Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

AQA

General Certificate of Secondary Education
June 2014

Electronics 44301

Unit 1 Written Paper

Thursday 5 June 2014 1.30 pm to 3.30 pm

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 and other information, which you may wish to use in your answers, is provided on page 2.
- 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 $\pm$ 5% SILVER $\pm$ 10%

Resistor printed code (BS 1852)

R means $\times$ 1 K means $\times$ 1000 M means $\times$ 1 000 000

Position of the letter gives the decimal point.

Tolerances are indicated by adding a letter at the end.

J $\pm$ 5% K $\pm$ 10% M $\pm$ 20%

e.g. 5K6J = 5.6 kΩ $\pm$ 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 $\times$ 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 = $\frac{1}{\text{Period}}$ $f = \frac{1}{T}$

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

1 (a) Write **two** safety rules that should be followed in an electronics laboratory or workshop. Give a reason for each rule.

[4 marks]

rule 1 .....

.....

reason .....

.....

rule 2 .....

.....

reason .....

.....

1 (b) A mains power supply unit contains an isolating step-down transformer and produces a dc output.

Explain the terms:

[3 marks]

isolating .....

.....

step-down transformer .....

.....

dc .....

.....

Question 1 continues on the next page

1 (c) The mains power supply unit has a mains fuse on its input, and a circuit breaker on its output.

[3 marks]

In which mains wire should the fuse be placed?.....

Explain how a fuse works.

.....

.....

State **one** difference between a fuse and a circuit breaker.

.....

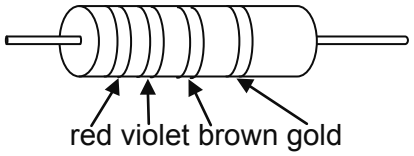
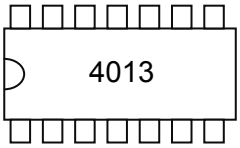
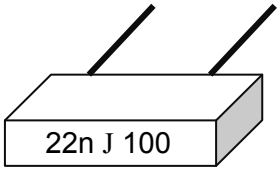
.....

10

2 For each component shown in the first column of **Table 1**, write its name in the second column and decode the markings on it in the third column. The number of dotted lines in each box indicates how much information is expected in each case.

[10 marks]

Table 1

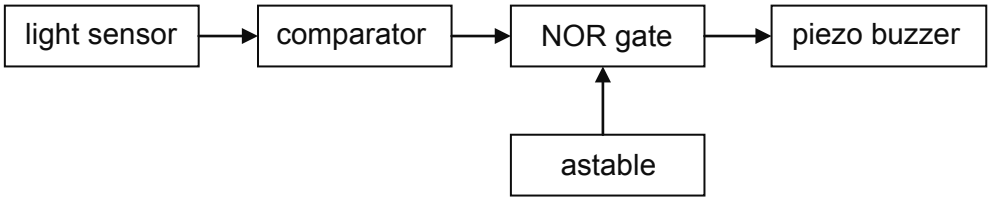
Component	Name	Markings
	.....	....
	.....	....
	.....	....

10

Turn over for the next question

3 A light level alarm is shown in the system diagram in **Figure 1**. It is to be used by a cricket umpire to decide if the light level falls below a set level. If it does, it will sound an audible alarm in the form of on-off bleeps.

Figure 1



3 (a) Which subsystem represents

[5 marks]

an input .....

an output .....

a pulse generator .....

a logic subsystem .....

an analogue to digital converter? .....

3 (b) In which subsystem would you expect to find

[5 marks]

an LDR .....

an op-amp .....

a 555 IC .....

a voltage divider to provide a reference voltage

.....

a control to vary the frequency of the input signal to the piezo buzzer?

.....

10

4 A seat belt system in a car flashes an icon on the dashboard and sounds an alarm if a person sitting on a front seat of a moving car has not fastened their belt.

When the car is moving, a movement sensor gives a logic 1.
When a person sits on a seat, a pressure sensor gives a logic 1.
When the belt is fastened, a belt sensor gives a logic 1.
The alarm sounds when it receives a logic 1.

4 (a) Complete the truth table (**Table 2**) to show when the alarm should be triggered.

[5 marks]

Table 2

Movement sensor	Pressure sensor	Belt sensor	Alarm
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

4 (b) The logic system required uses a NOT gate and **two** AND gates.
Draw the **three** gates on **Figure 2** and connect them to work as required.

[5 marks]

Figure 2

10

Turn over ▸

5 **Figure 3** shows an LED and a resistor connected to operate from a $9\ \mathrm{V}$ battery.

Figure 3

5 (a) (i) The battery has positive and negative terminals.
Label the ends of the circuit in **Figure 3** to show the correct battery connections.

[1 mark]

5 (a) (ii) Complete the sentence below about this circuit.

[1 mark]

The resistor and LED are connected in .....

5 (b) The forward voltage drop of the LED is $2.2\ \mathrm{V}$ when a maximum current of $20\ \mathrm{mA}$ flows through it.

5 (b) (i) Calculate the voltage across the resistor when the $9\ \mathrm{V}$ battery is connected.

[1 mark]

.....

5 (b) (ii) Calculate the required value of the resistor.

[2 marks]

.....

.....

5 (b) (iii) Resistors of the value calculated in part **(b) (ii)** are not available as it is not a preferred value. The two closest values from the E24 series are $330\ \Omega$ and $360\ \Omega$.
State which of these values should be used and give a reason for your answer.

[2 marks]

value .....

reason .....

5 (b) (iv) It is suggested that the exact value of the resistor in part **(b) (ii)** could be made using a combination of a $220\ \Omega$ resistor and which other E24 series value?

[1 mark]

.....

5 (b) (v) Another suggestion is to use two $680\ \Omega$ resistors for this instead.
How should these be connected to give the required value?
Show by calculation that this gives the correct resistance.

[2 marks]

connection .....

calculation .....

