Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

O21-C490U20-1

C490U20-1

TUESDAY, 23 NOVEMBER 2021 – AFTERNOON

ELECTRONICS – Component 2
Application of Electronics

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**5**	
2.	**15**	
3.	**5**	
4.	**10**	
5.	**5**	
6.	**6**	
7.	**12**	
8.	**6**	
9.	**16**	
Total	**80**	

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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 **8**.

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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

$$P = \frac{V^2}{R} \qquad G = 1 + \frac{R_F}{R_1}$$

$$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN} \qquad G = -\frac{R_F}{R_{IN}}$$

$$I_D = g_M(V_{GS} - 3) \qquad V_{OUT} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots\right)$$

$$I_C = h_{FE} I_B \qquad T = 1.1RC$$

$$\overline{A + B} = \overline{A}.\overline{B} \qquad f = \frac{1}{T}$$

$$\overline{A.B} = \overline{A} + \overline{B} \qquad f = \frac{1.44}{(R_1 + 2R_2)C}$$

$$G = \frac{V_{OUT}}{V_{IN}} \qquad \frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$$

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Answer **all** *questions.*

1. Ferries are used to transport vehicles and people from the UK to mainland Europe and back.

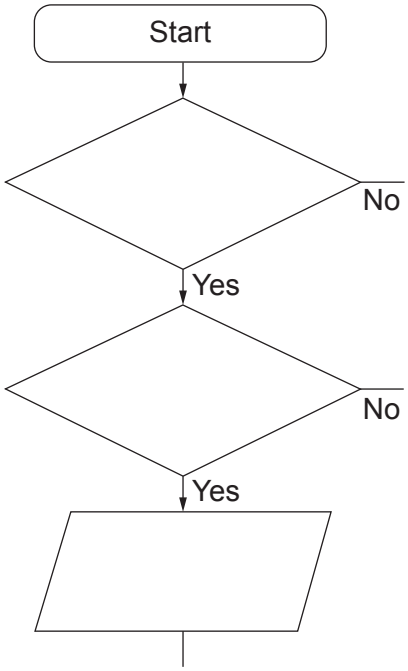
They have two special doors at the front of the ship that open to allow vehicles to drive straight onto the ferry. Each door is fitted with a switch which outputs a logic 1 when the door is closed.

A microcontroller program is used to check if both doors have been closed and to switch on a light in the control room so that the captain knows that the doors are closed and it is safe to leave port.

The switches are connected to the following inputs:

- The left hand door is connected to Input C2
- The right hand door is connected to Input C5
- The output light is connected to Output B6

Complete the flowchart below with a suitable program. [5]



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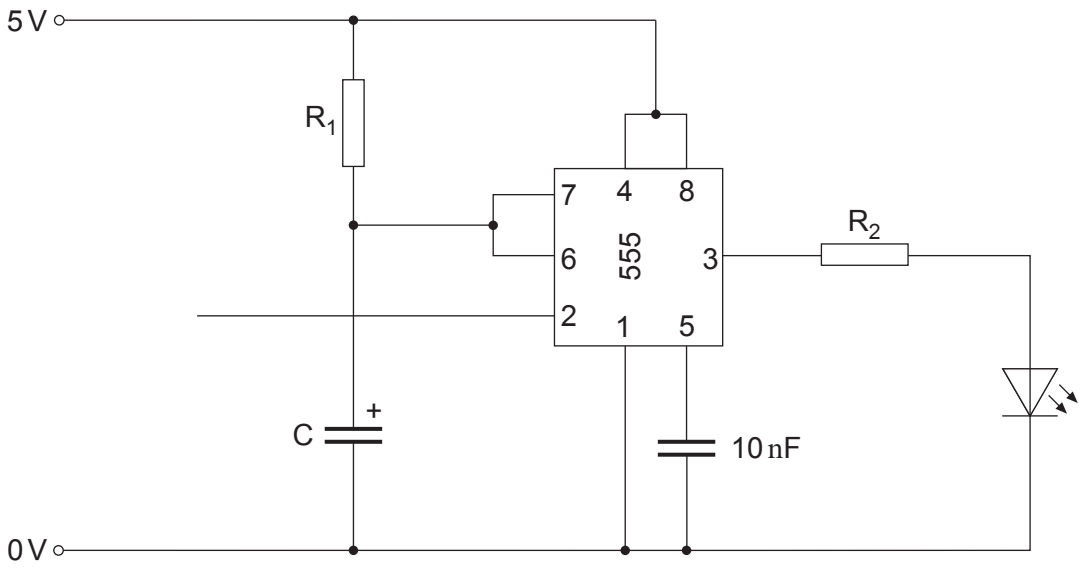
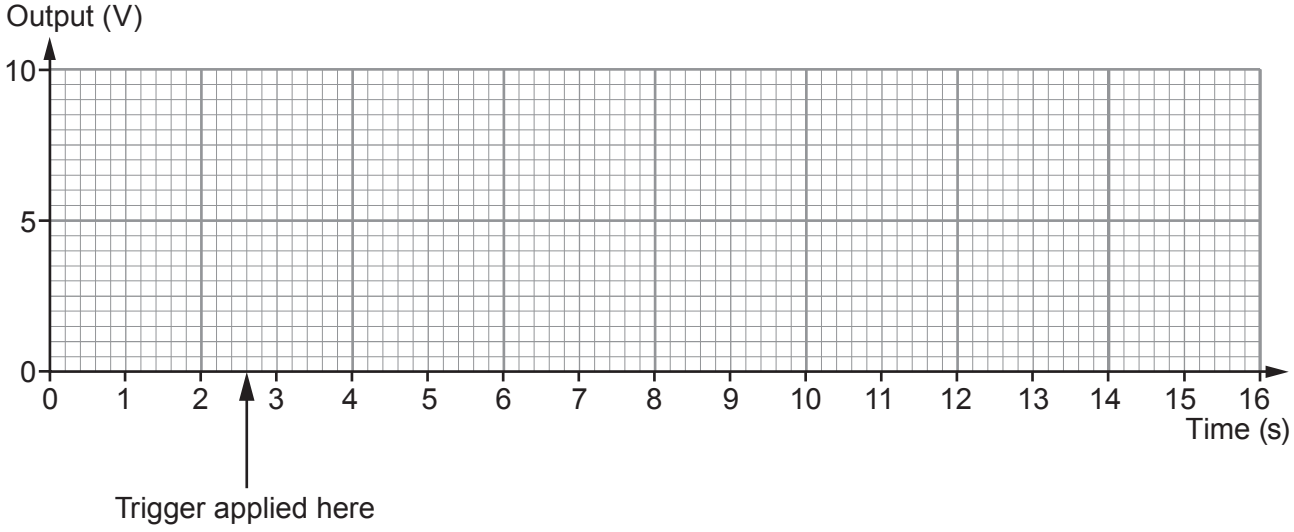
2. The following incomplete circuit diagram shows a monostable using a 555 timer.



