2024 ASSESSMENT REPORT

EAT3125124 ELECTRONICS AND ADVANCED TECHNOLOGIES

General Comments

The 2024 Electronics exam proved accessible for a new course, with a good range of questions catering to a variety of skill levels. This allowed all students to demonstrate their understanding while also providing opportunities for high-achieving students to be extended.

It was pleasing to see students perform strongly in Criterion 8, demonstrating a solid understanding of how to write a program to perform a desired outcome. However, there is a clear need for improvement in the use of correct technical communication and electronics terminology. Many students struggled to accurately describe safety devices, the appropriate use of equipment and components in circuit, Thevenin's Theorem, Switch Bounce, and the function of transistor blocks.

Additionally, a common area of difficulty was differentiating between current, voltage, and power. Students frequently used these terms incorrectly when explaining circuit operations.

To address these areas for improvement, teachers are encouraged to:

- **Emphasise precise language:** Incorporate regular activities that require students to explain concepts using accurate electronics terminology. This could include labelling diagrams, writing technical reports, or presenting oral explanations of circuit functions.
- **Clarify key concepts:** Provide explicit instruction on the distinctions between current, voltage, and power, using practical examples and analogies to reinforce understanding.
- **Promote hands-on experience:** Engage students in practical activities that involve troubleshooting faults, selecting appropriate equipment, and analysing real-world circuits.

The average marks for each section are detailed below (each section was out of 36 marks):

	Average Mark	Lowest Mark	Highest Mark
Criterion 3	26	12	34
Criterion 5	21	14	29
Criterion 6	20	3	29
Criterion 7	20	6	32
Criterion 8	23	7	36

Written Component

Section A

Question 1

a) This question was well answered. Markers accepted any reasonable explanation for either choice.
b) Time-delay fuses proved to be unfamiliar to many students, who chose to leave this question blank. Students who received marks often discussed slow-blow fuses in speakers.
c) While many students could identify the hazard present, very few students were able to demonstrate an understanding of how a residual current device works.

Question 2

This question was well answered. Some students identified that capacitors remain charged but did not state why this was a risk, which was needed to receive full marks.

Question 3

a) This question was well answered. Small mistakes were made with the polarity of the LED.
b) Most students were able to get partial marks for determining the values of the feedback resistors, connecting the non-inverting input to ground, or showing a dual power supply. Very few students did all these things at once.

Question 4

a) This question was well answered. Common errors were connecting the DMM in parallel to measure current.
b) Students appeared confident in drawing a function block diagram and correctly named the LED as the output. Many students incorrectly identified the water sensor as the processor.
c) To receive full marks, students needed to identify the strengths of each particular method of testing.
d) This question was well answered. Small mistakes were made connecting the components to the correct power rails.
e) Most students were able to give at least one consideration. Stronger answers gave multiple considerations and explained some of them with detail.

Question 5

a) This question was well answered.
b) The ambiguity of the question meant that markers rewarded students with marks using either signal as the input. Most students were able to name a function generator as the piece of equipment producing the input sine wave. Stronger students were able to determine its frequency.
c) About a third of the students were able to recognise the distortion as clipping. These students were confident in going on to suggest ways of removing the distortion.

Question 6

a) Markers were looking for ‘Quad’ and ‘NAND’ to receive full marks rather than a particular part number.
b) This question was well answered.
c) Students needed to offer some explanation to receive the full mark here.
d) This question was extremely well answered.

Section B

Question 7

a) This question was well answered.
b) About half of the students were able to recognise that using Kirchoff’s Voltage Law involved calculating the voltage of the known parallel branch. A common mistake was using Ohm’s Law with a current and voltage from different branches in the parallel combination, resulting in a partial mark.
c) About half of the students recognised that they needed to add the current in each branch of the parallel combination together. Another successful approach involved using the ratio of resistances in the parallel branches.

Question 8

a) This question was well answered.
b) Students who identified the current gain formula on the information sheet answered this question productively.
c) This question was generally well answered.

Question 9

a) While most students attempted this question, their answers were often quite vague and did not say how to determine the Thevenin Equivalent circuit in a logical method. Partial marks were awarded for naming a DMM or voltmeter as the tool to measure voltage, using a resistor, and making use of the voltage divider formula. Markers were disappointed that terminology such as ‘open circuit’ was omitted.
b) About a third of the students were able to draw the equivalent circuit involving the voltage source and resistor. Common mistakes were in placing these in parallel rather than series.

Question 10

a) This question was well answered. A slower method involved completing a full calculation using the voltage divider formula.
b) Less than half of students recognised that the capacitor would be discharging.
c) This question was well answered.
d) This question was very poorly answered. Very few students recognised the different components involved compared to the previous part. A partial mark was given for the charge time ten seconds by multiplying the previous part by five.
e) Half of the students recognised that an ideal op-amp saturates to (about) the power supply value.
f) Students who recognised that the LED voltage needed to be subtracted from twelve to obtain the resistor voltage were rewarded.

g) This question was poorly answered.
h) Most students who attempted this question knew that a resistor was required. A common mistake was in proving negative feedback by connecting the resistor from the comparator output to its inverting input.
i) About a third of students were able to provide a reasonable explanation of hysteresis.
j) Most students could identify the time-delay switch and/or voltage divider as inputs, or the comparator as the processor, or the LED and/or relay as separate outputs. Very few students had all these parts correctly connected within their IPO function block diagram.

Question 11

a) This question was generally well answered.
b) This question was generally well answered. A common mistake was stating 100 as the E12 resistor value which did not account for the question stating the maximum current.

Section C

Question 12

a) Well answered. Some students had problems converting to picocode.
b) Well answered.

Question 13

A well answered question and easily assessable to many. There are conventions when drawing circuit symbols and students should be well versed in standard SPDT and potentiometer symbols along with making the symbols large and easy to interpret.

Question 14

a) Many students could not successfully state the purpose of the capacitor.
b) Students need to be reminded when asked about a circuit's purpose to be specific and answer it based on the content that has been delivered in class.
c) Well answered.
d) Many students lost marks are they could not describe how the push pull amplifier works and the purpose of the diodes.

Question 15

Well answered.

Question 16

a) Full marks were hard to get here as students needed to cut half the wave off, drop the amplitude by 0.7 and then make it non-conductive either side of the wave.
b) Many left this blank.
c) Most only received half marks for this question as they could not correctly explain what DC means, only stating that it was "direct current".
d) Many only got 0.5 marks for this question.
e) Only about half the candidates could place the capacitor in the right location.

Question 17

a) Marks were given for both astable and monostable multivibrator as it was unclear as to how the circuit operated. Students need to be reminded to be specific when giving examples for circuits.
b) Well answered.
c) Many could only correctly identify the capacitor and picked the wrong resistor.
d) Many students only obtained part marks for this question as they needed to take into account the time constant for the circuit for full marks.

Section D

Question 18

a) Many gained full marks in this part but some got confused with the table having the units column on the right and only achieved partial marks.
b) Candidates didn't have much trouble identifying a characteristic but many had trouble articulating where their chosen example could be used.
c) Well answered.

Question 19

a) Poorly answered, no one could correctly identify the true purpose of C1.
b) Well answered.
c) Well answered.
d) Many correctly identified the answer but failed to explain why it was High.
e) Many answered this correctly but some lost marks as they could not fill in the truth table for Columns A, B and C and hence got EN wrong.
f) Well answered.
g) Well answered.
h) Too many candidates failed to discuss the current through the LEDs as the main issue. Many spoke about increasing voltage. Some put transistors on all the outputs to switch the LEDs on, which obtained some marks.

Question 20

a) Well answered. Answers varied with some students using a voltage divider into a NOT gate while others gave answers which included a comparator.
b) Students did very well in this question.
c) Well answered. Marks were assigned for both paths and the presence of the correct gates.
d) Many students did not correctly identify that it was only two chips. Most said it contained four chips. Students need to be reminded about how circuit simulation software denotes the number of ICs.
e) About half the students answered this correctly.
f) About half the students could not correctly identify the frequency.
g) There were many students who did not understand how to draw timing diagrams. Marks were awarded for gate triggering and frequency division.
h) Most answered this correctly.

Question 22

A lot of students got part marks for correctly identifying the common name, but did not seem to be able to state an advantage and disadvantage.

Section E

Question 23

a) Well answered.
b) Well answered.
c) Marks were given for ii, iii and iv as all of these use either PWM or digital on/off modes.

Question 24

a) About half the candidates were successful here.
b) Many candidates correctly identified the difference but failed to explain that SPI is synchronised to a clock pulse.
c) Many struggled to answer this question and many left it blank.
d) Varied answers here with many students getting half marks for attempting to give an example.

Question 25

a) There were many answers here that did not give the required detail. Students need to be reminded to be specific in their responses.
b) There were many answers here that did not give the required detail. Students need to be reminded to be specific in their responses. Too many students were giving broad uses instead of specific uses.

