Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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9	
10	
TOTAL	

AQA

General Certificate of Secondary Education
June 2015

Electronics 44301

Unit 1 Written Paper

Friday 12 June 2015 9.00 am to 11.00 am

For this paper you must have:
- a pencil
- a ruler
- a calculator.

Time allowed
- 2 hours

A

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 150.
- A list of formulae is provided on page 2, which you may wish to use in your answers.
- Any correct electronics solution will gain credit.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Information Sheet

The following information may be useful when answering some questions in this examination.

Resistor colour code
The colours in the resistor colour code correspond to the following values.

BLACK	0	YELLOW	4	GREY	8
BROWN	1	GREEN	5	WHITE	9
RED	2	BLUE	6		
ORANGE	3	VIOLET	7		

The fourth band colour gives the tolerance.
GOLD ± 5%   SILVER ± 10%

Resistor printed code (BS 1852)
R means × 1   K means × 1000   M means × 1 000 000
Position of the letter gives the decimal point.
Tolerances are indicated by adding a letter at the end.
J ± 5%   K ± 10%   M ± 20%
e.g. 5K6J = 5.6 kΩ ± 5%

Preferred values for resistors (E24 SERIES)
1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6,
3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 and their multiples of ten.

Resistance
Resistance = $\frac{\text{Voltage}}{\text{Current}}$ $R = \frac{V}{I}$

Effective resistance, R, of up to four resistors in series is given by $R = R_1 + R_2 + R_3 + R_4$

Effective resistance, R, of two resistors in parallel is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

Power
Power = Voltage × Current $P = VI$

Amplifiers
Voltage gain $G_V = \frac{V_{out}}{V_{in}}$

Astable and monostable generators using 555 timers
(a) Monostable mode   time period $T = 1.1\ R_1 \times C_1$
(b) Astable mode   time period $T = \frac{(R_1 + 2R_2)C_1}{1.44}$

ac theory

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

Frequency = $\frac{1}{\text{Period}}$ $f = \frac{1}{T}$

Do not write outside the box

Answer **all** questions in the spaces provided.

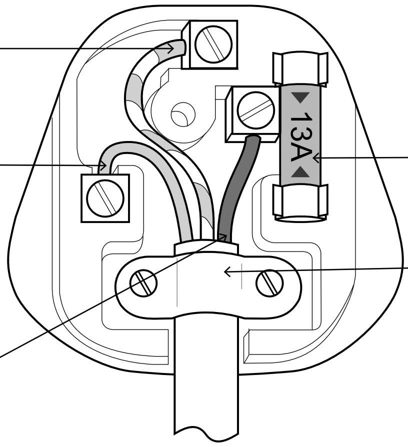
1 (a) Write the names of the **three** wires and **two** parts of the plug indicated in **Figure 1**.
[5 marks]

Figure 1

name.....................................
green and yellow wire

name.....................................
blue wire

name.....................................
brown wire



part 1
name.....................................

part 2
name...................................

1 (b) State the purpose of **part 1** of the plug.
[2 marks]

....

....

1 (c) An appliance draws 13 A and runs from 230 V mains.

Calculate the power of the appliance.
[3 marks]

....

....

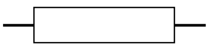
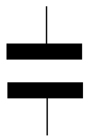
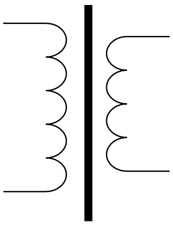
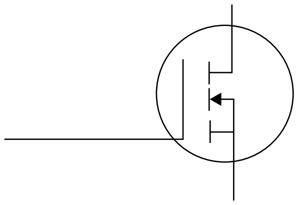
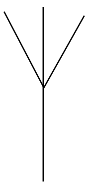
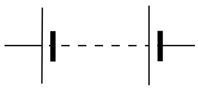
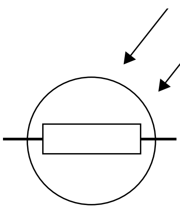
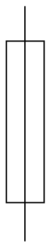
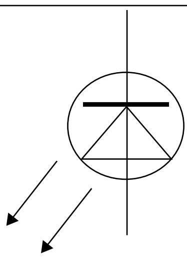
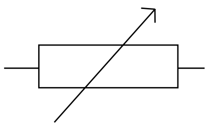
10

2 Use the list below to find the name of each component shown in **Table 1** and then write the correct letter for each name in the space provided.

[10 marks]

A – fuse
B – light emitting diode (LED)
C – resistor (fixed)
D – aerial
E – light dependent resistor (LDR)
F – MOSFET
G – transformer
H – battery
I – variable resistor
J – capacitor

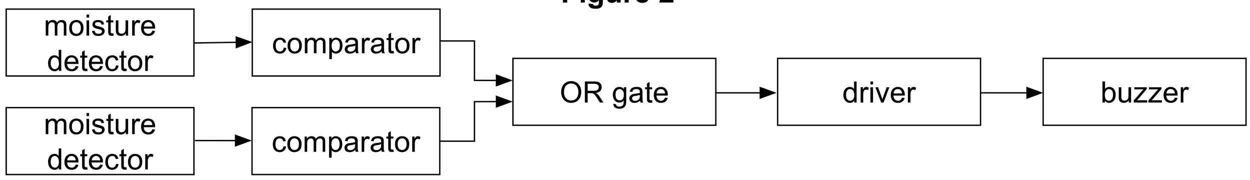
Table 1

Component symbol	Letter	Component symbol	Letter
	....		....
	....		....
	....		....
	....		....
	....		....

10

3 A student designs a warning alarm to detect moisture on the walls of an art gallery. The system diagram for her design is shown in **Figure 2**. There are two moisture detectors on different walls of the gallery.

Figure 2



3 (a) Complete **Table 2** by writing the name of a subsystem from **Figure 2** which performs the function given.

[4 marks]

Table 2

Function	**Name of subsystem**
Input	
Output	
Analogue to digital converter	
Logic operation	

3 (b) Name the subsystem in **Figure 2** which uses a small current to control a larger current.

[1 mark]

....

3 (c) Name a subsystem in **Figure 2** in which you would expect to find:

3 (c) (i) an op-amp...

[1 mark]

3 (c) (ii) a MOSFET. ....

[1 mark]

3 (d) When moisture is detected on a wall the output of a comparator becomes logic 1. Describe what happens in the rest of the circuit.

[3 marks]

....

....

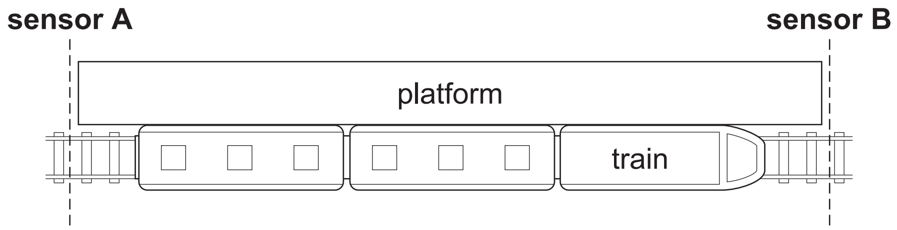
....

10

4 In a railway station, sensors at each end of the platform detect whether a train is too long for the platform or if it is not stopped in the right place.
Each sensor produces a high (1) output if a train is in front of it and a low (0) if not.

Figure 3 shows the output of **sensor A** and **sensor B** when a train is stopped at the platform between the sensors.