(a) **Add suitable components to the circuit diagram** to provide a falling-edge trigger pulse when a switch is pressed. [2]

(b) Using the axes provided, sketch the output signal produced by a 12 s monostable circuit which is triggered at the time shown. [3]



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(c) (i) Here are two resistor and capacitor sets.

Set	Resistor, R_1	Capacitor, C
A	5 kΩ	2200 μF
B	10 kΩ	1000 μF

Show by calculation which set will produce a time delay nearest to 12 s. [3]

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(ii) How could you modify the timing circuit so that the delay produced can be set to exactly 12 s? [1]

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(d) (i) The colour code on resistor R_2 is Yellow, Violet, Brown, Gold. What is the value of R_2? [3]

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(ii) The forward voltage drop across the LED is 1.95 V. Calculate the current that flows through the LED. [3]

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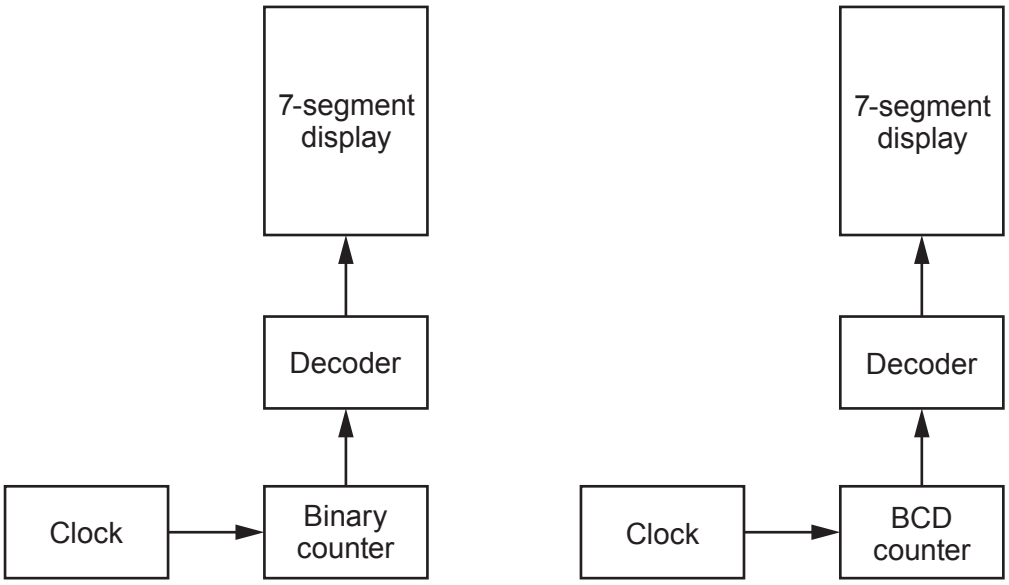
3. The following diagram shows **two** types of counter, connected to a 7-segment display.



(a) What does BCD stand for? [1]

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(b) Complete the following table to show the output from the binary counter and the BCD counter. [3]

Clock pulse	Binary counter output	BCD counter output
0	0 0 0 0	0 0 0 0
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		

(c) Why is the binary counter unsuitable for use with the 7-segment display? [1]