Question 26

A very good question overall with good questions ranging from C standard to A standard.

a) Many students received part marks for this question as they did not give the required detail.
b) Well answered.
c) Well answered.
d) Well answered.

Question 27

a) Students clearly had trouble interpreting the diagram in this question with some answering with an instantaneous output while others detailed outputs over the whole length. Marks were awarded for any reasonable response.
b) For full marks, students had to detail the setup of the microcontroller and the loop, including details about both the temperature regulation and the LCD, with other marks associated with correct numbers and pinMode identification.
c) Both parts were well answered.

Question 1

Marker use

a) The 3A fuse for a television needs replacing. However, the technician only has 2.5A and 5A fuses available. Explain which of these fuses they might select as a replacement.

/2

The 2.5A fuse, to protect the device from currents over 3A which may damage the television.

OR The 5A fuse, as the television may draw up to 3A to operate and 2.5A could be insufficient - although this is far from ideal!

b) Time-delay fuses are able to be overloaded for a short period of time. Describe a context where it would be appropriate to use a time-delay fuse.

/2

Any setting (such as a starter motor) where brief surges are acceptable and/or normal, but prolonged surges are not, and need to be protected against.

c) A residual current device is often connected to circuits in environments that have damp conditions where appliances - such as hair dryers - may be used. Explain the electrical hazard present in these environments and how the residual current device works to reduce potential harm.

/2

Water is able to conduct electricity. An RCD monitors the current flow into and out of a circuit - if these values are different (which would happen if water is conducting electricity via an undesired route) the RCD opens a switch, stopping any current flow. This may prevent electric shock.

Total Q1

/6

Question 2

Marker use

Explain why each of the following may be risks for an electronics student:

a) Capacitors

These can remain charged after being disconnected, and give a shock if rapidly discharged.

/1

b) Solder

Contains lead which is poisonous to consume.

/1

Total Q2

/2

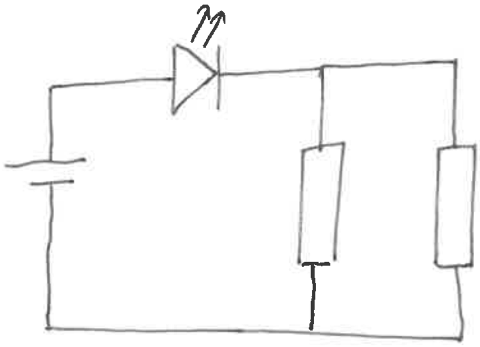
Question 3

Marker use

Design and draw the schematic diagram for:

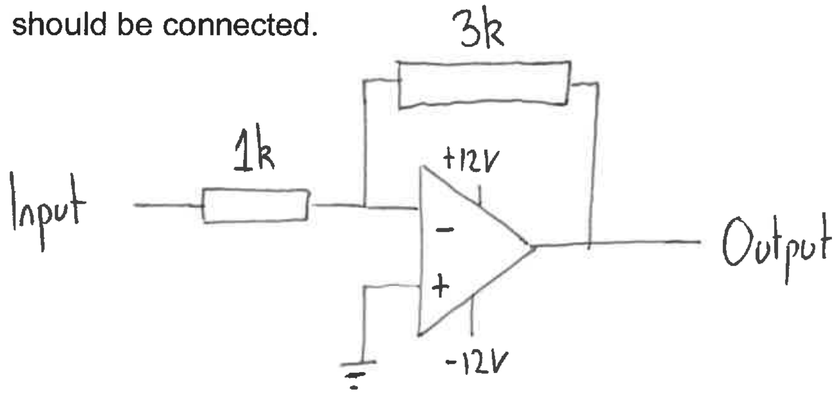
a) A battery connected to an LED that uses two resistors in parallel to limit the current. The values of the resistors are not required.

/2



b) An Op-Amp with a gain of -3 that is connected to a 12V dual power supply. Give possible values of any resistors used, and label where any inputs and outputs should be connected.

/3



* Other values of R_f and R_i acceptable if $R_f = 3 \times R_i$

Total Q3

/5

Question 4

Marker use

Figure 1 is a circuit schematic being used to monitor water levels for a water tank.

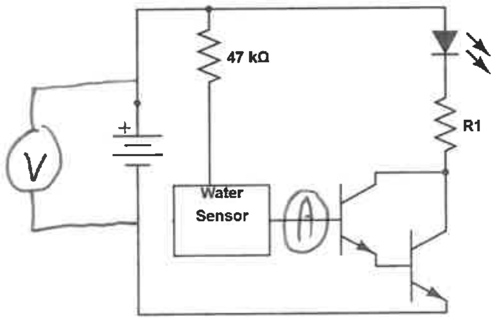


Figure 1: Circuit schematic to monitor water levels.

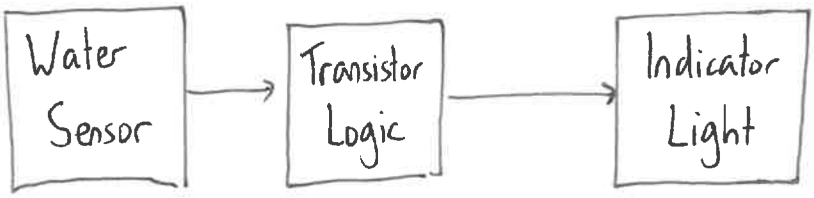
Spare diagram used (X) ☐

a) Using an appropriate symbol, show where you would connect each of the following to Figure 1:

i. A voltmeter to measure the voltage being supplied by the battery. /1

ii. An ammeter to measure the current running into the base of the principal transistor of the Darlington pair. /1

b) Represent the circuit in Figure 1 as a simple IPO function block diagram. /2



c) Why might it be useful to test the circuit in Figure 1 with both breadboarding the circuit and using simulation? /2

Simulation allows us to understand/test if the concept works in theory, without the hassle of buying & wiring components. Breadboarding the circuit shows if specific components will work, taking into account their tolerances etc.

Question 4 continues

Marker use

d) Compete the circuit using the breadboard in Figure 2, by referring to Figure 1 and filling in the missing wires.

/3

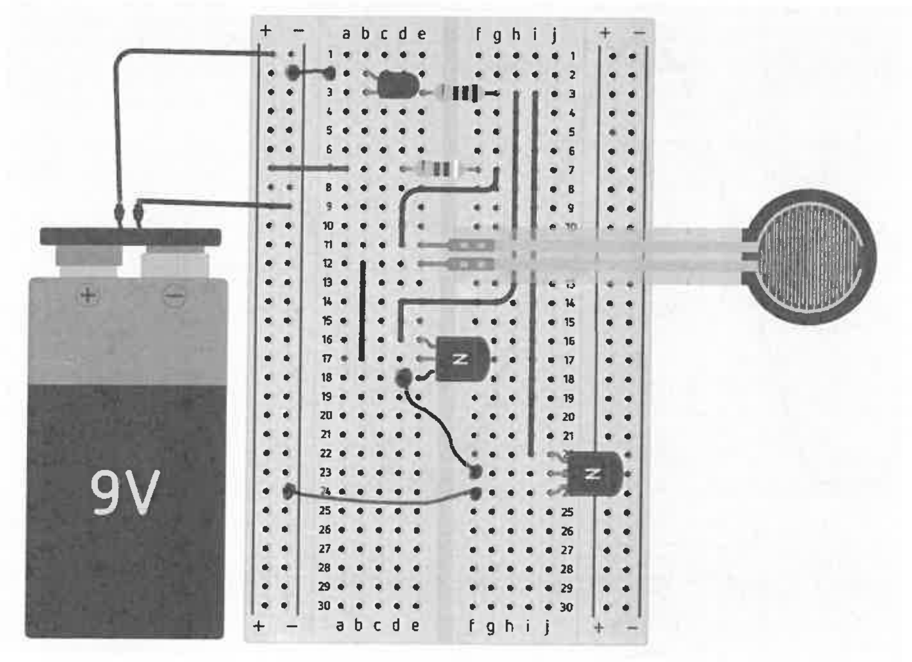


Figure 2: Breadboard of circuit to monitor water levels.

Spare diagram used (X) ☐

e) What considerations would be appropriate when determining the value of R1?

/2

The current rating of the LED and its voltage drop at the desired level of brightness.

Also, the collect current amount and heat R1 can disapate.

Total Q4

/11

Question 5

Marker use

Figure 3 shows the output signal of an amplifier circuit when it is connected to a given input signal.

