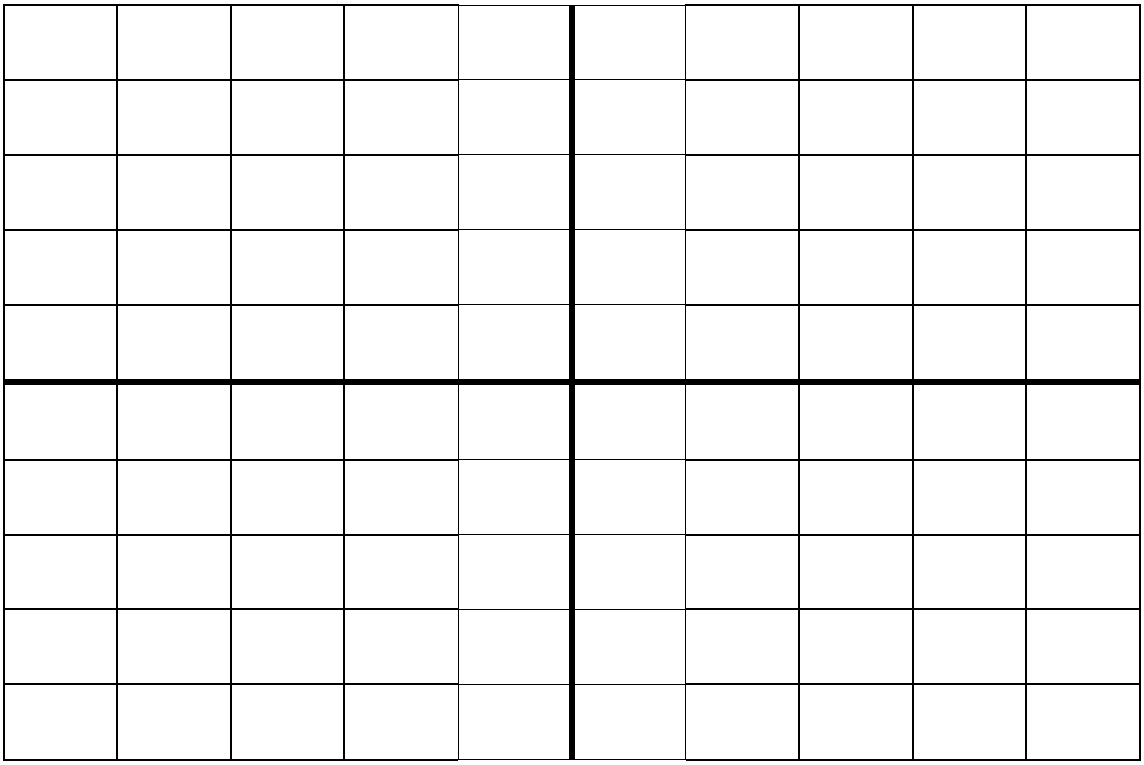
1. A power supply (set between 5–15 volts)
2. Components
3. Multimeter

4. Oscilloscope
5. Connecting wires
6. Breadboard
7. Tools

5. What you must do

1. Construct the prototype according to the supplied circuit
2. Connect an oscilloscope to pin 3 of the 555 IC to show the state of the output voltage over time.
3. Draw the oscillogram of the output wave form (Ensure that the signal is triggered to show a steady waveform)
4. Calculate the frequency of the waveform being generated.

Oscillogram (4 marks)



Frequency of Output Waveform (6 marks)

V/Div = _____

T/Div = _____

1 cycle (T) =_____ Frequency = _____

=_____ = _____

=_____ (3) = _____(3)

6. Conclusion

The a-stable multivibrator circuit is a type of oscillating circuit that produces a square wave output that can be used as a clock pulse for other circuits.

Subtotal: 10

Rubric for Electronic Simulation 2: The Multivibrator using a 555 Timer

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**
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or 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 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.
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.
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.
Identification and Purpose of parts	☐ The learner was unable to identify any parts.	☐The learner was able to identify less than 3 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.

Rubric (Maximum of 40)	
Oscillogram (Maximum of 10)	
Total (Maximum of 50)	