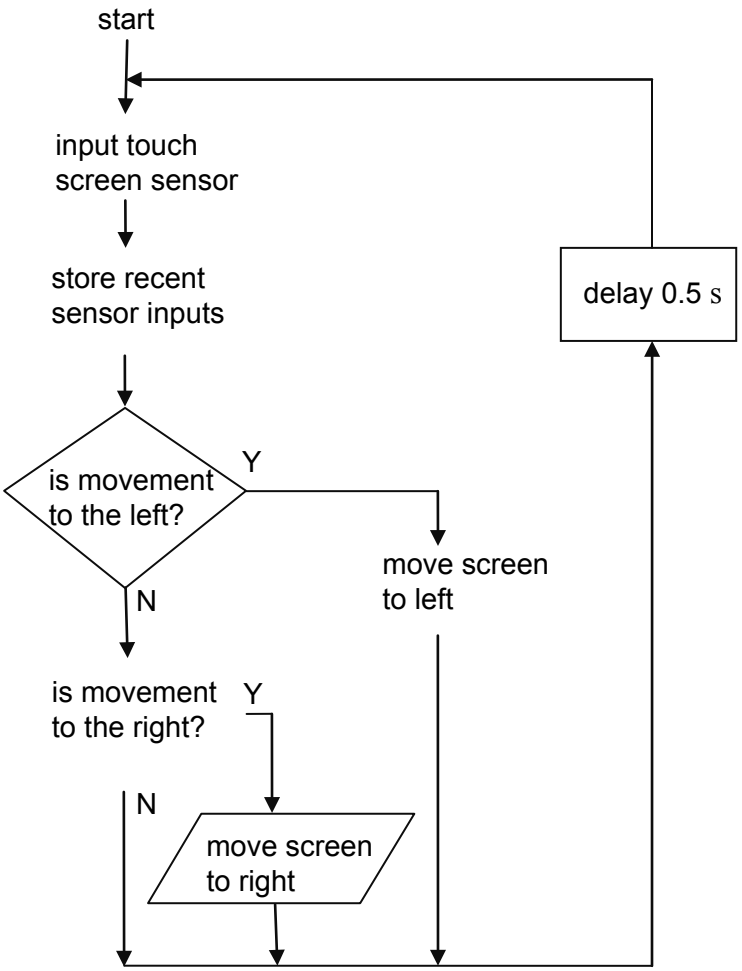
.....

10

Turn over for the next question

6 A student designs a flowchart to represent swiping a touchscreen display to the left or right on a mobile phone or tablet computer.
The flowchart is not complete and some of the symbols have been omitted, as **Figure 4** shows.

Figure 4



6 (a) Draw on **Figure 4** the correct flowchart symbols at **five** places where they are missing.
[5 marks]

6 (b) Label on **Figure 4**:

a decision box, an input box, a loop, an output box and a process box.
[5 marks]

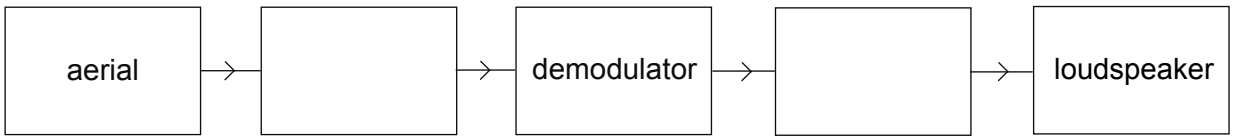
6 (c) It is also possible to increase or decrease the size of the image on a touchscreen display. To do this two fingers have to touch the screen at the same time, and then moving the fingers apart or together makes the image larger or smaller.
Design a flowchart that would represent this function in the space below.

[8 marks]

18

7 (a) **Figure 5** shows how subsystems can be connected together to make a simple radio receiver.

Figure 5



7 (a) (i) Write in the names of the **two** missing subsystems.

[2 marks]

7 (a) (ii) State the function of the aerial subsystem.

[2 marks]

.....

.....

7 (a) (iii) State the function of the demodulator subsystem.

[2 marks]

.....

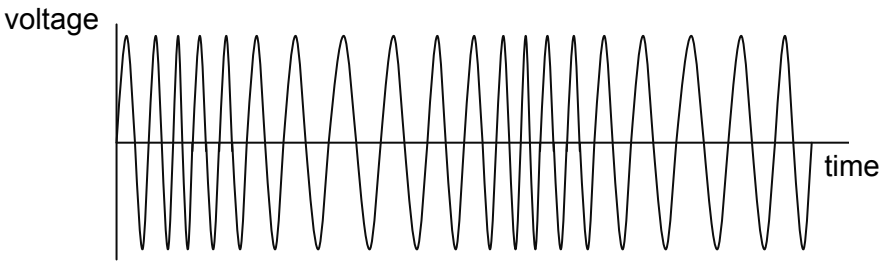
.....

7 (a) (iv) State the name of the type of modulation shown in **Figure 6**.

[1 mark]

.....

Figure 6



7 (a) (v) Draw another type of modulated signal on the axes of **Figure 7** which could be received by the simple receiver.

[2 marks]

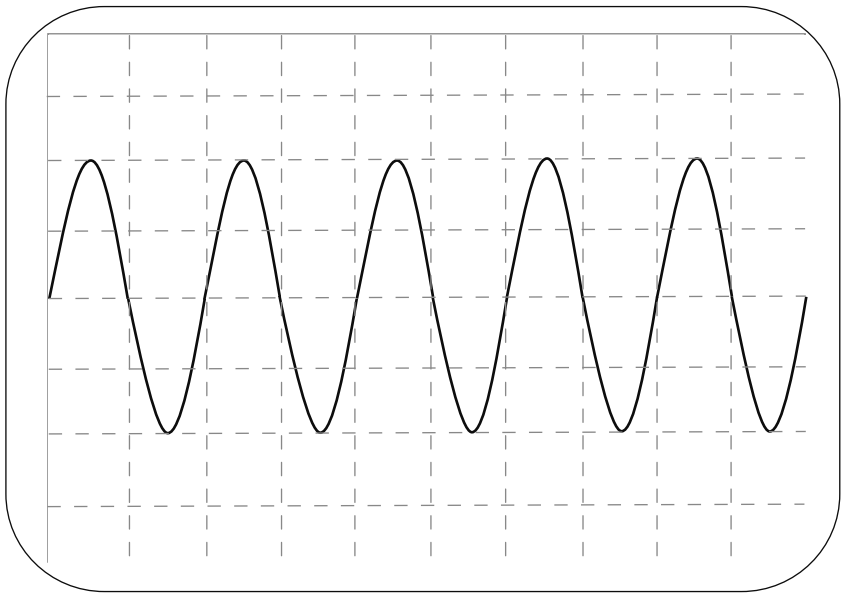
Figure 7

7 (b) An audio amplifier is being tested. **Figure 8** shows the input to the amplifier displayed on an oscilloscope and the following trace produced.

