



General Certificate of Secondary Education
2024

Centre Number

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Candidate Number

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Technology and Design

Unit 2

Option A:

Electronic and Microelectronic
Control Systems



[GTY21]

GTY21

WEDNESDAY 12 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Questions which require drawing or sketching should be completed using an H.B. pencil.

All other questions must be completed using black ink only.

Do not write in pencil or with a gel pen.

Answer **both** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.

Quality of written communication will be assessed in Question 1(f).

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

The Formula sheet is on page 3.

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(Questions start on page 4)

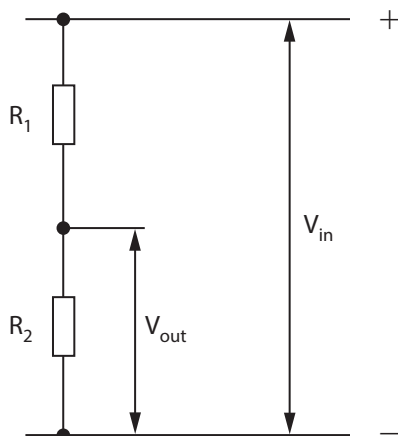


Formulae for GCSE Technology and Design

You should use, where appropriate, the formulae given below when answering questions which include calculations.

1 Potential Difference = current $\times$ resistance ($V = I \times R$)

2 For potential divider
$$V_{\text{out}} = \frac{R_2}{(R_1 + R_2)} \times V_{\text{in}}$$



3 Series Resistors $R_t = R_1 + R_2 + \dots + R_n$

4 Parallel Resistors $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$ or $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$

5 Time Constant $T = R \times C$

6 Period $T = \frac{1}{f}$

7 Frequency (Hz) $f = \frac{1.44}{(R_1 + 2R_2)C}$ for the output of an astable circuit using a 555 timer

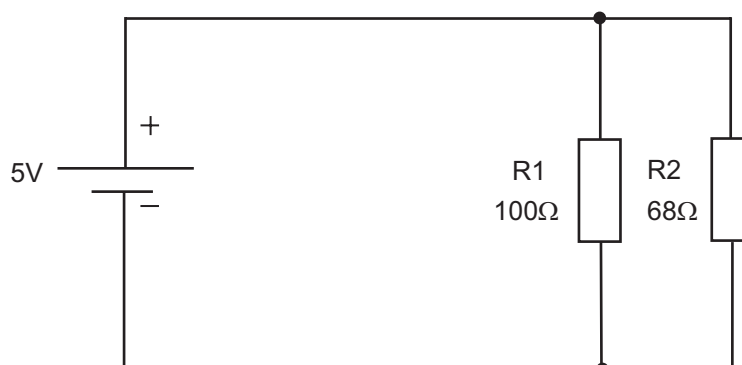
8 Time $T = 1.1 \times C \times R$ for the output of a monostable circuit using a 555 timer

[Turn over



Answer **all** questions

- 1 (a) The circuit diagram in **Fig. 1** shows a battery connected to two resistors R1 and R2.



Source: CCEA

Fig. 1

- (i) State if the resistors in **Fig. 1** are connected in series or parallel.

[1]

- (ii) Calculate the current flowing in resistor R2 in **Fig. 1**.
Show your working out in the space below and state the unit in your answer.

Answer _____ [3]



- (iii) Calculate the total equivalent value of the two resistors shown in **Fig. 1**.
Show your working out in the space below and state the unit in your answer.

Answer _____ [3]

- (b) A voltmeter and an ammeter are to be used to measure the voltage and the current at different points in the circuit shown in **Fig. 1**.

