Surname	Centre Number	Candidate Number
Other Names		0

GCSE – NEW

C490U20-1

S19-C490U20-1

WEDNESDAY, 12 JUNE 2019 – AFTERNOON

ELECTRONICS – Component 2
Application of Electronics

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**5**	
2.	**8**	
3.	**10**	
4.	**6**	
5.	**8**	
6.	**7**	
7.	**18**	
8.	**8**	
9.	**10**	
Total	**80**	

C490U201
01

ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions in the spaces provided in this booklet.

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 **9***(a)*.

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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 ± 5%

SILVER ± 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

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

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

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

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

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

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

$$I_C = h_{FE} I_B$$

$$T = 1.1RC$$

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

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

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

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

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

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

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Answer **all** *questions.*

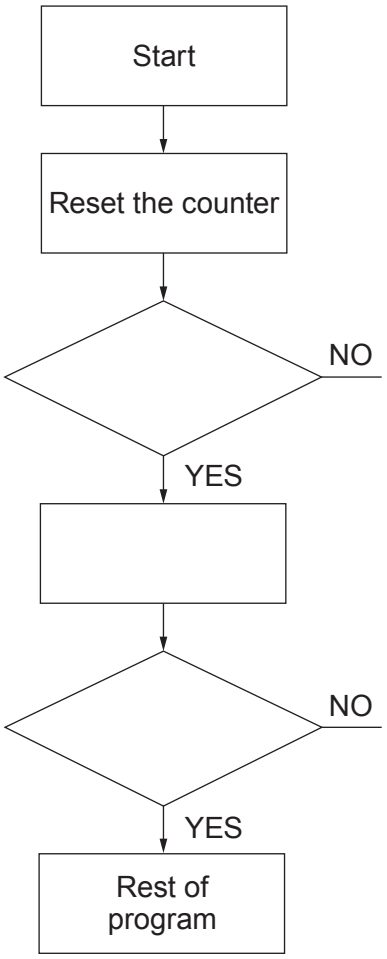
1. A microcontroller program is used to pack tins of soup into boxes in a canning factory.

The program should carry out the following.

- The microcontroller receives a signal when a soup tin moves past a sensor on a conveyor belt.
- The microcontroller uses a counter to keep track of how many tins have passed.
- At the end of the conveyor belt, the tins are placed in the box.
- When the box contains 12 tins, it is closed, and replaced with an empty box.

(a) Part of the flowchart for this control system is shown below.
Add these instructions to the correct boxes in the flowchart: [3]

Add 1 to 'count' **Has a can passed?** **Is 'count' equal to 12?**



(b) Add the links to the **two** decision boxes to show how the flowchart branches when the answer to each decision box question is 'No'. [2]

C490U201
03

5

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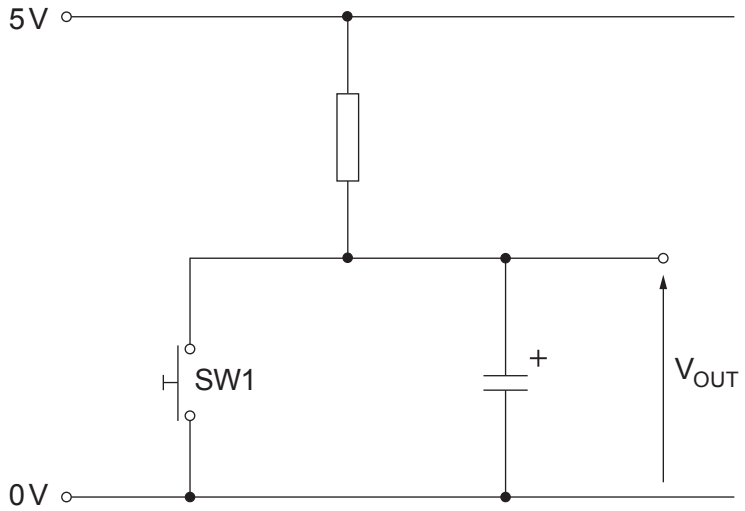
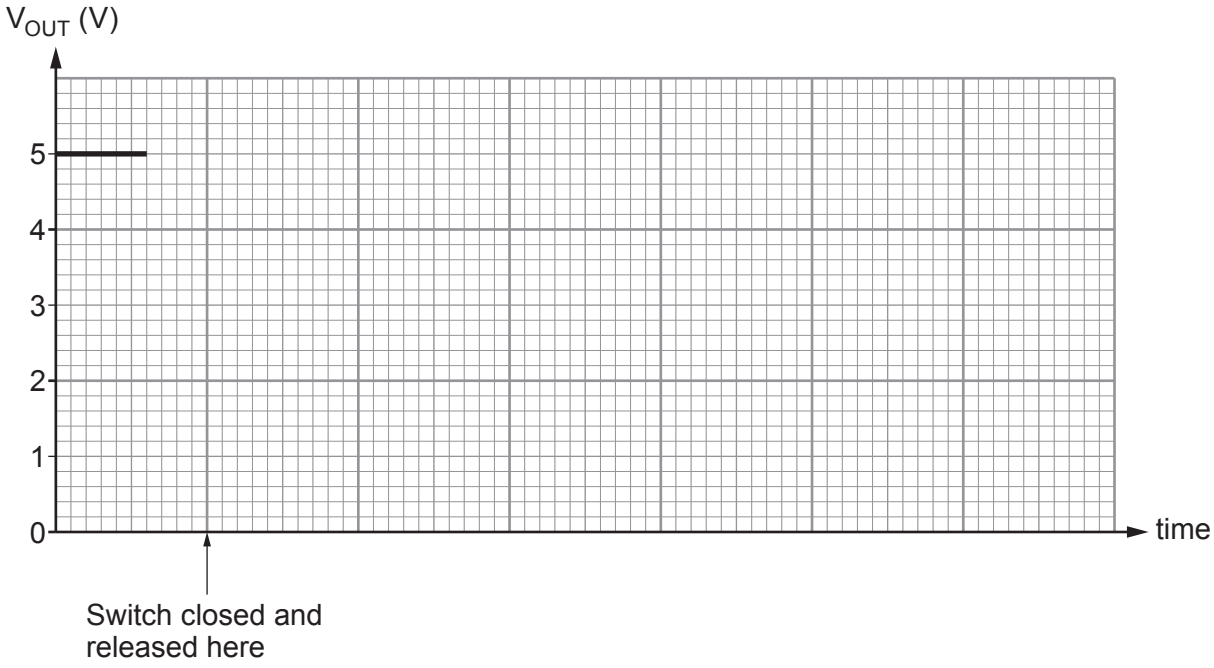
2. *(a)* Here is the circuit diagram for a timing sub-system.