Figure 3



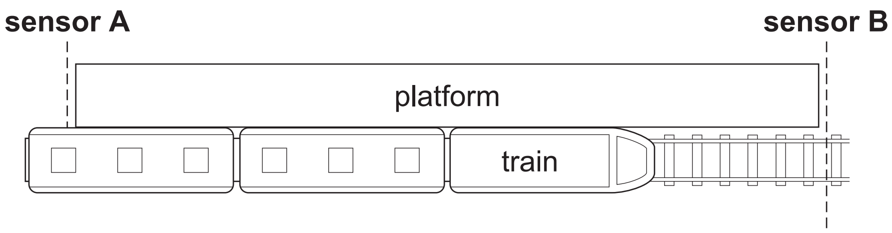
Sensor A	Sensor B
0	0

4 (a) **Figures 4**, **5** and **6** show different situations at the railway station.

4 (a) (i) Write the logic state for each of the sensors in **Figure 4**.

[1 mark]

Figure 4

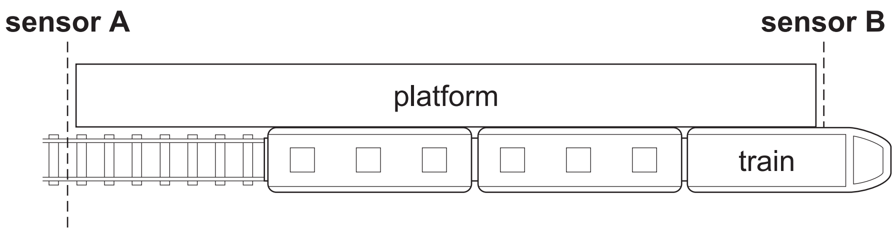


Sensor A	Sensor B

4 (a) (ii) Write the logic state for each of the sensors in **Figure 5**.

[1 mark]

Figure 5



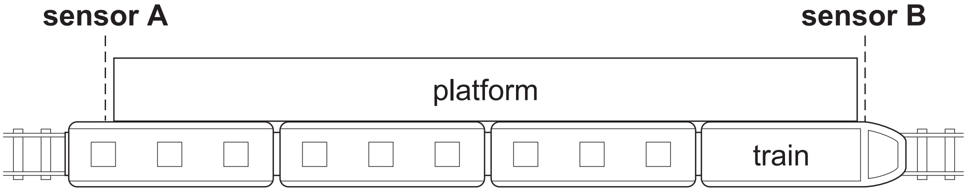
Sensor A	Sensor B

Do not write outside the box

4 (a) (iii) Write the logic state for each of the sensors in **Figure 6**.

[1 mark]

Figure 6



Sensor A	Sensor B

4 (b) The sensors are connected to a logic system.
An alarm sounds if a train is too long for the platform or does not stop in the right place.
A high output (1) is needed to sound the alarm.

4 (b) (i) Complete the truth table (**Table 3**) for the logic system of the alarm.

[2 marks]

Table 3

Sensor A	Sensor B	Output
0	0	
0	1	
1	0	
1	1	

4 (b) (ii) Name the single logic gate which would perform this logic function.

[1 mark]

....

4 (b) (iii) Draw the symbol for the logic gate you have named and label its inputs and output.

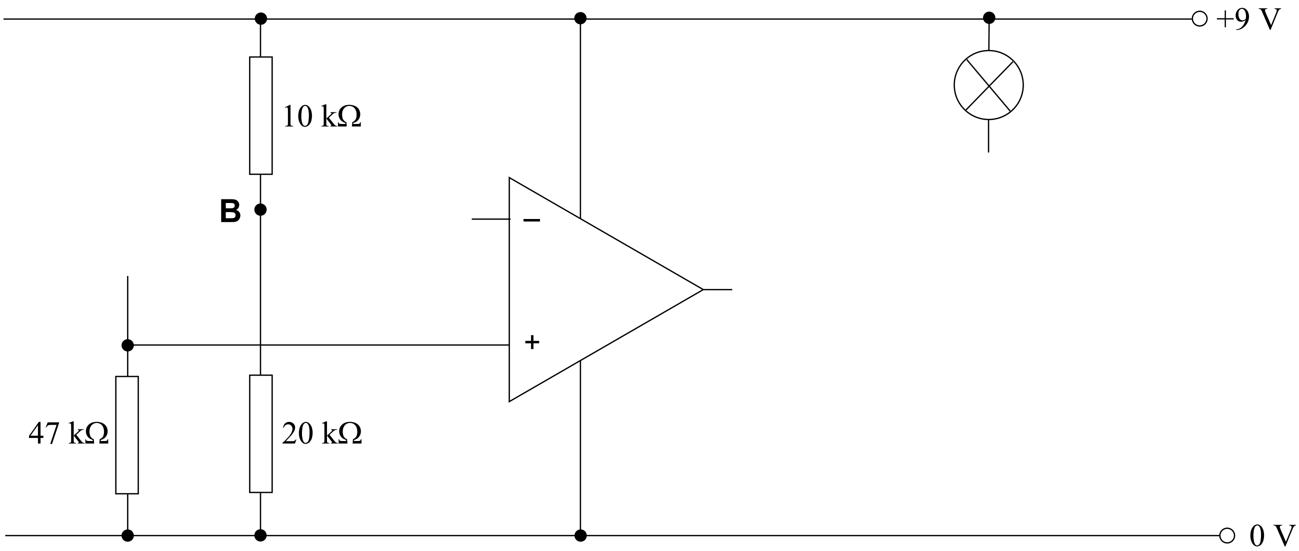
[3 marks]

9

Do not write outside the box

5 An engineer builds a circuit to light a lamp if an engine becomes too hot.
Figure 7 shows part of the circuit.

Figure 7



5 (a) Complete the circuit in **Figure 7** by adding:

- a thermistor
- a connection to the inverting input of the op-amp
- an npn transistor and protective resistor - the transistor should turn on the lamp if the output of the op-amp is high.

[7 marks]

5 (b) Calculate the voltage at point **B**.

[2 marks]

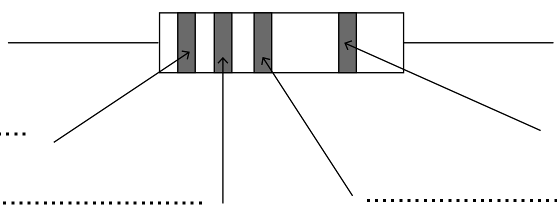
....

....

5 (c) The 47 kΩ (47 000 Ω) resistor in this circuit has a tolerance of ±5%.
Label the colour of its bands in **Figure 8**.

[4 marks]

Figure 8



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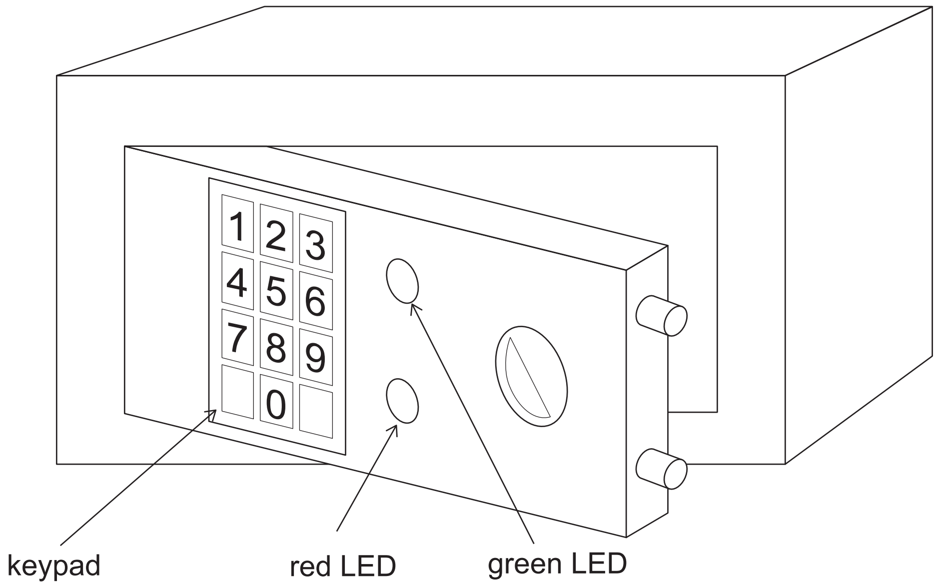
13

6 **Figure 9** shows a safe.
A code to open the safe is entered on the keypad.