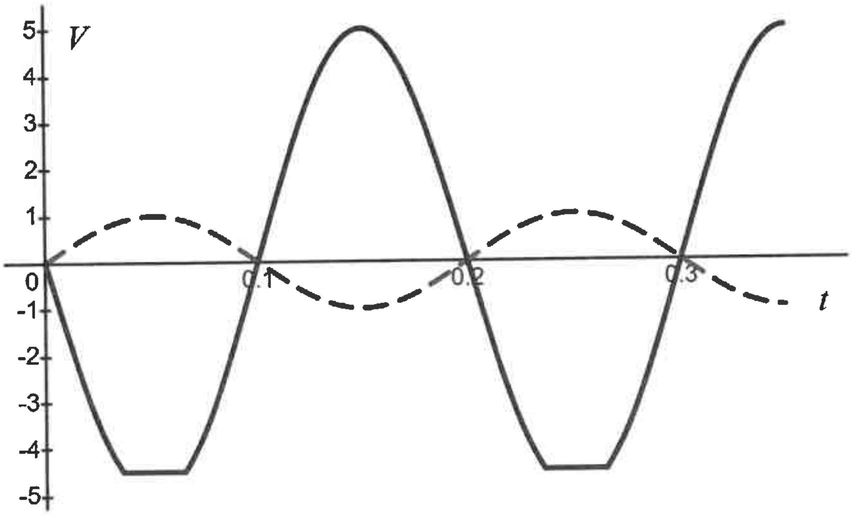


Figure 3: Input/Output signals for an amplifier circuit.

a) Name a piece of equipment that displays Figure 3.

Oscilloscope.

/1

b) Name the piece of equipment that may have been used to provide the input signal in Figure 3. Then, describe the input signal in terms of its shape, peak-to-peak voltage, and frequency.

A function generator: 2 Vpp sine wave at 5Hz.

As $f = \frac{1}{T} = \frac{1}{0.2} = 5\text{ Hz}$

/4

c) State the type of distortion shown in Figure 3, and detail a possible way in which the amplifier circuit might be adjusted so that the distortion is removed.

Clipping: Increase the negative output supply voltage, or decrease the gain factor, or reduce the input signal.

/2

Total Q5

/7

Question 6

Marker use

Figure 4 is a design for a PCB which uses an integrated circuit chip to create an OR gate.

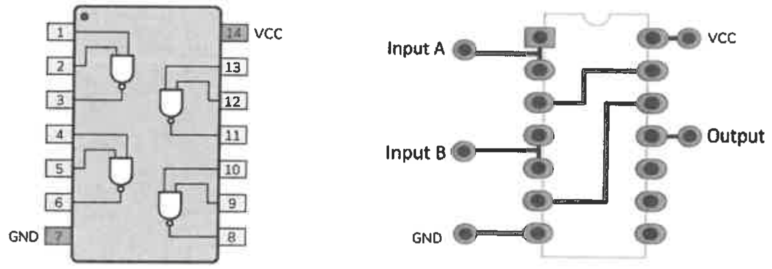


Figure 4: Integrated circuit chip and OR gate design.

a) What is the integrated circuit chip in Figure 4 called?

Quad NAND

/1

b) The integrated circuit chip uses complementary metal–oxide–semiconductor (CMOS) logic. Circle the correct statement below for handling CMOS chips:

/1

i. The voltage source must be exactly 6V to operate due to the limited power supply operation range.

[✓ ii.] Static discharge on the input pins should be avoided due to their high input impedance.

iii. Changes to the input voltage should be done slowly to ensure the slew rate is not exceeded.

iv. The pins are very sturdy and should be bent to make them more malleable for breadboarding with.

c) Explain how the track between pin 3 and pin 13 can be tested to ensure conductivity.

/1

Touch the leads of a multimeter to pin 3 and pin 13 in Ω or continuity mode. Should be 0Ω.

d) Use the information in Figure 4 to complete the following circuit diagram.

/2

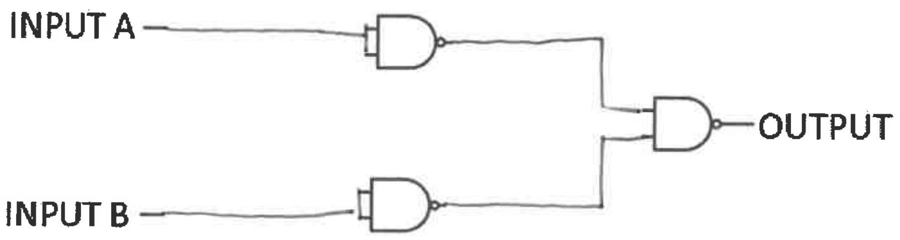


Figure 5: Circuit diagram to sketch your answer to Question 6 d)

Total Q6

Spare diagram used (X) ☐

/5

Question 7

Marker use

Figure 6 is a resistor network.

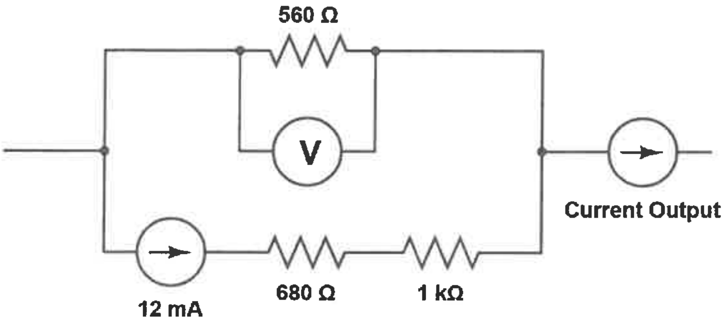


Figure 6: Circuit diagram of a resistor network.

a) Calculate the total equivalent resistance of Figure 6.

$$R = \frac{(1000 + 680) \times 560}{(1000 + 680) + 560}$$

$$= 420\Omega$$

/3

b) Use Ohm's Law and Kirchhoff's Voltage Law to determine the voltmeter reading.

V = Voltage over series resistors

$= I \times R$

$= 0.012 \times (680 + 1000) = 20.16\,V$

/2

c) Show that the current output is approximately 48 mA, by using Kirchoff's Current Law.

$I_{OUTPUT} = 12mA +$ Current through 560 resistor

$$= 12 + \frac{20.16}{560}$$

$$\approx 48mA$$

/2

Total Q7

/7

Question 8

Marker use

The transistor in Figure 7 has a DC current gain (hFe or β) of 25.

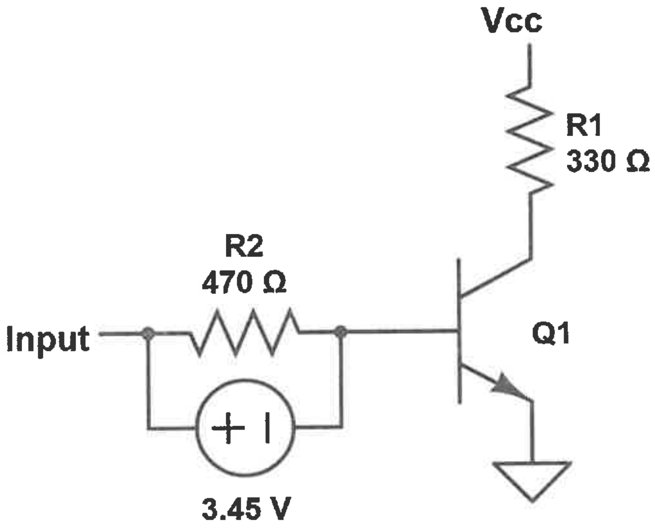


Figure 7: Circuit diagram of a transistor amplifier.

a) Show that the current flowing through R2 is approximately 7mA.

$I = {}^{3.45}/_{470}$

$= 7.34mA$

/1

b) Hence, calculate the current flowing through R1 assuming Q1 is unsaturated.

$25 \times 0.007 = 0.175A$

or 175mA

/1

c) Use an appropriate calculation to determine if R2 would overheat a **quarter watt** resistor.

$P = \frac{3.45^2}{470}$

$= 0.025 W$

< 0.25

∴ No, it would not overheat

/2

Total Q8

/4

Question 9

Marker use

The circuit inside the box shown in Figure 8 is a linear circuit, made of voltage sources, current sources, and resistors.

Figure 8: Diagram of a mystery linear circuit.

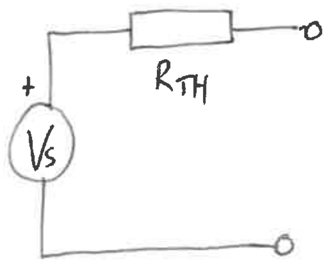
a) Outline how you would determine the Thevenin Equivalent circuit, making sure to include the names of any components or tools that you would use, circuit diagrams that show what measurements you would take, and formulae you would use.

/4

- Connect a DMM to the terminals of the circuit to measure open circuit voltage, V_s.
- Connect known R resistor in parallel with circuit & DMM to measure voltage drop over R, V_R.
- Use $V_R = V_s \times \frac{R}{R + R_{Th}}$ to calculate R_{TH}.

b) Sketch the Thevenin Equivalent circuit.

/2



Total Q9

/6

Question 10

Marker use

The circuit in Figure 9 is for a time delay switch.