Initially V_{OUT} is 5 V. The switch SW1 is then momentarily closed.

Complete the graph below to show what happens before and after the switch is closed then released. [3]



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(b) Another delay circuit is constructed using a 555 IC configured as a monostable with a 2200 μF capacitor.

(i) Calculate the resistance required to produce a 3 minute time delay with the 2200 μF capacitor. [4]

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(ii) The calculated value of resistance required is **not** part of the E24 series. How would you ensure that the specified time delay could be achieved? [1]

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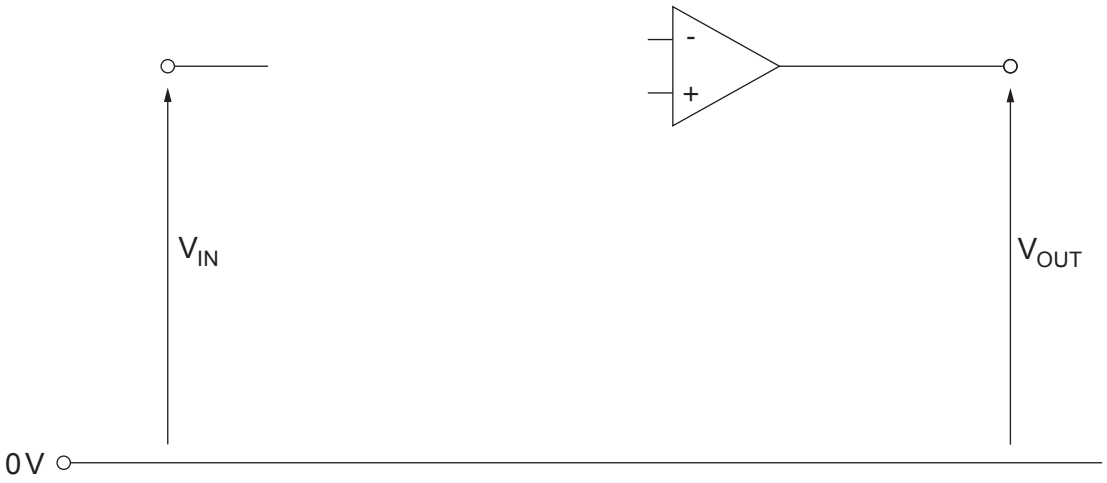
3. *(a)* (i) Complete the design for a non-inverting voltage amplifier by adding the required components and connections to the diagram below. [3]



(ii) The amplifier should have a voltage gain of 35. Calculate the values of the components required to achieve this gain and show these values on the completed diagram above. [3]