- (i) Using the symbol for a voltmeter, show on **Fig. 1** where it could be connected to measure the battery voltage. [2]

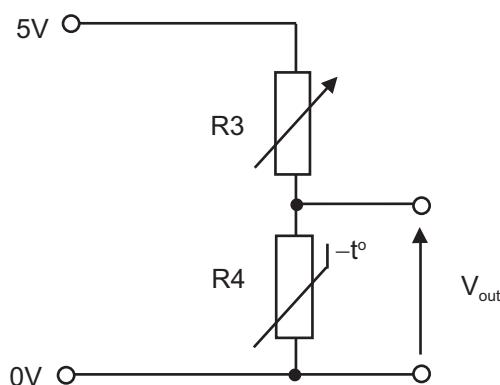
- (ii) Using the symbol for an ammeter, show on **Fig. 1** where an ammeter could be connected to measure the:

- current flowing in R1.
- total current flowing in the circuit. [3]

[Turn over]



- (c) **Fig. 2** shows a voltage divider circuit consisting of two components, R3 and R4, connected to a 5 volt power supply.



Source: CCEA

Fig. 2

- (i) Name the components represented by the symbols R3 and R4 in **Fig. 2**.

R3 _____ [1]

R4 _____ [1]

- (ii) The resistance of each of the components R3 and R4 in **Fig. 2** can be increased or decreased. Explain how the resistance of R3 can be increased and the resistance of R4 can be decreased.

R3 can be increased by _____
_____ [2]

R4 can be decreased by _____
_____ [2]



- (iii) Calculate the output voltage (V_{out}) in **Fig. 2** if the resistance of R_3 is $5\text{ k}\Omega$ and the resistance of R_4 is $3\text{ k}\Omega$.
Show your working out in the space below.

Answer _____ volts [4]

- (iv) Explain why the output voltage, V_{out} in **Fig. 2** can be considered as an analogue signal.

_____ [2]

- (d) A partly completed printed circuit board (PCB) design for the circuit shown in **Fig. 2** is shown in **Fig. 3**. Complete the PCB design by adding the remaining pads and tracks required. You should represent your design with circles and lines as shown. (You are not required to consider the dimensions of the components).

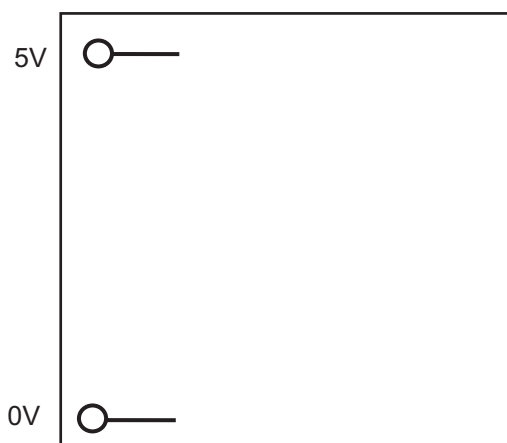


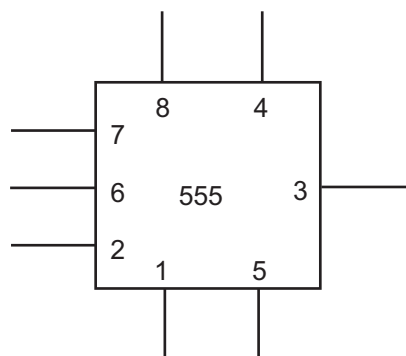
Fig. 3

[6]

[Turn over



(e) Fig. 4 shows the symbol for a 555 timer.



Source: CCEA

Fig. 4

(i) Explain the purpose of Pin 7 of the 555 timer.

[2]

Fig. 5 shows the output waveform for an astable circuit based on a 555 timer.

