Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

C490U20-1

O20-C490U20-1

TUESDAY, 10 NOVEMBER 2020 – MORNING

ELECTRONICS – Component 2
Application of Electronics

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**9**	
3.	**11**	
4.	**6**	
5.	**17**	
6.	**13**	
7.	**6**	
8.	**6**	
9.	**6**	
Total	**80**	

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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**.

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.*

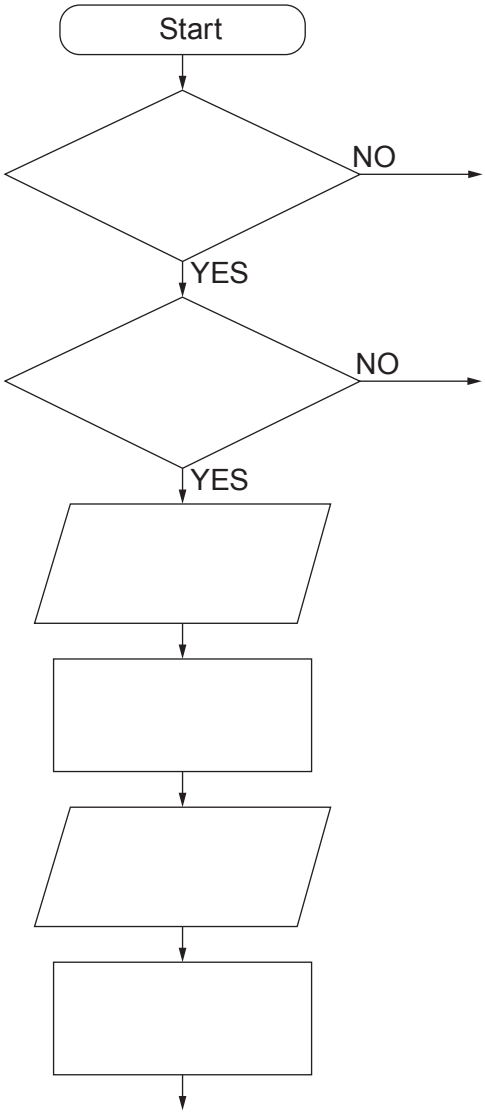
1. Modern buses have a buzzer installed to warn people outside the bus that it is about to reverse.

A microcontroller is fitted to the bus to pulse the buzzer when the ignition is on and reverse gear is selected, even if the bus is not actually moving.

(a) An incomplete flowchart for this control system is shown below.
Add these instructions to the correct boxes in the flowchart:
Instructions may be used once, more than once or not at all. [3]

Delay 0.5 s **Switch on buzzer** **Is Ignition On?**

Is reverse gear selected? **Switch off buzzer**



(b) Add links:
- so that the program repeats
- to complete the 'NO' paths from the decision boxes. [3]

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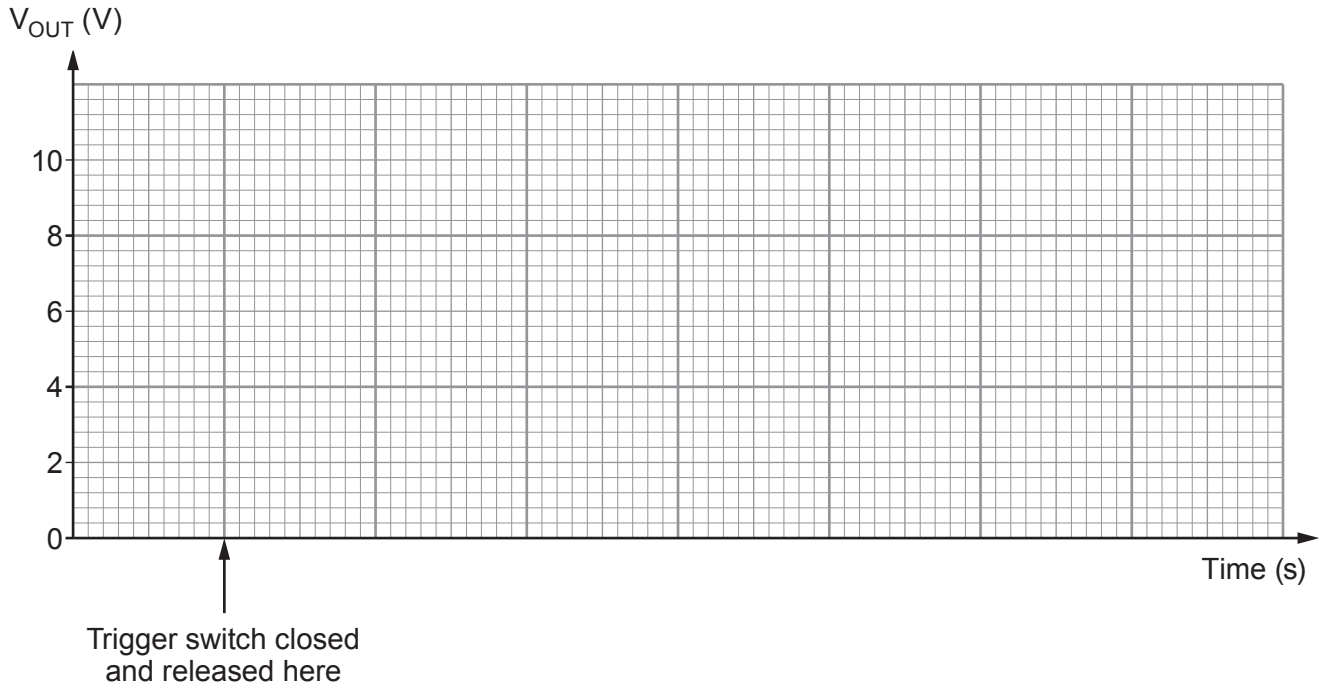
2. *(a)* A monostable produces a time delay of 4.3 s and has an output voltage of 9 V when triggered. Initially V_{OUT} is at 0 V.

Complete the graph below to show what happens before and after a trigger switch is closed then released.