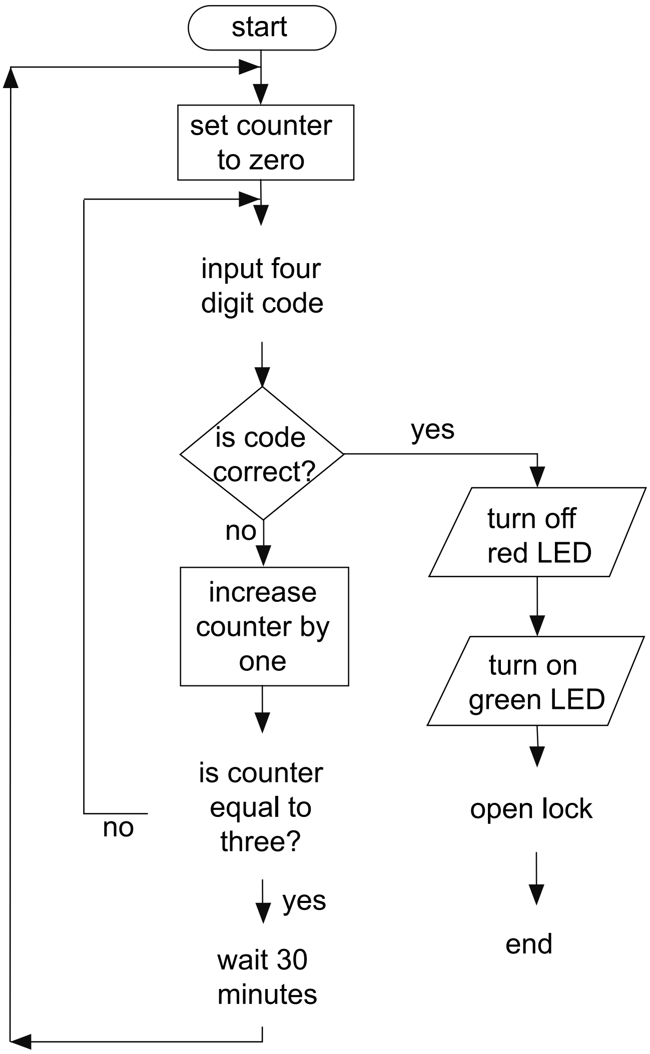
Figure 9



Question 6 continues on the next page

The flowchart which describes the opening process for the safe is shown in **Figure 10**.

Figure 10



6 (a) Draw the correct symbols at **five** places where they are missing on **Figure 10**.

[5 marks]

6 (b) Label on **Figure 10**:

a decision box an input box a loop an output box a process box

[5 marks]

6 (c) Explain what happens if the wrong code is entered three times.

[2 marks]

....

....

Do not write outside the box

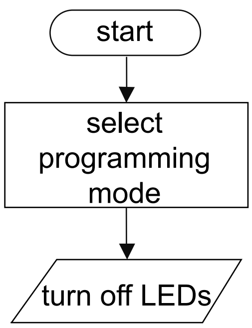
6 (d) The user can program the safe to use a new code.

- When the programming mode is selected both LEDs are turned off.
- The user inputs the new four-digit code.
- The red LED lights up.
- The user then inputs the new four-digit code again.
- The codes are compared.
    - If the codes are the same, the red LED goes out and the green LED lights up. The new code is stored in the system and programming is complete.
    - If the codes are different, the red LED flashes and the user must input the new four-digit code again.

Complete **Figure 11** for programming the safe with a new code.

[8 marks]

Figure 11



20

7 A student decides to build an audio amplifier to drive a small loudspeaker.

7 (a) Draw a circle around the name of the integrated circuit which would be the most suitable as the basis of the amplifier.

[1 mark]

4017 555 LM386 4013

7 (b) Draw a circle around the power value which would be the typical output of the audio amplifier referred to in part **(a)**.

[1 mark]

5 mW 1 W 25 W 100 W 300 W

7 (c) Draw a circle around the frequency range which is most suitable for an audio amplifier.

[1 mark]

20 Hz–100 Hz 10 Hz–500 Hz 25 Hz–1 kHz 30 Hz–15 kHz

7 (d) Calculate the voltage gain of the amplifier if an input of 150 mV rms gives an output of 3 V rms.

[2 marks]

....

....

7 (e) Calculate the peak value of the 3 V rms output signal.

[2 marks]

....

....

7 (f) A loudspeaker with a resistance of 8 Ω is connected to the amplifier output. Calculate the rms current that will pass through the loudspeaker when the output is 3 V rms.

[3 marks]

....

....

....

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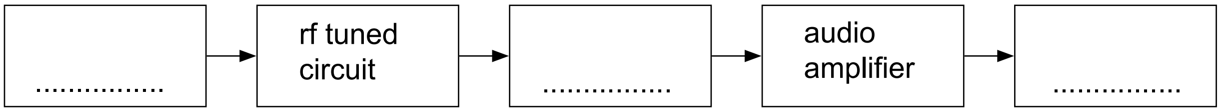
7 (g) The audio amplifier is one of the five subsystems in a simple radio receiver system.
Write the name for each of the **three** missing subsystems in **Figure 12.**

[3 marks]

Figure 12



7 (h) Radios can receive an amplitude modulated (AM) signal or a frequency modulated (FM) signal.
State **one** advantage of frequency modulation.

[1 mark]