Electronic

Simulation 3 **Time: 3 hours**

Learner Name: _____

School: _____

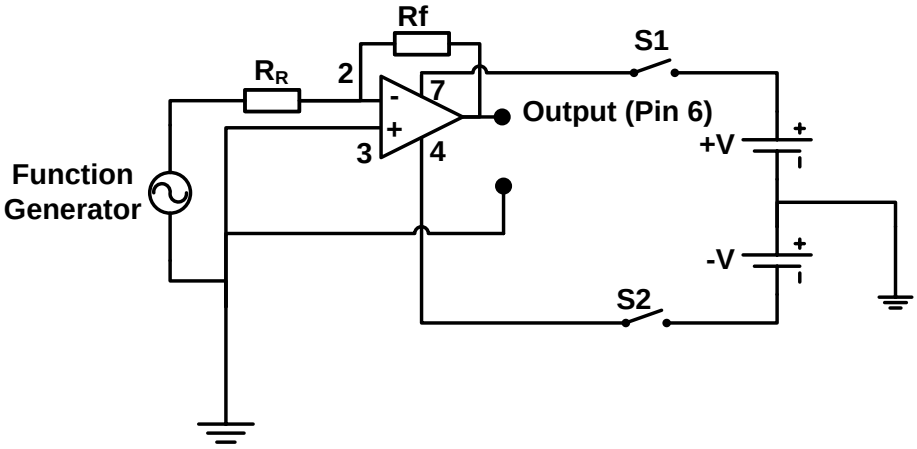
Examination Number: _____

Gain of an Op Amp

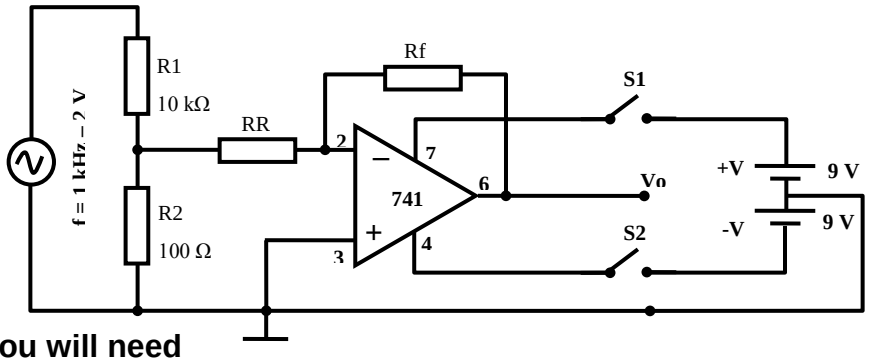
1. Purpose

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

2. Circuit diagram



(Alternative Circuit Below[8])



3. What you will need

- Breadboard/Proto Board
- 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)

[8] Circuit provided by Charl Marais HTS John Vorster

4. Procedure

- Connect the circuit shown above with Rf= R_R =100 kΩ on a breadboard.
- 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 & 0 V)
- Trigger/sync the oscilloscope to show the wave form.
- Connect the input wave from the function generator to trace/channel 1 of the oscilloscope (function generator).
- Close S1 and S2 applying power to the circuit.
- Slowly increase the output of the function generator to just below the point where the output signal is being distorted. (Look at both the input and the output waveforms and compare the shape to see if the output is being distorted.)
- With the oscilloscope measure and record the output voltage V_{out} from the amplifier (output pin 6) ***(peak to peak value)***.
- With the oscilloscope measure and record the input voltage V_{in} to the amplifier (output of the 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[9].

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. On completion replace all instruments and tools and apply housekeeping.

7. Conclusion

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

Subtotal: 20

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

Rubric for Electronic Simulation 3: Gain of an Op Amp

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
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or 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.
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.
Instrument selection and use	☐ The learner was unable to identify and select any instruments.	☐ The learner identified and selected the incorrect instruments.	☐ The learner was able to select the correct instruments, but used them incorrectly/unsafely.	☐ The learner was able to identify and select all instruments correctly and used them correctly.	☐ The learner identified and selected instruments quickly and without the help of the teacher. The learner was also able to use instruments correctly in a safe ergonomic manner.
Housekeeping	☐ The learner did no housekeeping.	☐ The learner did housekeeping under duress.	☐ The learner did housekeeping under the supervision of the teacher	☐ The learner did housekeeping after she/he was reminded by the teacher.	☐ The learner was able to do housekeeping without supervision or being reminded by the teacher. Housekeeping was done excellently.
Safety	☐ The learner did not work safely.	☐ The learner worked safely after being reprimanded.	☐ The learner did 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

