

Surname	Centre Number	Candidate Number
First name(s)		0



GCSE

C490UA0-1



MONDAY, 15 MAY 2023 – AFTERNOON

ELECTRONICS – Component 1

Discovering Electronics

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	8	
2.	11	
3.	10	
4.	9	
5.	13	
6.	11	
7.	6	
8.	4	
9.	8	
Total	80	

ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 7.



JUN23C490UA0101

INFORMATION SHEET

This information may be of use in answering the questions.

Resistor Colour Codes

Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

The fourth band colour gives the tolerance as follows:

GOLD \pm 5%

SILVER \pm 10%

Resistors E24 series values

10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91.

Useful equations

$$P = \frac{V^2}{R}$$

$$G = 1 + \frac{R_F}{R_1}$$

$$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN}$$

$$G = -\frac{R_F}{R_{IN}}$$

$$I_D = g_M(V_{GS} - 3)$$

$$V_{OUT} = -R_F \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \dots \right)$$

$$I_C = h_{FE} I_B$$

$$T = 1.1RC$$

$$\overline{A + B} = \overline{A} \cdot \overline{B}$$

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

$$\overline{A \cdot B} = \overline{A} + \overline{B}$$

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

$$G = \frac{V_{OUT}}{V_{IN}}$$

$$\frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$$



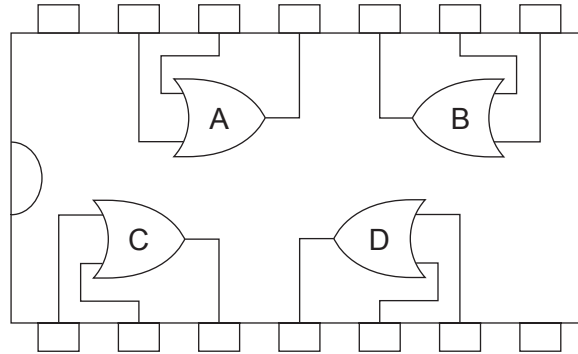
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Answer **all** questions.

1. (a) The diagram shows the pinout for an IC (integrated circuit).



(i) **Label** pin 7 and pin 14 on this IC. [1]

(ii) Which logic gate has an input connection on pin 12? [1]

(iii) Which logic gate has an output connection on pin 3? [1]

(iv) Name the type of logic gate found on this IC. [1]

(b) Draw the logic gate symbol for:

(i) an AND gate [1]

(ii) a NOR gate. [1]



(c) Complete the following truth tables for:

(i) an OR gate

[1]

B	A	Q
0	0	
0	1	
1	0	
1	1	

(ii) a NAND gate.

[1]

B	A	Q
0	0	
0	1	
1	0	
1	1	



2. (a) Complete the table by writing the sub-systems given below into the correct column. [3]

latch unit

OR gate

comparator

light sensing unit

solenoid unit

moisture sensing unit

Input sub-system	Processing sub-system	Output sub-system

(b) A museum uses individual alarm systems to protect each exhibit on display. If an exhibit is moved the contacts of a pressure switch open and trigger an audible alarm. The specification is as follows:

SPECIFICATION

- The alarm operates as soon as the exhibit is lifted off its base.
- The alarm produces a pulsing sound output.
- The alarm continues to sound even if the exhibit is replaced.
- A reset switch located in the security office cancels the alarm once the exhibit has been replaced properly.



The following sub-systems are available.