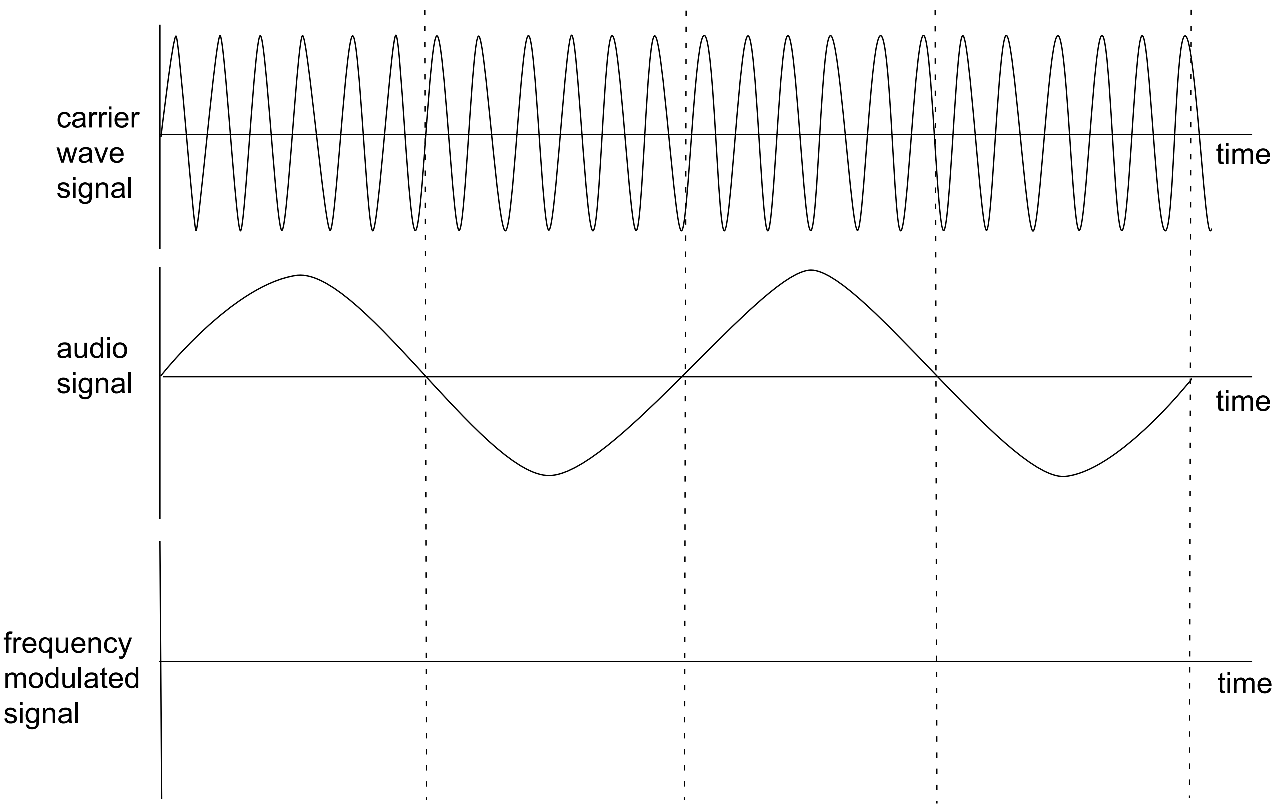
....

....

7 (i) Complete **Figure 13** to show the frequency modulated signal produced by combining the carrier wave signal and the audio signal.

[3 marks]

Figure 13



17

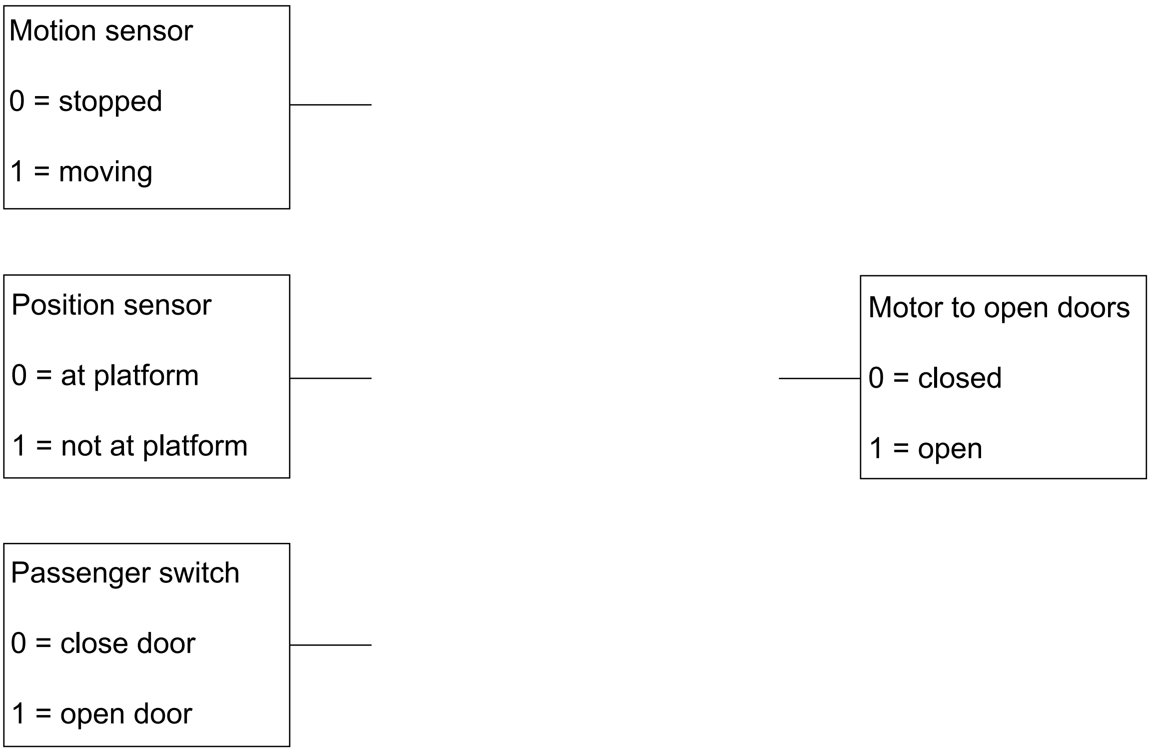
8 The doors on a train can only be opened if the train is stopped at a platform and a passenger presses a switch.

8 (a) **Figure 14** shows part of a logic diagram for the door control system.

Draw on **Figure 14** how the system is connected using only NOT and AND gates.

[4 marks]

Figure 14



8 (b) The system in part **(a)** could also be made using NOR gates.

8 (b) (i) **Table 4** is an incomplete truth table for a NOR gate.

Complete the **three** blank cells in **Table 4**.

[2 marks]