Label the time axis with suitable values. [3]



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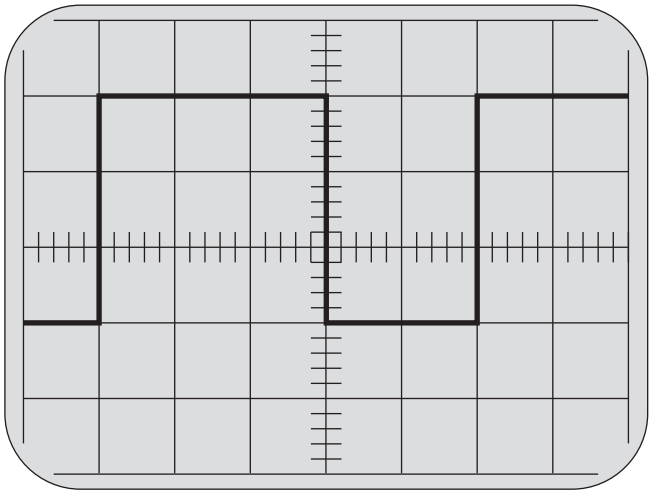
(b) The following signal from a pulse generator is displayed on an oscilloscope screen. The time base is set to $5\,\text{ms/cm}$ and the voltage gain is set at $2\,\text{V/cm}$.



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

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(ii) I. Determine the **space** time for this signal. [1]

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II. Determine the **mark** time for this signal. [1]

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III. Calculate the frequency of this astable. [3]

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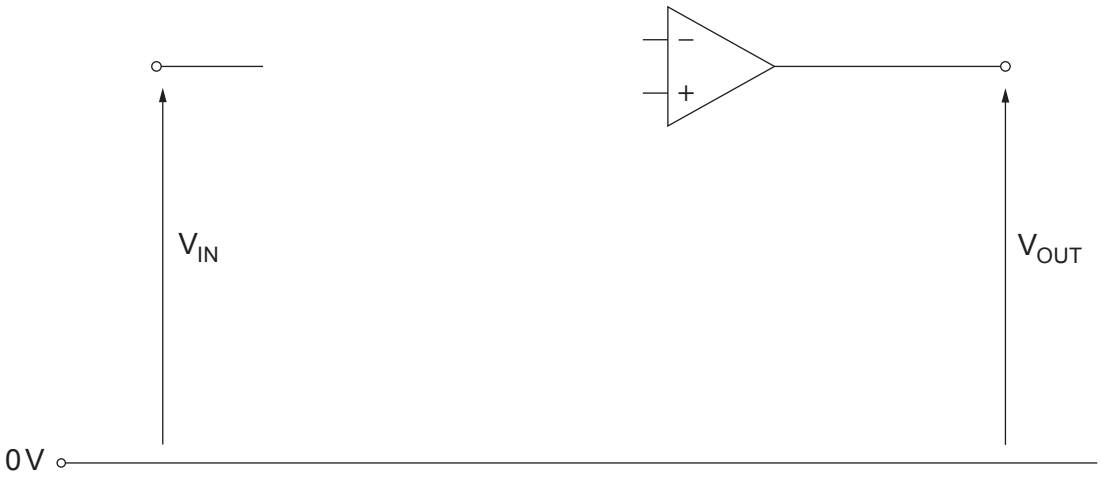
3. *(a)* (i) Complete the design for an inverting voltage amplifier by adding the required components and connections to the diagram below. [3]



(ii) The amplifier has a voltage gain of –40. Calculate the values of the components required to achieve this gain and show these values on the diagram above. [3]

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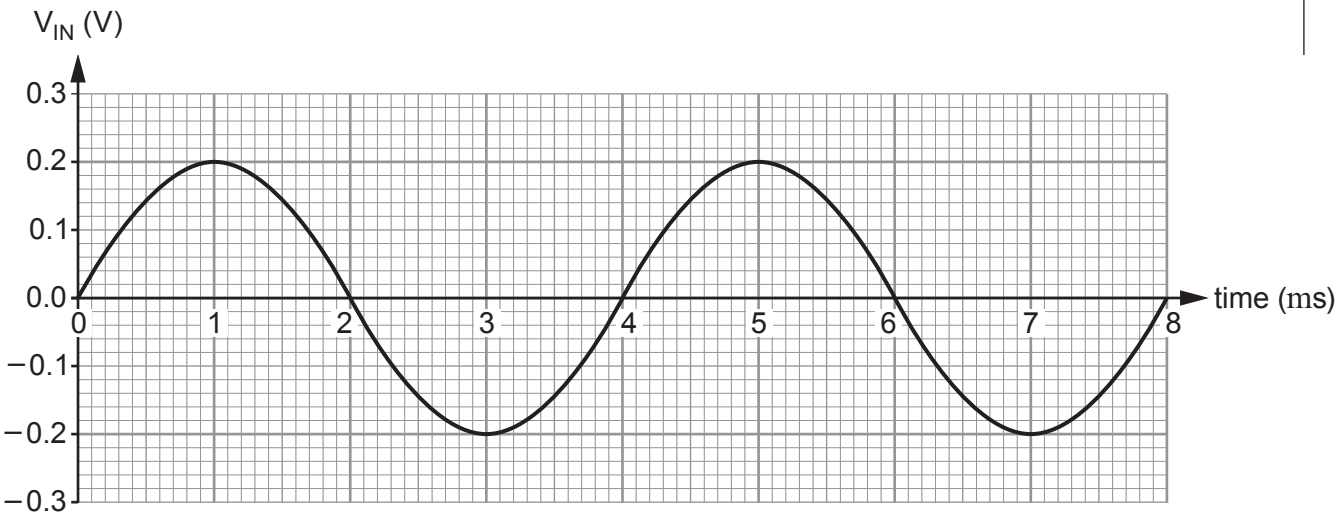
(b) The power supply is ±12 V and the op-amp saturates at ±10 V.
The following input signal is applied to the op-amp.