The y-sensitivity is set to 0.1 V per division.

The timebase is set to 2 ms per division.

Figure 8



7 (b) (i) Calculate the time period of the input signal.

[2 marks]

.....

.....

Question 7 continues on the next page

7 (b) (ii) Calculate the frequency of the input signal.

[3 marks]

.....

.....

7 (b) (iii) Calculate the peak voltage of the input signal.

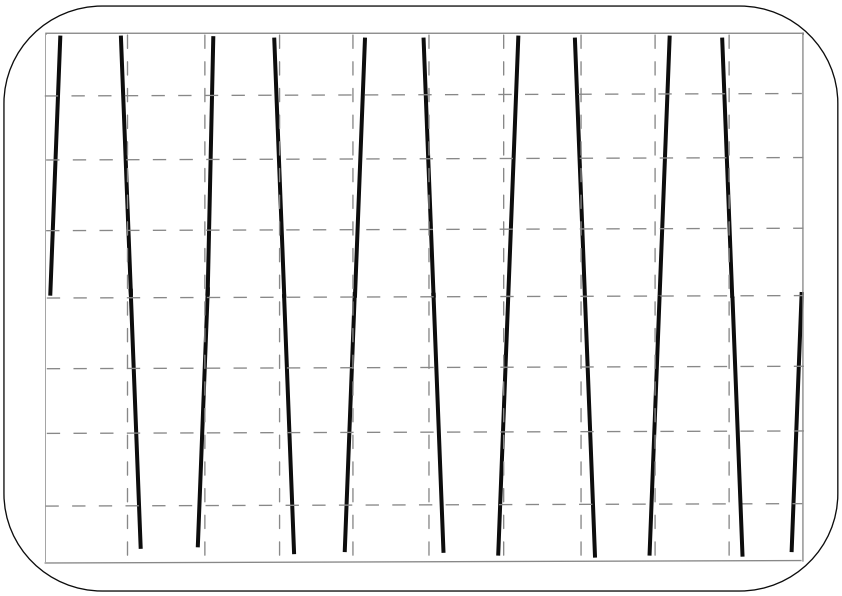
[1 mark]

.....

.....

7 (c) When the output of the amplifier is connected to the oscilloscope the trace in **Figure 9** is obtained.

Figure 9



Which control on the oscilloscope should be adjusted so that the top and bottom of the signal can be seen?

[1 mark]

.....

7 (d) When the peak voltage of a different input signal is 0.5 V the peak voltage of the output from the amplifier is 10 V.

7 (d) (i) Calculate the voltage gain of the amplifier.

[2 marks]

.....

.....

7 (d) (ii) Calculate the rms value of this voltage when the output has a peak value of 10 V.

[2 marks]

.....

.....

7 (d) (iii) The amplifier has a bandwidth of 10 kHz.
Explain what is meant by the term **bandwidth**.

[2 marks]

.....

.....

22

Turn over for the next question

8 The basement of a house sometimes floods. The householder has designed a control circuit for a pump which will automatically pump the flood water out.
The water is detected by two metal probes connected to a comparator circuit.

8 (a) The comparator circuit uses an op-amp.

Compare the output resistance of an op-amp with its input resistance.

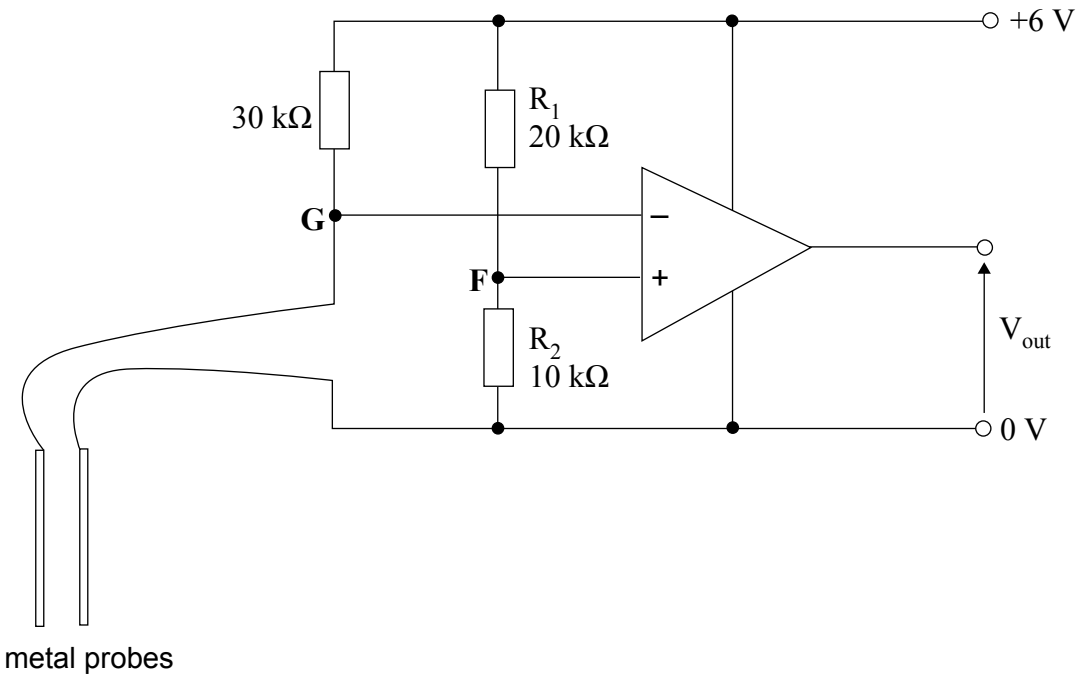
[2 marks]

.....

