Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

Leave blank

General Certificate of Secondary Education
June 2006

ELECTRONICS
Written Paper
Higher Tier

3432/H

H

Thursday 25 May 2006 1.30 pm to 3.30 pm

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

Time allowed: 2 hours

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Show the working of your calculations.

Information
- The maximum mark for this paper is 150.
- The marks for questions are shown in brackets.
- A list of formulae and other information, which you may wish to use in your answers, is provided on page 2.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Number	Mark	Number	Mark
1		5	
2		6	
3		7	
4		8	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Information Sheet

The following information may be useful in answering the questions.

1. **Power**
   Power = voltage x current; $P = VI$

2. **Amplifiers**
   Voltage gain $G_V = \frac{V_{OUT}}{V_{IN}}$

3. **Resistor colour code**
   The colours in the resistor colour code correspond to the following values.

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.
   GOLD ±5% SILVER ±10% No fourth band ±20%

4. **Resistor printed code** (BS 1852)
   R means × 1
   K means × 1000
   M means × 1 000 000
   Position of letter gives the decimal point.
   Tolerances are indicated by adding a letter at the end.
   J ± 5% K ± 10% M ± 20%

   e.g. 5K6J = 5.6 kΩ ± 5%

5. **Preferred values for resistors** (E24 SERIES)
   1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0 3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1 and multiples of ten.

6. Resistance = $\frac{\text{voltage}}{\text{current}}$; $R = \frac{V}{I}$

7. Effective resistance, R, of resistors in series is given by $R = R_1 + R_2 + R_3$

8. Effective resistance, R, of two resistors R_1 and R_2 in parallel is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

9. **A.C. waveforms**
   (a) Frequency of waveform = $\frac{1}{\text{time period}}$; $f = \frac{1}{T}$

   (b) peak value = 1.4 x rms value

10. **Astable and monostable generators using 555 timers**

    (a) Monostable mode, time period $T = 1.1\ R_1 \times C_1$

    (b) Astable mode, time period $T = \frac{(R_1 + 2R_2)\ C_1}{1.44}$

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

1 (a) (i) What are the colours of the earth wire in a three pin plug?

.....

(ii) Name a device, other than a fuse, which can automatically disconnect the electricity supply if the current is too high.

.....

(iii) What is the name of a component that can store a lethal charge, even when it is in a circuit which has been disconnected from the power supply?

.....

(iv) What effect does water have on skin which makes it dangerous for a person with wet hands to use electrical equipment?

.....

(5 marks)

(b) (i) In a microprocessor system what is hardware?

.....

(ii) In a microprocessor system what is software?

.....

(iii) What is the binary equivalent of the decimal number 9?

.....

(iv) What is the decimal equivalent of the binary number 1101?

.....

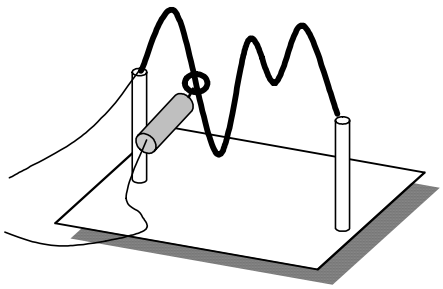
(v) Noise is the unwanted signal sometimes produced in the cables between the different parts of a computer system. Name a type of cable which can be used to reduce noise in the system.

.....