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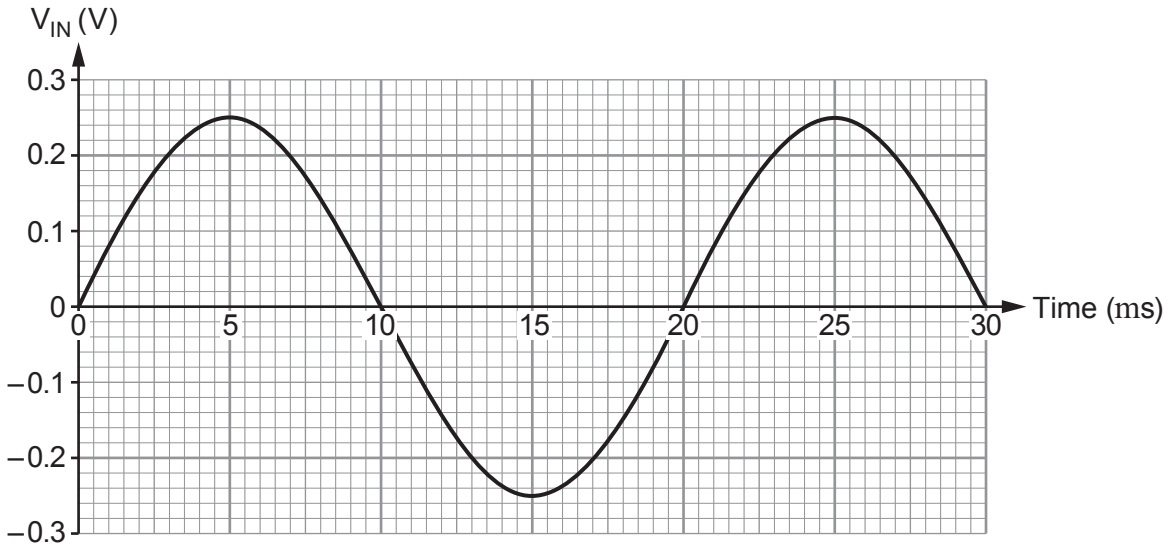
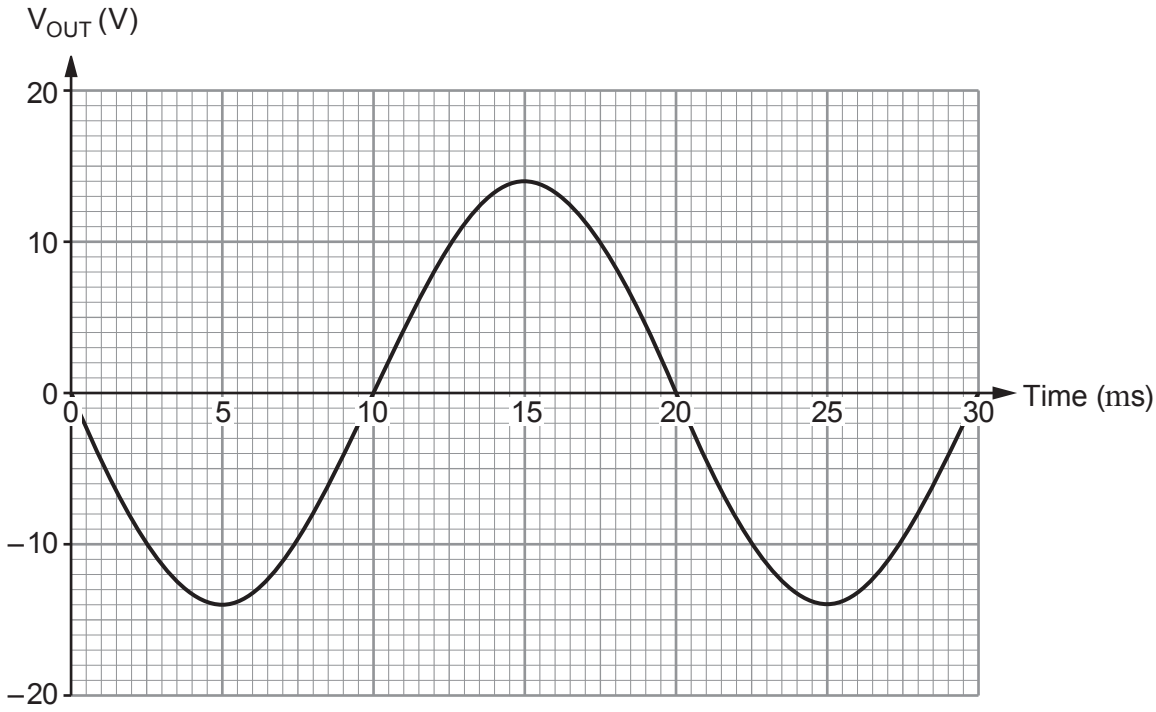
Turn over.

4. *(a)* The following graph shows the signal applied to the input of a voltage amplifier based on an op-amp.



The following graph shows the corresponding output from the amplifier.



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(i) What is the amplitude of the input signal? ..... [1]

(ii) What is the amplitude of the output signal? ..... [1]

(iii) Calculate the voltage gain of the amplifier. [2]

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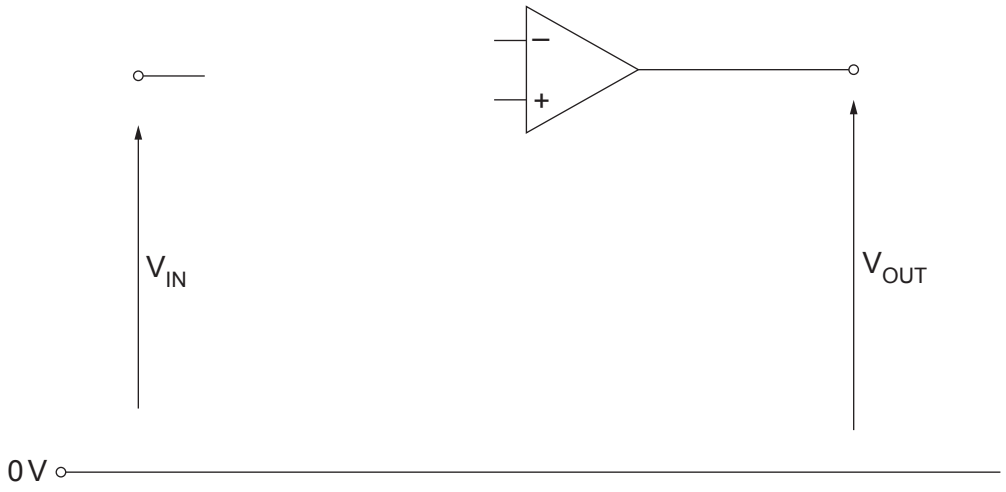
(b) Design a different voltage amplifier with a gain of –24 by adding components and connections to the diagram below. Show the values of any components used and how their values were determined. [6]