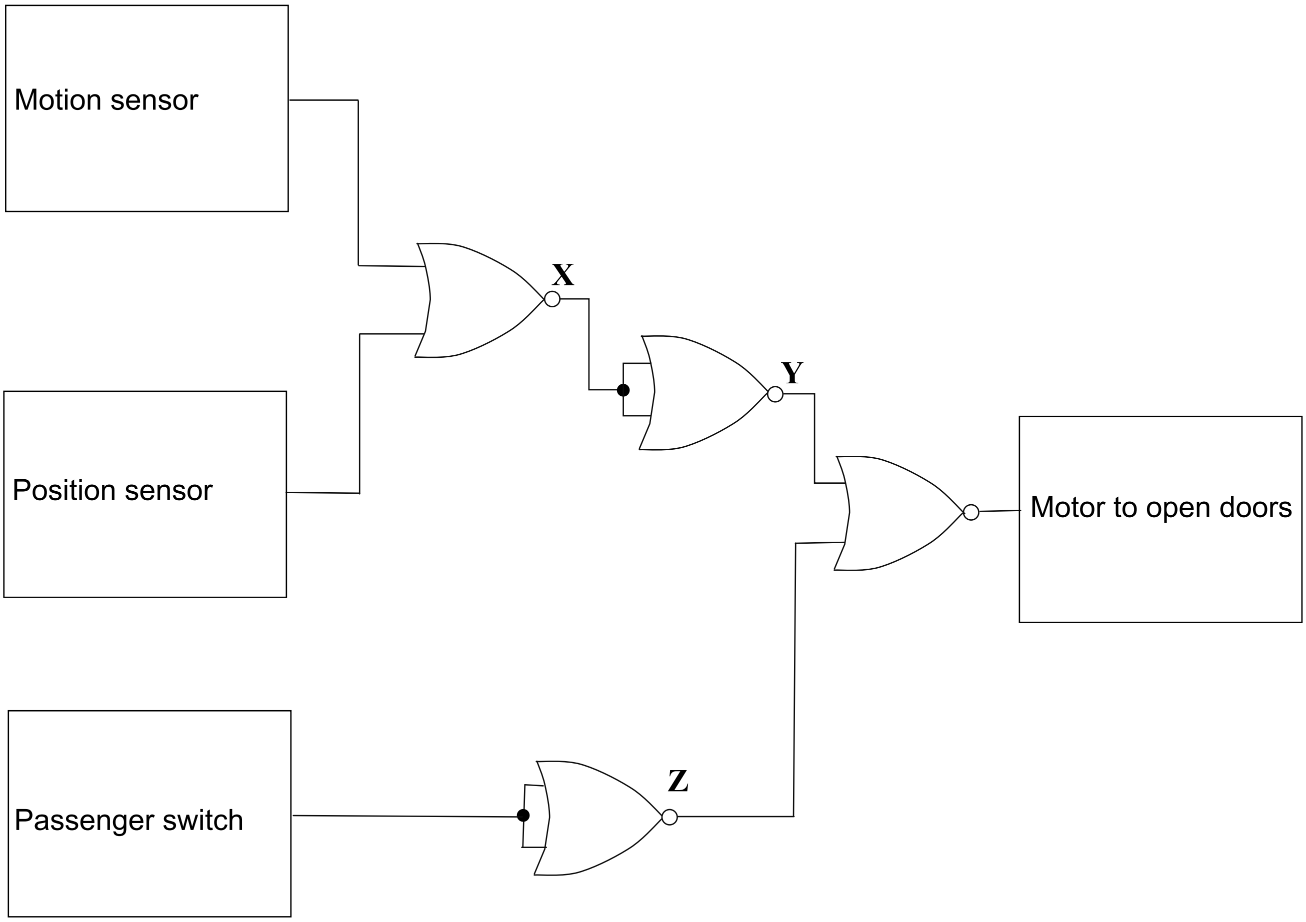
Table 4

A	B	Q
0	0	
0	1	0
1	0	0
		0

Do not write outside the box

8 (b) (ii) **Figure 15** shows the system in part **(a)** made using NOR gates.

Figure 15



Complete the truth table (**Table 5**) for the NOR gate system in **Figure 15**.

[4 marks]

Table 5

Motion sensor	Position sensor	Passenger switch	X	Y	Z	Motor to open doors
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

10

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

9 (a) **Figure 16** shows a D-type flip-flop.
Four inputs are labelled with the abbreviations S, R, D and CK.
Write the correct full names of the four inputs in **Table 6**.

[2 marks]

Figure 16

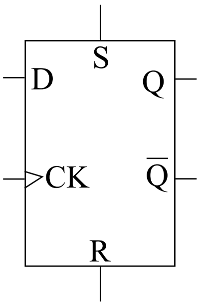
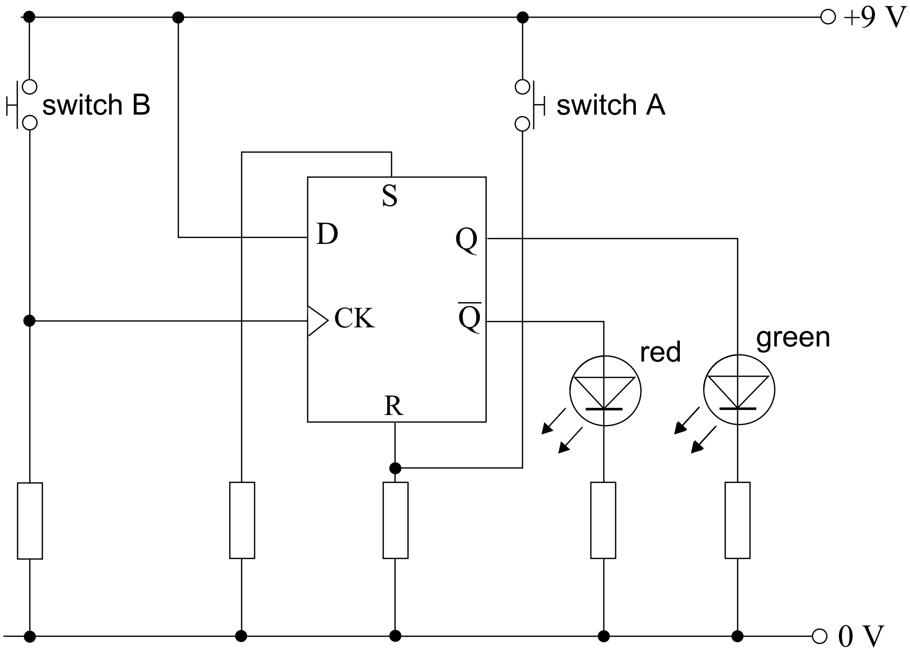


Table 6

Abbreviation	Full name
S	
R	
D	
CK	

9 (b) A student investigates a D-type flip-flop so that he can use it in his project.
Figure 17 shows the circuit he uses.

Figure 17



Write either **on** or **off** to describe the state of the red and green LEDs in the situations given in **Table 7**.

[2 marks]

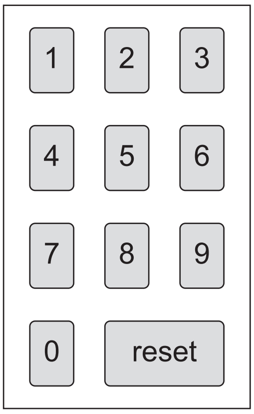
Table 7

Situation	Red LED	Green LED
Switch A has been pressed and released		
Switch B has been pressed and released		

Turn over ▸

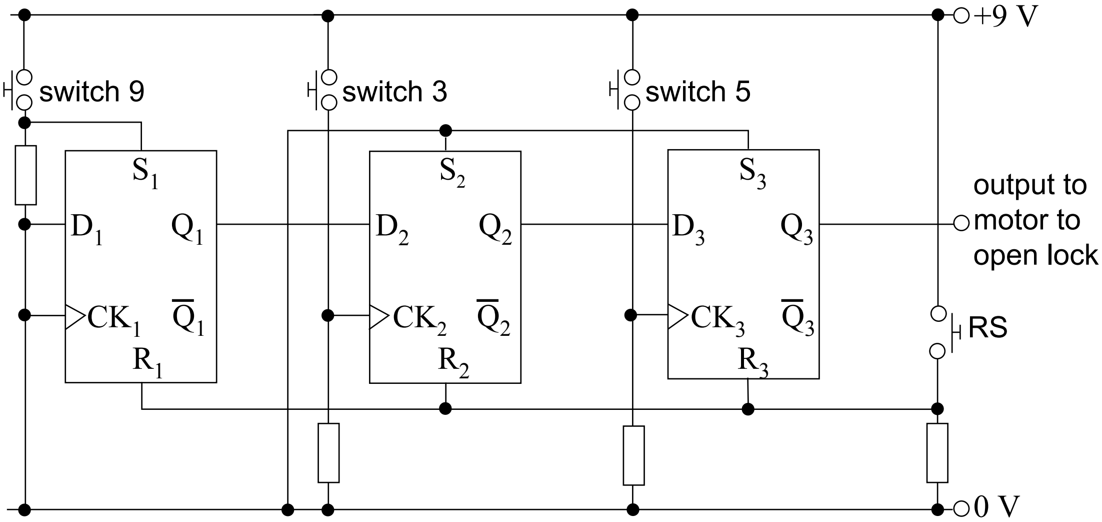
9 (c) The student decides to use flip-flops in his project to make a combination lock. The lock is operated by a keypad which consists of 11 switches labelled from 0 to 9 and reset as shown in **Figure 18**.

Figure 18



He decides the code will be 9 3 5 and these three switches are connected in the circuit shown in **Figure 19**. The other switches are not connected.

Figure 19



The reset switch (RS) is pressed and released.
Table 8 shows the states of some of the inputs and outputs of the flip-flops.

Table 8

D_1	Q_1	D_2	Q_2	D_3	Q_3
0	0	0	0	0	0

Do not write outside the box

9 (c) (i) Switch 9 is now pressed and released.

Complete **Table 9** to show the states of the inputs and outputs.