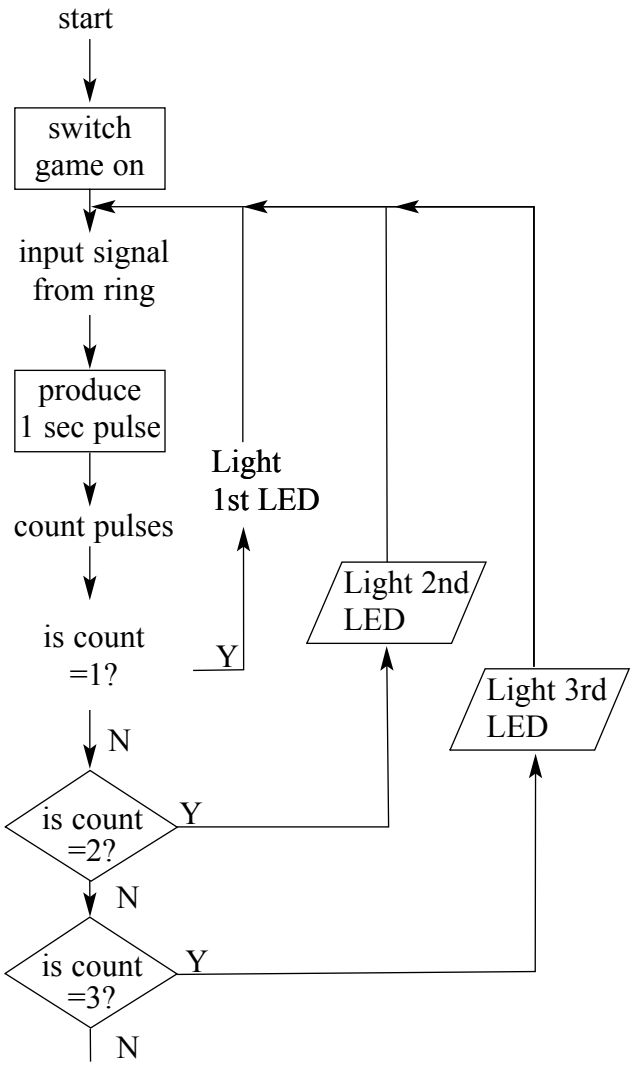
(5 marks)

10

2 The diagram below shows a bent wire game, where a contestant tries to pass a metal ring over a bent wire track without touching it.



The flowchart describes what happens when the ring touches the wire for the first, second, and third time. Each time the ring touches the wire, a 1 second pulse is produced and the number of touches is shown by three green LEDs.



(a) Draw the correct flowchart symbols at **five** places where they are missing above.

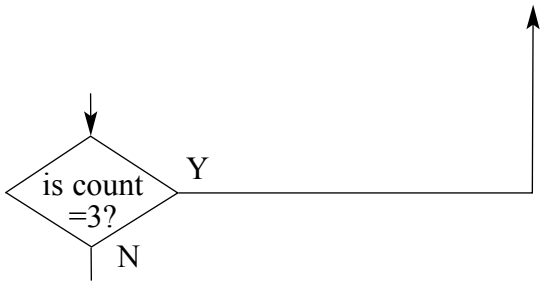
(5 marks)

(b) Label on the flowchart

a decision box, **an input box**, **a loop**, **an output box** and **a process box**

(5 marks)

(c) The action of the bent wire game continues after the third touch.
The fourth touch makes a yellow LED flash on and off as a warning sign that the contestant has no more chances. The fifth touch makes a red LED flash on and off and a buzzer sound to mark the end of the game.
Draw a flowchart for this part of the game, to follow on from the flowchart on **page 4**. Use that flowchart to help you. The lower part of that flowchart is drawn here; start your flowchart from it.



(10 marks)

20

3 A student decides to construct a bent wire game similar to that described in **Question 2**.

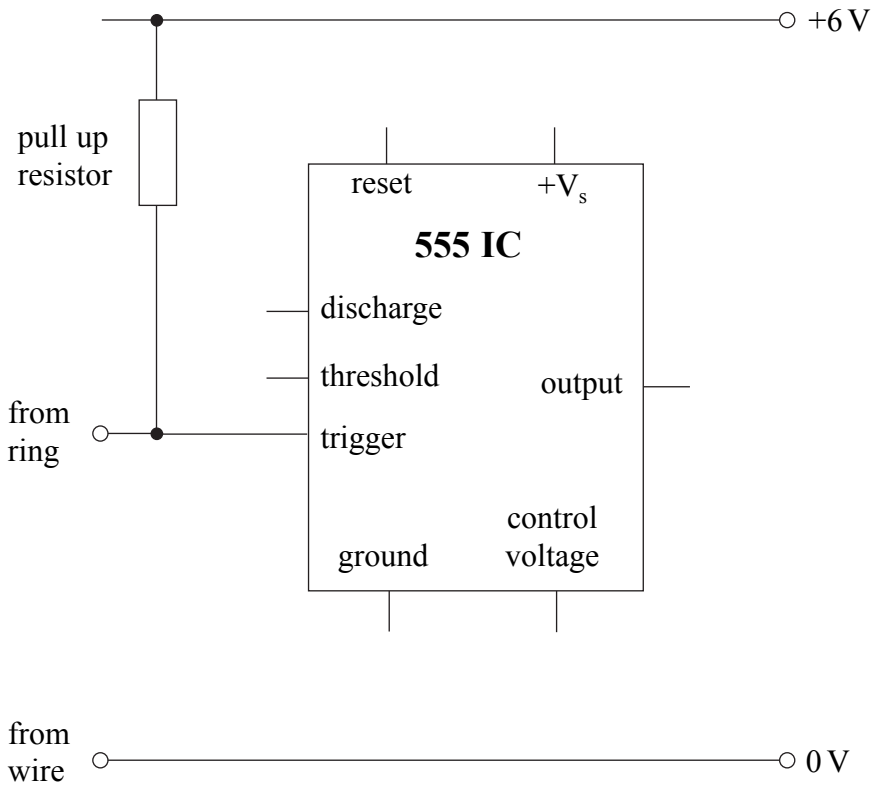
It is not necessary to have completed your answer to Question 2 before attempting this question.