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

(ii) Calculate the amplitude of the output signal. [1]

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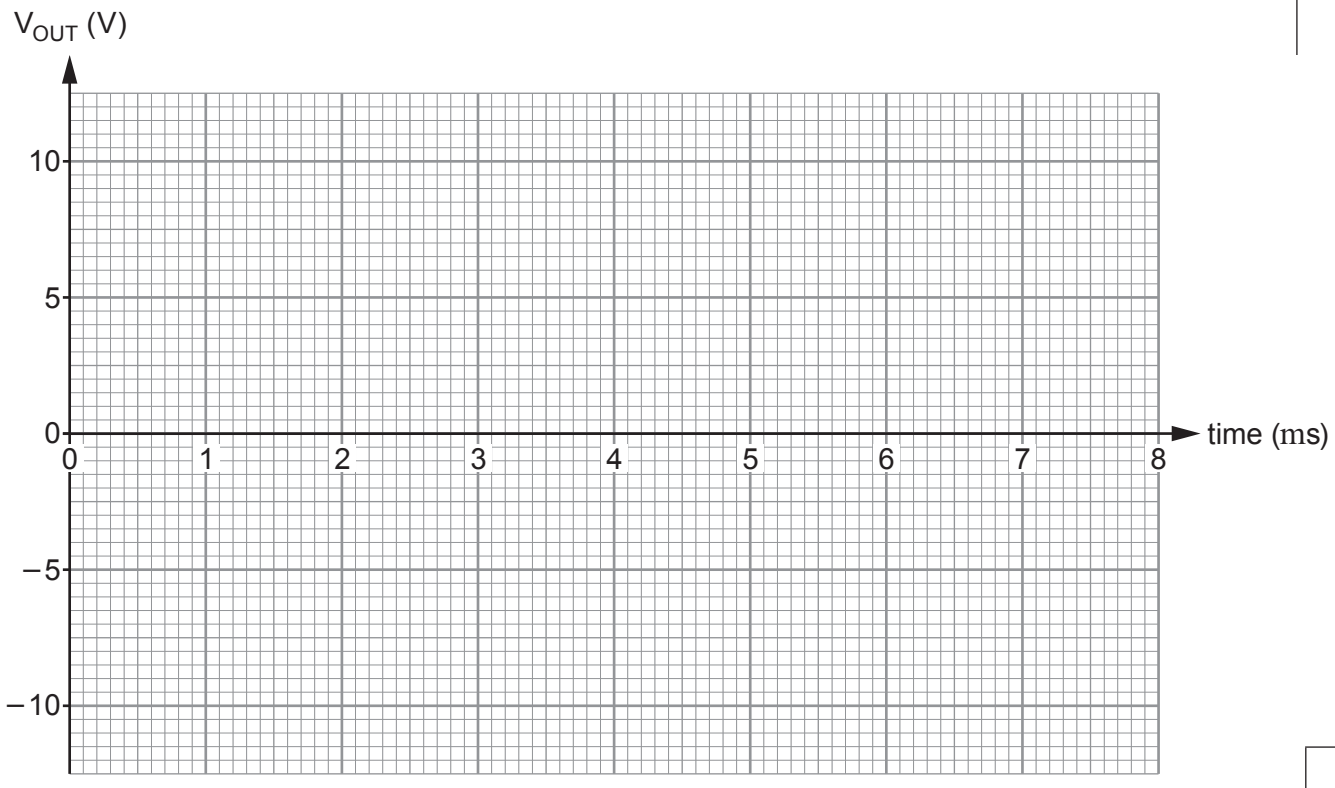
(iii) Complete the graph to show the corresponding output voltage. [3]



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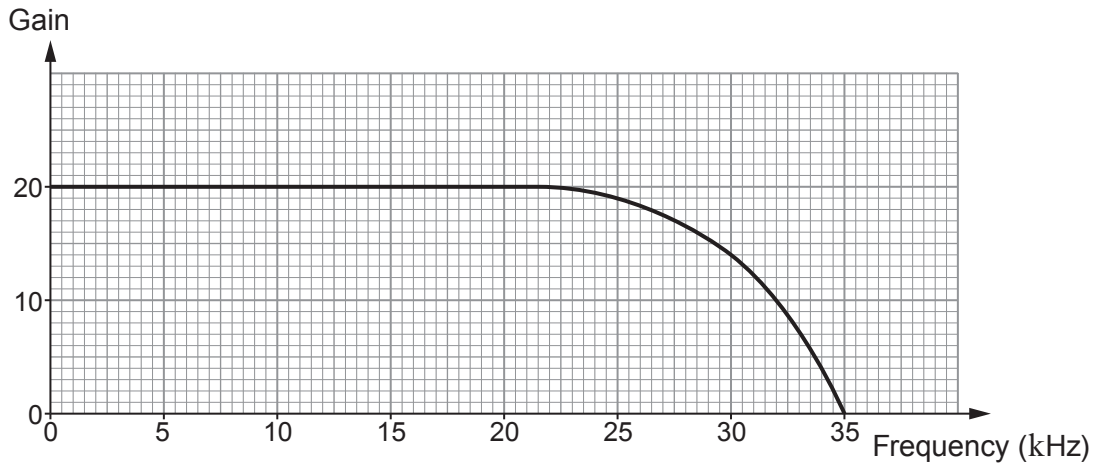
4. The following shows the gain-bandwidth graph for an amplifier circuit based on an op-amp.



(a) What is the gain of the amplifier at 10 kHz? [1]

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(b) Determine the bandwidth of this amplifier. Show clearly on the graph how you obtained your answer. [3]

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(c) What is the effect on the bandwidth when the gain is doubled? [2]

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Turn over.