.....

8 (b) **Figure 10** shows the comparator circuit to control the pump.

Figure 10



8 (b) (i) Calculate the voltage at point **F** in the circuit.

[3 marks]

.....

.....

8 (b) (ii) Estimate the value of the output voltage V_{out} when the voltage at **G** is **less** than the voltage at **F**.

[1 mark]

.....

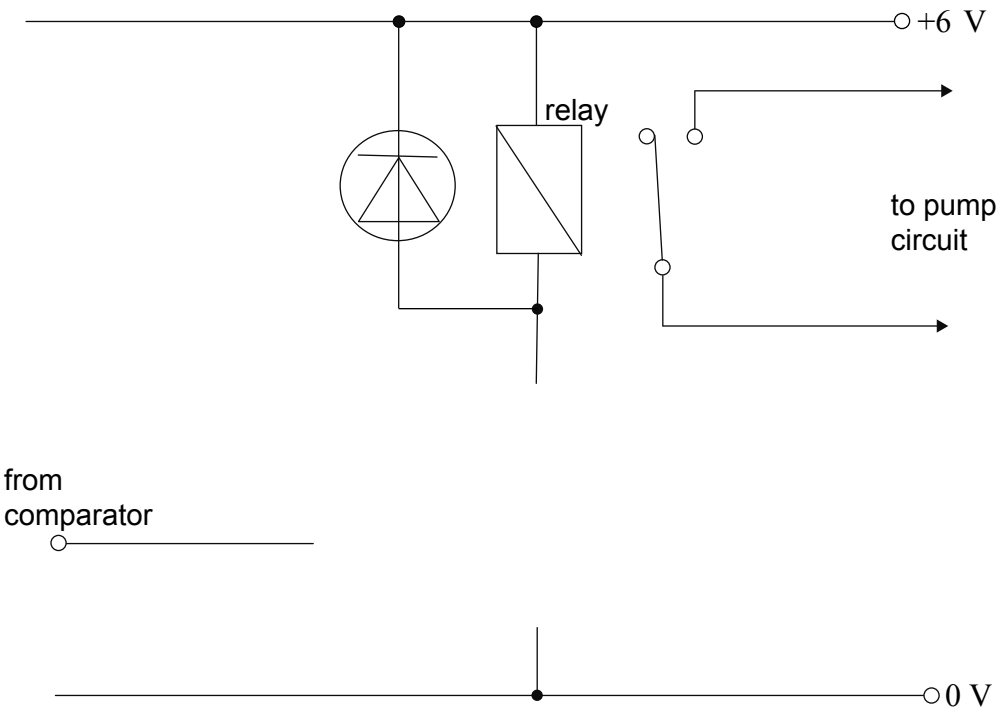
8 (b) (iii) Estimate the value of the output voltage V_{out} when the voltage at **G** is **greater** than the voltage at **F**.

[1 mark]

.....

8 (c) The output of the comparator is connected to a MOSFET which is being used to control a relay, as in **Figure 11**.

Figure 11



8 (c) (i) Add to **Figure 11** the symbol for a MOSFET connected so that it will control the relay. Label the **three** connections of the MOSFET with their correct names.

[5 marks]

Question 8 continues on the next page

8 (c) (ii) Explain why the diode shown in **Figure 11** is needed by stating what it protects, what causes the risk to the component and how the diode provides protection.
Answer the question in continuous prose.