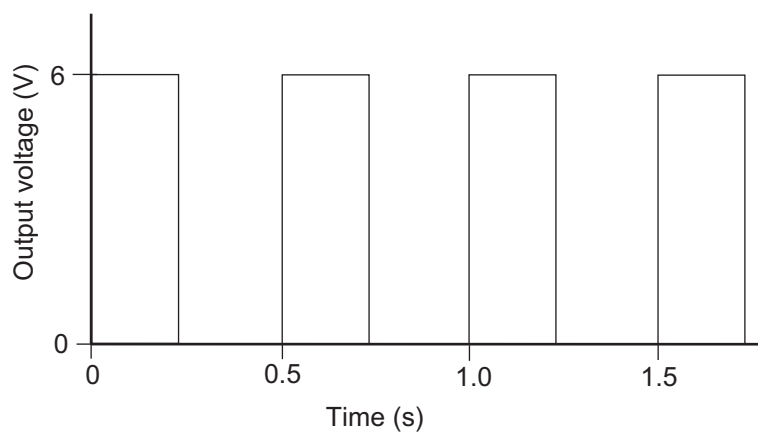


Fig. 5

(ii) Explain what is meant by the term astable when referring to 555 timer circuits.

[2]



(iii) Using the astable waveform shown in **Fig. 5**, determine the following:

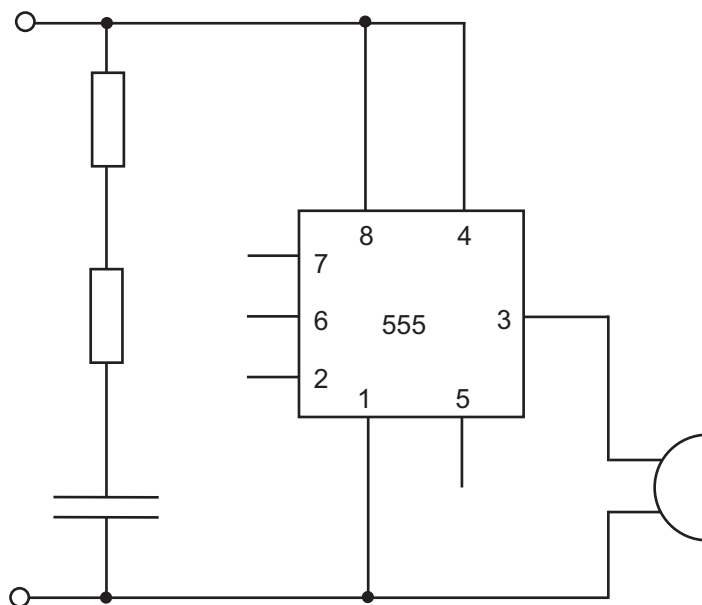
- The maximum output voltage of the waveform.
- The time period (in seconds) of the waveform.
- The frequency (in Hertz) of the waveform.

Maximum output voltage _____ V [1]

The time period _____ s [1]

The frequency _____ Hz [1]

(iv) Complete the circuit in **Fig. 6** below by adding the required connections to make an astable circuit.



Source: CCEA

Fig. 6

[3]

[Turn over





[10]



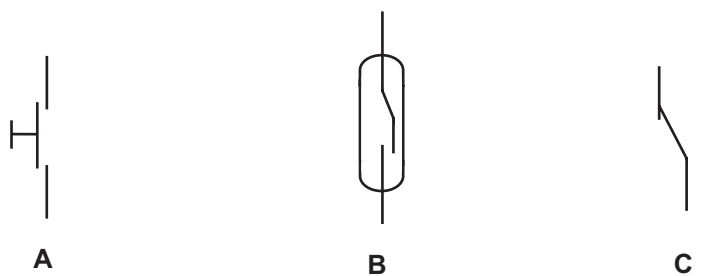
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2 (a) Three switch symbols are shown in **Fig. 7**.



Source: CCEA

Fig. 7

(i) Name the switch represented by symbol **C**.

_____ [1]

(ii) Explain the operation of the switch represented by symbol **B**.

_____ [2]

(iii) Choose the switch from **Fig. 7** most likely to have a 'latching' action and explain your choice.

Choice _____ [1]

Explanation _____
_____ [2]

[Turn over]



- (b) A microcontroller (PIC) with two inputs and one output is shown in **Fig. 8** which is to be used to control a home security alarm.

