Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2010

Electronics ELEC2

Unit 2 Further Electronics

Tuesday 25 May 2010 1.30 pm to 2.30 pm

For this paper you must have:
- a pencil and ruler
- a calculator
- a Data sheet.

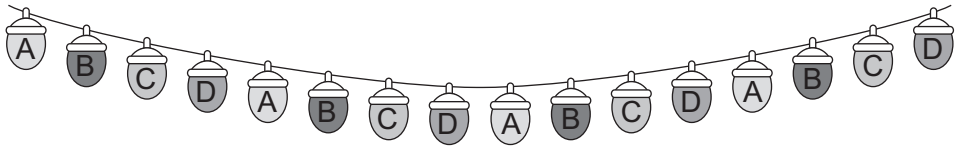
Time allowed
- 1 hour

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

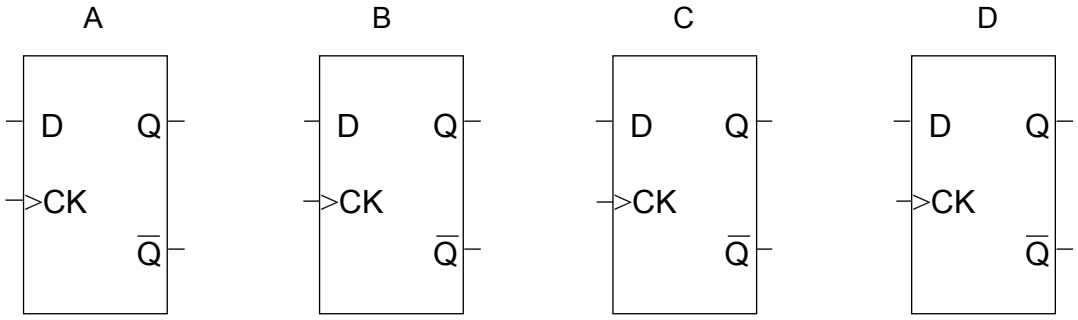
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 67.

Answer **all** questions in the spaces provided.

1 The lamps in a string of decorative party lights are made to light in an apparently random way, by controlling them using the outputs from a 4-bit shift register. Each lamp is connected to one of the shift register outputs A, B, C or D.



1 (a) Complete the diagram below for a shift register made using D-type flip-flops, showing the data input, clock input and the connections to the four outputs A, B, C, D.



(4 marks)

1 (b) Describe how the clock input controls the operation of the shift register.

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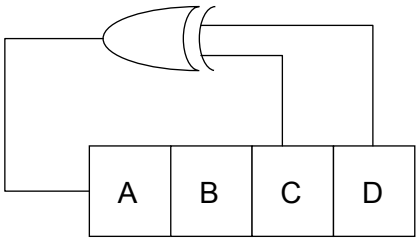
(2 marks)

The data input to the shift register controlling the lamps comes from an exclusive-OR gate connected to outputs C and D.



1 (c) The initial contents of the shift register are shown in row 0 of the table below. Complete the table for the four remaining clock cycles.

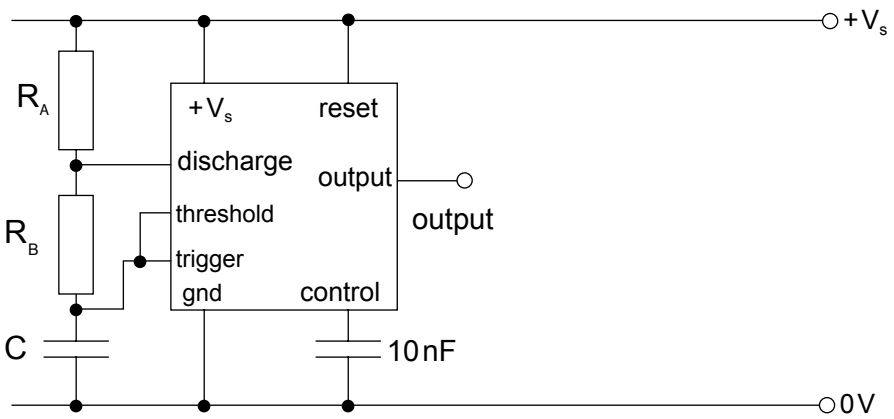
clock cycle	A	B	C	D
0	0	1	0	1
1	1	0	1	0
2	1	1	0	1
3				
4				
5				
6				