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

[5 marks]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

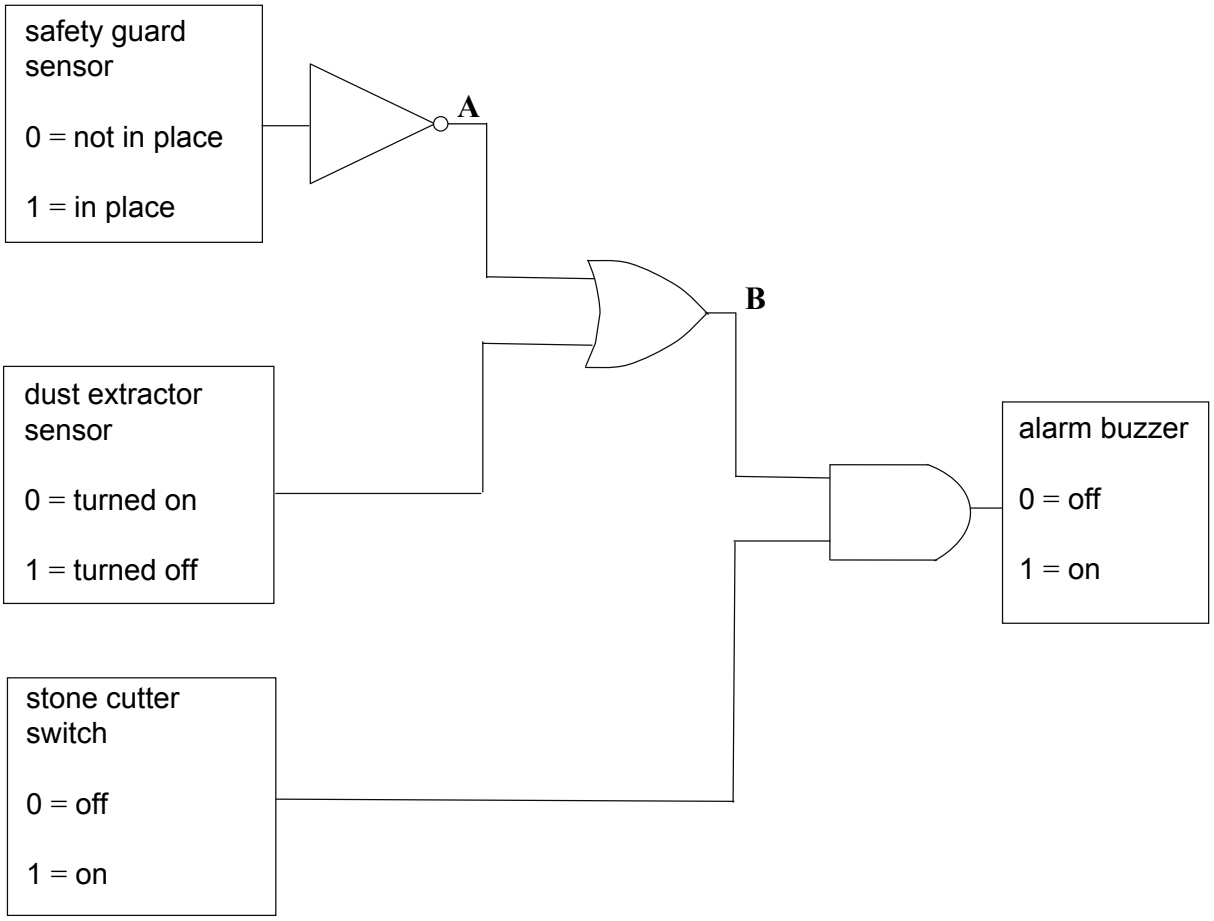
17

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

9 (a) In a workshop an electric stone cutter has a safety system. There are sensors connected to the safety guard and to the dust extraction system.
A logic system is connected to the sensors and to an alarm buzzer, as **Figure 12** shows.

Figure 12



9 (a) (i) Complete the truth table (**Table 3**) for this system.

[3 marks]

Table 3

Safety guard sensor	Dust extractor sensor	Stone cutter switch	A	B	Alarm buzzer
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

9 (a) (ii) Under what conditions will the alarm buzzer sound?

[4 marks]

.....

.....

.....

9 (b) The system in part **(a)** could also be made using NOR gates.
Table 4 is an incomplete truth table for a NOR gate.

Table 4

P	Q	S
0	0	
0	1	
1	0	
1	1	

Here are the options for column **S**.

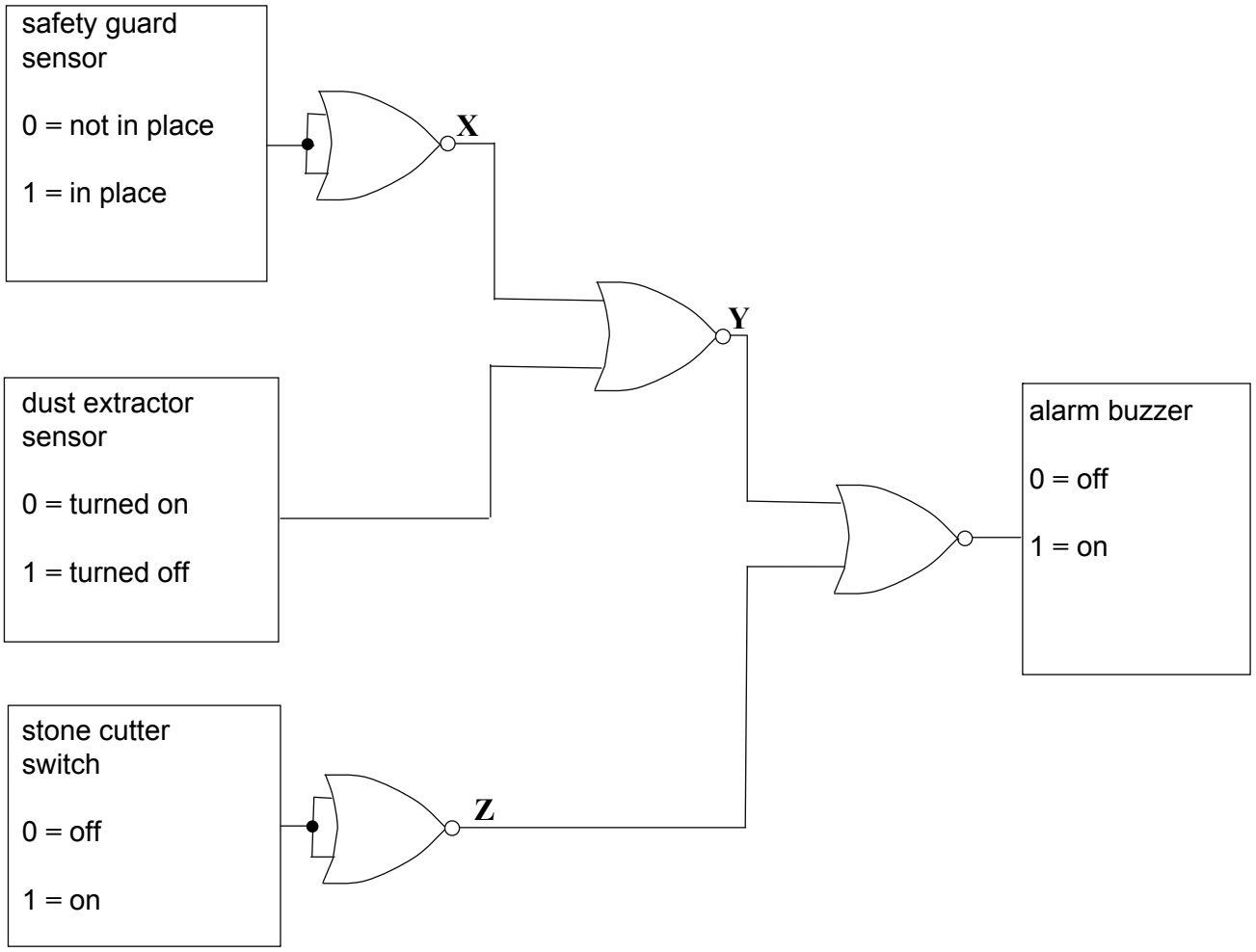
A	B	C	D
0	1	0	1
0	1	1	0
0	1	1	0
1	0	1	0

9 (b) (i) Write the correct letter in the box to complete **Table 4**. ☐

[1 mark]

Question 9 continues on the next page

Figure 13



9 (b) (ii) Complete the truth table (**Table 5**) for the NOR gate system in **Figure 13**.