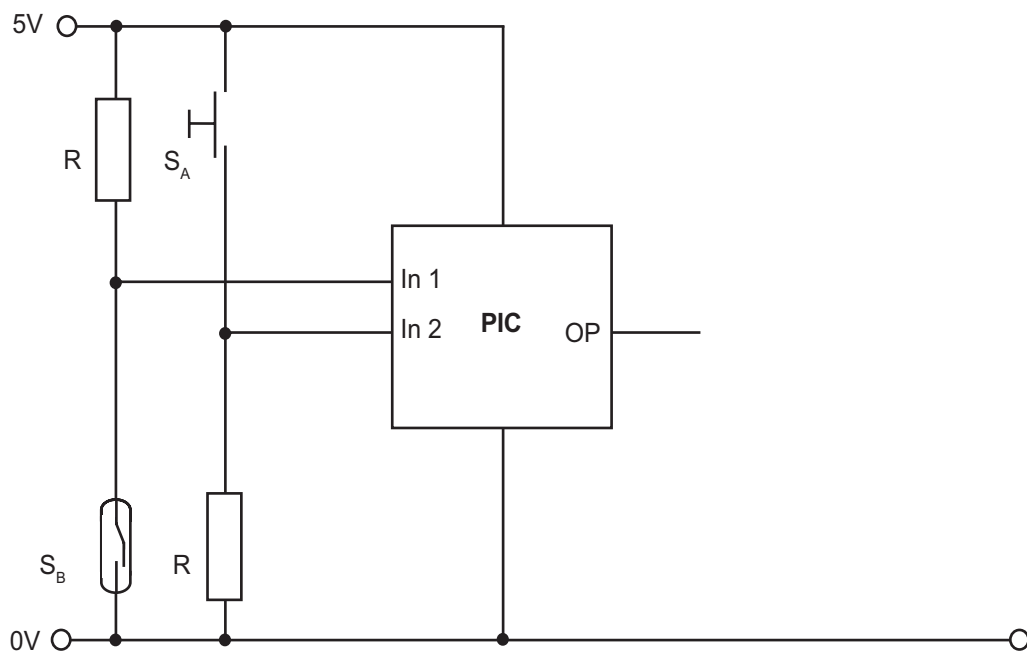


Fig. 8

Source: CCEA

- (i) Explain **two** benefits of using microcontrollers (PICs).

1. _____

2. _____

[4]



- (ii) State the expected voltage at the **In 2** input in **Fig. 8** when switch **S_A** is pressed and explain how you determined the voltage.

Voltage _____ volts [1]

Explanation _____

_____ [2]

- (iii) Produce a flowchart program in the space below to produce a high output from the microcontroller (PIC) in **Fig. 8** only when **S_B** is operated.

START

[5]

- (iv) The output from the PIC circuit in **Fig. 8** is to be used to switch on a 12 volt solenoid using a transistor. Complete the circuit diagram in **Fig. 8** to achieve this outcome. [5]

[Turn over]



(c) **Fig. 9** shows a model for part of a production line controlled by a PIC. Components moving along a motorised conveyor are sorted into batches of five by a motorised push rod.

A buzzer will sound when a batch of five has been made. The conveyor will stop to allow the batch to be wrapped and moved on to the next stage.

The total number of batches is recorded and displayed on a batch display.

A green (Go) LED on the operator panel shows when the conveyor is moving and a red (Stop) LED shows when it is stopped. The operator starts the conveyor again by pressing a push button start switch.