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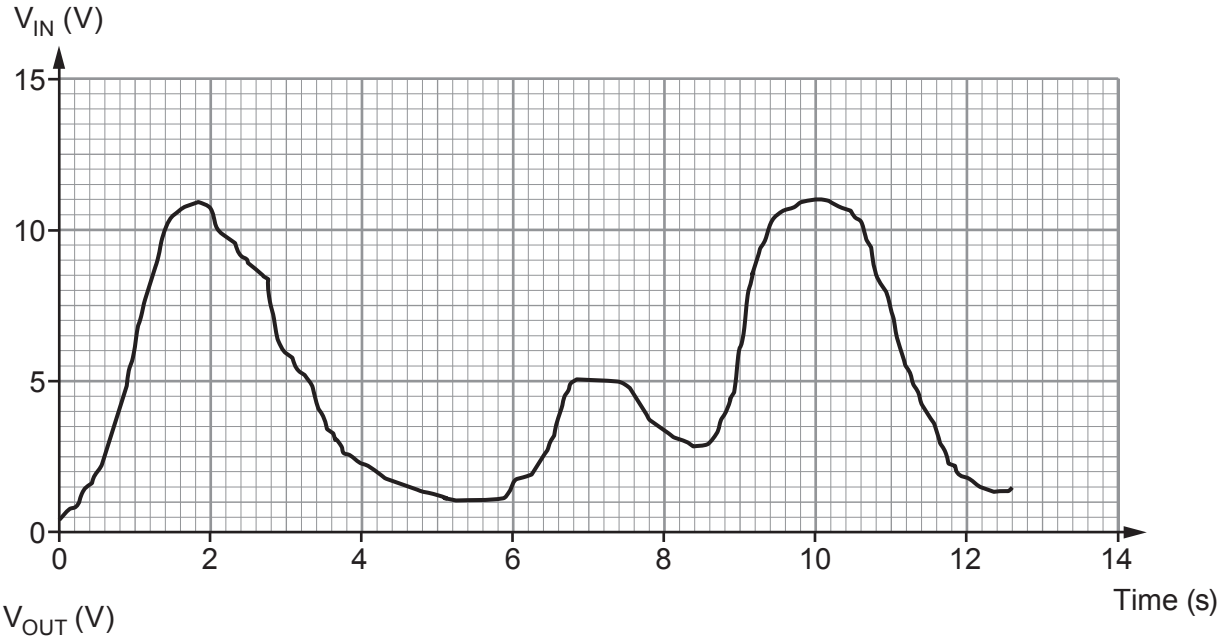
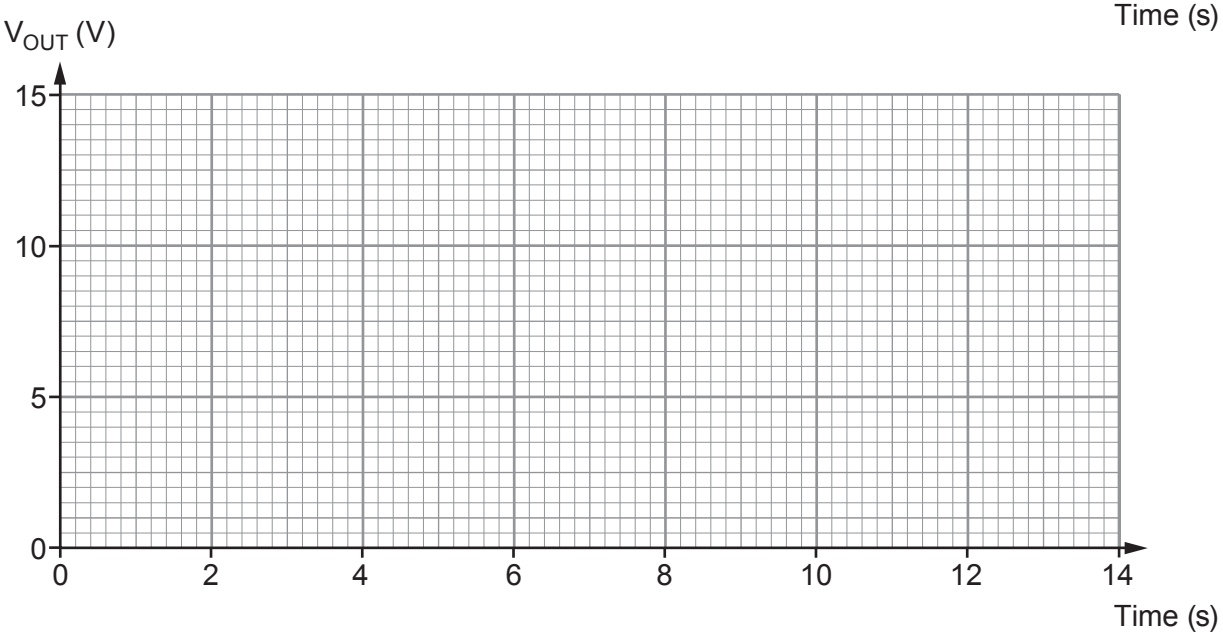
5. A data sheet gives the following information about a Schmitt inverter:

- The output changes from logic 1 to logic 0 when a **rising** input voltage reaches 10 V
- The output changes from logic 0 to logic 1 when a **falling** input voltage reaches 4 V
- Schmitt inverter output: logic 0 = 0 V and logic 1 = 12 V

Draw the graph of the waveform obtained at the output of the Schmitt inverter for the input waveform shown below. [5]