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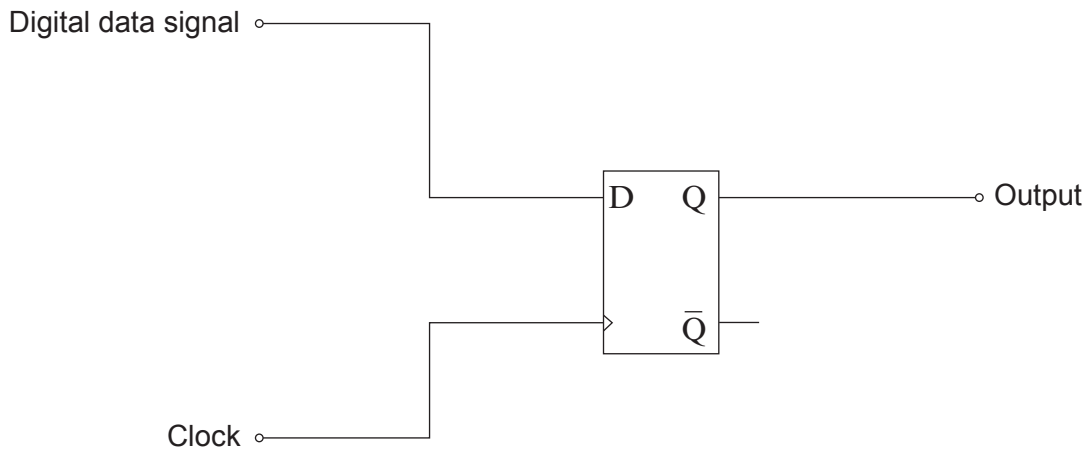
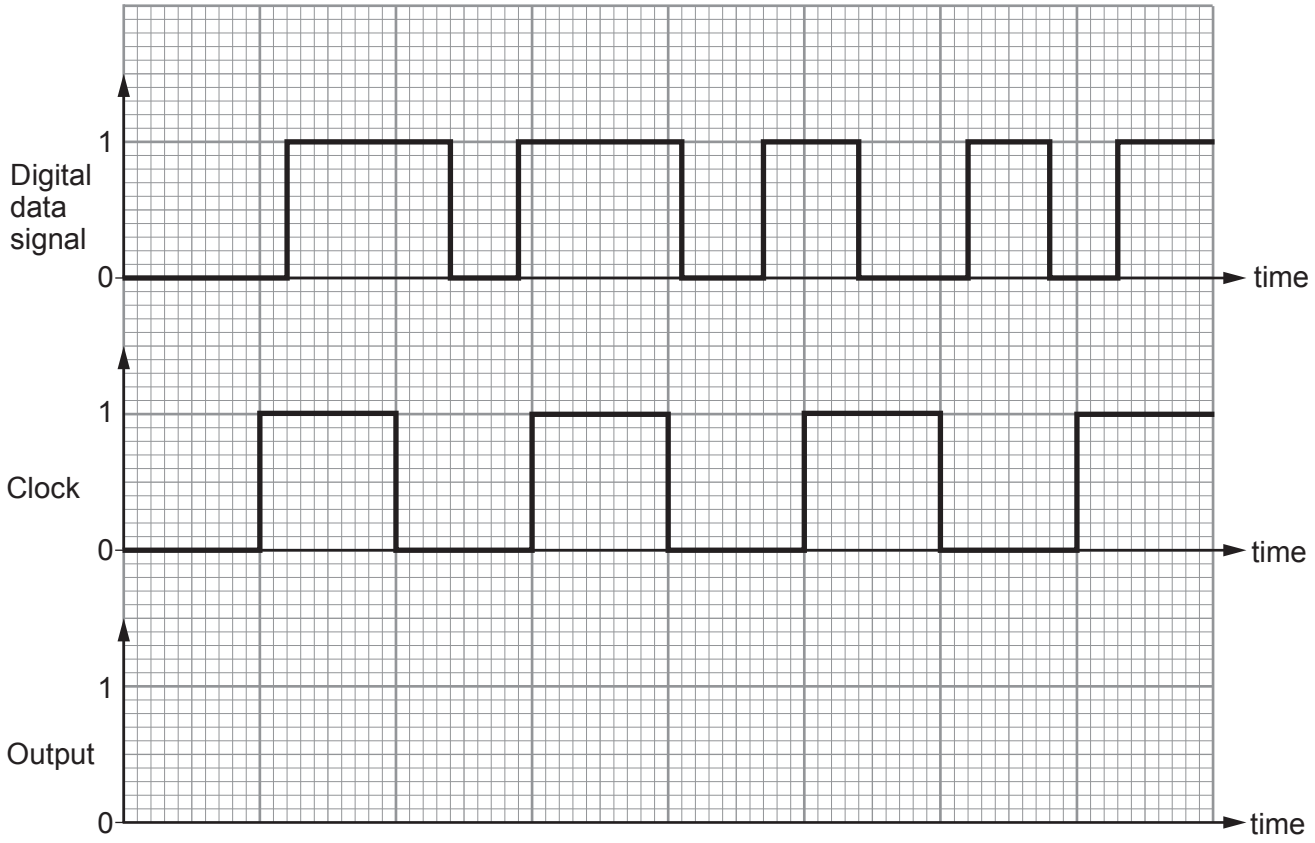
5. The D-type flip-flop is a very useful component and can be used in a variety of applications.

(a) The following diagram shows a rising-edge triggered D-type flip-flop connected to a digital data signal and a clock.



Complete the output graph below for the digital data and clock signals shown below. The output is initially low. [3]



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(b) The diagram shows a pulse generator and a D-type flip-flop.

(i) The D-type performs a divide-by-two action on pulses from the pulse generator. Draw the two connections needed to do this on the diagram. [2]

(ii) The frequency of the signal at the Q output is 100 Hz.