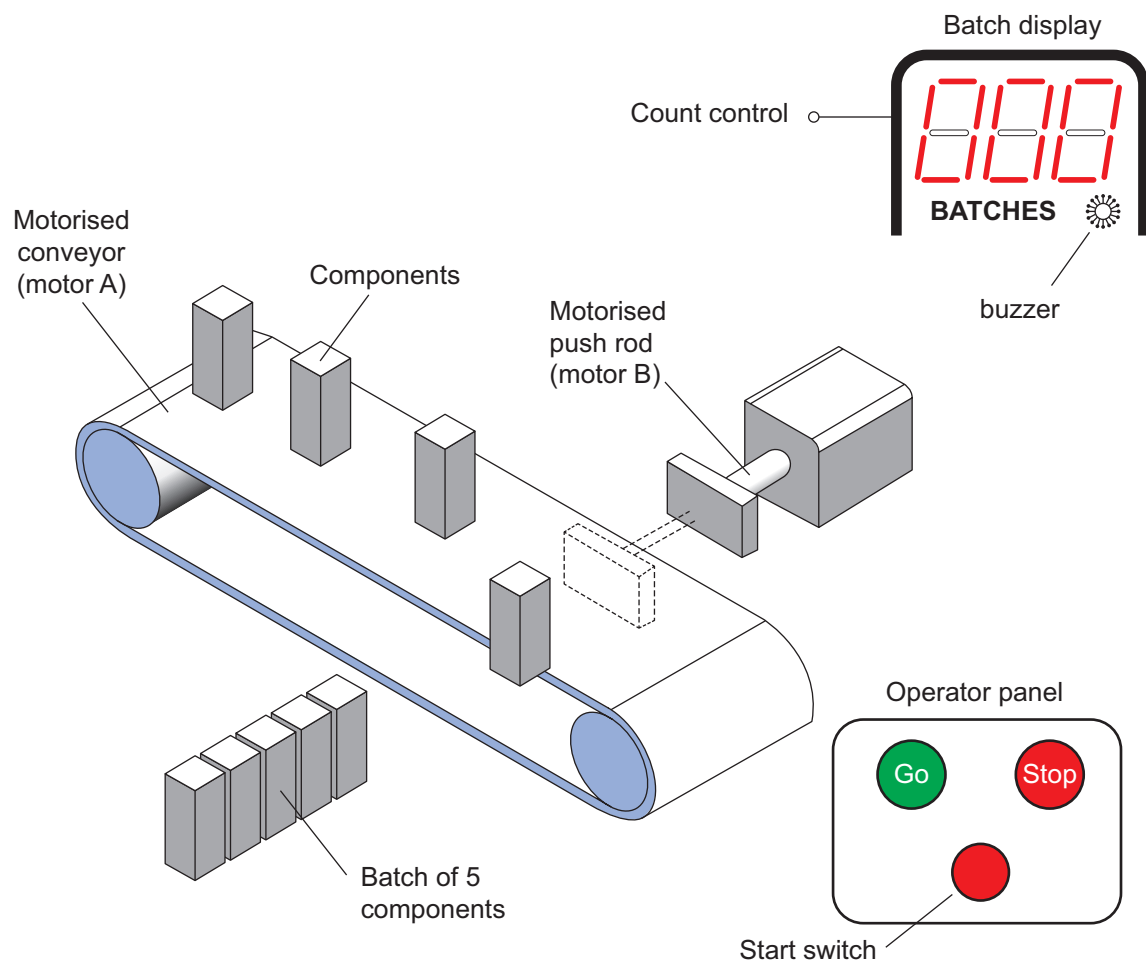


Fig. 9

Source: CCEA



(i) Complete the macro flowchart **BATCH** in **Fig. 10** (using the minimum number of commands) to control the operation of the motorised push rod on the production line model as follows:

- Motor B turns clockwise for 1 second, moving the push rod out to push the component off the conveyor.
- Motor B stops, then turns anticlockwise for 1 second to bring the push rod back in.
- This is repeated a further four times. When the batch of five components has been made, Motor B stops.



Fig. 10

[11]

[Turn over



(ii) Complete the macro flowchart **DISPLAY** in **Fig. 11** to control the operation of the batch display on the production line model as follows:

- A 0.4 second (high) pulse will be sent to the buzzer control to make an audible sound each time a batch is completed.
- Send a 0.1 second (high) pulse to the count control of the batch display to increase the batch count by 1.