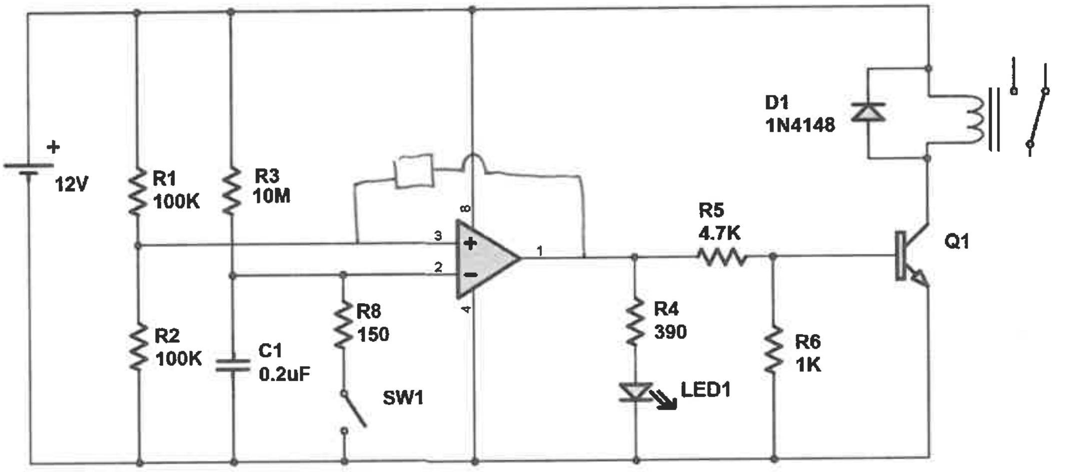


Figure 9: Circuit diagram of a time delay switch.

Spare diagram used (X) ☐

The circuit can be broken up into the following function blocks.

R1 and R2 form a voltage divider that sets the reference voltage of the Comparator.

a) Calculate the voltage at the non-inverting input.

As $R_1 = R_2$, $V = 12/2$

$= 6V$

/1

C1, R3 and R8 form two different RC timing circuits that set the time delay of the switch.

b) Will the capacitor be charging or discharging when SW1 is closed?

Discharging

/1

c) Calculate the time constant of C1 and R3.

$T = R \times C = 0.2 \times 10^{-6} \times 10 \times 10^{6} = 2$ seconds

/1

d) When the capacitor is fully charged, approximately how long will it take to discharge to its minimal voltage?

$T = 0.2 \times 10^{-6} \times 150$

$= 30 \mu s$

$\therefore 5\tau \approx 150 \mu s$

/2

Question 10 continues

Question 10 continued

Marker use

The comparator will saturate **high** when the capacitors charge is less than the reference voltage set by the voltage divider. This turns the indicator LED1 on.

e) What is the output voltage of the comparator when it saturates **high**?

Ideal op-amp would be 12V

/1

f) If the forward voltage of LED1 is 3V, calculate the current through R4.

V = 12 - 3 I = 9/390

= 9V = 0.023 A

/2

This activates the relay-switch.

g) What is the purpose of D1?

Flyback diode protects Q1 from reverse voltage induced by relay.

/1

Rapid switching of the relay is referred to as relay chatter. This can be eliminated by adding a component to give the comparator **hysteresis**.

h) Add the component symbol to Figure 9.

/2

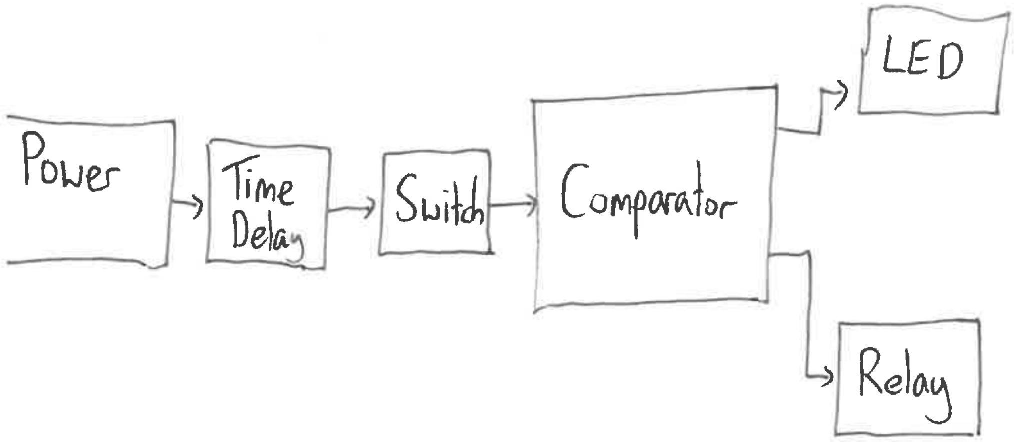
i) Briefly outline the effect hystensis has on the comparator.

The switch-on verse switch-off input voltage of the op-amp will be different.

/1

j) Using the sub-circuits mentioned in the previous parts of this question, summarise the circuit in Figure 9 as an input-processor-output function block diagram.

/4



Total Q10

/16

Question 11

Marker use

Figure 10 is a simple voltage regulator that utilises a Zener diode. The breakdown voltage of D1 when the current is above 70mA is approximately 5.6V.

a) Calculate the voltage across R1 when the current is above 70mA.

/1

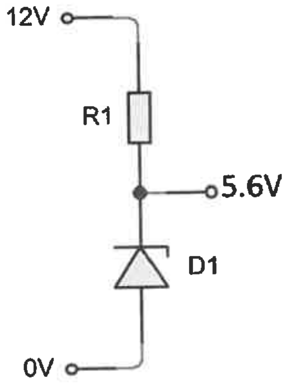


Figure 10: Circuit diagram of a voltage regulator.

$12 - 5.6 = 6.4V$

b) Determine a suitable E12 resistor value for R1.

/2

$R = V/I$

$= \frac{6.4}{0.07}$

$= 91.42\ \Omega$

$\therefore$ 100Ω E12 Resistor

Total Q11

/3

Question 12

Marker use

a) Complete the rows in Table 1 with the corresponding capacitor codes and values.

/3

pF Code	picofarads (pF)	nanofarads (nF)	microfarads (uF)
223	22000	22nF	0.022
154	150.000	150 nF	0.15
392	3900	3n9	0.0039

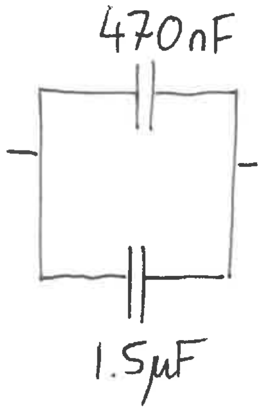
Table 1

Spare diagram used (X) ☐

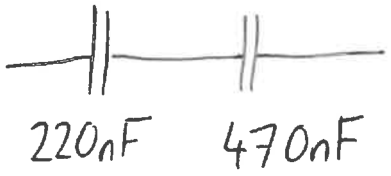
b) Three capacitors, 1.5µ, 220n and 470n are given. Arrange **two (2)** of these capacitors to give the:

/3

i. Maximum total capacitance



ii. Minimum total capacitance



Total Q12

/6

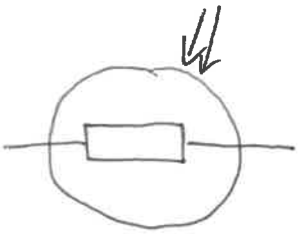
Question 13

Marker use

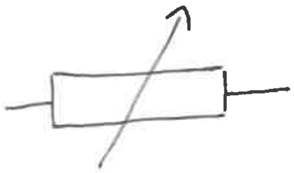
/4

Sketch the circuit symbol for each of the following components:

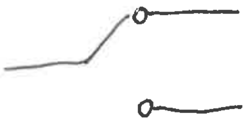
Light dependent resistor



Potentiometer



SPDT Switch



NPN Transistor

Total Q13

/4

Question 14

Marker use

Figure 11 is a transistor amplifier circuit.

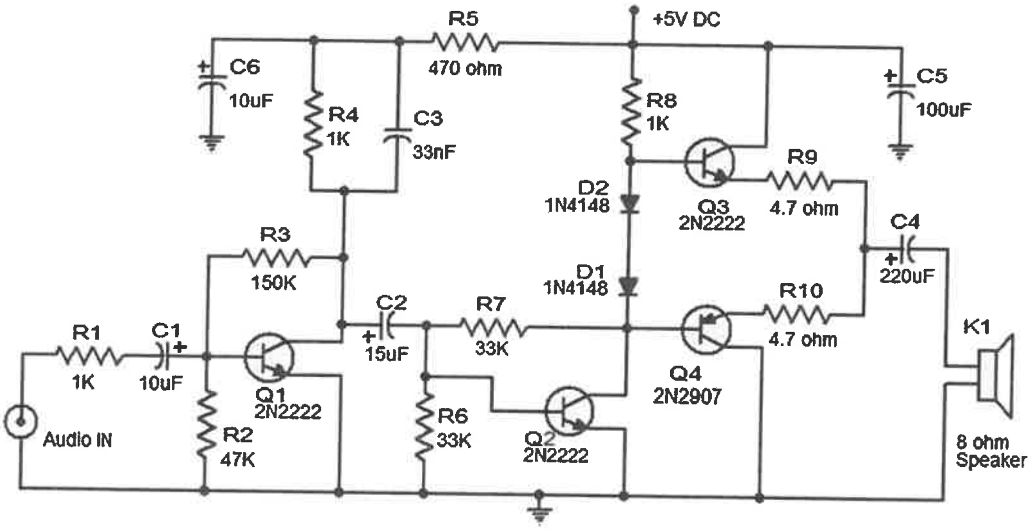


Figure 11: Circuit diagram of a transistor amplifier circuit.

a) Name the component C5 and state its purpose.