[2 marks]

Table 9

D_1	Q_1	D_2	Q_2	D_3	Q_3
0				0	

9 (c) (ii) Switch 3 is now pressed and released.

Complete **Table 10** to show the states of the inputs and outputs.

[2 marks]

Table 10

D_1	Q_1	D_2	Q_2	D_3	Q_3
	1	1			

9 (c) (iii) Switch 5 is now pressed and released.

Complete **Table 11** to show the states of the inputs and outputs.

[2 marks]

Table 11

D_1	Q_1	D_2	Q_2	D_3	Q_3
	1	1			

9 (c) (iv) Complete **Table 12** to indicate which combinations would open the lock after pressing reset.

[2 marks]

Table 12

Combination	Does the lock open?
9 3 5	yes
8 7 6	no
9 8 3 5	
9 9 3 5	

Question 9 continues on the next page

Do not write outside the box

9 (d) A better combination lock could be built using a microcontroller.

Explain the advantages of using a microcontroller.

You should write about:

- the number of components
- the complexity of the wiring
- the ease of changing the combination.

Answer the question in continuous prose.

The quality of written communication will be assessed in your answer.

[5 marks]

....

....

....

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....

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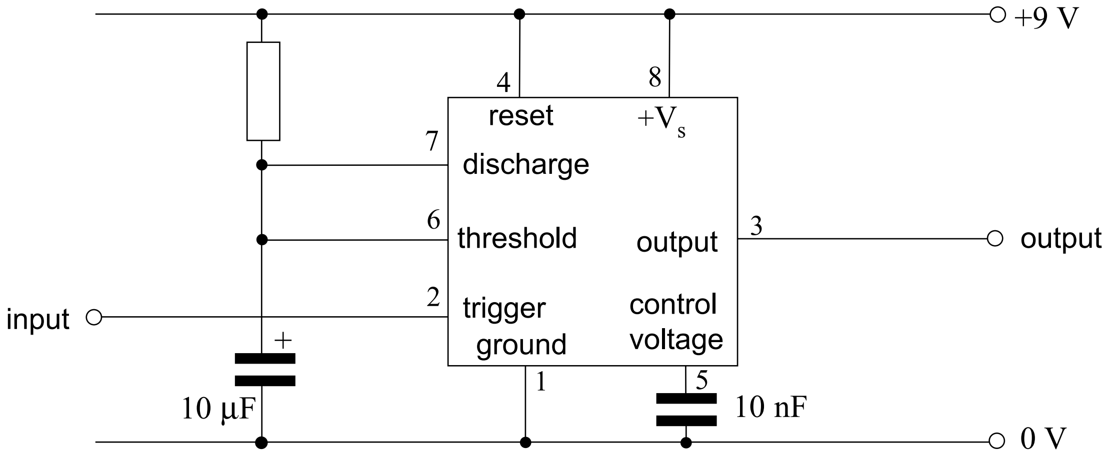
....

9 (e) The student considers adding a time delay to his lock.
Figure 20 shows the monostable circuit he decides to use.
Pin numbers 1–8 are given.

Figure 20

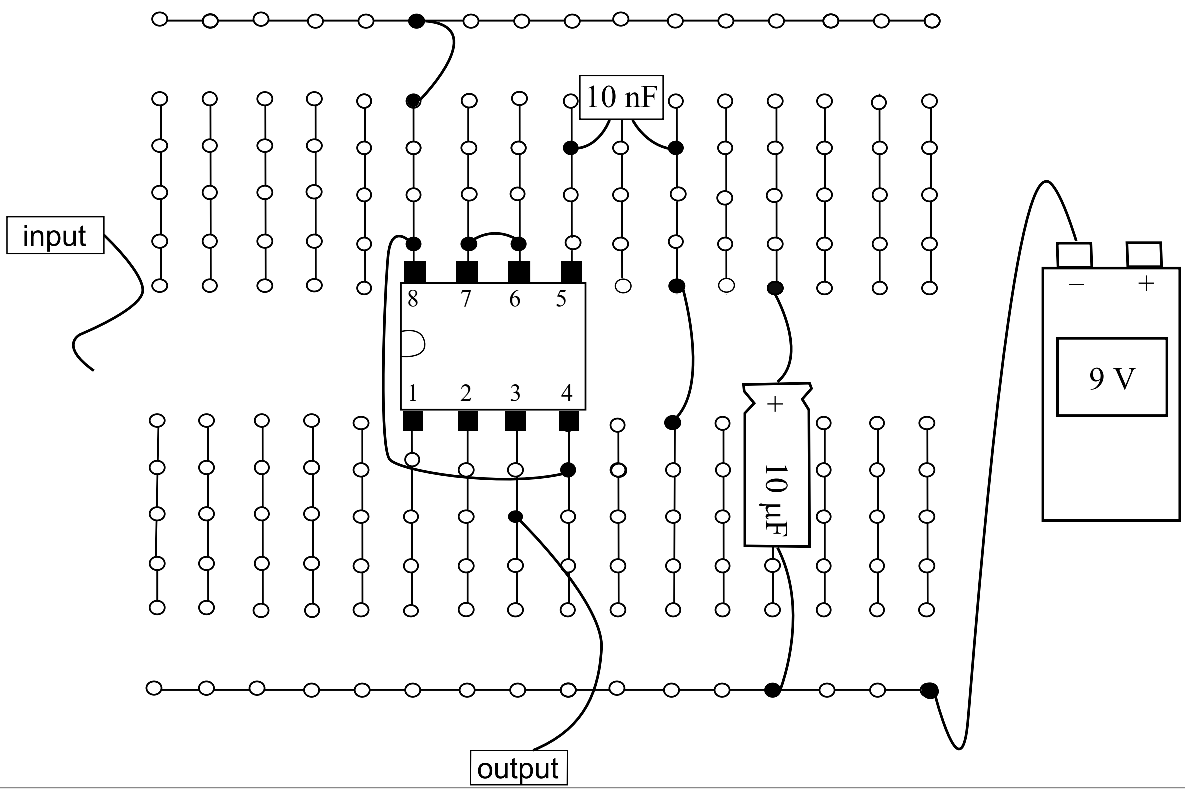


Complete **Figure 21** to show how this circuit could be completed on a prototyping board.

- Add a resistor.
- Complete the connection to the input.
- Draw the other connection to the battery.
- Draw **three** wire links.

[6 marks]

Figure 21



23

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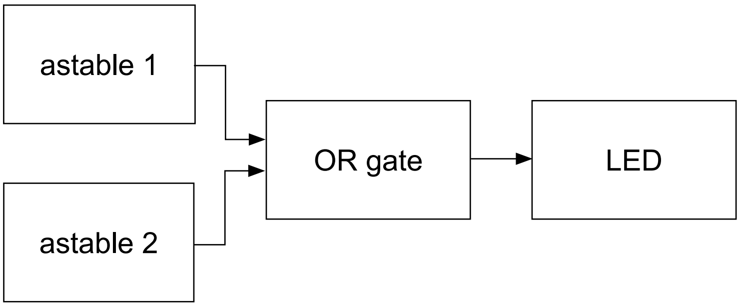
10 A student wants to make an LED flicker like a candle flame instead of being on all the time.
Figure 22 shows the system he tries.