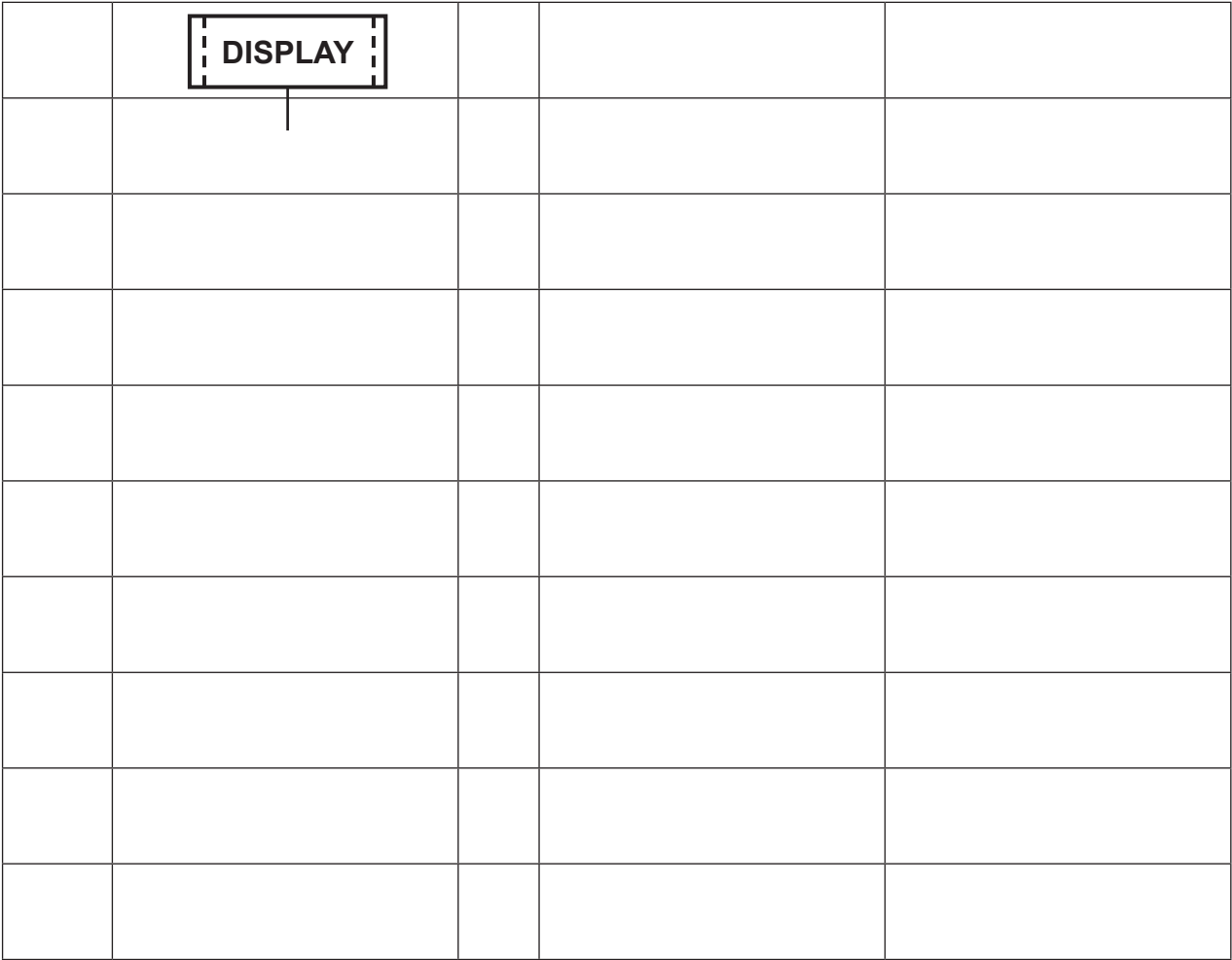


Fig. 11

[7]



(iii) Complete the flowchart in **Fig. 12**, (to include the **BATCH** and **DISPLAY** macros) in order to control the full operation of the production line model in **Fig. 9**.