[4 marks]

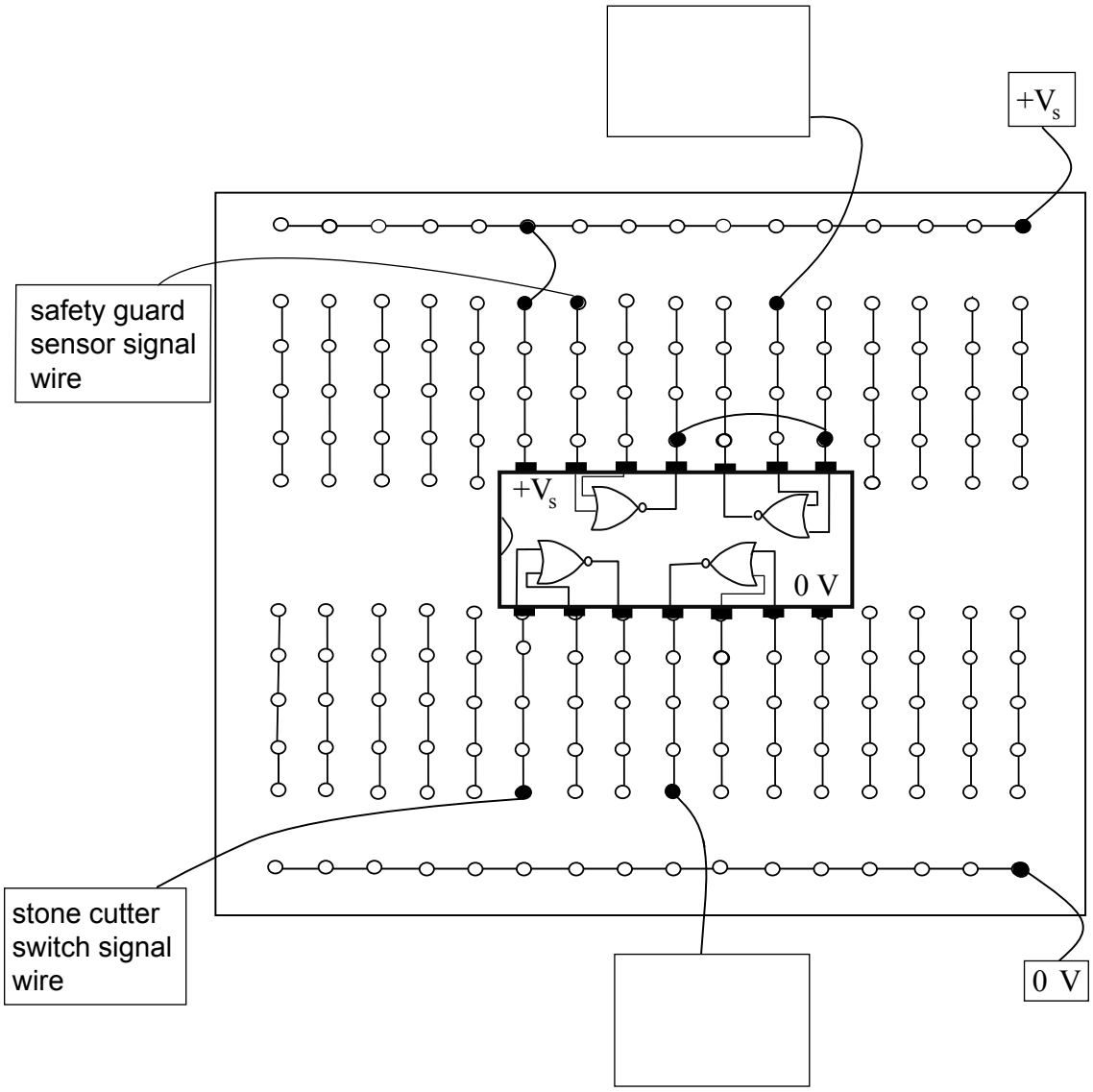
Table 5

Safety guard sensor	Dust extractor sensor	Stone cutter switch	X	Y	Z	Alarm buzzer
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

9 (c) The NOR gate system is to be built on a prototyping board using a quad two-input NOR gate IC.
Add **five** connecting wires to **Figure 14** to complete the circuit.
Label, in the boxes, the **two** unlabelled wires.

[7 marks]

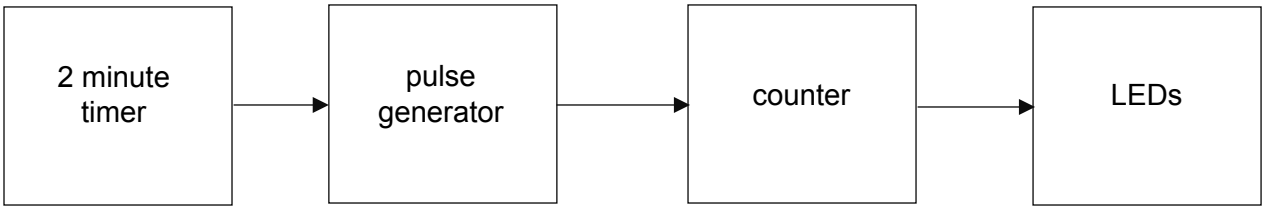
Figure 14



19

10 For her project a student decides to build a toothbrush timer circuit which will flash LEDs on and off after 2 minutes.
Figure 15 is the system diagram for her timer circuit.

Figure 15



10 (a) (i) She uses a 555 IC for the 2 minute timer.
What mode should the IC be connected in for this application?