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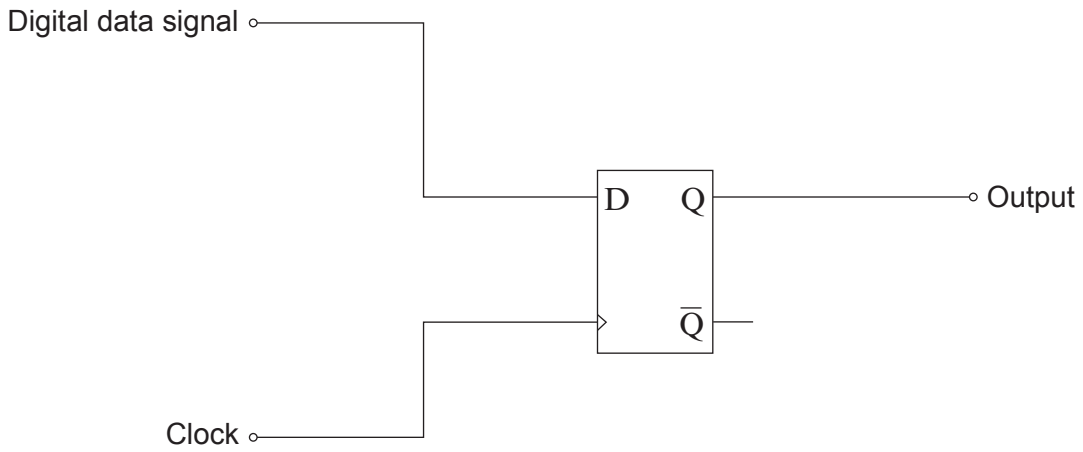
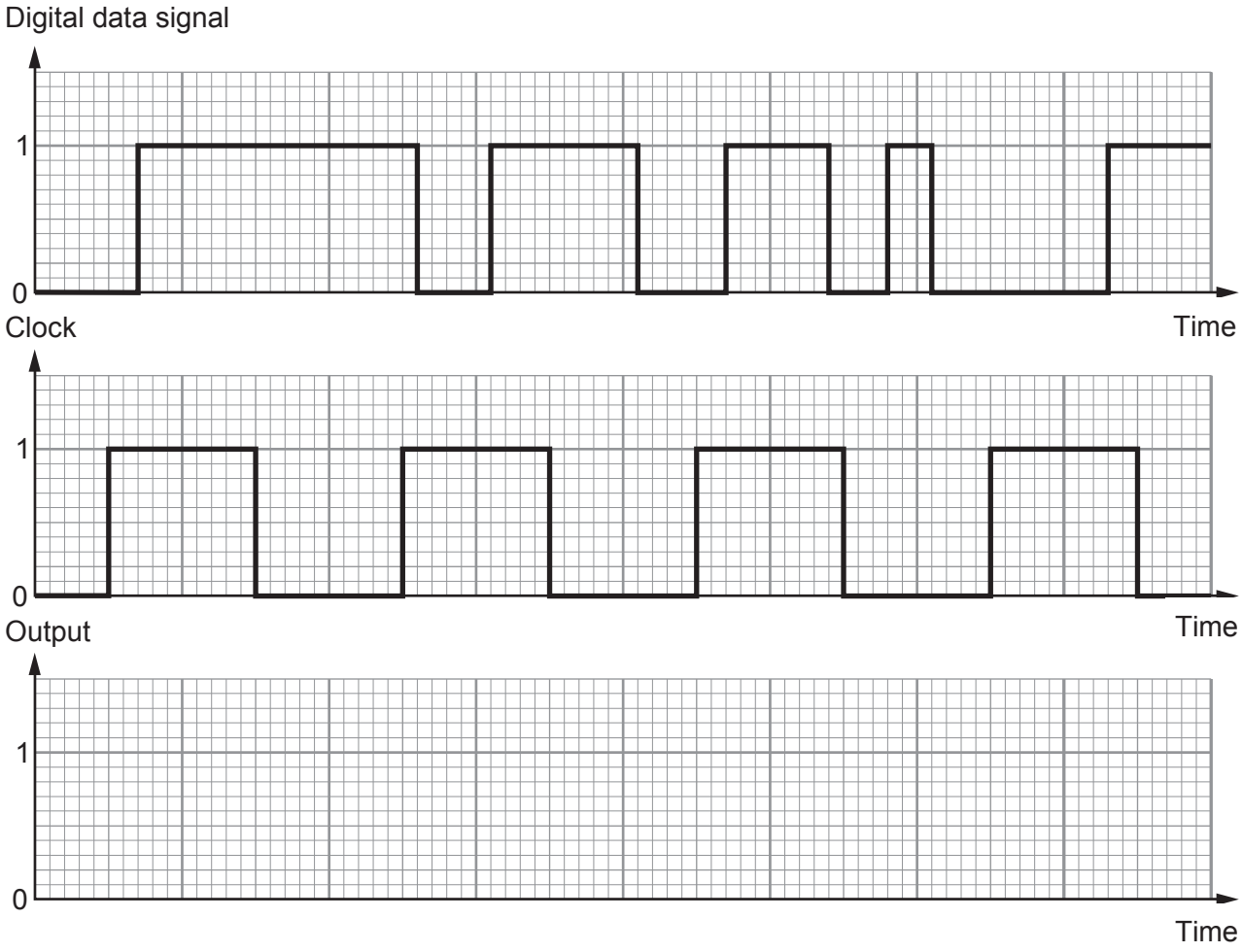
6. The following diagram shows a D-type flip-flop being used for data transfer. The D-type is rising-edge triggered.



(a) The digital data and clock signals are shown below. Complete the output graph. The output is initially low. [3]