I. What is the frequency of the $\overline{Q}$ output? ..... [1]

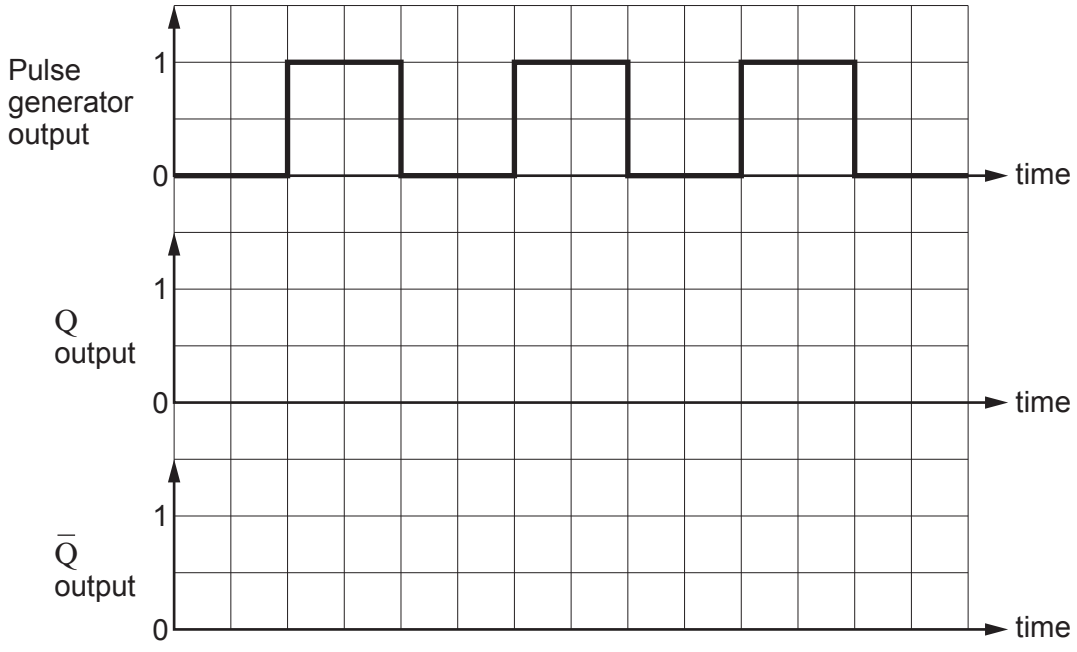
II. What is the frequency of the pulse generator output? ..... [1]

(iii) The D-type flip-flop is rising-edge triggered.

I. Label a rising-edge on the pulse generator output graph. [1]

II. The Q output is initially at logic 1.
Complete the second graph to show the signal at the Q output. [3]

III. Complete the third graph to show the signal at the $\overline{Q}$ output. [1]



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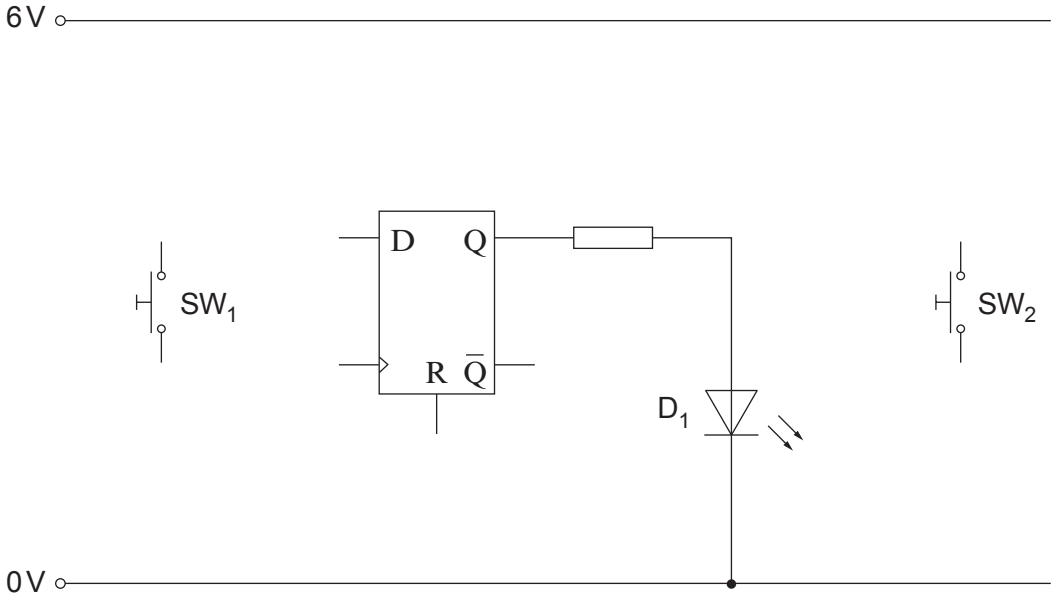
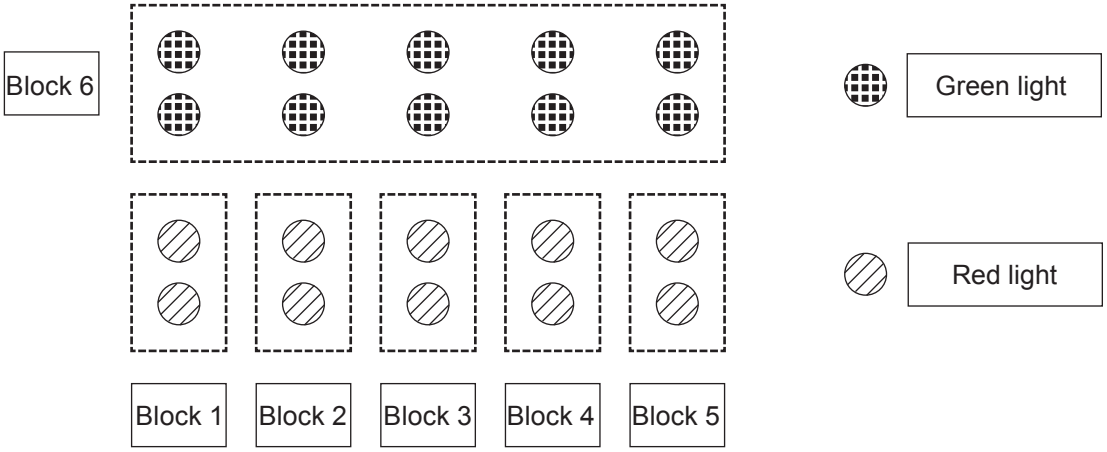
(c) Another use of a D-type flip-flop is as a latch.

Complete the design of a latch below so that switch SW_1 makes the LED come on, and switch SW_2 resets the latch so that the LED goes off. Additional components can be added to your design as required. [5]



6. A student wants to create a Formula 1 style starting display for their model car racing track. The display looks like this:

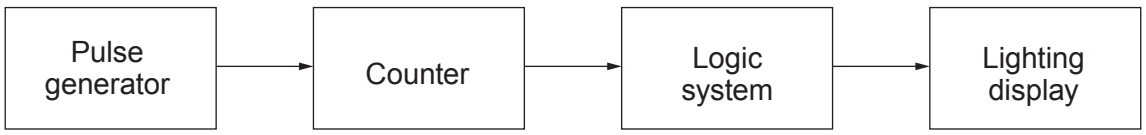


The race start sequence begins with all red lights on and all green lights off. The red lights then go off block by block. When they are all off the green lights then come on.