Simulation 4 **Time: 3 hours**

Learner Name: _____

School: _____

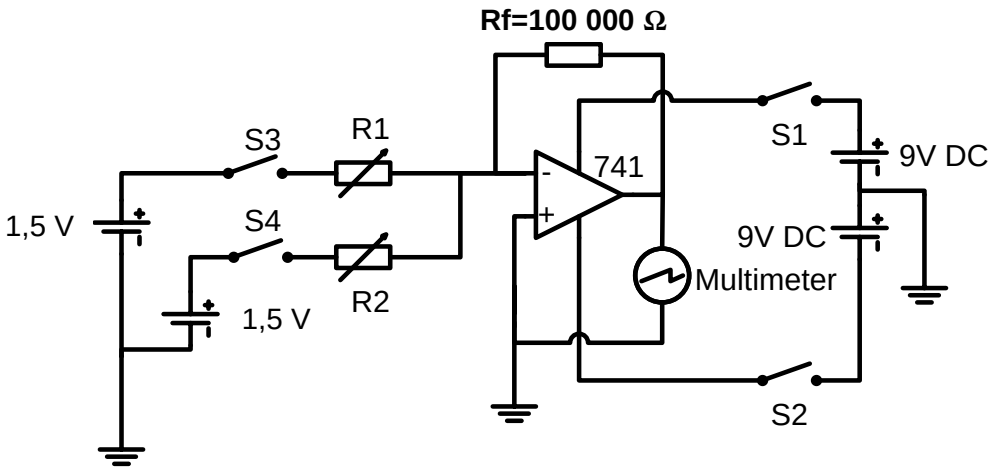
Examination Number: _____

Experimental Summer Circuit

1. Purpose

To examine the properties of a summer circuit.

2. Circuit Diagram[10]



3. What you will need

- Breadboard/Proto Board
- 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.

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

- 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 below for all the possible positions for S_3 and S_4.

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

- Note the polarity of the input voltages in each case.
- On completion replace all instruments and tools and apply housekeeping.

5. Conclusion

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

Subtotal: 10

Rubric for Electronic Simulation 4: Experimental Summer Circuit

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**
Breadboard planning and layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or less components correctly on the breadboard.	☐The learner was able to correctly plan and place more than 4, but less than 8 components correctly on the breadboard.	☐The learner was able to successfully plan and place all the components correctly on the breadboard with links.	☐ The learner was able to successfully plan and place all the components correctly on the breadboard taking onto consideration space used, alignment of components and component types.
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

Simulation 1 **Time: 3 hours**

Learner Name: _____

School: _____

Examination Number: _____

NAND Gate Applications

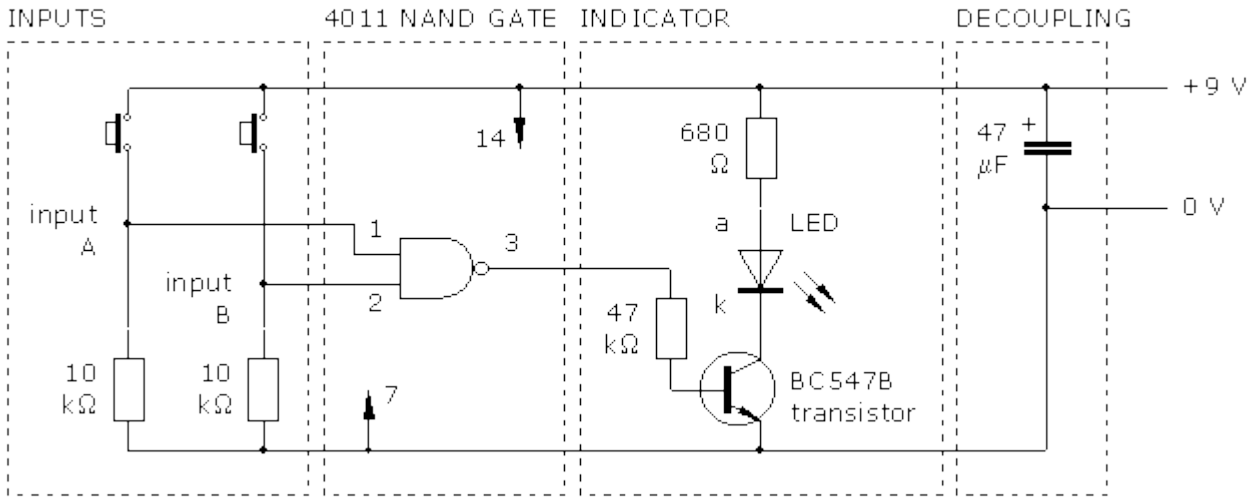
1. Purpose

To practise the use of NAND gates in logic circuits.

2. What you will need

- Breadboard
- 9 V power supply
- Miniature tactile switch x2
- BC547B NPN transistor
- 680 Ω resistor
- 47 kΩ resistor
- 10 kΩ resistor x2
- 47 µF capacitor
- 4011 IC