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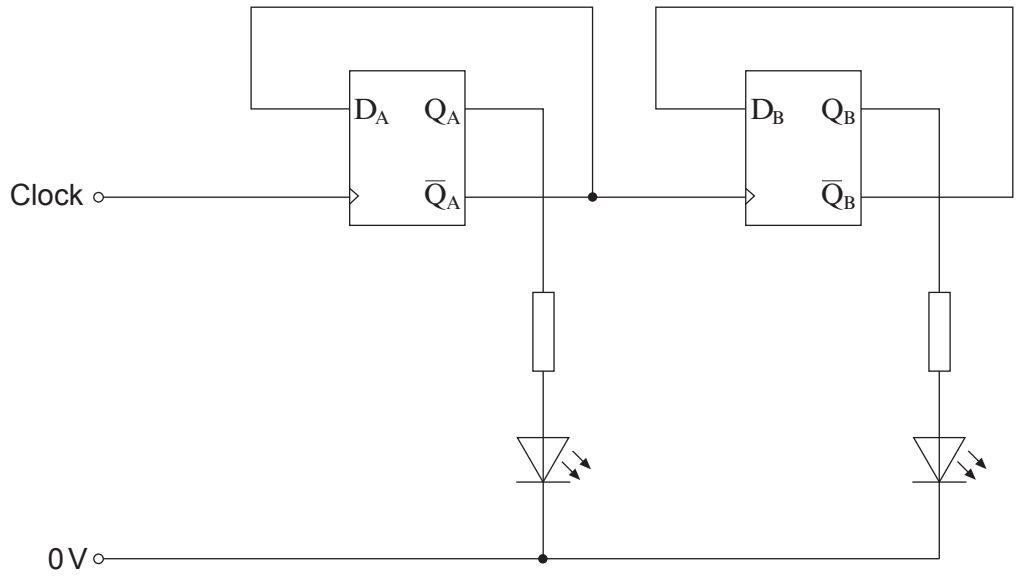
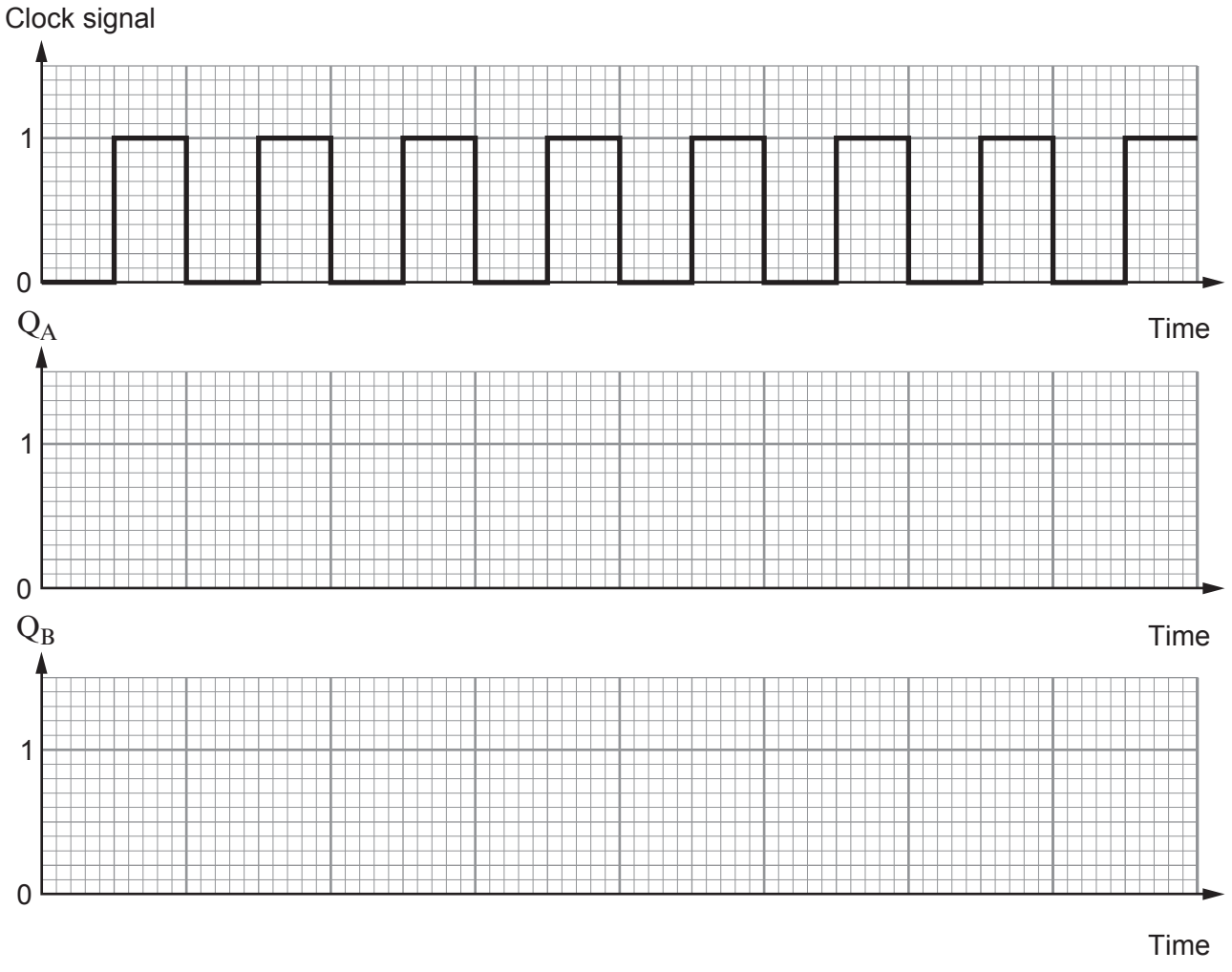
(b) The diagram shows two D-type flip-flops connected as a 2-bit counter connected to a clock.



Complete the graph below for Q_A and Q_B. Both outputs are initially at logic 0. [3]



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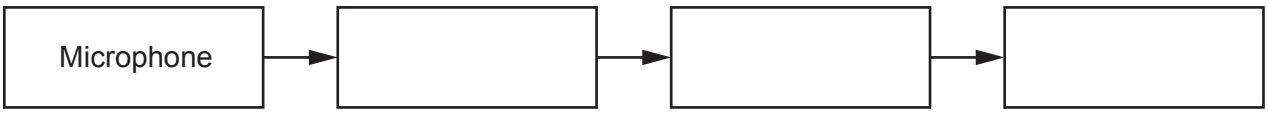
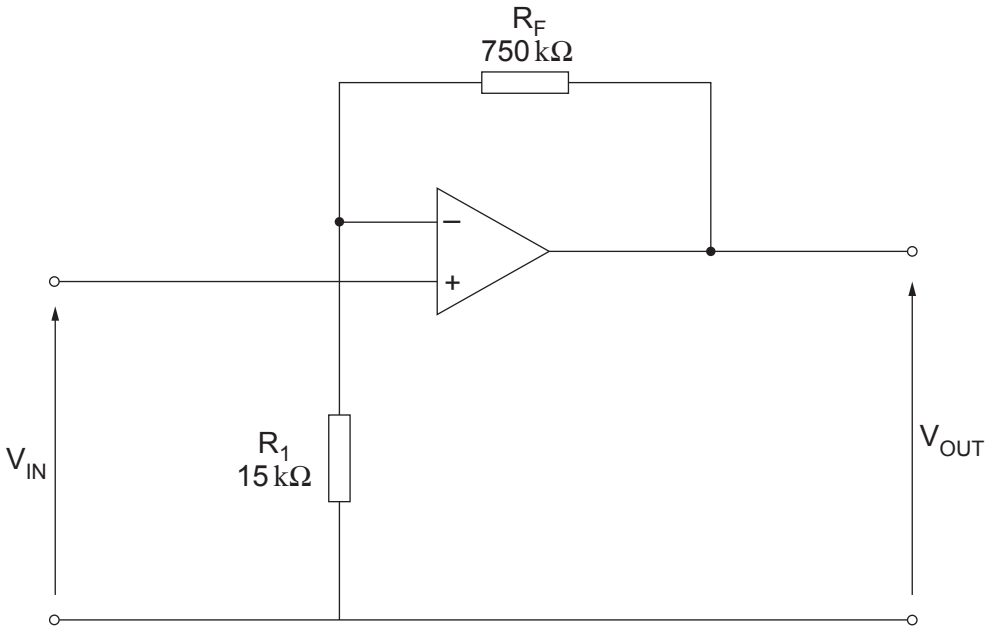
7. *(a)* Complete the block diagram of a PA system (public address system) below: [3]



(b) The following circuit shows an amplifier to be used in the PA system.