pulse generator

OR gate

temperature sensing unit

AND gate

NAND gate

comparator

pressure switch unit

transistor switch

NOT gate

latch unit

delay unit

buzzer unit

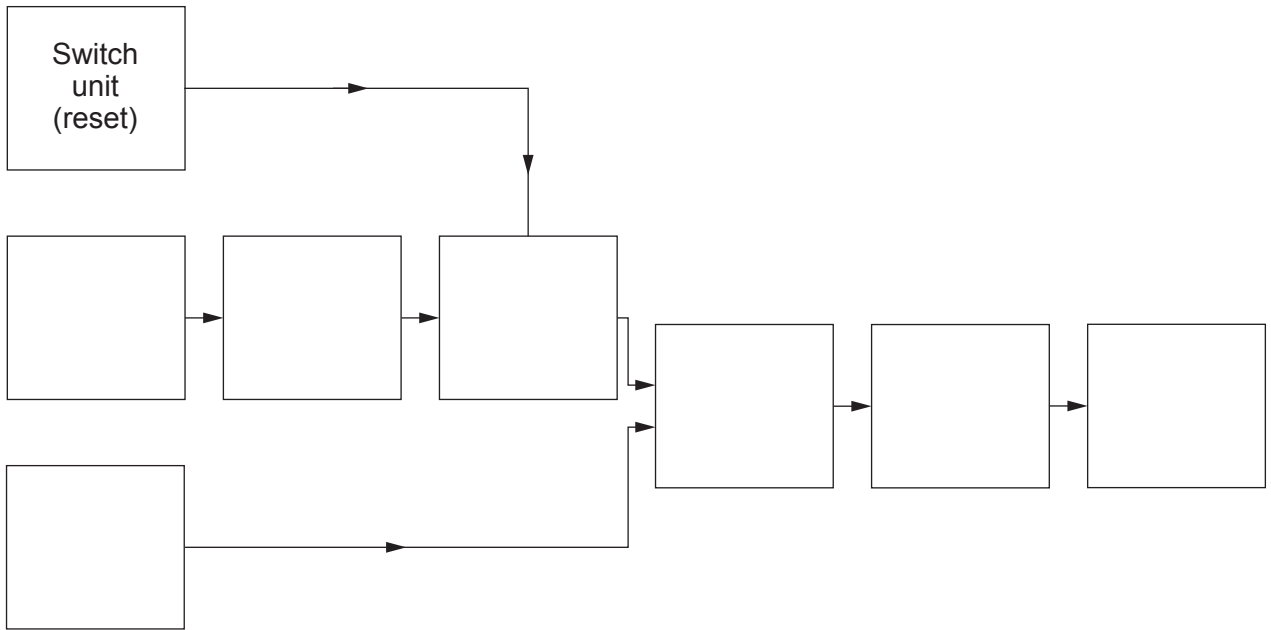
light sensing unit



The available sensing sub-systems behave as follows:

- The light sensor outputs logic 0 in the dark.
- The pressure switch sensor outputs logic 1 when closed.
- The temperature sensor outputs logic 1 when hot.

Select the correct sub-systems to complete the block diagram design. [7]



(c) Which of the following can be used for a pulse generator? [1]

astable

bistable

monostable

Answer:

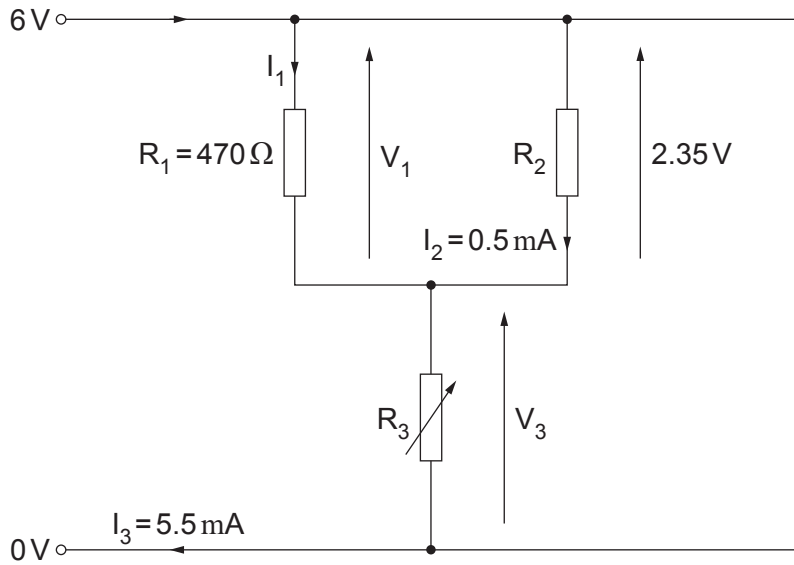


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3. (a) The diagram shows a circuit.