(4 marks)

10

Turn over for the next question

2 A cleaning company needs an electronic system to operate a device which releases a 0.5 s spray of 'air freshener' at intervals of approximately 9 minutes. Their design engineer decides that this can be achieved using the 555 timer IC astable circuit shown below.



2 (a) The output of the 555 circuit is to be low for 0.5 s. If the timing capacitor, C, has a value of 1000 µF, calculate a suitable value for R_B.

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(3 marks)

2 (b) The output of the 555 circuit is to be high for approximately 9 minutes (540 s). Calculate a suitable value for R_A.

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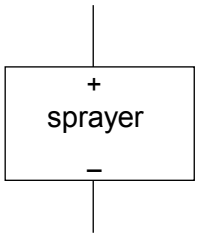
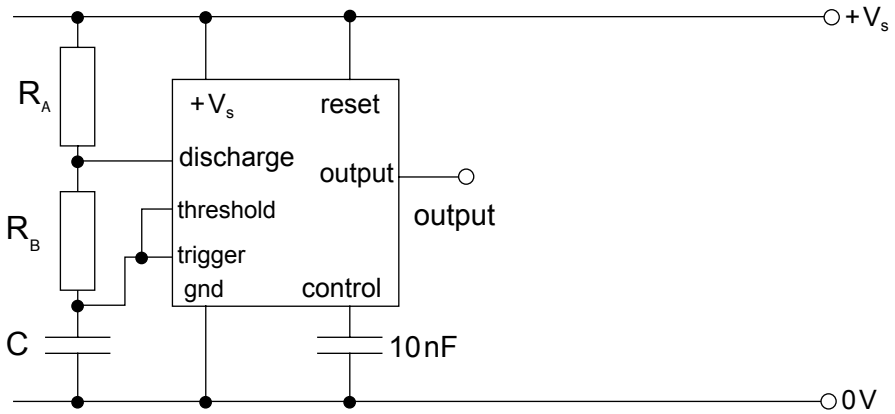
(3 marks)

2 (c) The 'air freshener' sprayer operates when there is a voltage across it. The circuit symbol for the sprayer is shown below.



Mark on the circuit diagram below how you would connect the sprayer to the output of the 555 circuit.



(2 marks)

2 (d) The system is to operate from a 9V battery. Describe how the timing periods change as the battery is discharged.

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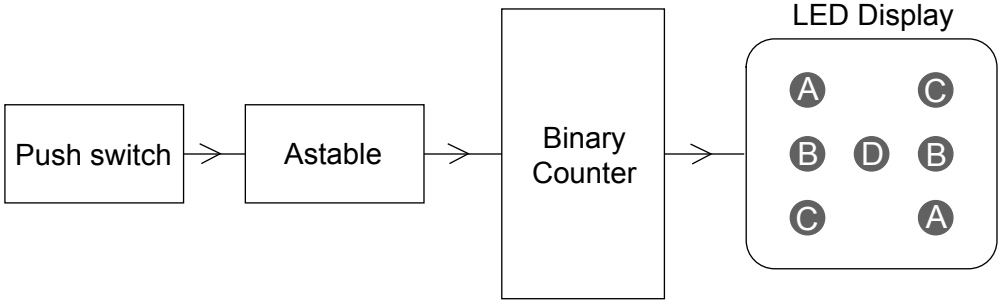
(2 marks)