Calculate the voltage gain of this amplifier. [3]

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(c) A different voltage amplifier has a voltage gain of 40.

The signal shown opposite is applied to the input of this voltage amplifier.
The power supply is ± 12 V, and the op-amp saturates at ± 11 V.

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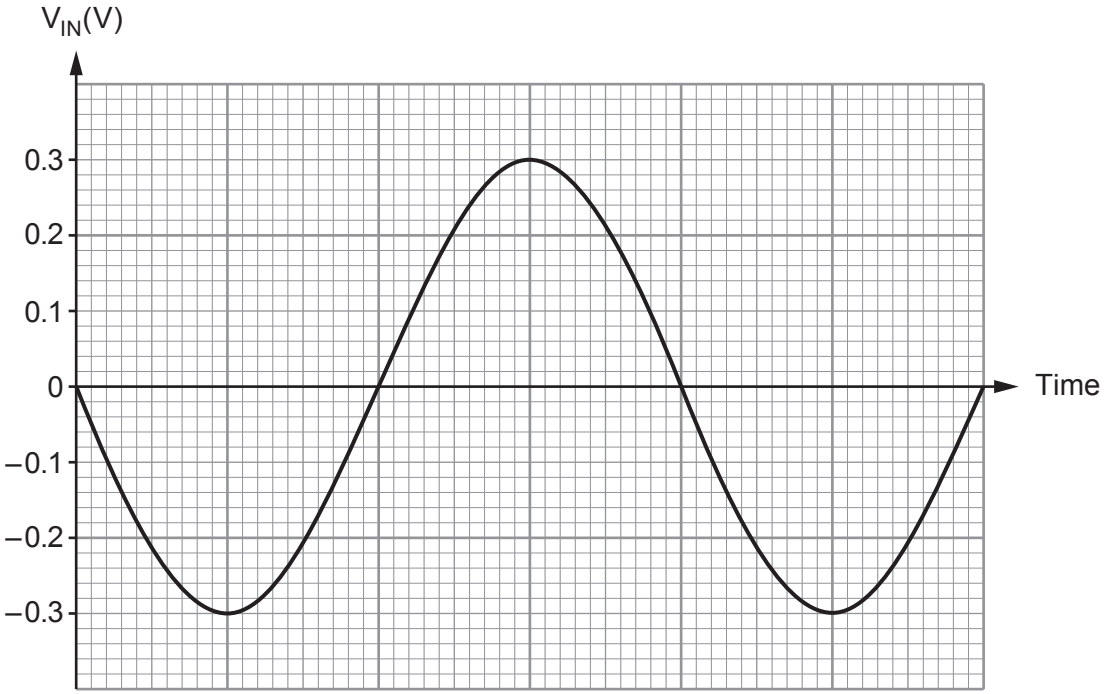

(i) Complete the following graph to show the corresponding output from the amplifier. [3]

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(ii) The amplifier has a gain-bandwidth product of 4 MHz. What is the bandwidth of the amplifier? [3]

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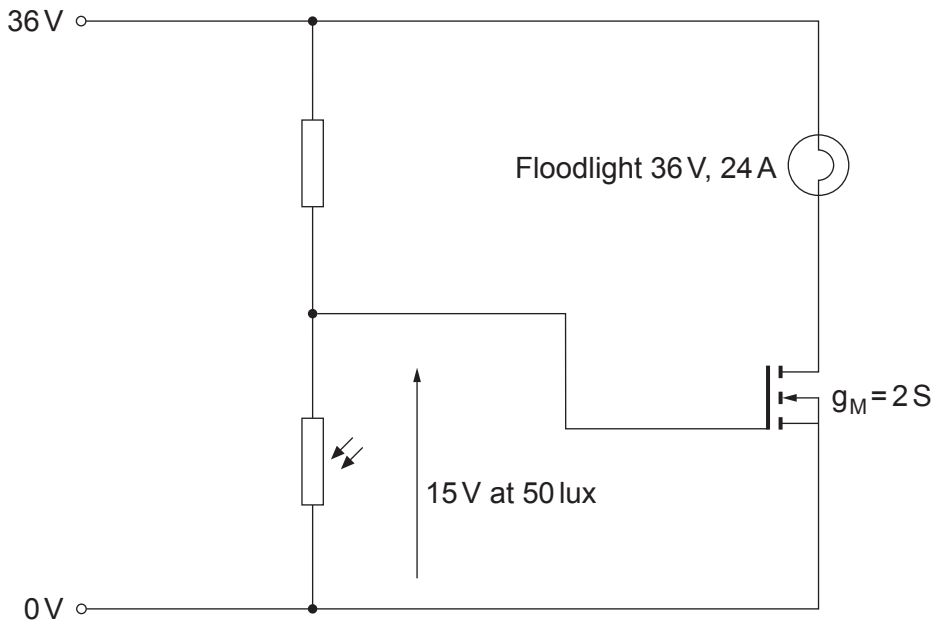
8. A system is required to switch on a 36 V, 24 A floodlight at night.

The specification for the design is:

- The floodlight should switch on fully when the light level drops to 50 lux.
- The floodlight should switch off when the light level rises significantly above 50 lux.
- The system should be adjustable so that the light level at which the light switches on can be adjusted.

The following circuit shows a possible solution.