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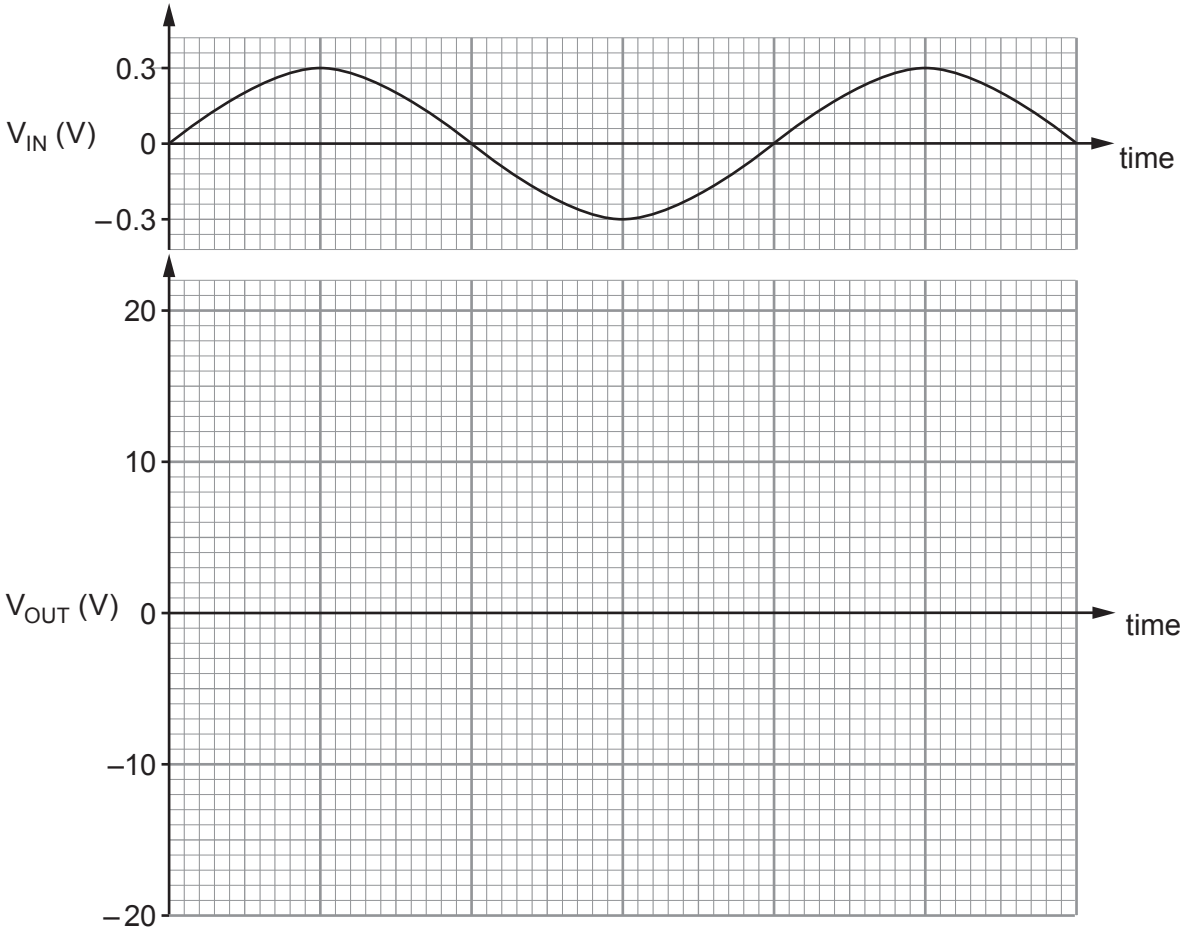
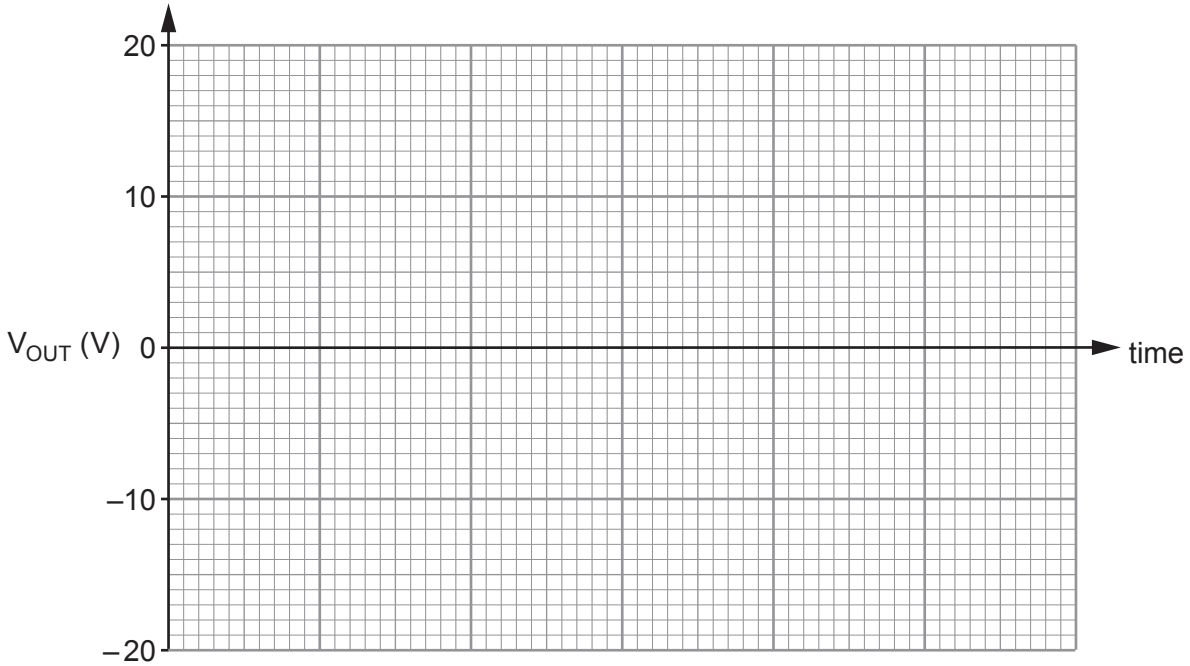
(b) The power supply is ±15 V and the op-amp saturates at ±13 V.

(i) An input signal of peak value 0.3 V is applied to the op-amp. Complete the graph to show the corresponding output voltage. [3]



(ii) The input signal peak value is now increased to 0.5 V. Draw the new output voltage from the amplifier on the graph paper below. [1]