The sequence is as follows:

	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
Start	On	On	On	On	On	Off
Pulse 1	Off	On	On	On	On	Off
Pulse 2	Off	Off	On	On	On	Off
Pulse 3	Off	Off	Off	On	On	Off
Pulse 4	Off	Off	Off	Off	On	Off
Pulse 5	Off	Off	Off	Off	Off	On
Pulse 6	Off	Off	Off	Off	Off	On
Pulse 7	Off	Off	Off	Off	Off	Off

Here is the overall block diagram for the starting display system.



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(a) (i) To turn a light on in the display a logic 1 is required.
Complete the following truth table to produce the necessary lighting display. [1]

Counter outputs			Display outputs					
C	B	A	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6
0	0	0						
0	0	1						
0	1	0						
0	1	1						
1	0	0						
1	0	1						
1	1	0						
1	1	1						

(ii) The **Block 4** output can be obtained using a single logic gate. Write down the Boolean equation for this output. [1]

Block 4 = ...

(iii) The **Block 6** output cannot be obtained from a single logic gate. Write down the Boolean equation for this output. [3]

Block 6 = ...

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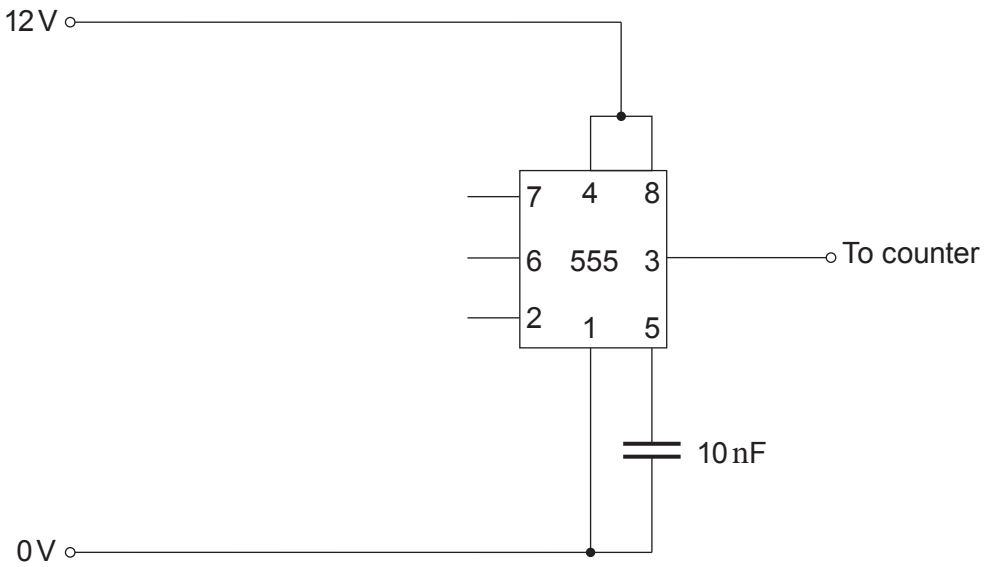
(b) Complete the design of the pulse generator by adding the necessary components and connections. [4]



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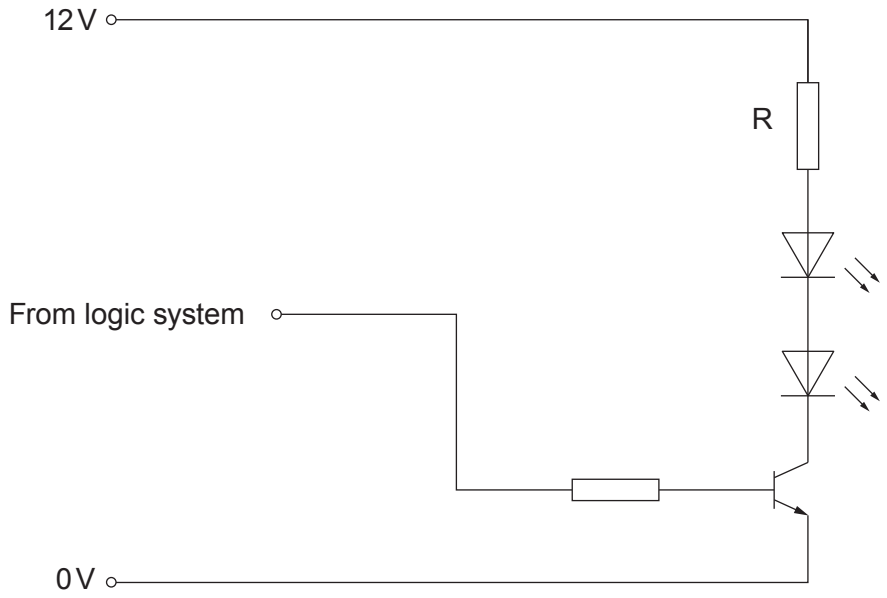
(c) The red LEDs are driven from a transistor switch as shown below.