Evaluate the circuit design against the specification and if necessary suggest any modifications required to meet the specification. [6 QER]

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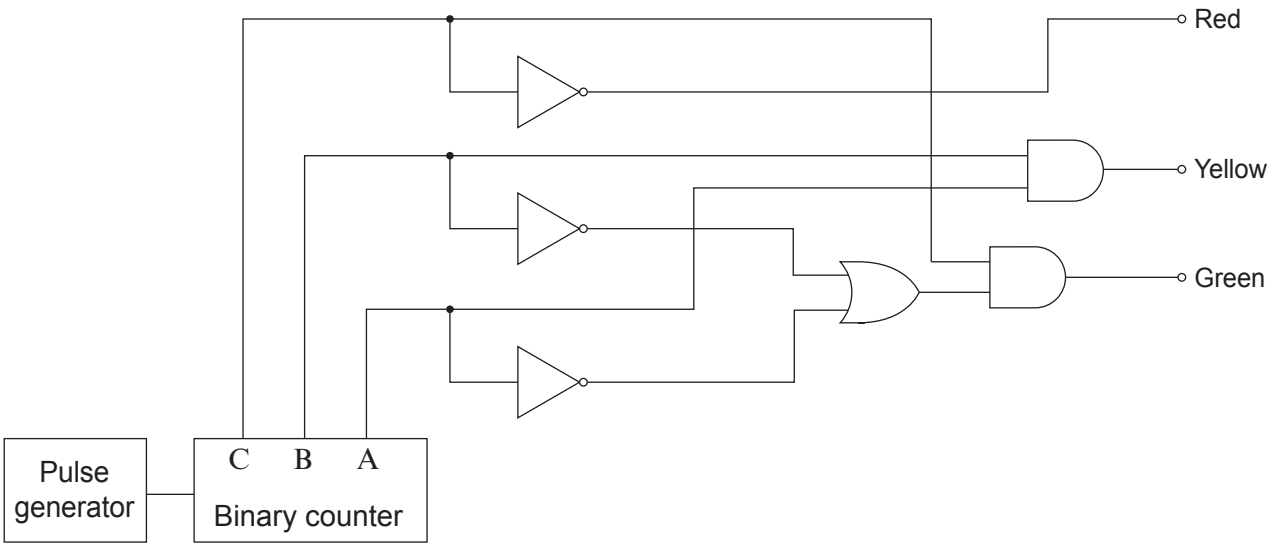
9. The following circuit diagram is a sequence generator that repeats continuously.



(a) Write the Boolean expression for red and yellow outputs. [2]

(i) Red = ...

(ii) Yellow = ...

(b) Complete the truth table for the circuit. [3]

Counter outputs			Display outputs		
C	B	A	Red	Yellow	Green
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

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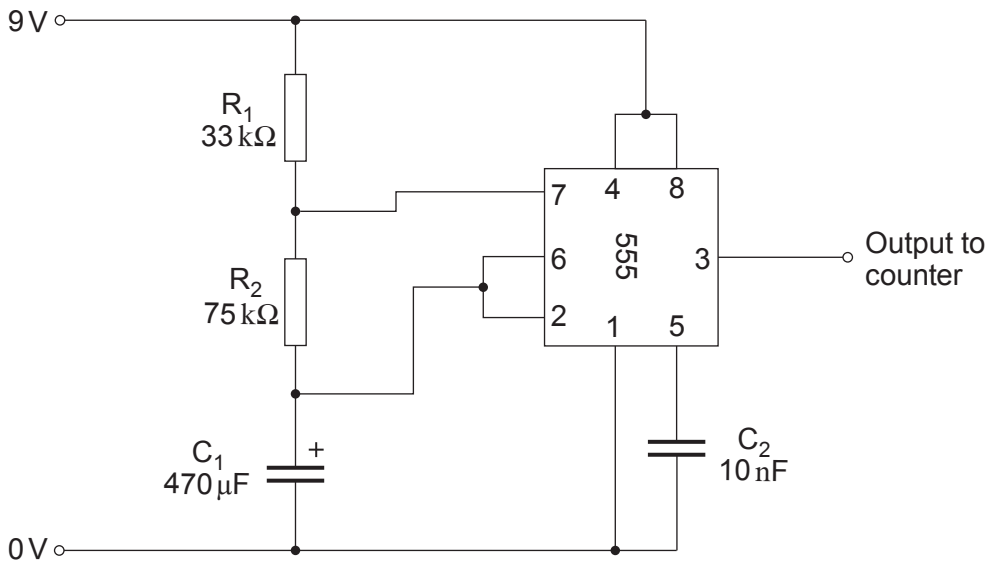
(c) The pulse generator is made from the 555 astable timer shown below.



(i) Calculate the frequency of the astable. Give your answer to 4 decimal places. [3]

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(ii) Calculate the period of the astable. Give your answer to the nearest second. [3]

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(d) Use your answers to *(b)* and *(c)* to determine the time the red light is on in each sequence. [2]

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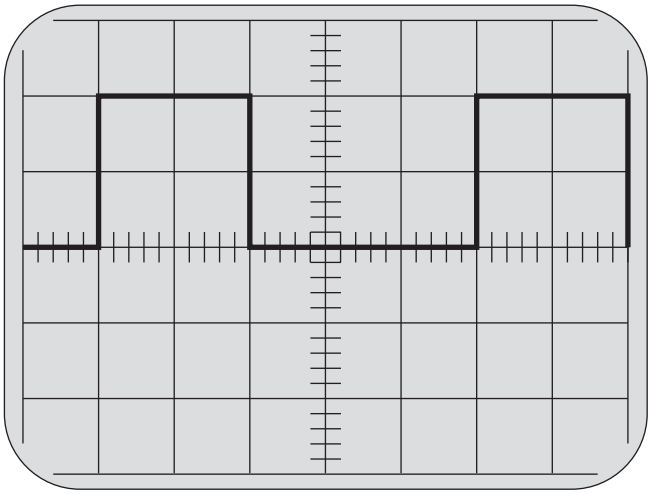
(e) The following diagram shows the output of a different 555 astable displayed on an oscilloscope screen. The squares on the screen are 1 cm × 1 cm.



Oscilloscope Settings

Time Base = 2 ms / cm

Voltage Gain = 5 V / cm

Calculate the frequency of this astable. [3]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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