(i) Determine the values of the following: [3]

$V_1 =$

$I_1 =$

$V_3 =$

(ii) Calculate the resistance setting of the variable resistor R_3 . [3]

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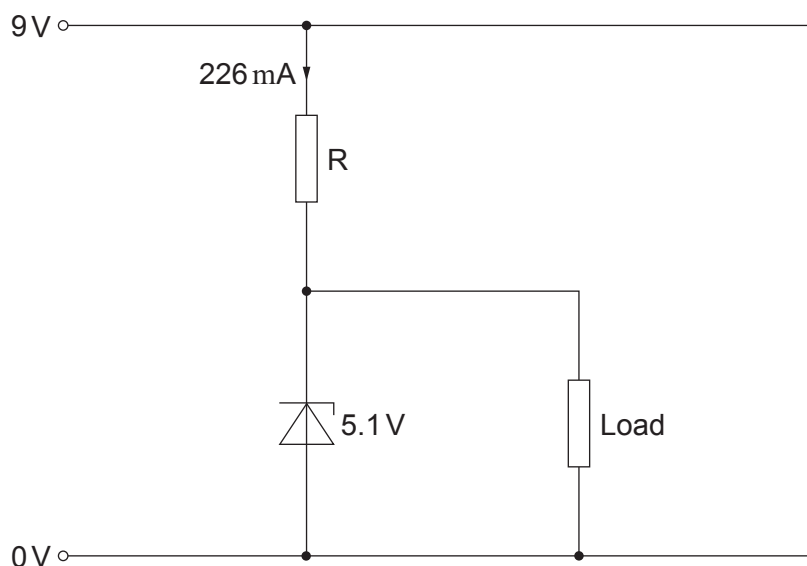
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(b) What is the colour code on resistor R_1 which has a tolerance of $\pm 10\%$? [4]

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4. A design for a simple regulated power supply is shown below. The zener diode requires a minimum current of 10 mA to maintain the zener voltage. The current through resistor R is 226 mA .



- (a) (i) What is the maximum load current that the power supply can provide whilst maintaining the zener voltage? [2]

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- (ii) What is the voltage across the load when the load current is at this maximum? [1]

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- (b) The load is now disconnected. Calculate the power dissipated in the zener diode. [3]

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- (c) The following table lists some zener diodes that are being considered for use in this circuit.

Component	Model Number	Power Dissipation _(Max)
1	BZX55C5V1	500 mW
2	BZX84C5V1	350 mW
3	BZX85C5V1	1.3 W
4	1N4733A5V1	1 W

Which component would be a suitable zener diode?

[1]

- (d) The circuit supply is now changed from 9 V to 12 V.

(i) What is the voltage now across the load?

[1]

(ii) What is the voltage now across the resistor, R?

[1]



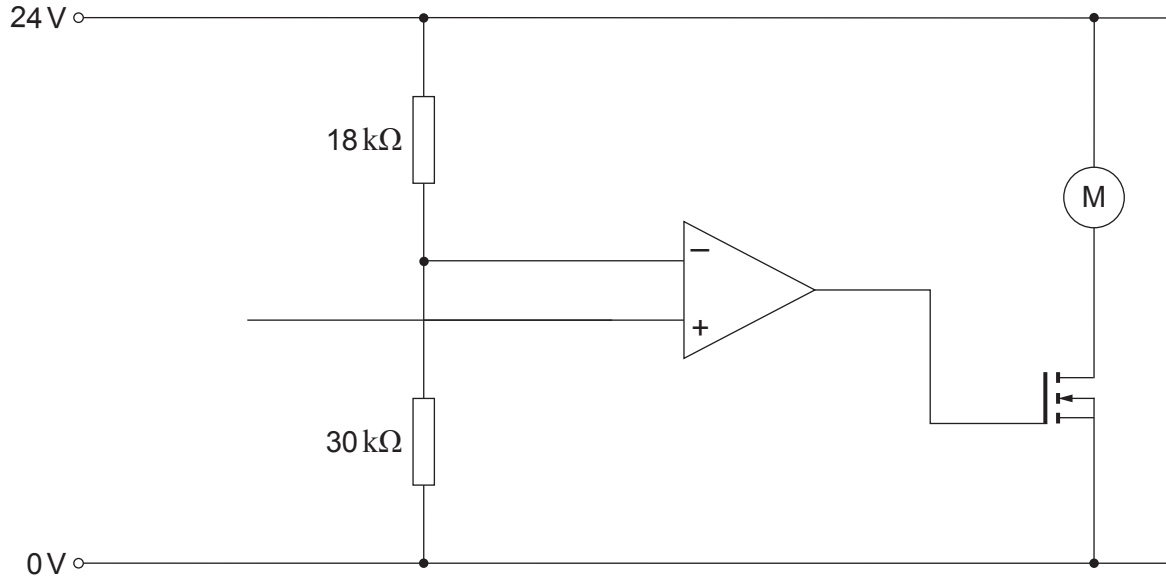
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5. A cooling system activates the motor of a fan if the temperature is too high.