DC smoothing capacitor (electrolic)

/2

b) Describe the role of C1.

AC coupling capacitor

/1

Q1 and its associated components are wired as a pre-amplifier circuit.

c) What is the purpose of a pre-amplifier circuit?

A low noise, high gain amplifier to boost current.

/1

d) Which component provides collector to base biasing for Q1? Why is it needed?

R3 (with R2) to bias Q1 in active region & prevent thermal runaway.

/2

A transistor block is formed involving Q3 and Q4.

e) Give the common name of this transistor block and describe how it works, making sure to reference the role of components D1 and D2.

Class AB push pull amplifier.

D1 and D2 provide bias voltage to remove coss-over distortion.

/3

Total Q14

/9

Question 15

Marker use

/4

Fill in Table 2 by giving approximate output voltage for each of the circuits shown:

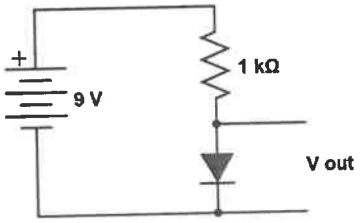
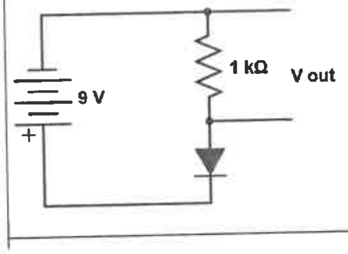
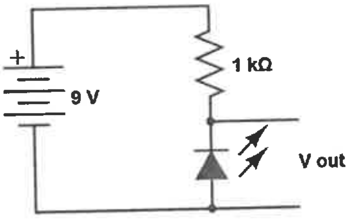
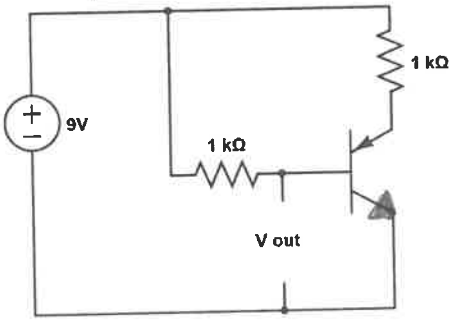
Circuit	Vout
	0.7
	0
	9
	0.7

Table 2

Spare diagram used (X) ☐

Total Q15

/4

Question 16

Marker use

Figure 12 is a circuit diagram of a half wave rectifier.

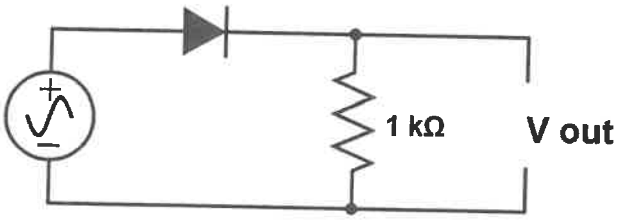


Figure 12: Circuit diagram for a half wave rectifier.

a) Complete the graph (Figure 13) showing the output voltage for the input voltage given.

/2

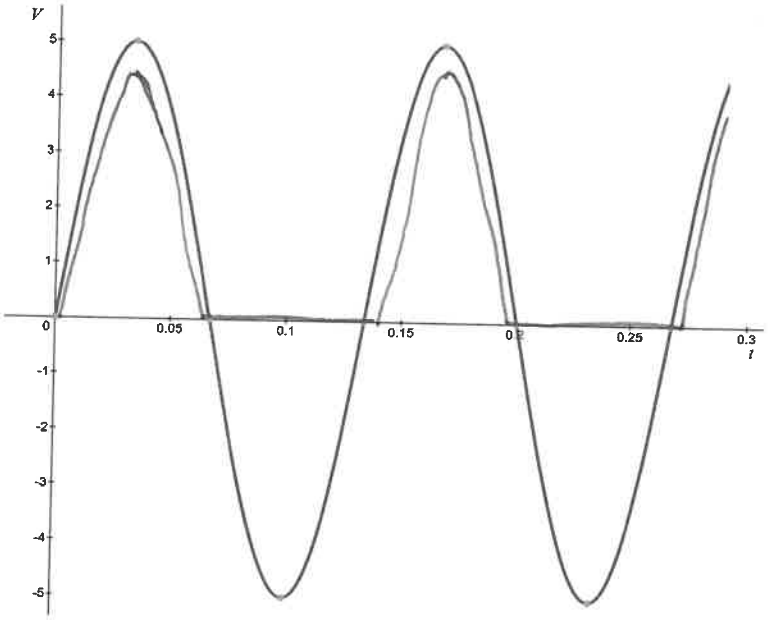


Figure 13: Input voltage for a half wave rectifier circuit..

Spare diagram used (X) ☐

b) Determine the RMS value of the input voltage.

5× 0.707 = 3.535V

/1

Question 16 continues

Question 16 continued

Marker use

The circuit diagram can be expanded on to make a bridge rectifier that outputs full-wave rectified DC voltage as shown in Figure 14.

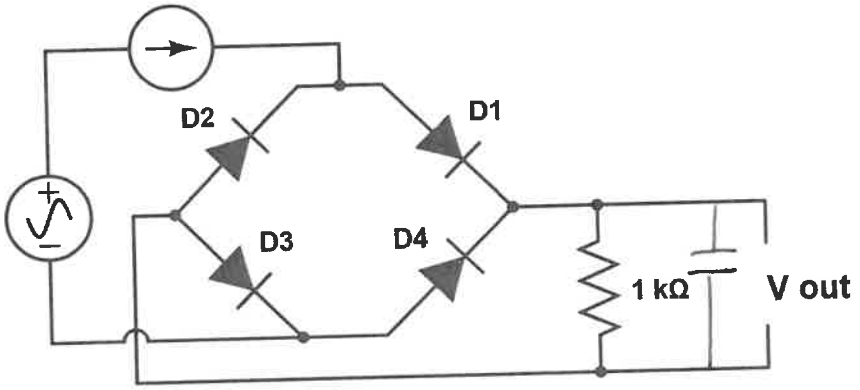


Figure 14: Circuit diagram of a bridge rectifier.

c) Explain what DC means.

Direct current where current only travels from + to -.

/1

d) Which diodes will have current flowing through them when the ammeter is showing a *negative* value?

D3 & D4.

/1

e) A certain component can be used to smooth the output voltage. Add the necessary component to the circuit diagram in Figure 14.

/1

- Capacitor in parallel with the resistor.

Total Q16

/6

Question 17

Marker use

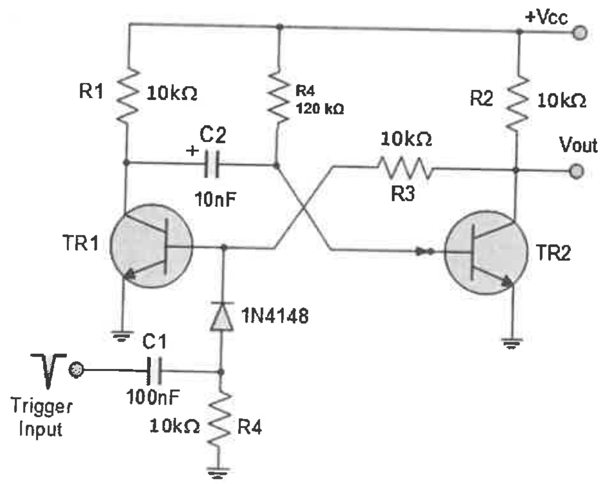


Figure 15: Circuit diagram

a) Name the circuit in Figure 15 and give an example of what it could be useful for.

Astable multivibrator that could be used for a toaster timer.

/2

b) When Vcc is turned on, which transistor will be active?

TR2

/1

c) Which components are responsible for determining the timing of Vout after the pulse has been fed in?

C2 and R4.

/1

d) When the negative trigger input shown is applied to the circuit, describe what change will be seen at Vout.