The transistor is saturated. The forward voltage drop V_F for a red LED is 1.85 V. Determine the preferred value of R required to limit the current through each LED to no more than 20 mA. [4]

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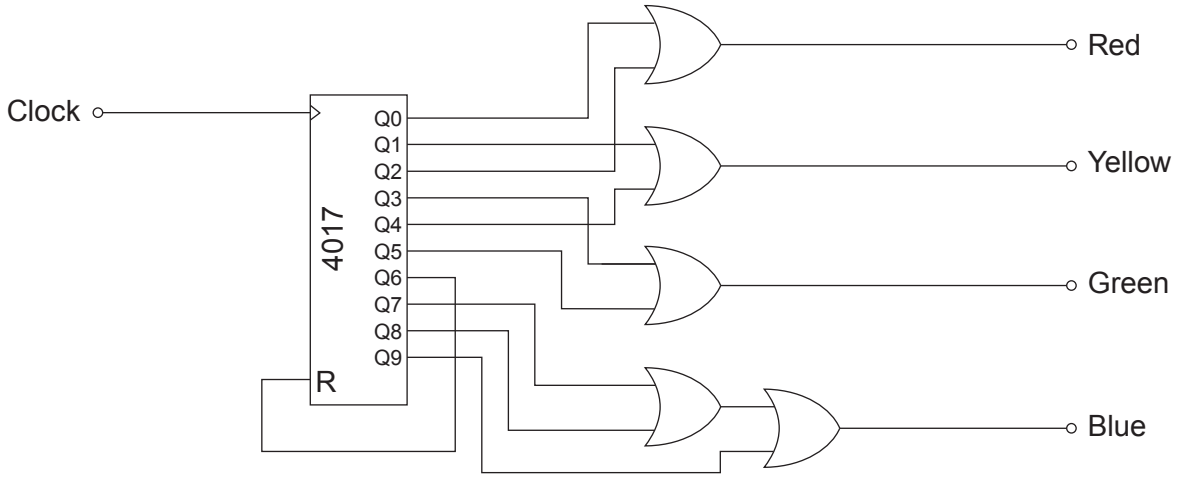
7. Here is a design for a party light sequence generator using a 4017 decade counter connected to a 1 Hz clock.



On the graph paper opposite, complete the timing diagram. Initially $Q_0 = 1$ [6]

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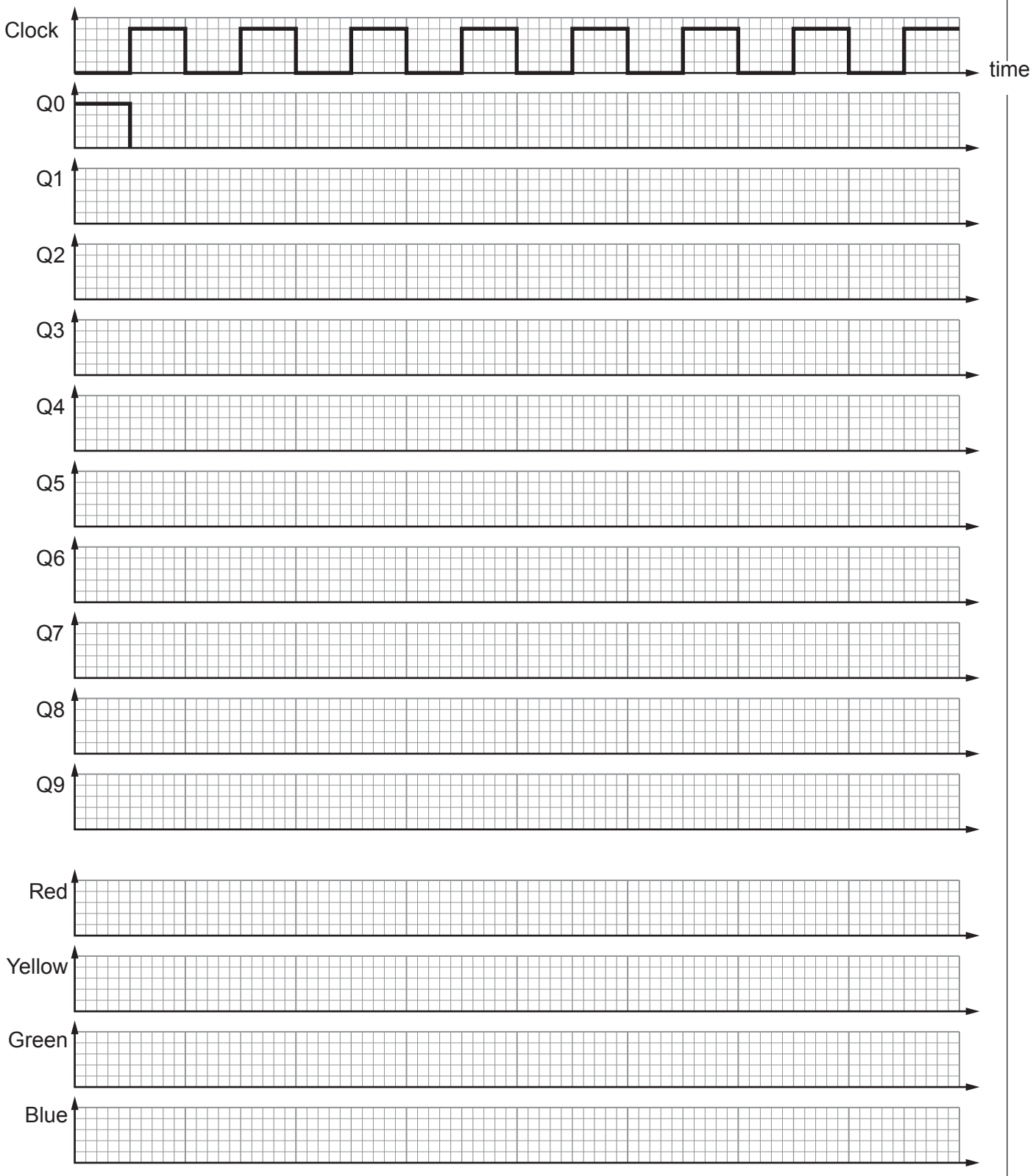