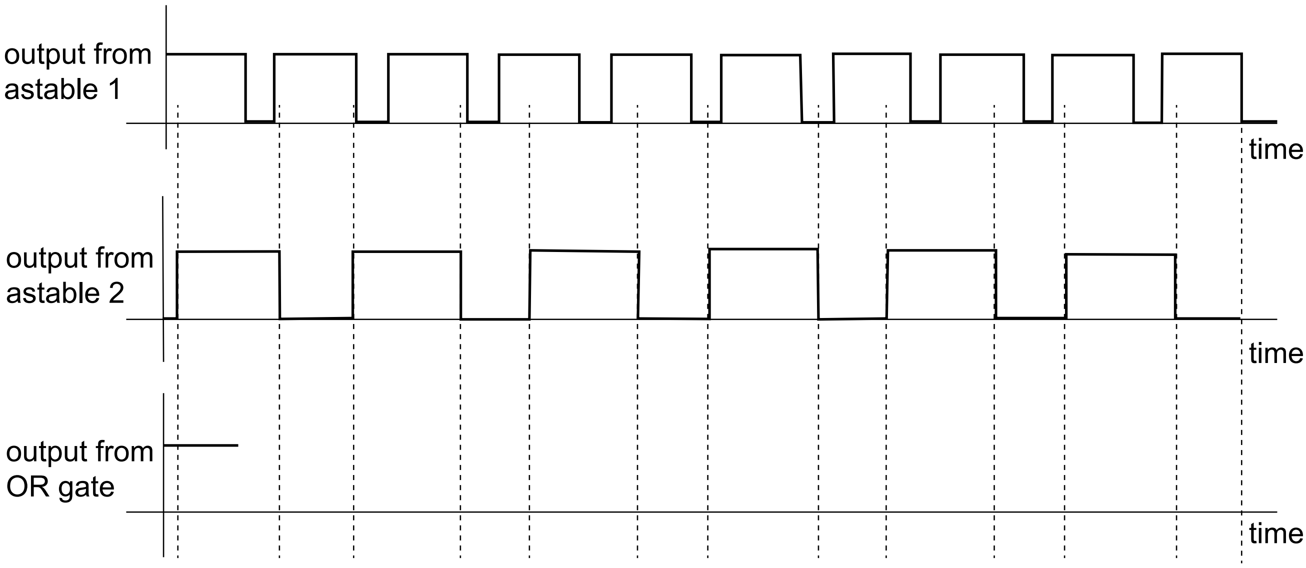
Figure 22



10 (a) Complete **Figure 23** for the output from the OR gate.

[4 marks]

Figure 23

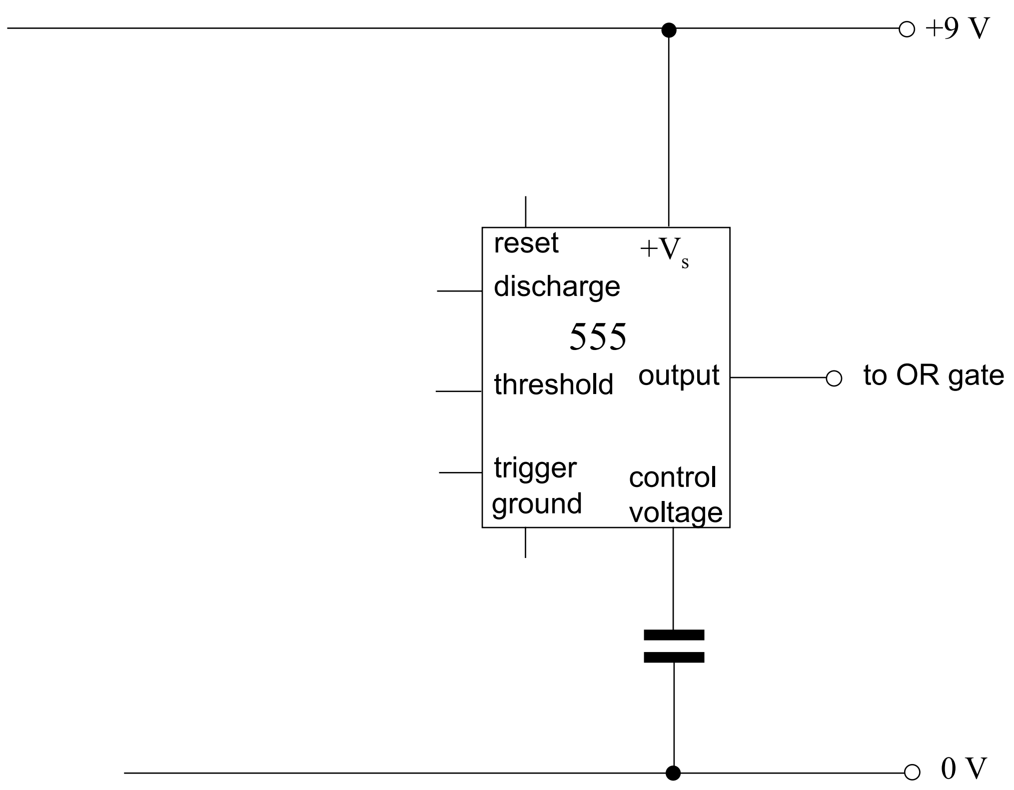


10 (b) Astable 1 is constructed using a 555 timer.

Complete **Figure 24** for the 555 astable.

[6 marks]

Figure 24

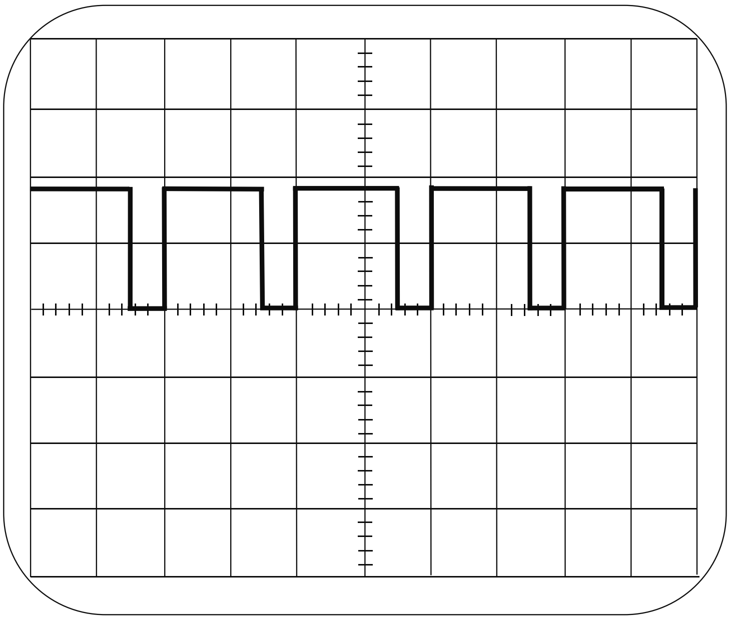


Question 10 continues on the next page

10 (c) The output of astable 1 is connected to an oscilloscope.
Figure 25 shows the trace produced.

The y-sensitivity is set to 5 V per division.
The timebase is set to 200 ms (0.2 s) per division.

Figure 25



10 (c) (i) Use the trace to calculate the time when an output pulse is high.

[2 marks]

....

....

10 (c) (ii) Use the trace to calculate the time period of the astable.

[2 marks]

....

....

10 (c) (iii) Calculate the frequency of the pulses.

[2 marks]

....

....

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10 (c) (iv) Use the trace to calculate the maximum voltage of the pulses.

[2 marks]

....

....

10 (d) Astable 2 has the following values for its timing components:

$R_1 = 30\ \text{k}\Omega$, $R_2 = 30\ \text{k}\Omega$ and $C_1 = 10\ \mu\text{F}$

Calculate the time period of these pulses.