3. The Circuit: NAND gate indicator



Circuit 1 – The NAND Gate Indicator

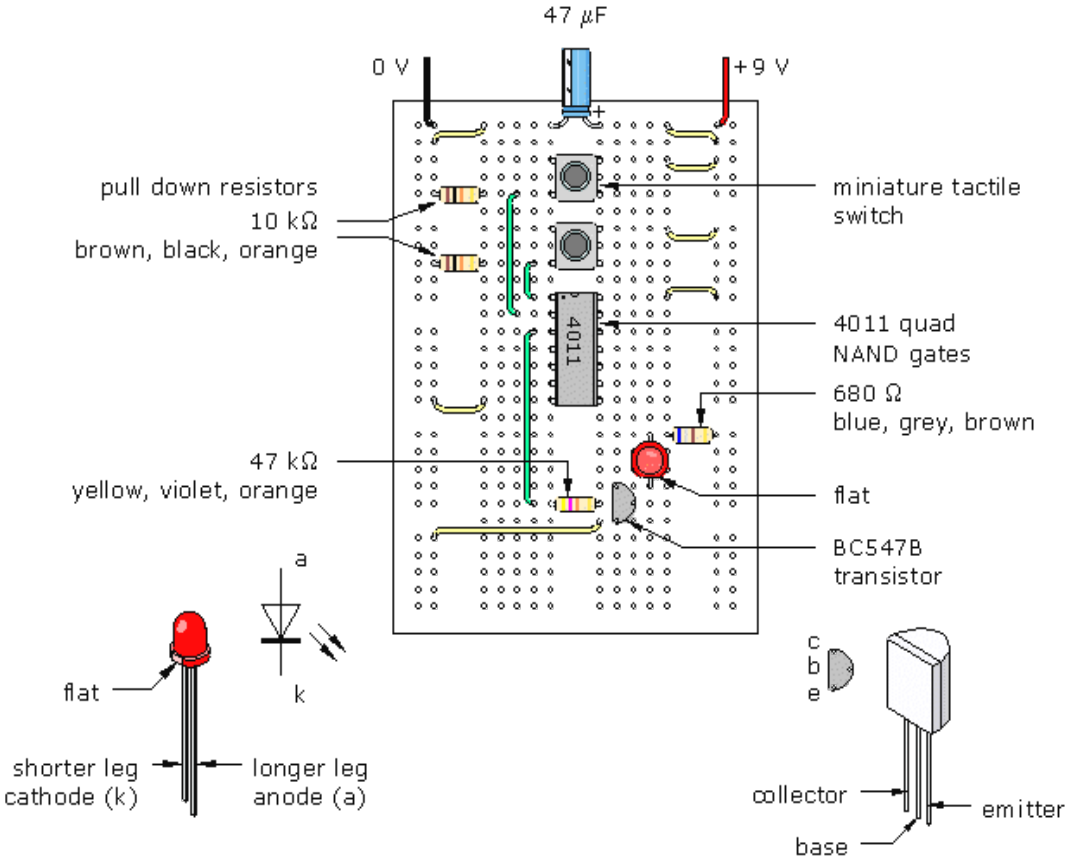
4. What you are going to do:

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

5. Part A: Procedure

What you must do

- Assemble the NAND gate indicator as shown below.
- The inputs of the gate must be connected, either to LOW or to HIGH, and MUST NOT be left open circuit. This is the function of the input switches with 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.)
- Complete the truth table (1= Input Switch On and 0= Input Switch Off).
- You must follow the layout below.



Proto-board Layout: The NAND gate test circuit

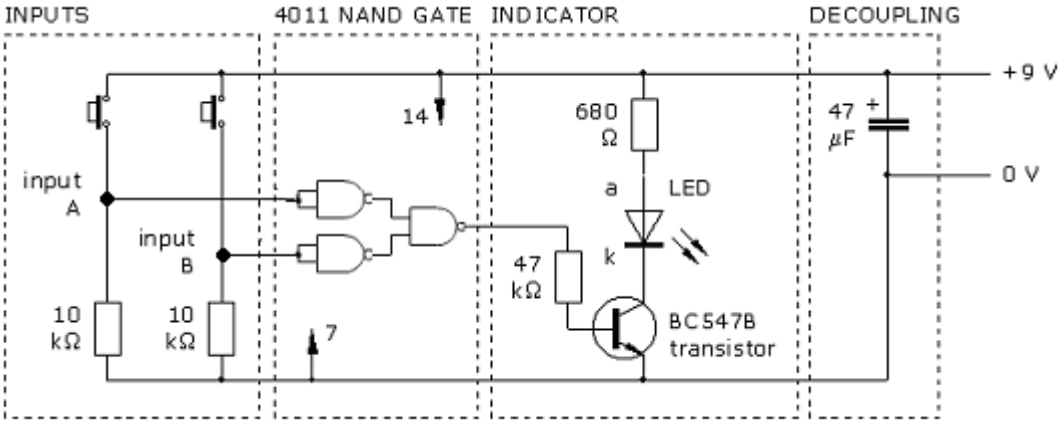
Input A	Input B	Output – LED
0	0	
0	1	
1	0	
1	1	