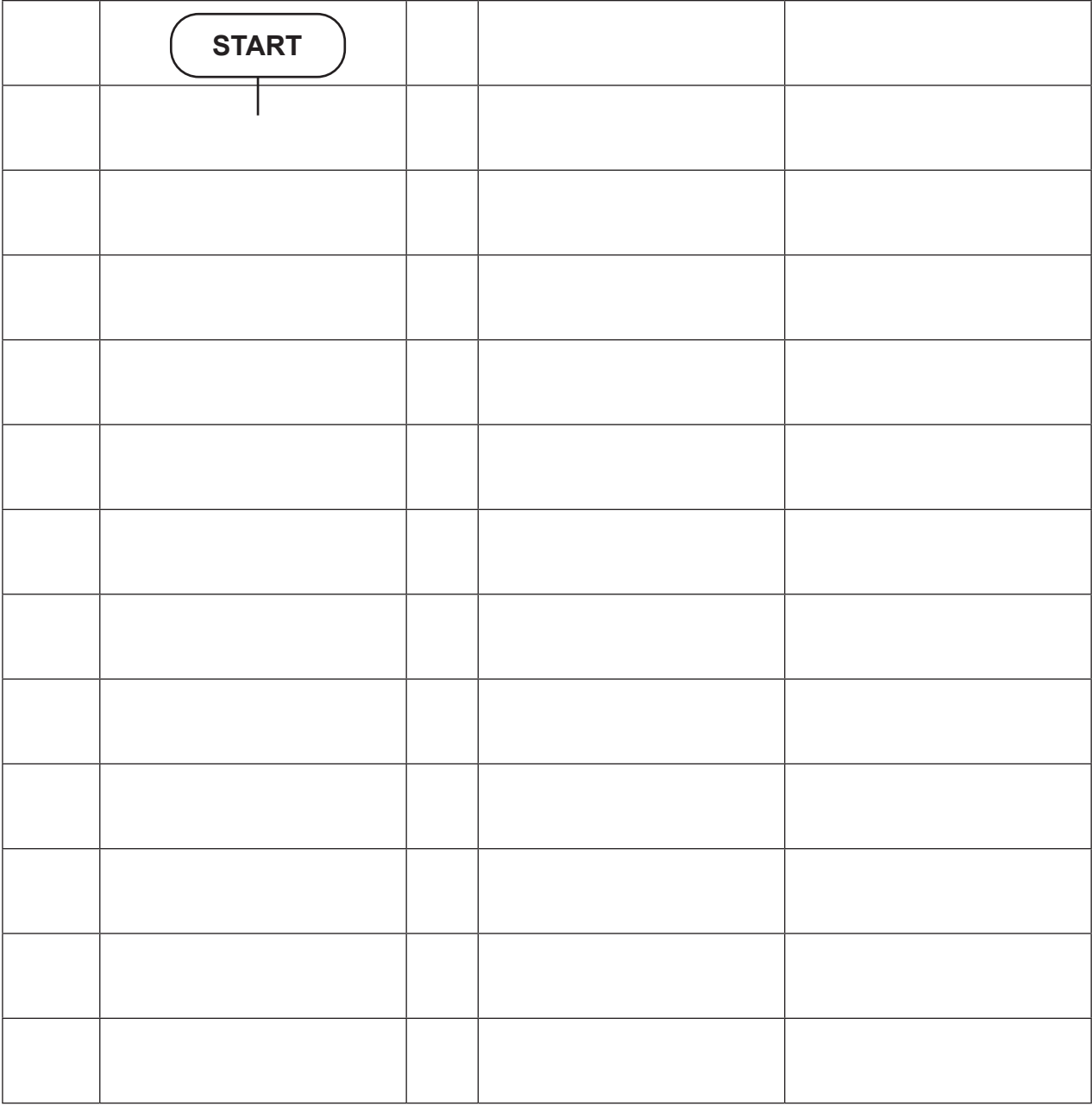


Fig. 12

[9]

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Question Number	Marks
1	
2	

Total Marks	
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Examiner Number

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