The bent wire and the ring form the input sub-system which triggers a 555 IC monostable circuit when the ring touches the wire. A 4017 counter IC counts the pulses from the monostable and provides outputs to switch the LEDs, and also a buzzer which sounds only when the ring touches the wire for a fifth time.

(a) Draw a system block diagram to show how all the sub-systems should be connected.

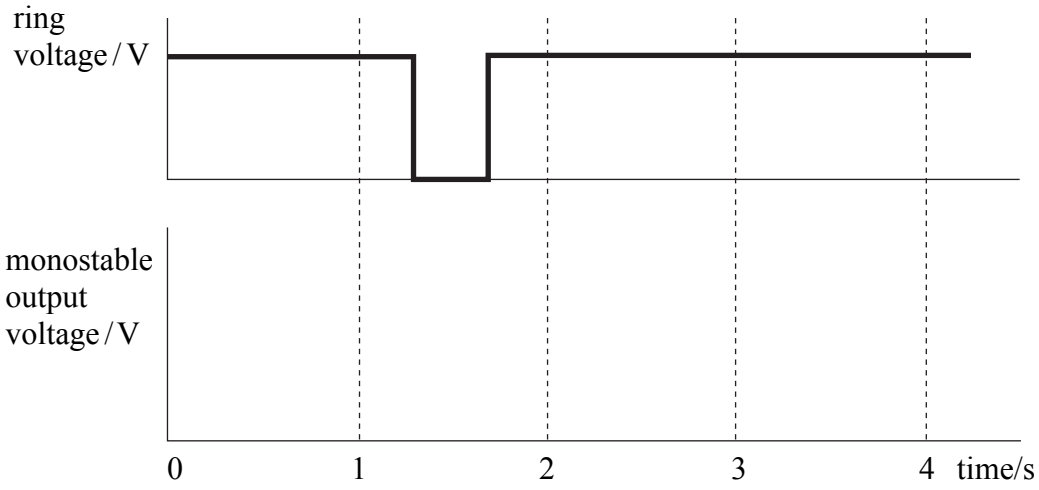
(5 marks)

(b) Complete the circuit diagram below to show how the 555 IC should be connected to form the monostable. Include a timing resistor and capacitor, any other components needed and label the connection that goes to the counter.



(8 marks)

(c) (i) Complete the timing diagram below to show the output voltage from the monostable during the time interval shown. The monostable has a period of 1 second.



(ii) What component in the monostable circuit keeps the trigger voltage high?