C490U201
07

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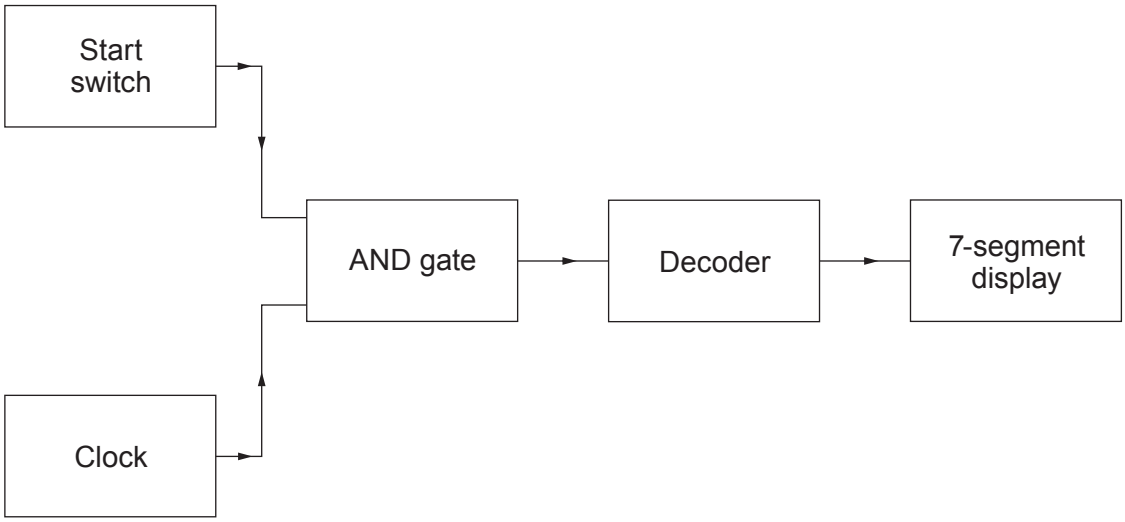
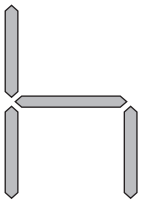
4. A student wants to design a 'heads or tails' game. The block diagram is shown below.

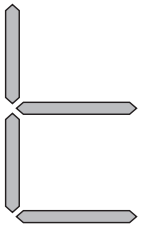
When the start switch is pressed, the clock pulses are fed through an AND gate and the 7-segment display switches rapidly between **h** and **t**. When the switch is released the display will show either **h** or **t**.



The Decoder converts the output from the AND gate into the signals required to show the following:

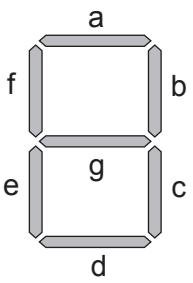


For heads



For tails

The segments are allocated on the 7-segment display as shown below.



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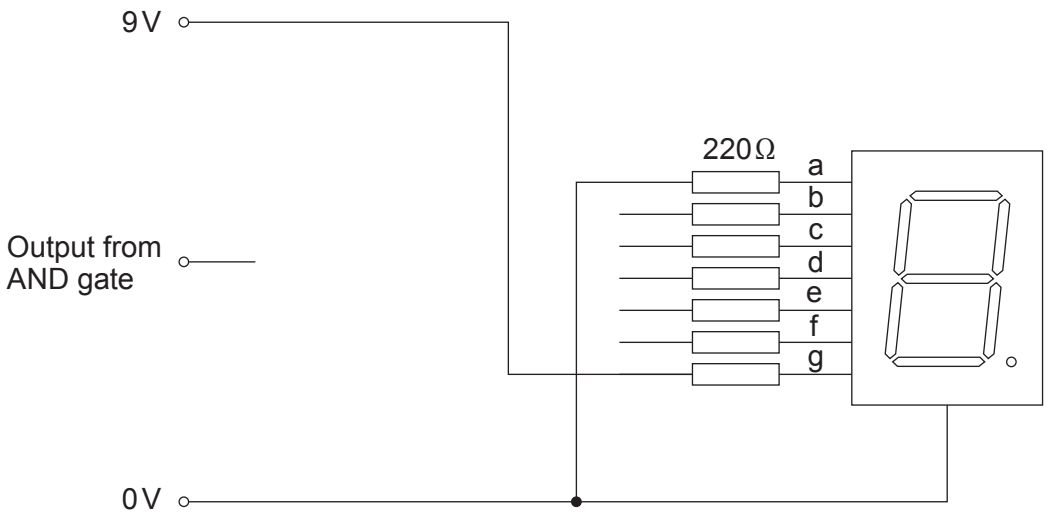
(a) The logic system needs to provide the signals required to light the correct segments on the 7-segment display to show either **h** or **t**. Complete the following table to show the logic levels required for each segment output. A logic 1 at the input to a segment causes that segment to light. [2]

Display	AND gate output	Display segments						
		a	b	c	d	e	f	g
h	1	0						1
t	0	0						1

(b) Complete the following diagram to show how the decoder is connected to the 7-segment display, including any voltage rail connections and logic gate(s) required. [4]