[1 mark]

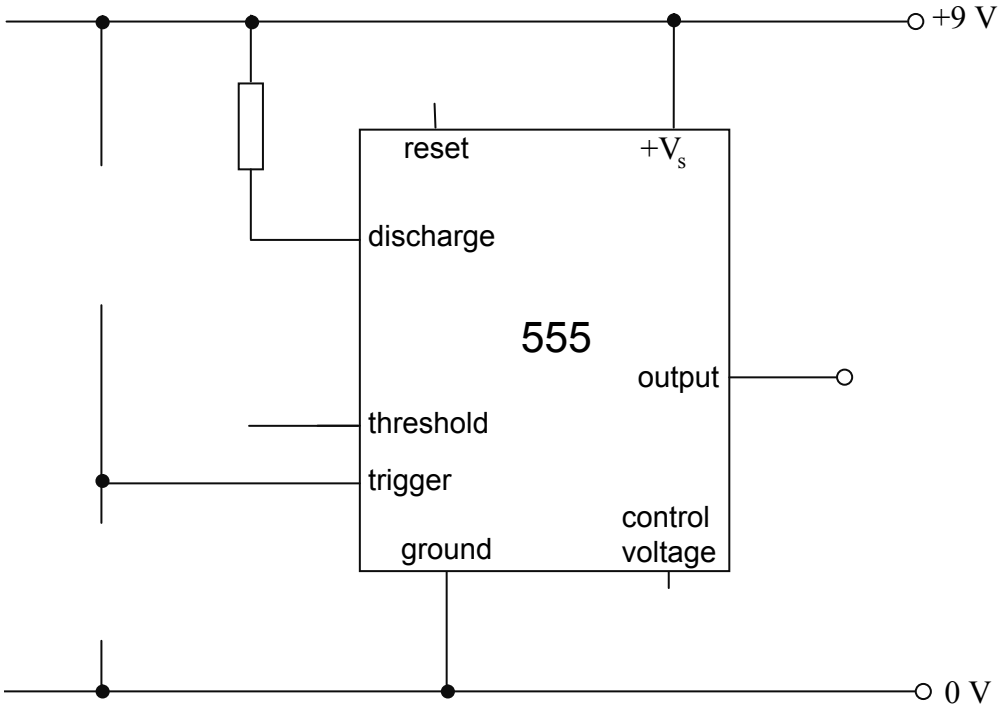
.....

10 (a) (ii) For the 2 minute timer circuit shown in **Figure 16**:

- draw a push switch and a resistor which will produce a low voltage at the trigger input when the switch is pressed and +9 V when not pressed
- draw **two** capacitors and the missing wire links.

[6 marks]

Figure 16



Question 10 continues on the next page

10 (b) (i) The pulse generator uses another 555 timer.
In what mode should this be connected?

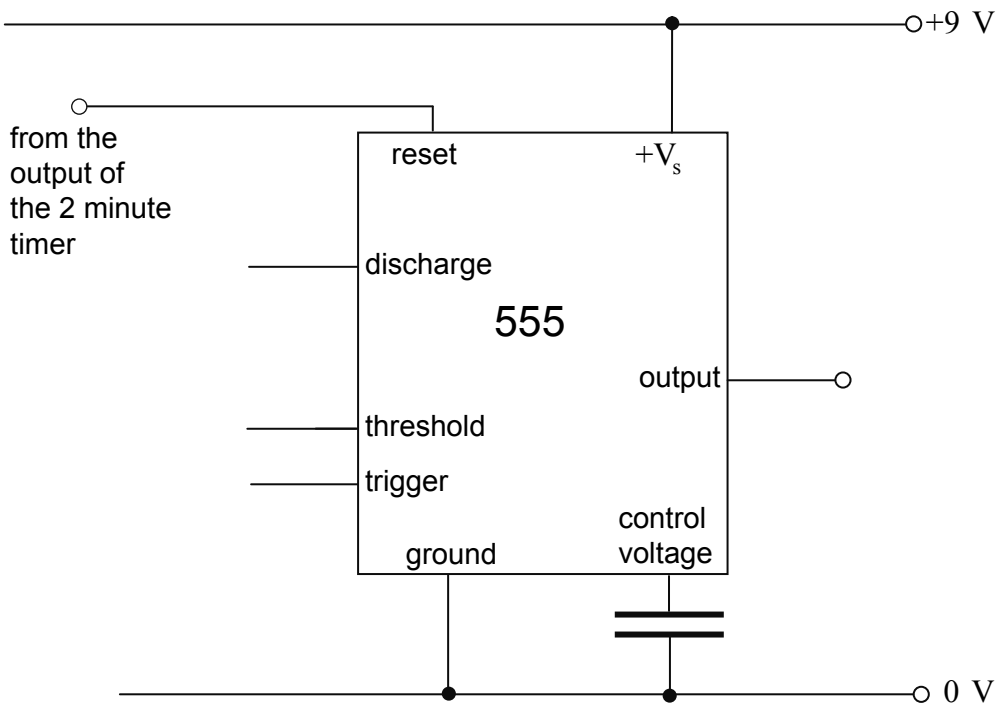
[1 mark]

.....

10 (b) (ii) In this mode the circuit only produces pulses when the reset input is receiving a high voltage from the 2 minute timer.
Add to **Figure 17** the missing timing components connected correctly.

[4 marks]

Figure 17



10 (b) (iii) The timing components have the values $R_1 = 5.6\ k\Omega$, $R_2 = 30\ k\Omega$ and $C = 10\ \mu F$.
Calculate the period of the pulses.

[3 marks]

.....

.....