Part of the solution is shown below.



(a) **Complete the circuit diagram above** by adding the temperature sensing sub-system made from a thermistor and a 47 kΩ variable resistor. [2]

(b) Determine the voltage at the inverting input of the comparator. [3]

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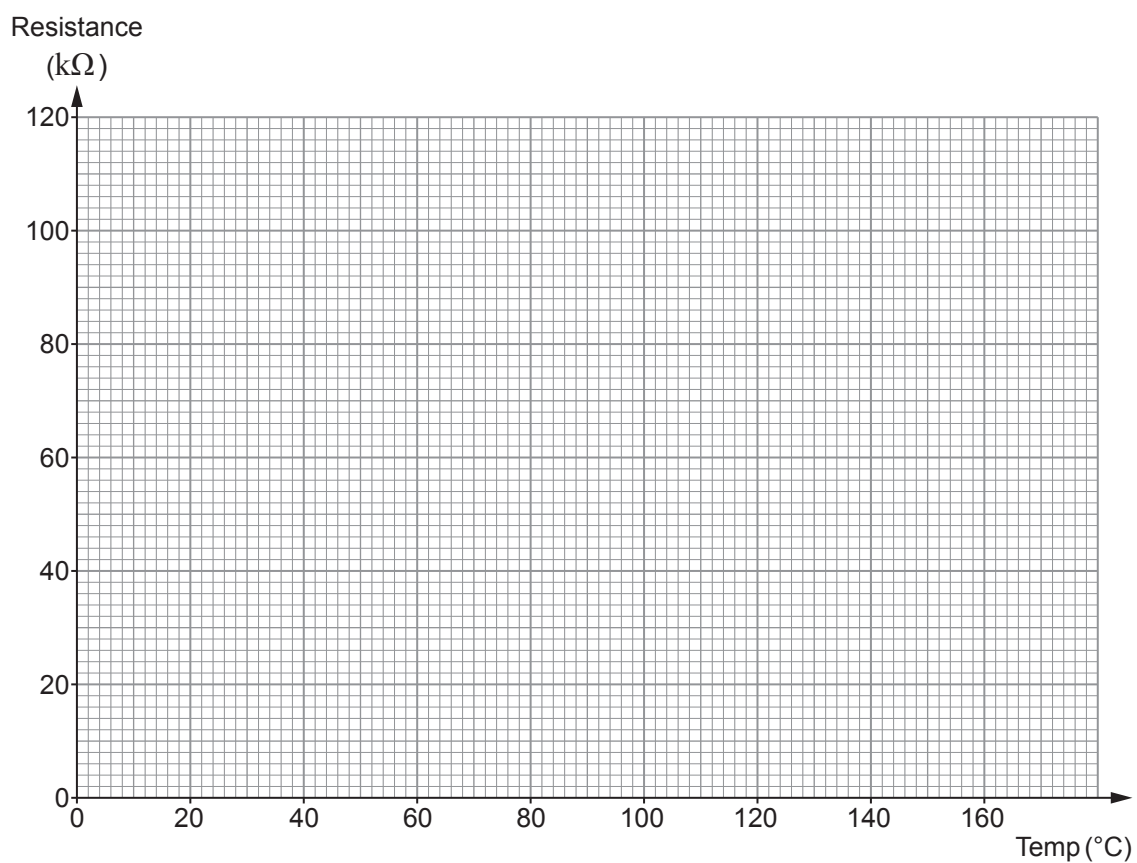
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- (c) The resistance of the thermistor is measured at different temperatures and the results are recorded in the table below.