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09

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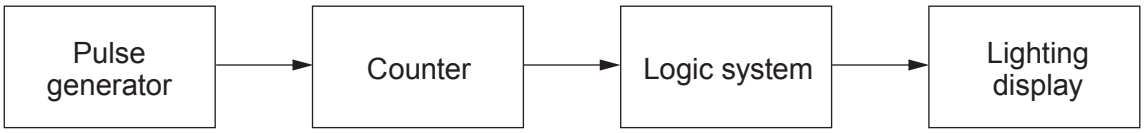
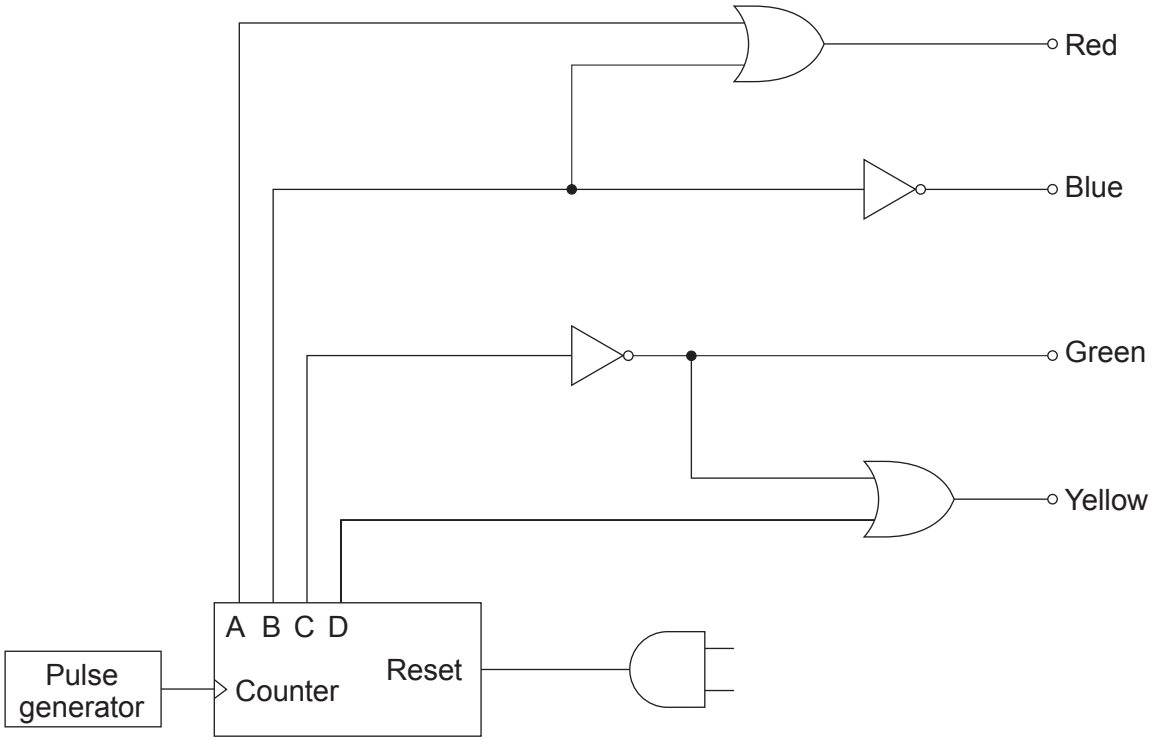
5. A student has designed a disco light generator based around a counter IC and a logic system.

Here is the block diagram for the control system.



The diagram for the counter and logic sub-systems is shown below.



(a) (i) Write down the Boolean equation for the Red output. [1]

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(ii) Write down the Boolean equation for the Yellow output. [1]

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(b) (i) Add connections to the diagram so that the counter resets on the 10^{th} pulse (A is the least significant bit). [2]

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(ii) Complete the truth table for the Red, Blue, Yellow and Green outputs. [4]

Pulse number	Counter outputs				Logic outputs			
	D	C	B	A	Red	Blue	Green	Yellow
0	0	0	0	0				
1	0	0	0	1				
2	0	0	1	0				
3	0	0	1	1				
4	0	1	0	0				
5	0	1	0	1				
6	0	1	1	0				
7	0	1	1	1				
8	1	0	0	0				
9	1	0	0	1				
10	1	0	1	0	Reset			

C490U201
11

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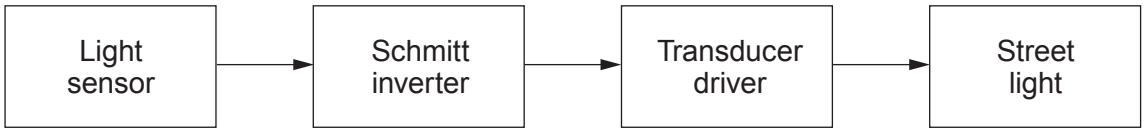
6. A local council wishes to automate its street lighting so that street lights come on automatically when it gets dark and switch off again when it becomes light.

A block diagram of the system is shown below.



(a) Give a reason for using a Schmitt inverter in this application. [1]

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(b) Here is part of the data sheet for the Schmitt inverter.

When connected to 6 V supply:
- Logic 0 = 0 V
- Logic 1 = 6 V
- The output changes from logic 1 to logic 0 when a **rising** input voltage reaches 4 V
- The output changes from logic 0 to logic 1 when a **falling** input voltage reaches 2 V