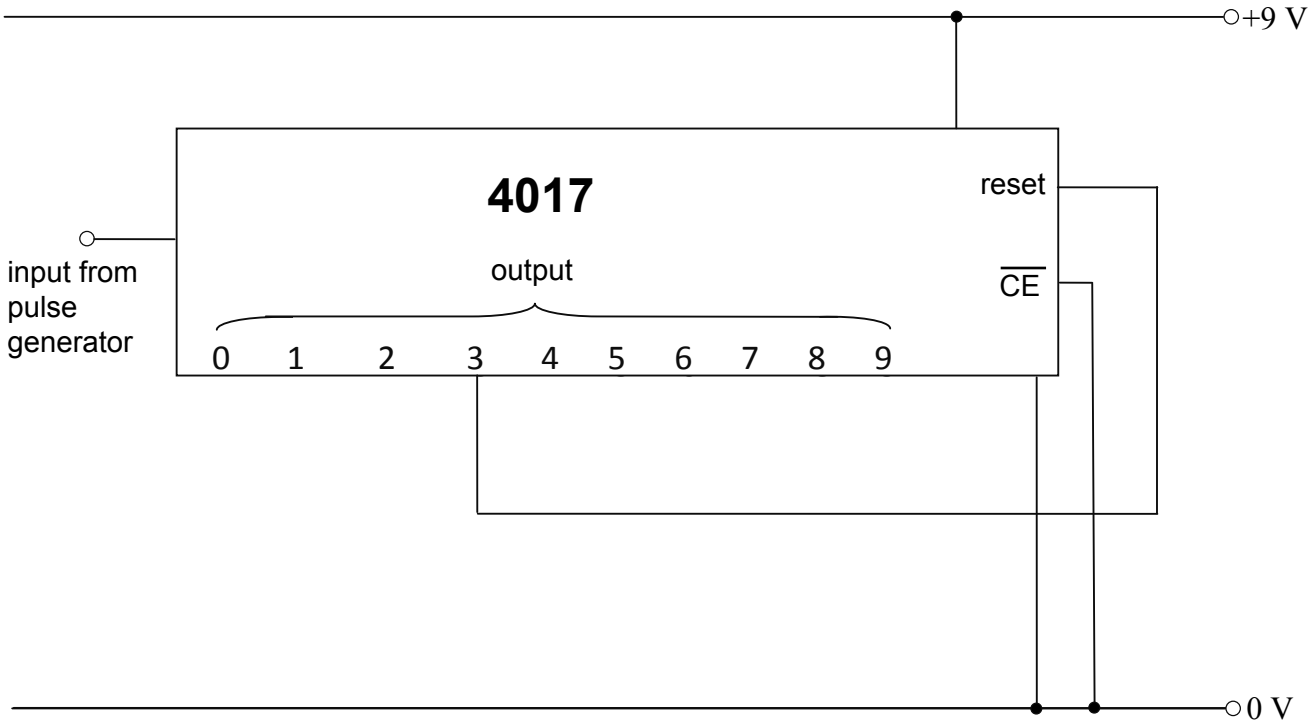
.....

10 (c) Pulses from the pulse generator subsystem are fed to a 4017 counter.

10 (c) (i) Add to the circuit in **Figure 18 three** light emitting diodes (LEDs) which will light one after the other when pulses arrive at the input and include any protective resistors needed.

[3 marks]

Figure 18

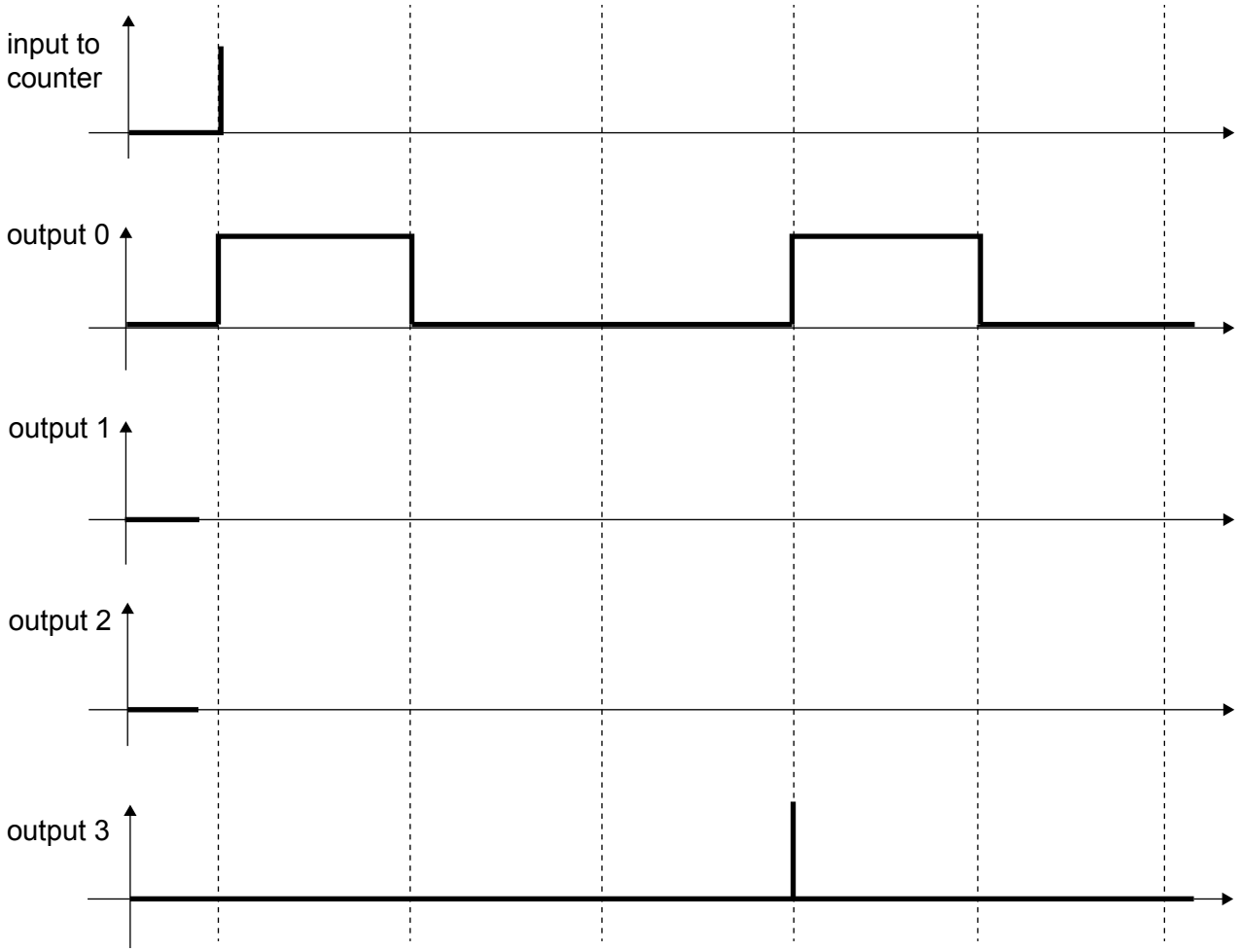


Question 10 continues on the next page

10 (c) (ii) Complete the timing diagram in **Figure 19** for the 4017 counter by drawing the input to the counter and outputs 1 and 2.

[6 marks]

Figure 19



24

END OF QUESTIONS