Temperature ($^{\circ}\text{C}$)	Resistance ($\text{k}\Omega$)
2	110.0
20	70.0
40	35.0
60	20.0
80	14.5
100	11.8
120	11.0
140	10.6
160	10.0

- (i) Plot the temperature characteristic of the thermistor on the grid below. [3]



- (ii) **Show on your graph** how you determine the resistance of the thermistor at 70°C and record the value below. [2]

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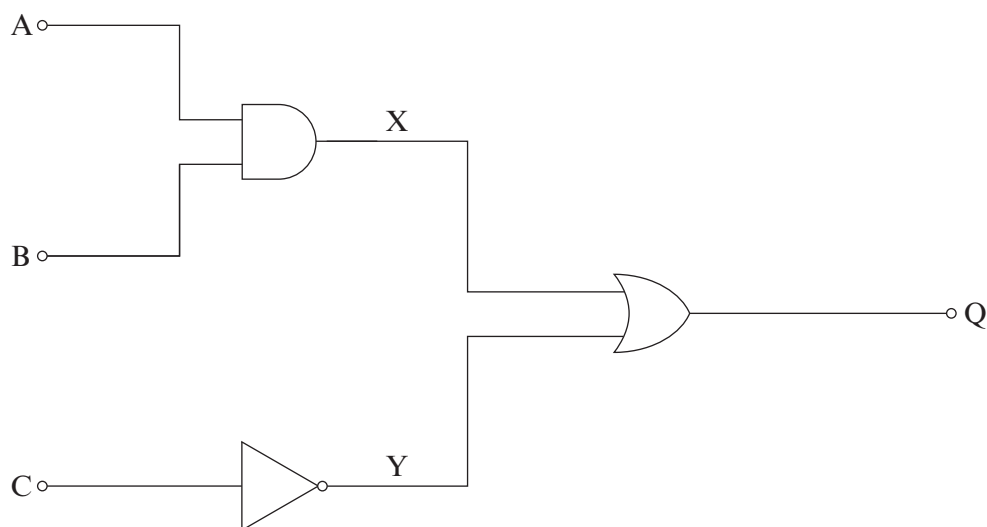
- (iii) The resistance of the variable resistor is set at 35 kΩ. Determine if the fan will be running at 70°C. [3]

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6. The diagram below shows a logic system.



(a) Write down, in terms of the inputs A, B and C, the Boolean expressions for: [3]

(i) output X;

(ii) output Y;

(iii) output Q.

(b) Complete the following truth table for this logic system. [3]

C	B	A	X	Y	Q
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			



(c) (i) Redraw the logic circuit using NAND gates only.

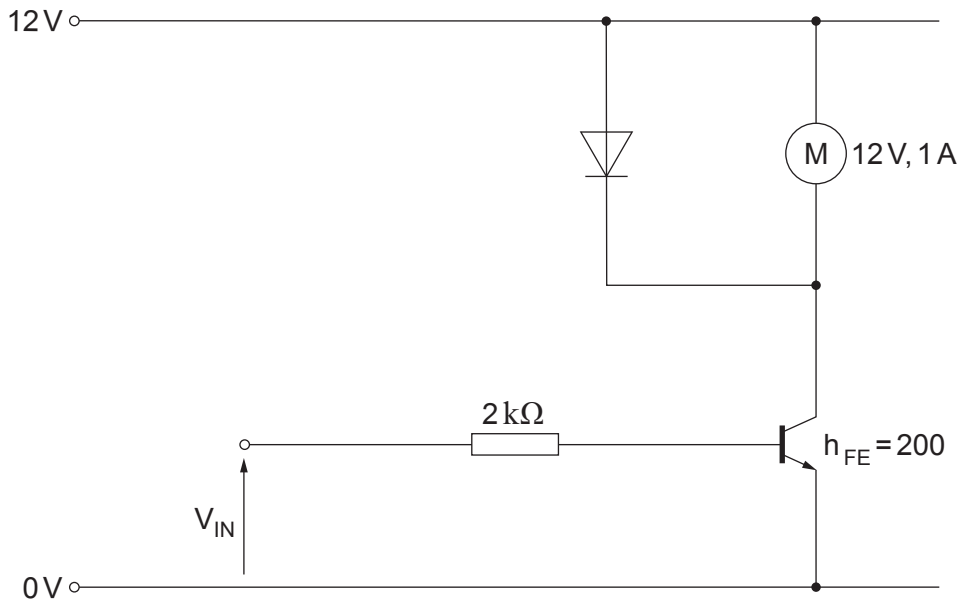
[3]

(ii) Cross out all redundant gates on your redrawn circuit above.