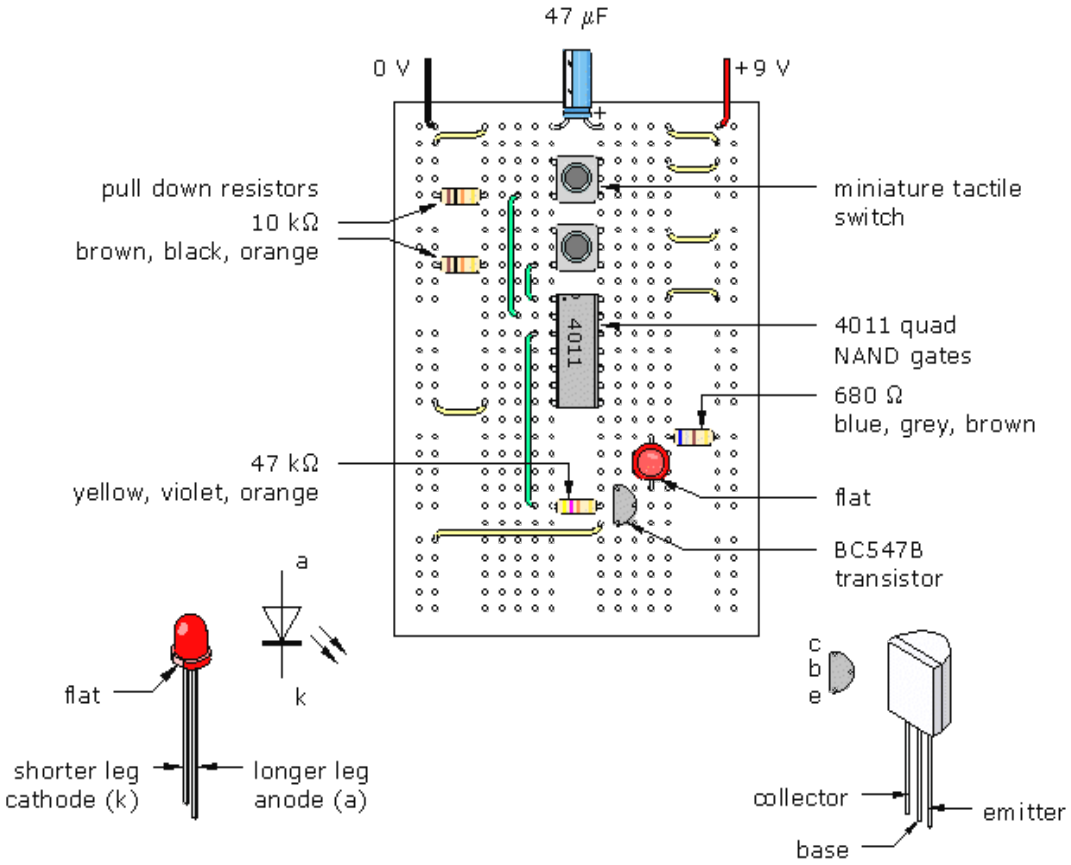
(4)

Part B: Procedure

What you must do

- Modify your existing NAND gate circuit to the combinational NAND gate circuit as in the diagram shown below[11]
- Operate the Input A and Input B switches to confirm the output action of the circuit.





[11] Ref: http://www.doctronics.co.uk/4011.htm

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.

Rubric for Digital Simulation 2: 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.
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or less components correctly on the breadboard.	☐The learner was able to correctly plan and place more than 4, but less than 8 components correctly on the breadboard.	☐The learner was able to successfully plan and place all the components correctly on the breadboard with links.	☐ The learner was able to successfully plan and place all the components correctly on the breadboard taking onto consideration space used, alignment of components and component types.
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

Simulation 2 **Time: 3 hours**

Learner Name: _____

School: _____

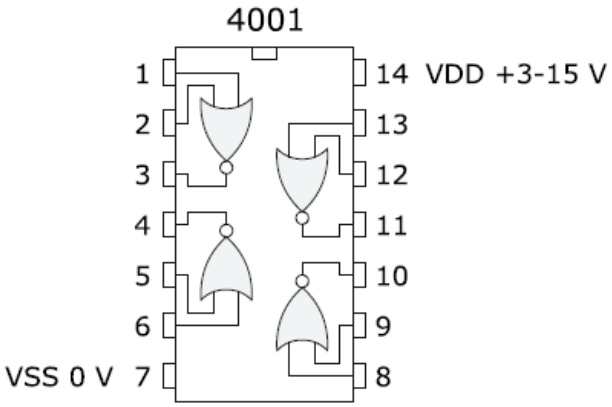
Examination Number: _____

NOR Gate Application

1. Purpose

To practise the application of NOR gates in logic circuits.