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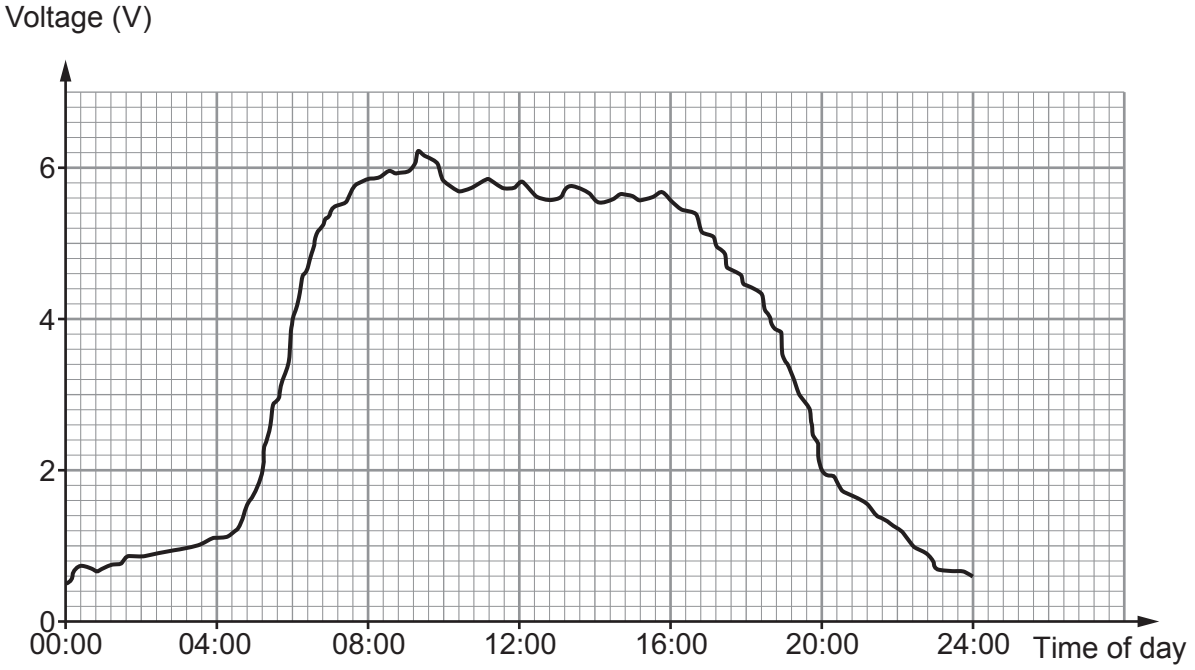
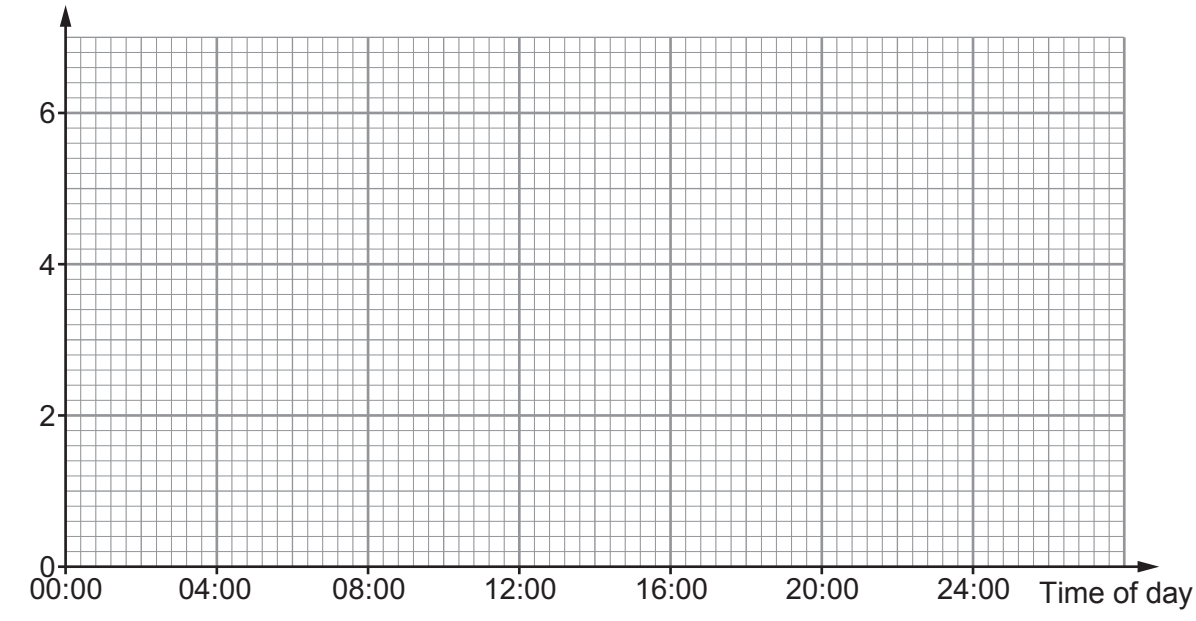
The output of the light sensor is shown in the graph below over a 24 hour period.



(i) Use the axes provided to draw the resulting output signal produced by the Schmitt inverter. [4]



(ii) Use your results to write down at what time the lights switch on and off. [2]

Lights switch OFF ..... Lights switch back ON .....

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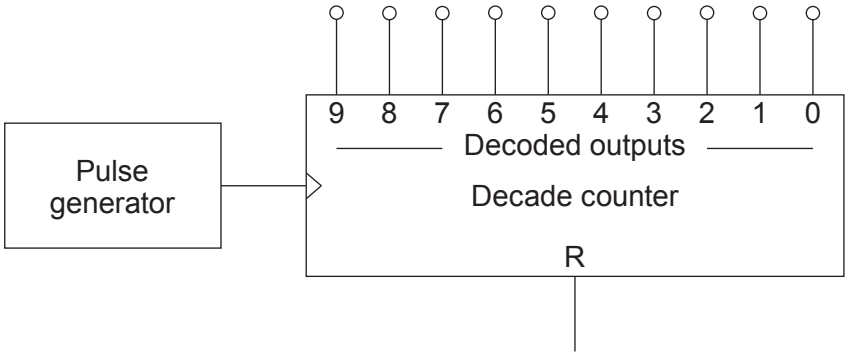
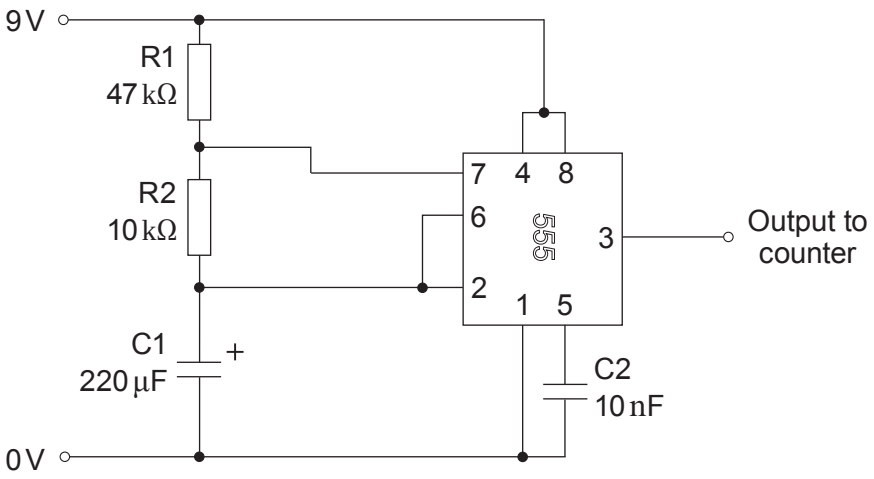
7. The diagram shows a pulse generator connected to the clock input of a decade counter.