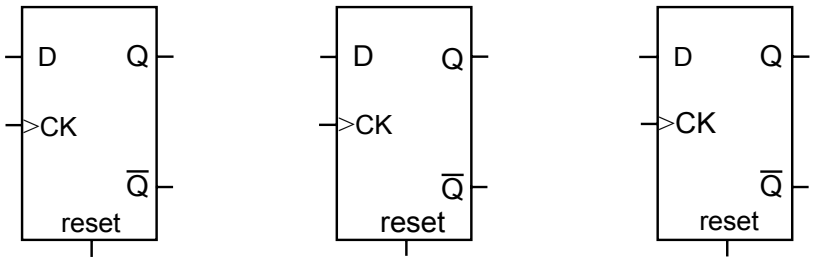
10

Turn over ▶

3 An electronic dice is to be constructed so that when a push switch is operated, the dice counts very quickly and continuously from 1 to 6. When the push switch is released, the number the dice has counted to, is displayed. The dice will consist of the following subsystems.



The binary counter consists of three rising edge triggered D-type flip-flops. The counter outputs are X, Y and Z. The most significant bit is Z.



3 (a) (i) On the diagram of the binary counter above, show how these flip-flops must be connected to form a 3-bit binary up-counter. Label the input from the astable and the three outputs X, Y and Z.

(5 marks)

3 (a) (ii) Only six possible output states are required from the binary counter for the operation of the dice. Add to the diagram of the binary counter the additional connections and components needed to make the counter count from 0 to 5 and then reset on the sixth input pulse. *(3 marks)*

3 (b) The outputs from the binary counter are to be decoded to operate the display to produce the dice numbers. Complete the table below to show how the dice output is related to the binary counter output.

Binary counter output		**Dice output**	
Denary	**Binary Z Y X**	**Dice number**	**LED on**
0	0 0 0	1	D
1	0 0 1	2	A
2	0 1 0	3	D, A
3		4	
4		5	A, C, D
5		6	

(5 marks)

13

Turn over for the next question

4 A student reads in a medical physics book that the electrocardial potential difference across a typical person's chest has a peak value of 2 mV. She wishes to record this on her computer, which requires a peak input signal of 1 V and decides to build a difference amplifier.

4 (a) Calculate the voltage gain required from the difference amplifier.

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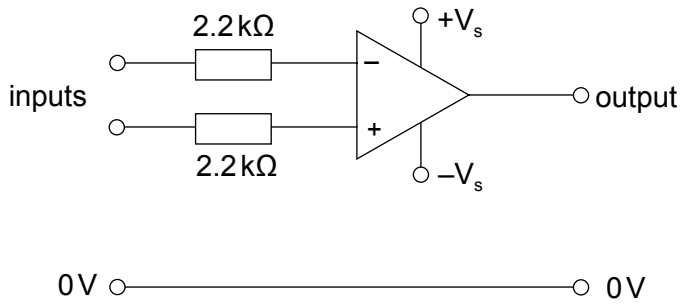
(3 marks)

4 (b) Complete the circuit diagram below for the difference amplifier by adding **two** resistors.



(4 marks)

4 (c) Calculate a suitable value for the resistors in part (b).

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(3 marks)

In practice, the results were very disappointing. Her teacher suggested that it was because the input resistance of the difference amplifier was too low and that each input should be buffered by an op-amp voltage follower.

4 (d) (i) State the approximate input resistance of the difference amplifier inputs.

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(1 mark)