/3

Total Q17

/6

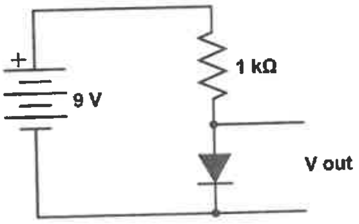
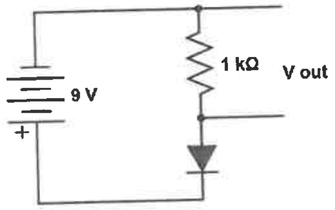
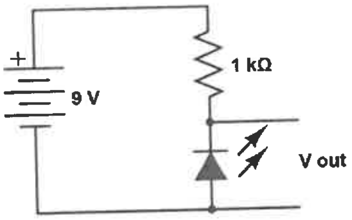
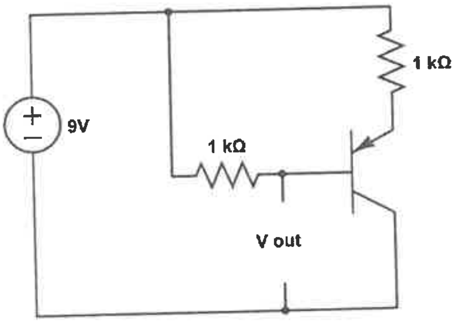
Spare Diagram

Marker use

Question 12 a)

pF Code	picofarads (pF)	nanofarads (nF)	microfarads (uF)
223			
			0.15
		3n9	

Question 15

Circuit	Vout
	
	
	
	

Spare diagrams continue

Question 18

Marker use

Characteristics gathered from the data sheet of two operational amplifiers are shown in Table 3.

Characteristics	Op Amp 1	Op Amp 2	Units
Input Impedance	1	4	MΩ
Output Impedance	5	100	Ω
Max Supply Voltage	±30	±30	V
Output Voltage Swing	±25	±28	V
Slew Rate	0.2	4.5	V/μs
Open-loop Gain	100	10	dB
Unity Gain Bandwidth	0.5	5	MHz

Table 3

a) Name 2 characteristics from Table 3 that make Op Amp 1 more ideal than Op Amp 2?

Output Impedance

Open-loop Gain

/2

b) Give an example of an application where it be more appropriate to use Op Amp 2.

High frequency applications (slew rate)

/1

Often a discrete circuit involving a transistor is used for amplification rather than an integrated circuit such as an Operational Amplifier.

c) Explain **one (1)** advantage and **one (1)** disadvantage of using a discrete circuit rather than an integrated circuit.

A discrete circuit does not require its own power supply, is often less expensive and reliable at high frequencies. However, it may not be able to provide the gain required.

/2

Total Q18

/5

Question 19

Figure 16 is a counting circuit for determining the amount of airport luggage. A suitcase travelling between the **LED** and **phototransistor** interrupts the beam of light between the two components.

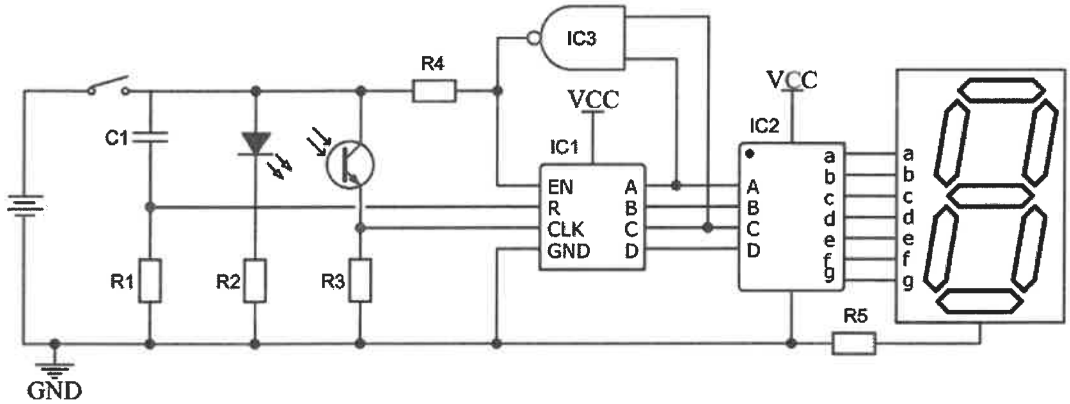


Figure 16: Circuit diagram for counting airport luggage.

a) When luggage is loaded for a new flight, the circuit is connected to the power supply by closing the switch. Explain the role of C1.

/3

C1 is connected to the reset of IC1 and thus is used to reset the count to zero when the switch is first closed.

b) When the phototransistor is activated by light, is the logic level at the clock of IC1 High or LOW?

/1

High

c) Explain how switch bounce occurs with mechanical switches and why a phototransistor has chosen instead.

/2

Switch bounce occurs when multiple contacts are made as a switch settles, rather than just one. The phototransistor isn't mechanical and is less likely to have this phenomenon.

d) Is EN 'Active High' or 'Active Low'? Explain how you can tell.

/2

Active High.

When IC1 A&C are high, IC3 goes low, stopping the count.

Question 19 continues

Question 19 continued

Marker use

e) Complete the truth table shown by Table 4 to determine when EN changes state.

/2

C	B	A	EN
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	
1	1	1	

← Changes State

Table 4: Truth table to complete for Question 19 e).

Spare diagram used (X) ☐

You wish to change how many suitcases are counted before counting is paused.

f) Which outputs of IC1 should be connected to IC3 so that counting now pauses after 9 bags have been counted?

A and D

/1

g) Is the display common cathode or common anode?

Common Cathode

/1

h) When the circuit operates, it is found that the brightness of the display varies depending on what number is showing. Why is this happening, and what adjustment to the circuit in Figure 16 would fix this?

/2

Different numbes require different amounts of LEDs to operate, which varies the current through R5 and thus the brightness. Replace R5 with individual resistors on IC2 outputs.

Total Q19

/14

Question 20

Marker use

Geese Lighting has asked for you to design a circuit which turns car headlights on manually or automatically. The headlights can be switched on manually by using a switch. They also turn on automatically when it is dark outside and the key detector senses the keys are in the ignition. When the headlights are manually switched on and the key is removed from the ignition, an alarm sounds. A Block Diagram of this circuit is shown in Figure 17.

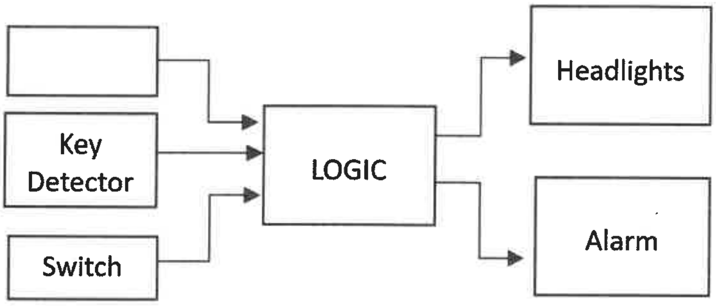


Figure 17: Block Diagram for a headlight circuit.

a) Detail an integrated circuit with associated components that you could use to fill in the blank box responsible for returning logic HIGH when it is dark outside.

/2

A light dependant resistor with a regular resistor, creating a voltage divider as the input for an op-amp.

b) Complete the truth table shown by Table 5.

/2

Darkness (Dark = 1)	Keys (In Ignition = 1)	Switch (On = 1)	Headlights (On = 1)	Alarm (On = 1)
0	0	0	0	0
0	0	1	1	1
0	1	0	0	0
0	1	1	1	0
1	0	0	0	0
1	0	1	1	1
1	1	0	1	0
1	1	1	1	0

Table 5

Spare diagram used (X) ☐

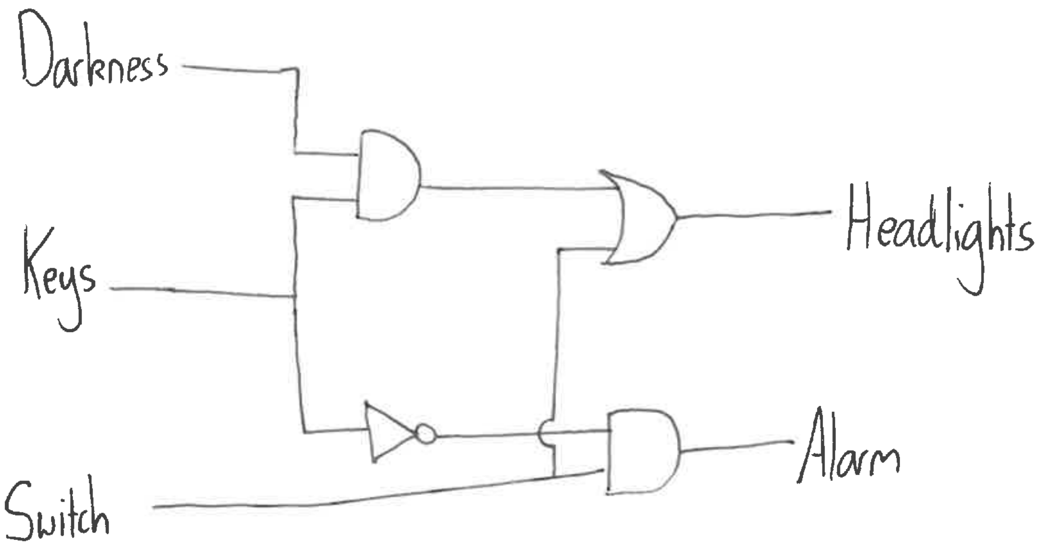
Question 21 continues

Question 20 continued

Marker use

c) Design a circuit using logic gates that would be appropriate for the 'Logic' block.