(a) The pulse generator is made from a 555 timer IC configured as an Astable as shown below.



(i) Determine the mark/space ratio of this astable. [3]

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(ii) Calculate the frequency of this astable. [3]

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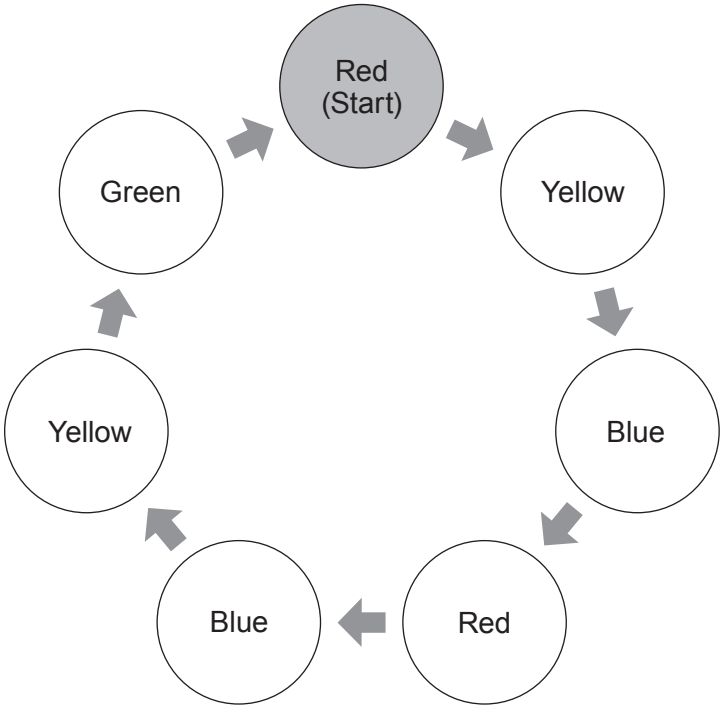
(b) The decade counter is used to produce a light sequence which continuously repeats. The lighting sequence is as follows.



(i) Complete the following table for the sequencer. [4]

Decade counter outputs	Red	Yellow	Green	Blue
0				
1				
2				
3				
4				
5				
6				
7	RESET			
8				
9				

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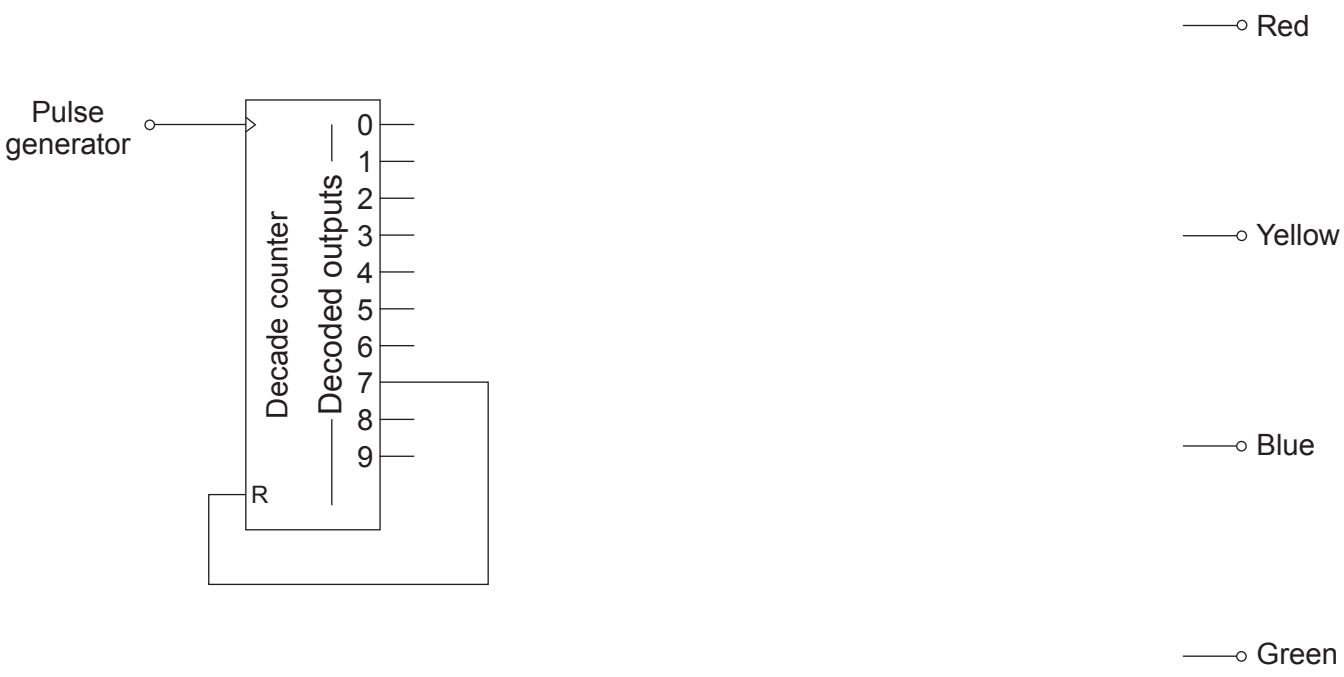
(ii) Complete the diagram below, adding any appropriate logic gates to provide the required sequence indefinitely. [4]