2. The 4001 Logic IC[12]

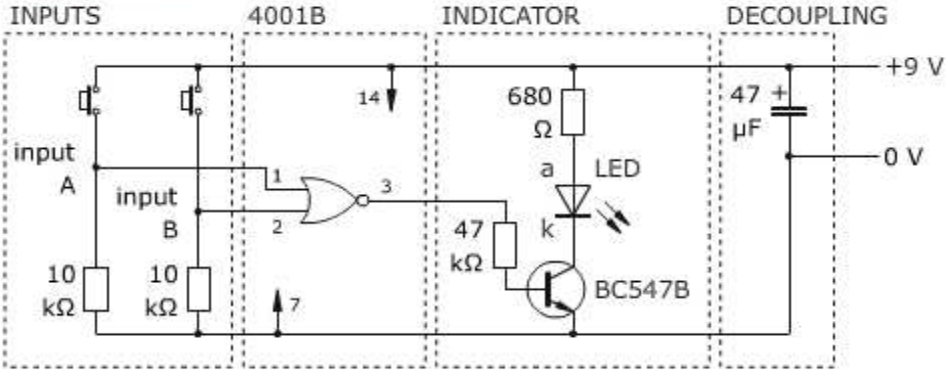


The truth table of each individual gate is:

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 the circuit below.

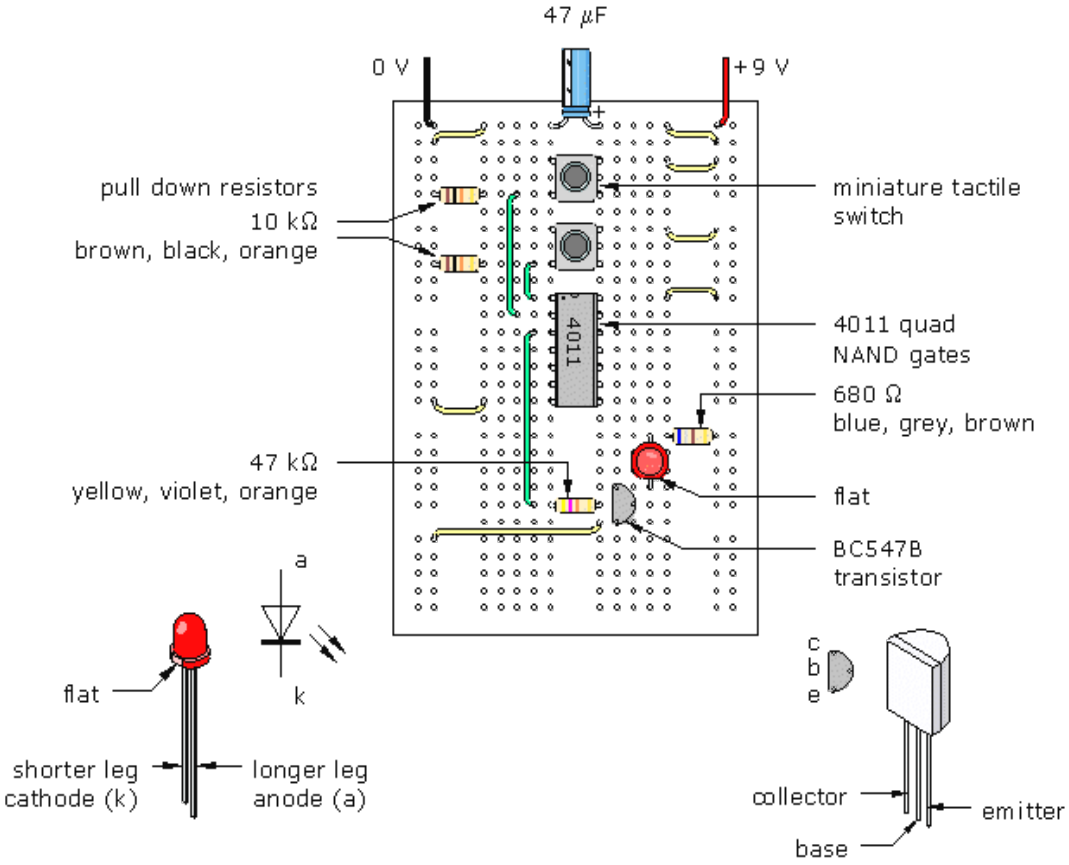


[12] Ref: www.doctronics.com

The inputs of the gate *must* be connected, either to LOW or to HIGH, and *must not* be left open circuit. This is the function of the input switches with their pull-down resistors. To avoid loading the output of the gate, a transistor switch indicator circuit should be used.

It is good practice with CMOS circuits to insert a decoupling capacitor, 47 µF or 100 µF, across the power supply. (This helps to prevent the transfer of spikes along the power supply rails.)
Do not forget to connect pin 14 of the 4001 to +9 V and pin 7 to 0 V.

Build the NOR gate application as shown below.
(5 marks for a working circuit)



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. However, be aware of the inputs and leave any unused outputs unconnected.

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

$$A.B = X$$

3. Conclusion

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

Rubric for Digital Simulation 2: NOR Gate Application

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
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or 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.
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.
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.
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.