/4



Total Q20

/8

Question 21

Marker use

The four-bit binary ripple counter in Figure 18 is constructed using D-Type flip flops.

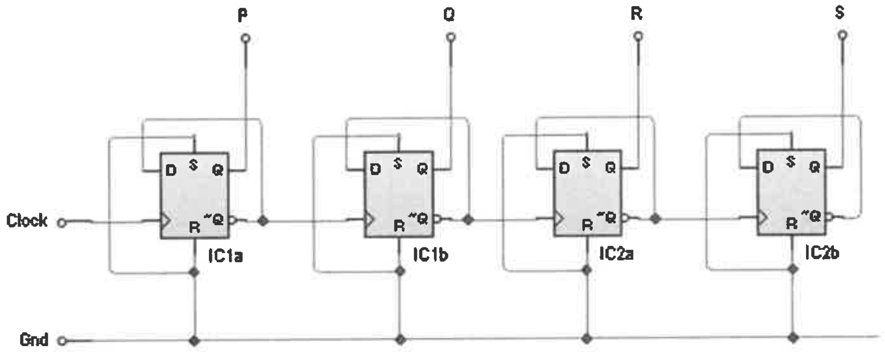


Figure 18: Circuit diagram of a four-bit binary ripple counter.

a) How many integrated circuit chips have been used to build this circuit?

2

/1

b) Explain why S and R are connected and wired as shown above.

To prevent accidental set/reset of count from stray static.

/1

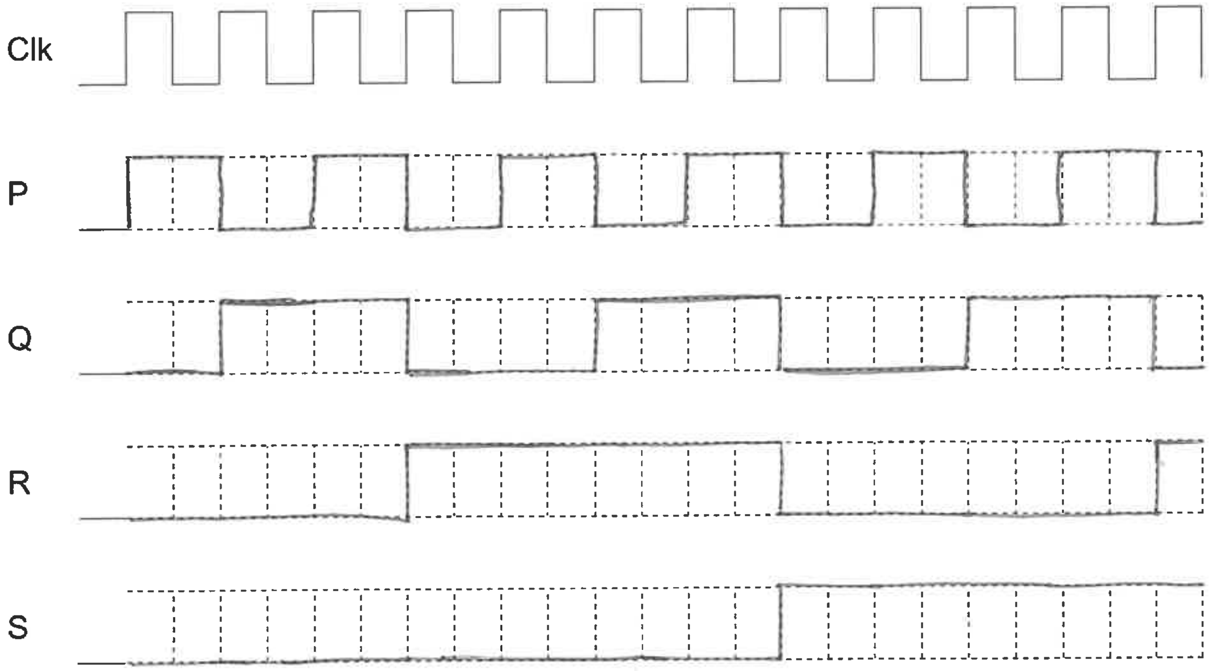
c) If the input is a square wave of frequency 512Hz, what is the frequency at S?

32Hz

/1

d) Complete the timing diagram for the counter.

/2



Spare diagram used (X) ☐

Question 21 continues

Question 21 continued

Marker use

e) Is the counter synchronous or asynchronous?

Asychronous.

/1

Total Q22

/6

Question 22

Marker use

/3

Describe an advantage and a disadvantage of using the analogue to digital conversion method described by the block diagram shown in Figure 19, as opposed to other methods of analogue to digital conversion. In your answer, state the common name given to this method of conversion.

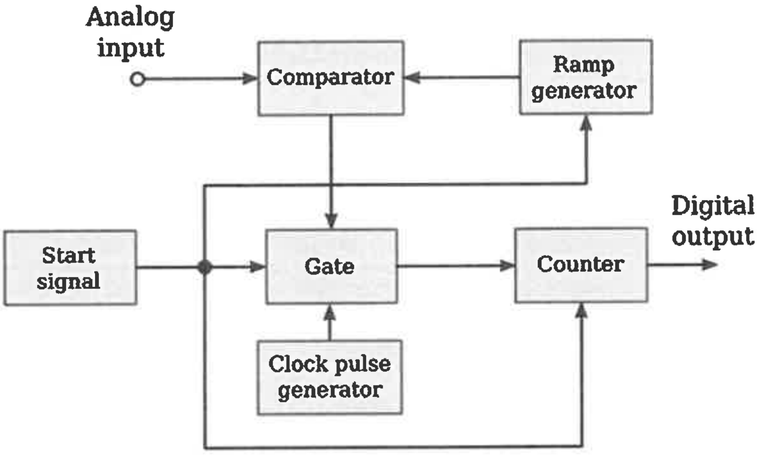


Figure 19: Block diagram of an analogue to digital conversion circuit.

Ramp ADC is slower than flash ADC as it only gives one output value per 'ramp'. However, it can give a highly accurate output value with fewer components required.

Total Q22

/3

Question 23

Marker use

Circle the correct response for each of these questions.

a) Where is the program stored on a microcontroller?

/1

i. Input device.

[✓ ii.] Memory.

iii. Power supply module.

iv. Processing core.

b) Which of the following is an output device?

/1

[✓ i.] Fan.

ii. Thermistor.

iii. Light detector.

iv. Sensor.

c) Which of the following is a digital control?

/1

i. Adjusting the volume of music.

ii. Controlling the rotational speed of a motor.

iii. Varying the brightness of a light.

[✓ iv.] Turning a heater on or off.

Total Q23

/3

Question 24

Marker use

UART (Universal Asynchronous Receiver-Transmitter) and SPI (Serial Peripheral Interface) are two different serial communication methods.

a) Describe the difference between 8-bit serial and 8-bit parallel communication.

8-bit parallel communicates 8 bits simultaneously and 8-bit serial communicates each of the bits one at a time.

/2

b) Describe the differences between UART and SPI methods.

UART is an asynchronous method that has a protocol for when data starts/stops transmission, whilst SPI is synchronised to a clock and is typically faster

/2

c) UART communication can be used to control a lamp and an air conditioner from a central device with only one signal wire – going from the central device to the lamp and on to the air conditioner. Explain how this works.

The lamp and air conditioner both 'listen' to the central contol device, but have different 'addresses' or 'codes' that they respond to.

/2

d) Give an example of a device that would use SPI, and state why.

High speed memory as it requires synchronous operation to be totally reliable.

/2

Total Q24

/8

Question 25

a) Give **two (2)** reasons why microcontrollers have become more widespread.

Cost-effective → they are relatively inexpensive to produce as advances in semi-conductor technologies have been made.

Versatile → they integrate CPU, memory, I/O peripherals on a single chip, making them suitable for many applications.

b) Give examples of uses for a microcontroller in two different industries.

Automotive industry → to monitor sensors and trigger air bags in the event of a collision

Healthcare industry → to monitor glucose levels, heart-rate and other vital signs, to provide continuous health data and respond accordingly.

Marker use

/2

/4

Total Q25

/6

Question 26

Marker use

Yoshi has designed the circuit in Figure 20 which uses a microcontroller and a joystick to control which direction a DC motor spins. Figure 21 shows the microcontroller coding.

a) Outline **two (2)** advantages of using a microcontroller in a context such as this.