(iii) How long is the blue signal on for in **one** full sequence? [4]

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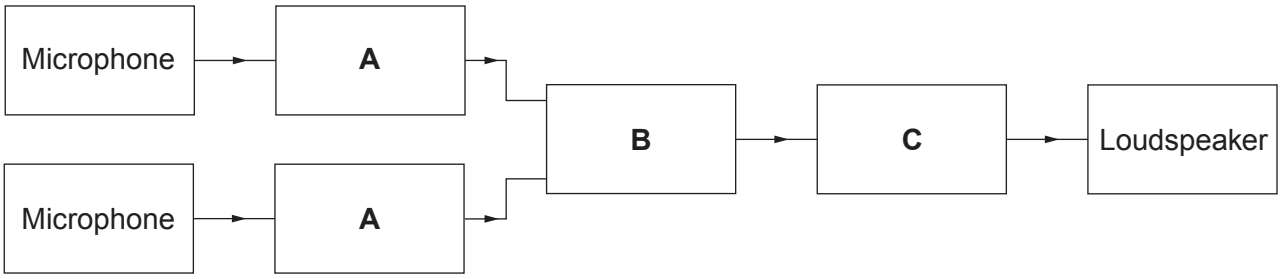
8. The block diagram represents a typical amplifier system.



(a) What do the blocks **A**, **B** and **C** represent?

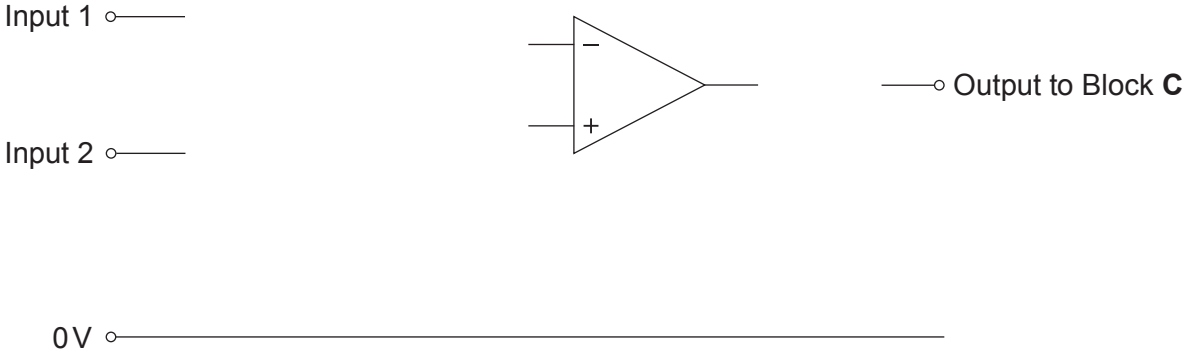
A = ...

B = ...

C = ...

[3]

(b) Complete the circuit diagram below for the design of Block **B**. [4]



(c) What is the purpose of Block **C**? [1]

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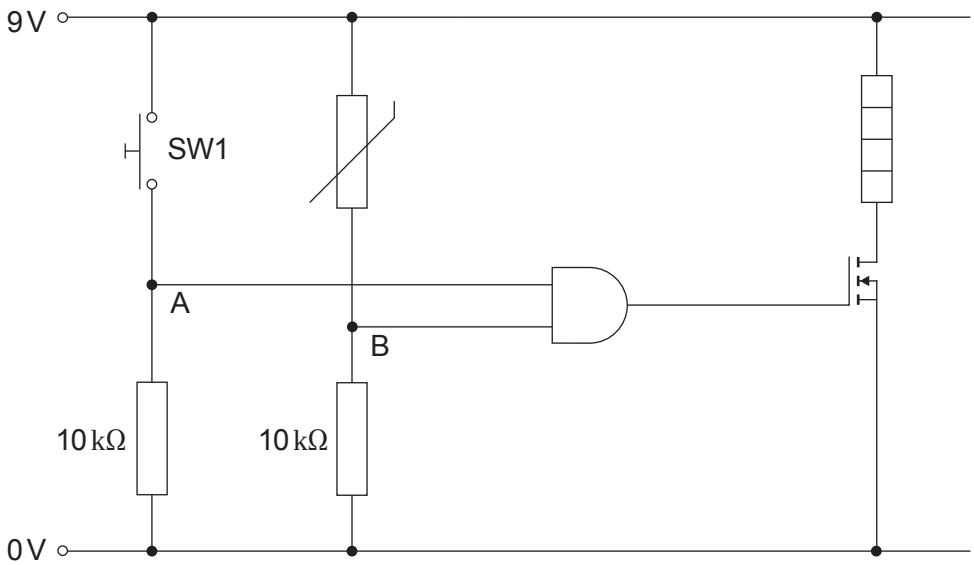
9. A heater control system for a tropical fish aquarium is shown below.



(a) The specification for the design of the circuit is:

- a heater should operate when either the temperature drops below 25 °C or a switch is pressed;
- when switch SW1 is pressed, point A should be at logic 1;
- when the water temperature drops below 25 °C, point B should be at logic 1.

Evaluate the function of the design shown in the circuit diagram against the specification and suggest any changes required to fully meet the specification. [6 QER]

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(b) The heater is rated at 9 V, 4 A and the MOSFET has a value of g_M = 0.8 S

Calculate the minimum output voltage of the logic gate to allow the heater to work at its rated current. [4]

10

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