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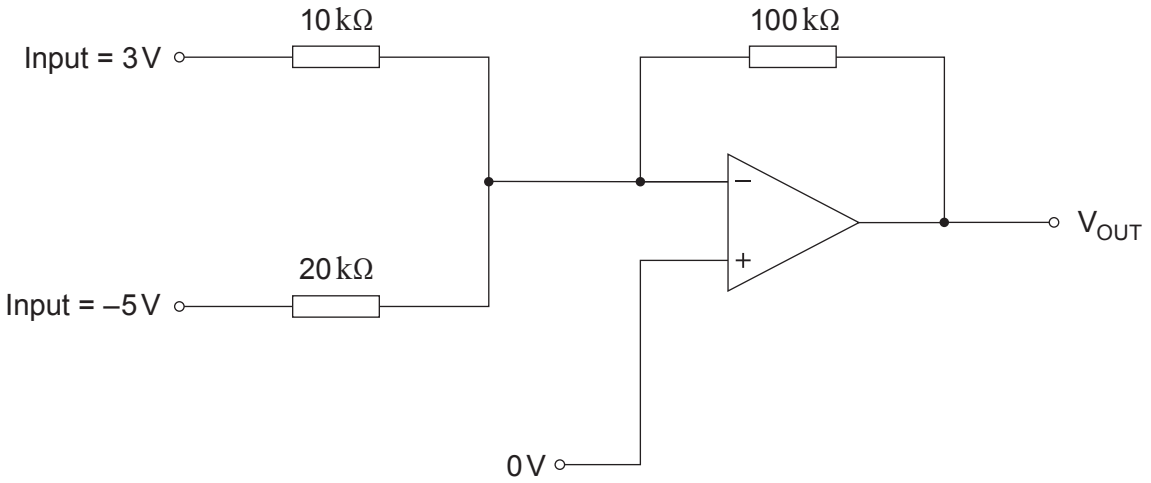
8. A circuit for a mixer is shown below with two test signals applied.



(a) Calculate the output voltage of the mixer. The power supply is ±10 V and the op-amp saturates at ±9.5 V. [4]

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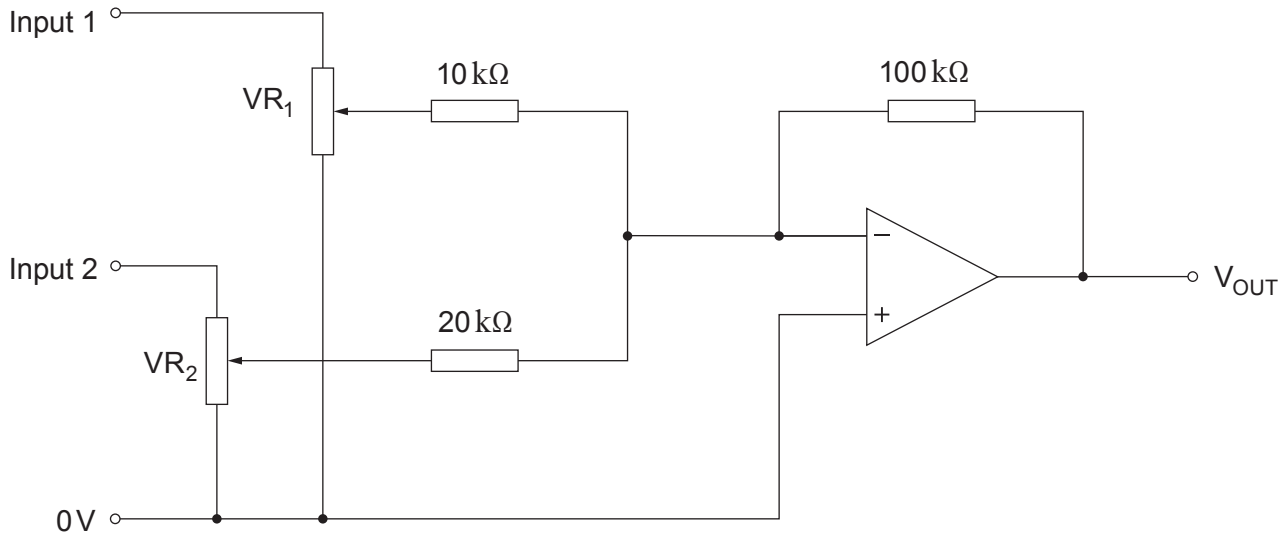
(b) An improved design for the mixer is shown below.



Explain why this circuit is more useful than the previous design. [2]

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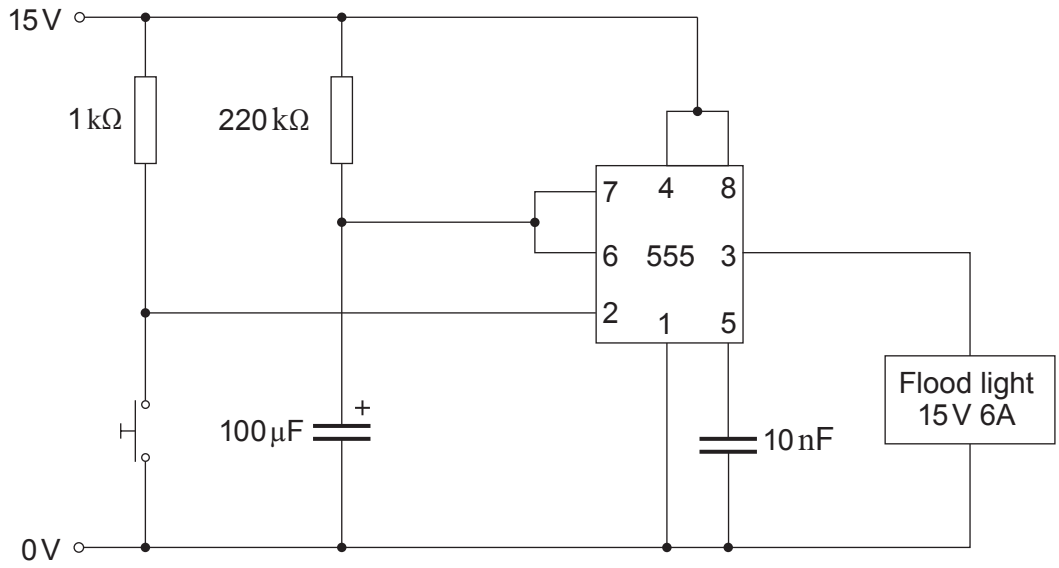
9. A shopkeeper has to walk down a dark path after locking the rear door of the shop. A student has been given the task of designing a system that can switch on a floodlight when the shopkeeper leaves the shop and stays on for a short time.

The specification for the design of the circuit is:

- the light should be operated by pressing a switch;
- the light should remain on for a minimum period of 4 minutes and then go off automatically.

The student's design solution is shown below.



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

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