/4

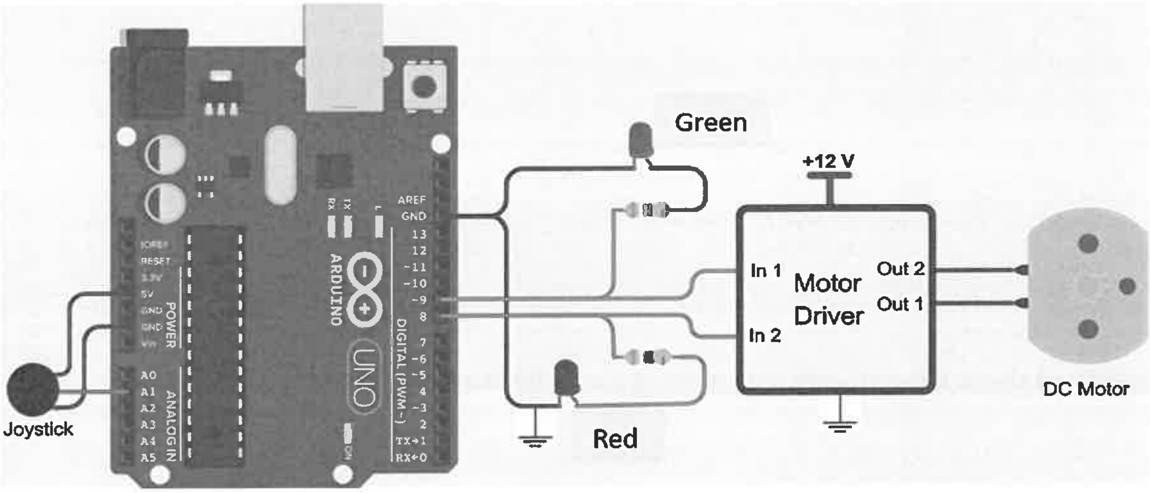


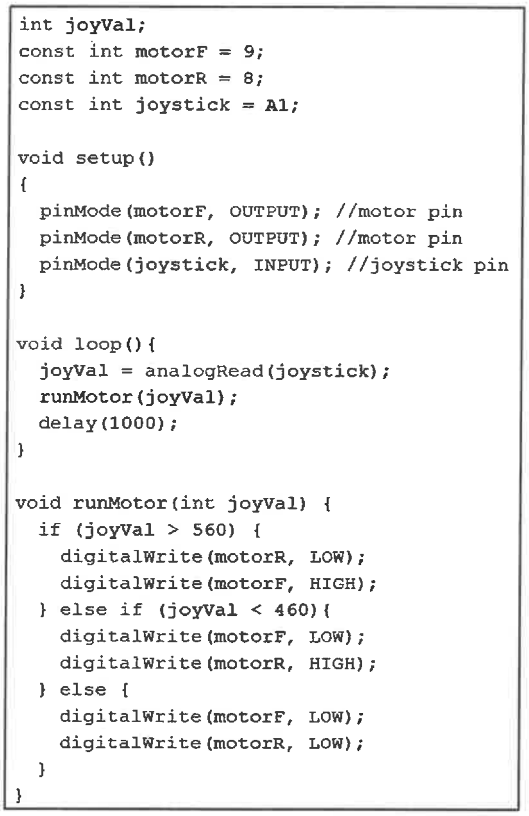
Figure 20: Block diagram showing analogue to digital conversion method.

It can easily interface to other devices such as a siren or speaker system. The values in the code can be modified without rewiring any components.

Question 26 continues

Question 26 continued

Marker use



```
int joyVal;
const int motorF = 9;
const int motorR = 8;
const int joystick = A1;

void setup()
{
  pinMode(motorF, OUTPUT); //motor pin
  pinMode(motorR, OUTPUT); //motor pin
  pinMode(joystick, INPUT); //joystick pin
}

void loop(){
  joyVal = analogRead(joystick);
  runMotor(joyVal);
  delay(1000);
}

void runMotor(int joyVal) {
  if (joyVal > 560) {
    digitalWrite(motorR, LOW);
    digitalWrite(motorF, HIGH);
  } else if (joyVal < 460){
    digitalWrite(motorF, LOW);
    digitalWrite(motorR, HIGH);
  } else {
    digitalWrite(motorF, LOW);
    digitalWrite(motorR, LOW);
  }
}
```

Figure 21: Picture of microcontroller coding

b) Is the joystick connected as an analog or digital input?

Analog

/1

c) Which coloured LED lights up with a joystick input value of 320?

Red

/1

d) For what range of joystick input values will the motor not run?

460-560

/1

During testing, Yoshi discovers that the motor runs in reverse when it should be going forward, and that it responds very slowly to changes in the joysticks position.

e) What modifications could Yoshi make to address these concerns?

Reduce the delay to 200. Reverse the motor wiring - this can be done by swapping pin 8 & 9 or In 1 and In 2 or Out 1 and Out 2, or motorF and motorR in the code.

/3

Total Q26

/10

Question 27

Marker use

Michelle Fardy intends to use a microcontroller to control the temperature of a science experiment she is undertaking by using a heating element, temperature sensor and display. The microcontroller turns the element on when the temperature of the science experiment is lower than 60 °C, and off when it is more than 63 °C. The display shows the current temperature.

a) What output would you expect when the display gives the data shown in Figure 22?

/2

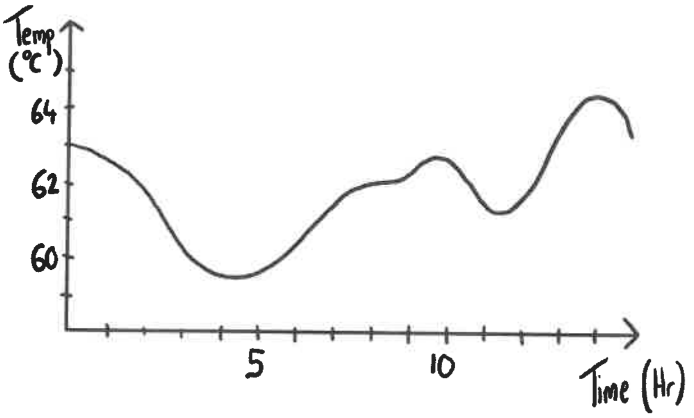


Figure 22: Graph showing the current temperature of a science experiment.

ON at 3 hrs, OFF at 12.5 hrs.

b) Use any common programming language/structure to write some code which shows how the sensor data will be acquired, processed, and displayed.

/5

```
void setup () {
    pinMode (heater, Output);          //set heater as output
    pinMode (sensor, Input);           // set temperature sensor as input
    lcd.print (" Temp "),              // display the LCD
}

void loop () {
    if (sensor < 60°c) { digitalWrite (heater, HIGH); }      // ON < 60°c
    else if (sensor > 63°c) { digital Write (heater, Low); }  //OFF >63°c
    LCD.print ( sensor),                                      // Display temp
    delay (1000);                                             // Wait 1 sec
}
```

Question 27 continues

Question 27 continued

Marker use

c) If Michelle Fardy were to use the microcontroller shown in Figure 23, which pin is a good option to connect the following to:

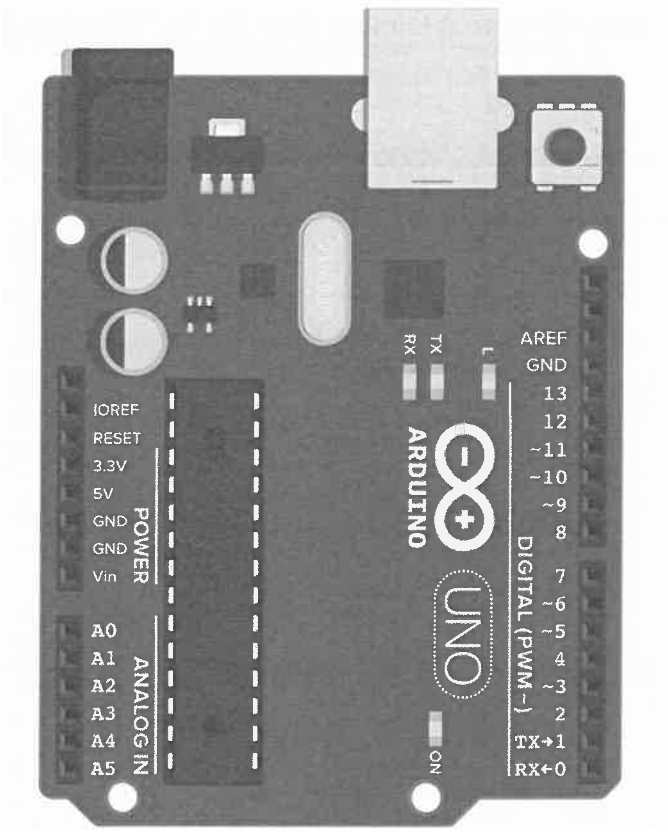


Figure 23: Microcontroller for connecting components.

i. Heating element.

Digital Out (2-13) /1

ii. Temperature sensor.

Analog In (A0-A5) /1

Total Q27 /9