[2]



7. The following circuit diagram shows a proposed design for an output driver circuit.



The design specification requires that when the input voltage $V_{IN} = 4\text{ V}$ the transistor is just saturated, and the motor operates at its rated voltage.

Evaluate the circuit using relevant calculations to determine whether it is a suitable design. Describe any modifications required to meet the specification. [6 QER]

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8. A model pedestrian crossing is controlled by a microcontroller. When a pedestrian presses the button to cross the road it:

- lights a pedestrian wait light on the control box
- changes the traffic lights from green to amber then red to stop the traffic
- switches on the pedestrian lights to show when it is safe to cross
- allows traffic to continue after a delay.



The program flow chart is shown opposite.

(a) The statements in the list below are missing from the flowchart. After each statement write the letter (A, B or C) from the flowchart to indicate where each statement should appear. [3]

Flowchart statement

Position on flowchart

Turn on the 'green person' sign

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Turn on 'wait' sign

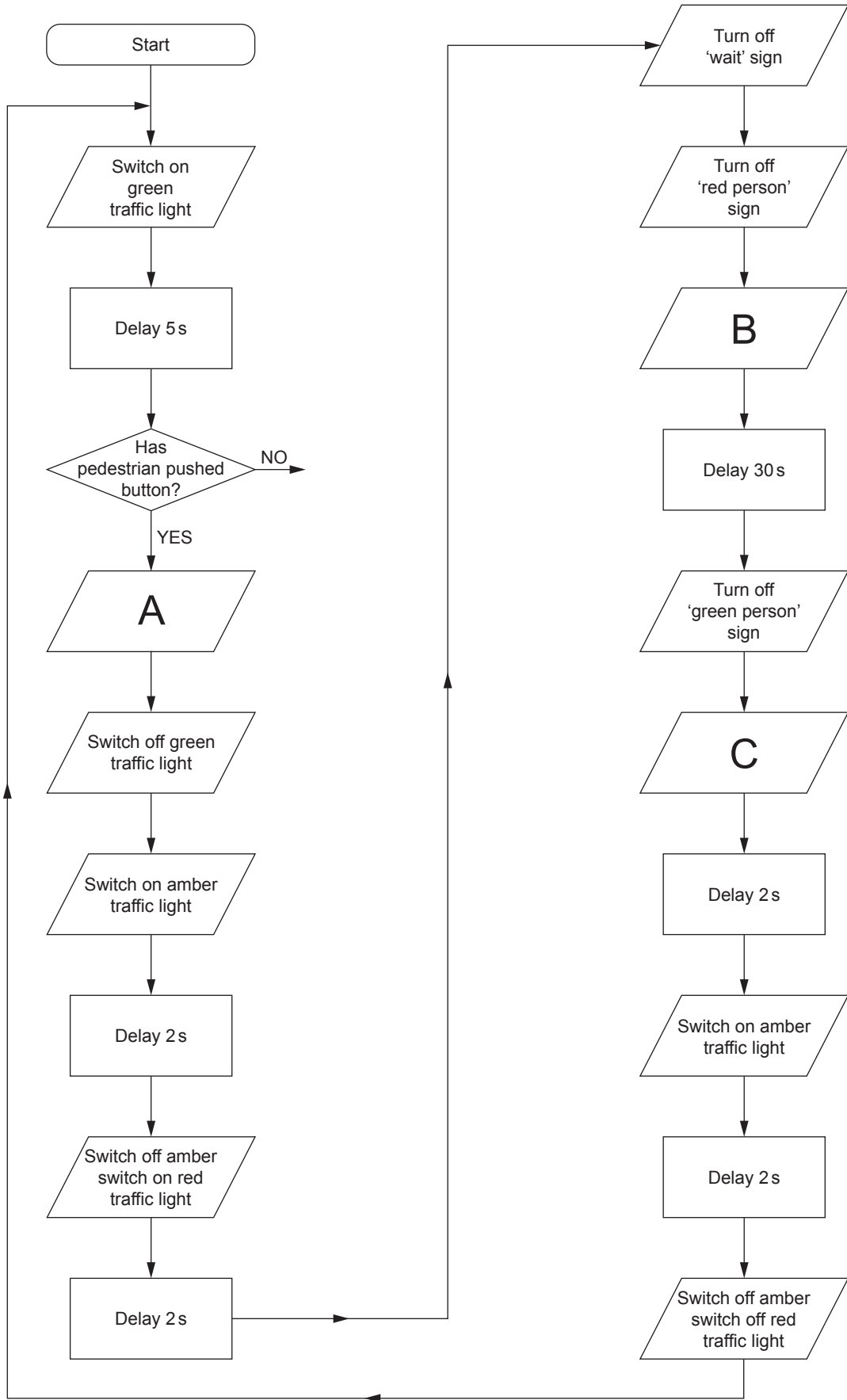
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Turn on 'red person' sign