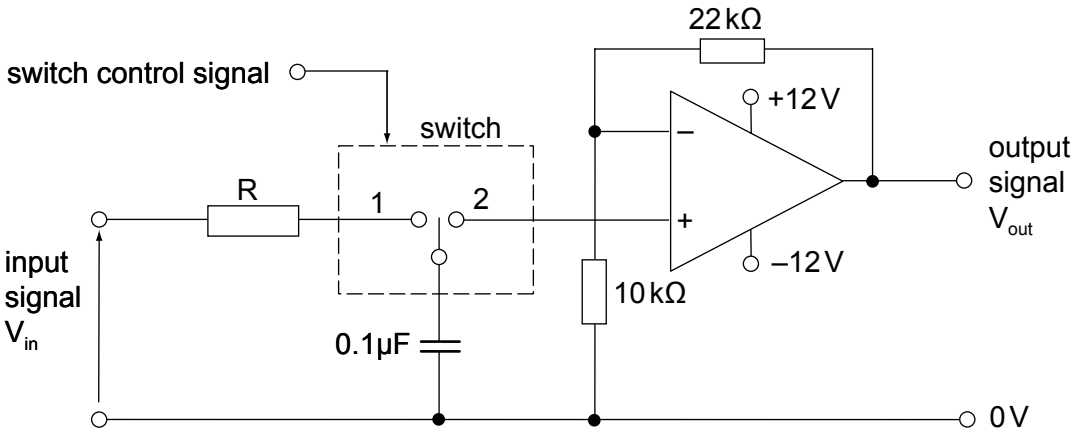
4 (d) (ii) Draw the circuit diagram of an op-amp voltage follower.

(2 marks)

13

Turn over for the next question

5 In many systems it is required to take an instantaneous 'snapshot' of a changing signal before processing it.



The control signal changes the switch between positions 1 and 2.

5 (a) (i) V_{in} has a steady value of 3 V.
The control signal moves the switch to position 1.
If R has a value of 100 Ω, calculate the time for which the switch must remain in position 1 so that the voltage across the capacitor effectively reaches V_{in}.

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(3 marks)

5 (a) (ii) The switch is now moved to position 2.
Calculate the resulting output, V_{out}, from the op-amp.

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(3 marks)

5 (a) (iii) If the op-amp has an input resistance of 1.5×10^9 Ω, calculate the time constant when the switch is in position 2.

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(2 marks)

5 (a) (iv) Describe what now happens to V_{out} over time.

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(2 marks)

5 (b) The op-amp could have been used in the inverting configuration.
Explain why using it in the non-inverting configuration, as shown, is better for this type of circuit.

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(2 marks)

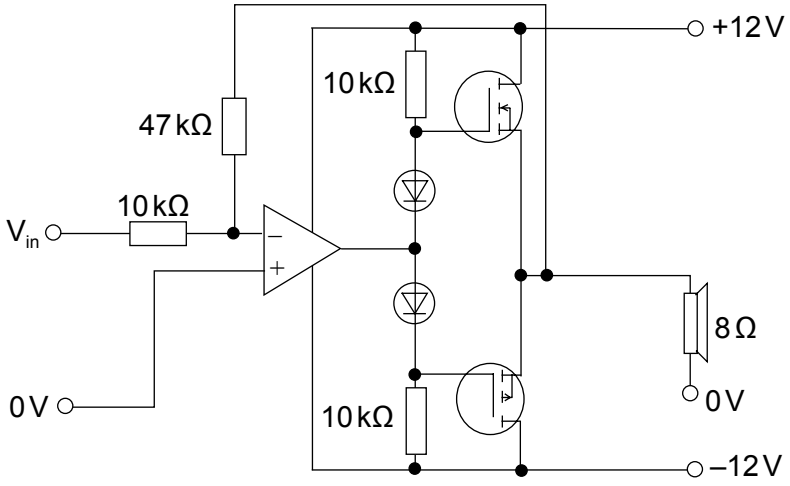
12

Turn over for the next question

6 A student needs an audio amplifier for part of the system for his coursework. From his research he knows that the amplifier must have:

- a voltage gain of at least 20
- a bandwidth of at least 15 kHz
- a power output of at least 5 W into an 8 Ω loudspeaker.

He finds the circuit below on the Internet.



(The op-amp has a gain bandwidth product of 3 MHz)

Briefly assess the suitability of this circuit under the following headings, supporting your answer with calculations.

6 (a) Voltage gain

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(3 marks)

6 (b) Bandwidth

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(3 marks)

6 (c) Output power

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(3 marks)

9

END OF QUESTIONS

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