Rubric (Maximum of 40)	
Working Circuits (Maximum of 10)	
Total (Maximum of 50)	

Digital

Simulation 3 **Time: 3 hours**

Learner Name: _____

School: _____

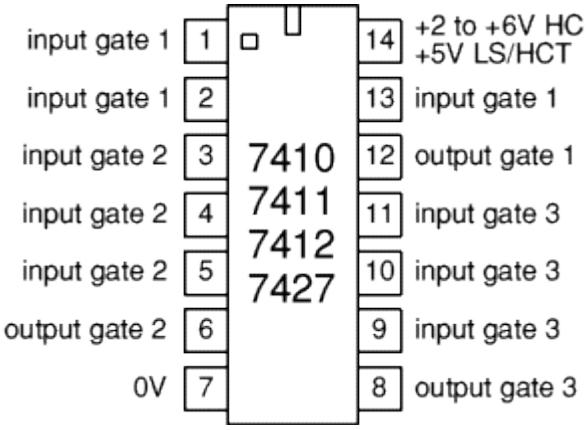
Examination Number: _____

NOR Gate Application using the 7427

1. Purpose

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

2. The 7427 logic IC



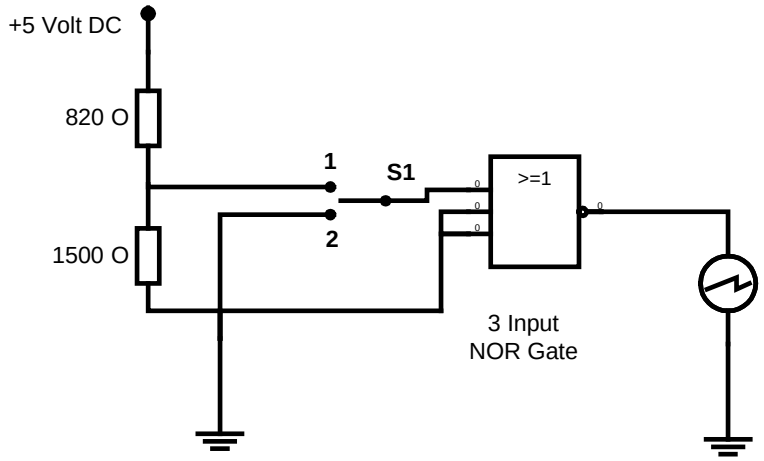
NOTE: This IC can only handle up to 6 V DC

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
- Breadboard
- Hook-up wire

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

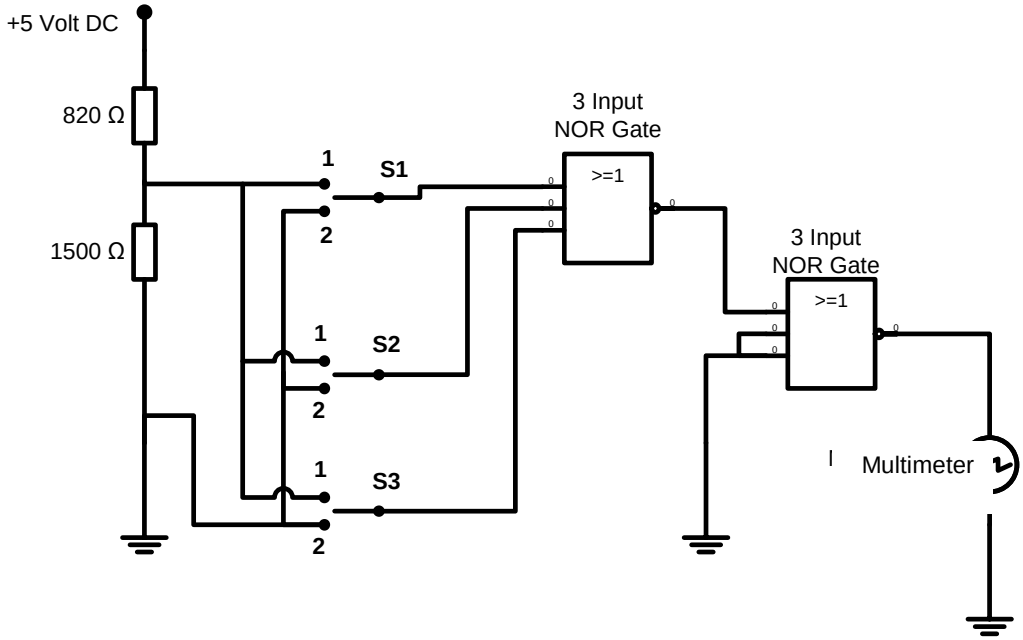
- Connect one of the NOR gates of the 7427 as shown below. The voltage divider provides the proper DC levels for the IC.
- Positive Logic 1 = 2,4–5 volts
- Positive Logic 0 = 0–0,5 volts
- S1 provides between 0–3,2 volts to the IC depending on its state.
- Complete the truth table.