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(b) **Complete the missing link** from the 'Has pedestrian pushed button?' decision box labelled 'No'. [1]

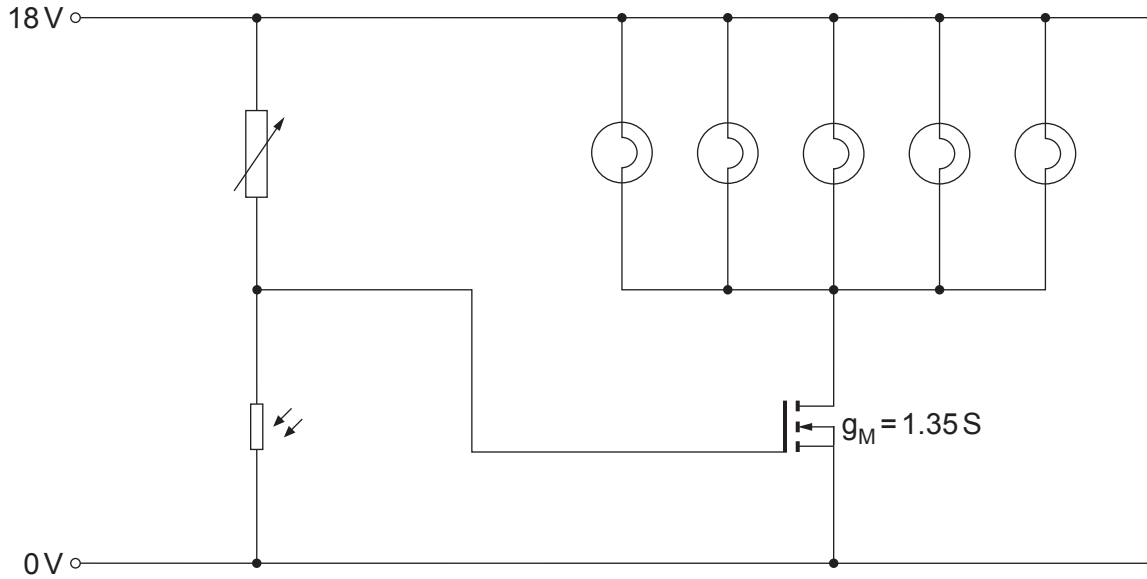




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9. A builder's yard uses a light sensing circuit to switch on a bank of identical floodlights automatically when the light level falls below a safe operating level.



- (a) The output voltage from the light sensing sub-system is 10V and the MOSFET is just saturated. Calculate the drain current. [3]

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- (b) Calculate the power dissipated in **one** of the floodlights. [3]

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- (c) The floodlights flicker on and off unnecessarily during the day when a dark cloud passes overhead. Draw a modified circuit that will overcome this problem in the space below. Additional components can be added. [2]

8

END OF PAPER