[3 marks]

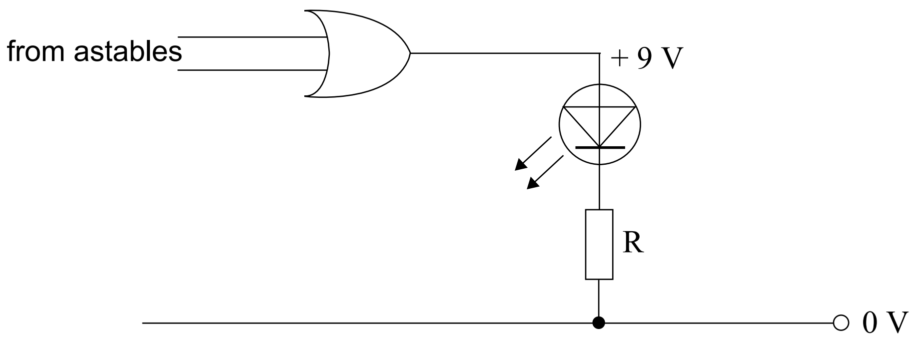
....

....

....

10 (e) **Figure 26** shows an LED with its protective resistor (R) connected to the output of an OR gate.
The OR gate output is + 9 V.

Figure 26



When the LED is lit, the voltage across it is 2.4 V and the current through it is 5 mA.

10 (e) (i) Calculate the voltage across R.

[1 mark]

....

10 (e) (ii) Calculate the value of R.

[2 marks]

....

....

Question 10 continues on the next page

10 (f) **Figure 27** shows a different system tested by the student to make an LED flicker like a candle flame.

Figure 27

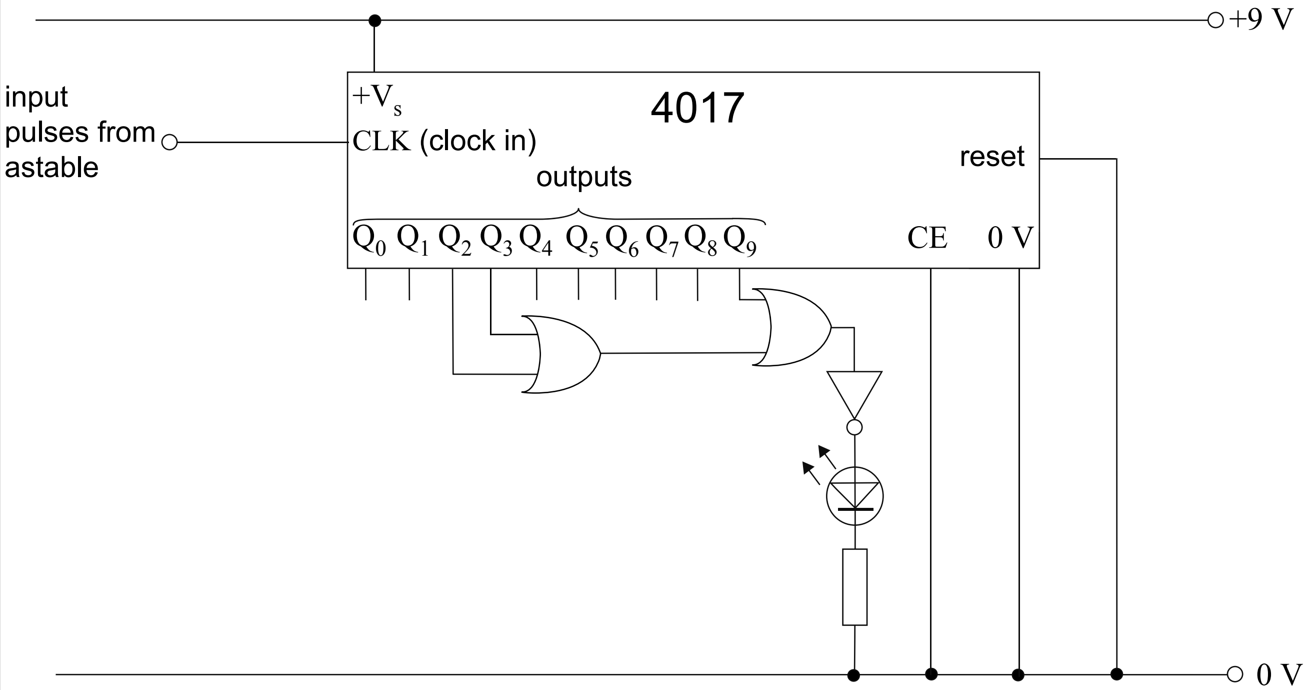
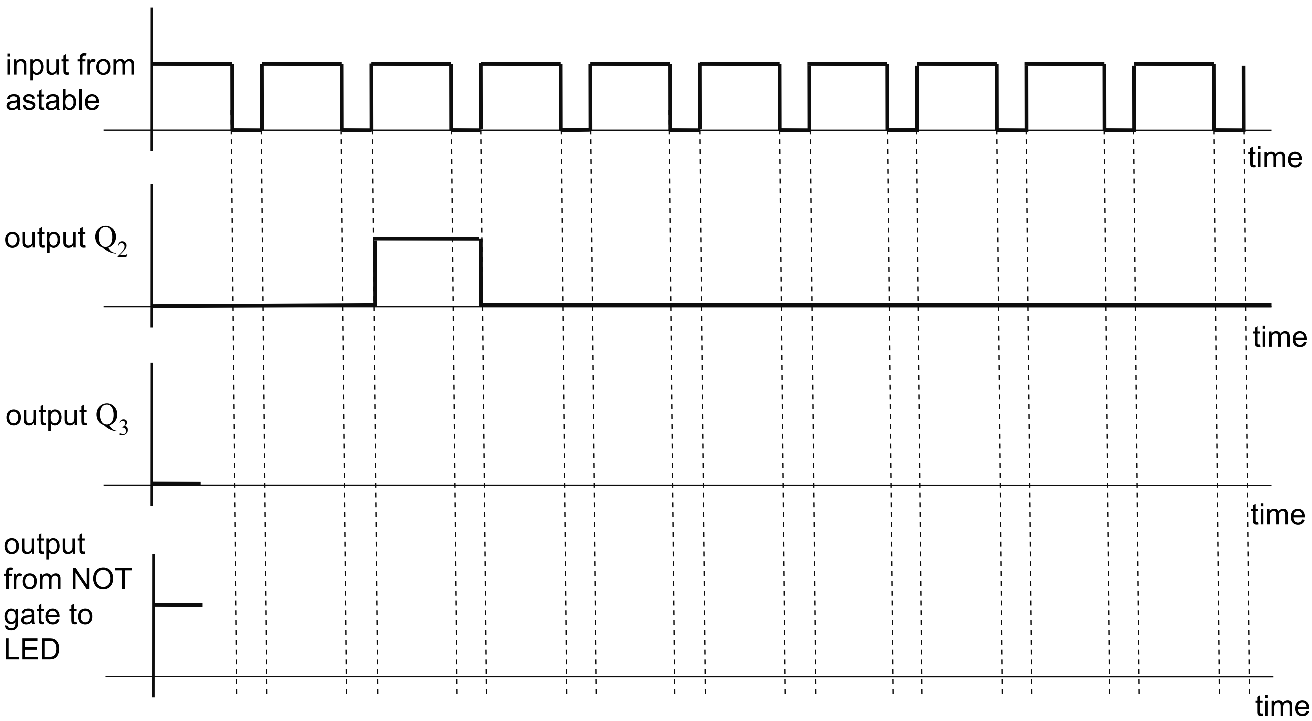


Figure 28 shows the input to the 4017 counter and the output from Q_2.
Complete **Figure 28** for output Q_3 and the output from the NOT gate to the LED.

[4 marks]

Figure 28



END OF QUESTIONS

28

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