S1	Multimeter	
		(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	Multimeter = D	
0	**0**	**0**		(1)
0	**0**	**1**		(1)
0	**1**	**0**		(1)
0	**1**	**1**		(1)
1	**0**	**0**		(1)
1	**0**	**1**		(1)
1	**1**	**0**		(1)
1	**1**	**1**		(1)

Boolean expression = _____ (5)

6. Conclusion

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

Subtotal: 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
Breadboard planning layout	☐ The learner was unable to plan the board layout using the supplied circuit diagram.	☐The learner was able to correctly plan and place 4 or 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

Simulation 4 **Time: 3 hours**

Learner Name: _____

School: _____

Examination Number: _____

Boolean Algebra

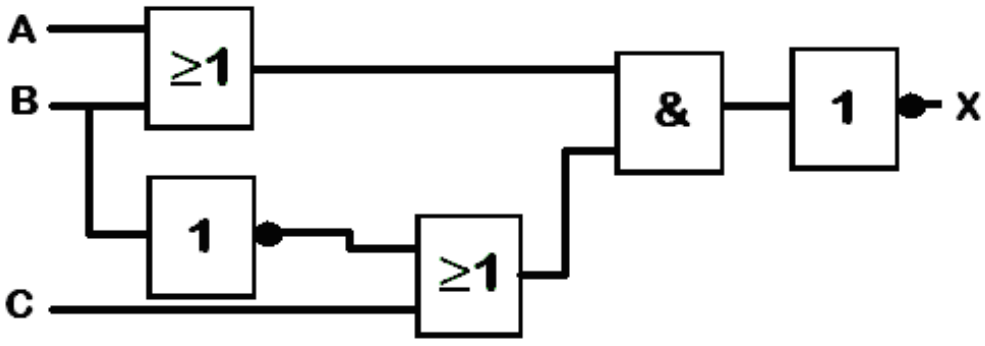
1. Purpose[13]

To test Boolean Algebra and construct an electronic circuit that simulates an 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)



[13] Simulation prepared and revised by Clinton de Kock GDE

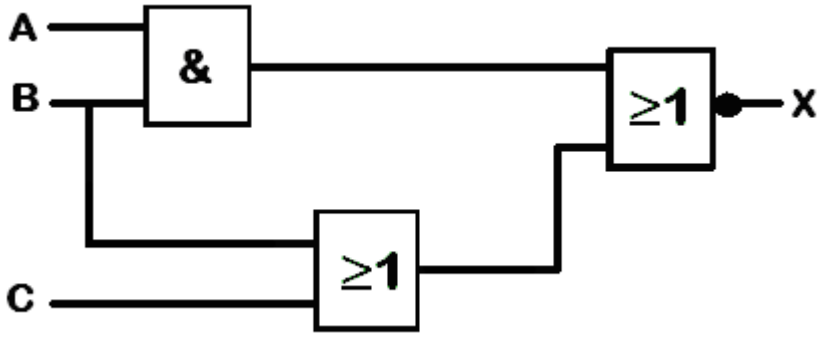
3. Draw the logic gate circuit for the Boolean equation $X = \overline{(A+B)}\ \overline{C}$ (4)

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 breadboard**, 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 PLCs may opt to simulate this question on PLC) (10)

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

Total: 50

10. Conclusion

Boolean Algebra equations can be constructed and applied electronically.

Declaration by the Learner

Declaration: I _____(Name) herewith declare that the work represented in this Learner Evidence (L.E) is entirely my own effort. I understand that if proven otherwise, my final results will be withheld.

_____ _____
Signature of learner Date

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

_____ _____
SIGNATURE OF PARENT/GUARDIAN **DATE**

_____ _____
SIGNATURE OF TEACHER **DATE**

SCHOOL STAMP

Working Mark Sheet (A working Excel file is available from the national co-ordinator)

PAT Mark Sheet		Term 1		Term 2		Project			Total = 250 Term1 + 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: _____ Moderator Name: _____ Principal Name: _____

Signature: _____ Signature: _____ Signature: _____

Date: _____

School Stamp

ANNEXURE: COMPONENT LIST FOR ELECTRONIC/DIGITAL SIMULATIONS

Component List – The Regulated Power Supply	
D1	Diode bridge
C1	2 000 uF 25 V
R1	200 R
D2	1N579 Zener – 12 V
Q1	2N3053 or equivalent
R2	10 K ¼ W 5%
R Load	100 ohm ¼ W 5%
T1	240–20 V or nearest available value. 100 VA

Component List – 555 Multivibrator	
IC1	555 IC
R1	4 k 7 ¼ W 5%
R2	50 K ¼ W 5%
R2 - Alternative	50 K Pot

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

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

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

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

Component List – NOR Gate Using the 7427	
IC1	7427 Quad 3-input NOR gate - DIP package
R 1	820 ohm ¼ W 5%
R 2	1 k 5 ¼ W 5%
S1, S2, S3	SPST toggle switch