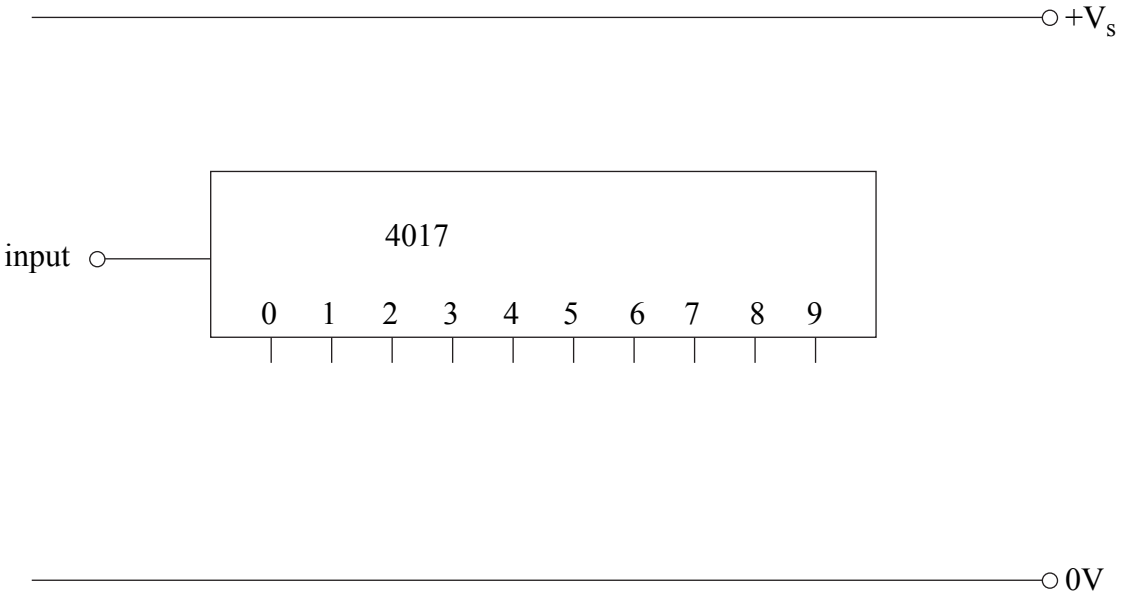
.....

(iii) What action forces the trigger voltage to go low?

.....

(6 marks)

(d) Add to the counter circuit diagram below **three** LEDs and their series resistors that would indicate the first three pulses from the monostable.



(6 marks)

Question 3 continues on the next page

(e) What extra sub-system is required to make an LED flash on and off?

.....

(1 mark)

(f) The 4017 IC can supply a current of 10 mA to each output, and is connected to a 9 V battery. The LEDs have a forward voltage of 2 V.

(i) Calculate the voltage drop across the LED current limiting resistor.

.....

(ii) Calculate the required resistance of the LED current limiting resistor.

.....

(iii) State which resistor from the E24 range would be suitable if the current limit is not to be exceeded.

.....

(4 marks)

30

4 (a) A transformer gives an output with a peak value of 9 V.

(i) Calculate the rms value.

.....

.....

(ii) Name the component which could be connected to the transformer to rectify the alternating current.

.....

.....

(iii) Name the component which could be used to smooth the rectified output.

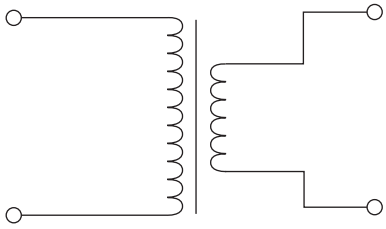
.....

(iv) Name the component which could be used to give a stabilised voltage output.

.....

(v) Draw a circuit diagram of a stabilised power supply using the components you have named above.

transformer



(8 marks)

(b) Calculate the power output of the power supply when the output voltage is 5 V and the current drawn from it is 0.6 A.

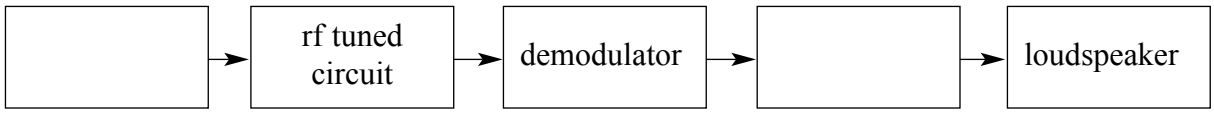
.....

.....

(2 marks)

10

5 A block diagram of a simple radio system is shown below:



(a) Label each empty block with the name of the sub-system. *(2 marks)*

(b) Explain the function of the rf tuned circuit sub-system.

.....

.....

(2 marks)

(c) Explain the function of the demodulator sub-system.

.....

.....

(2 marks)

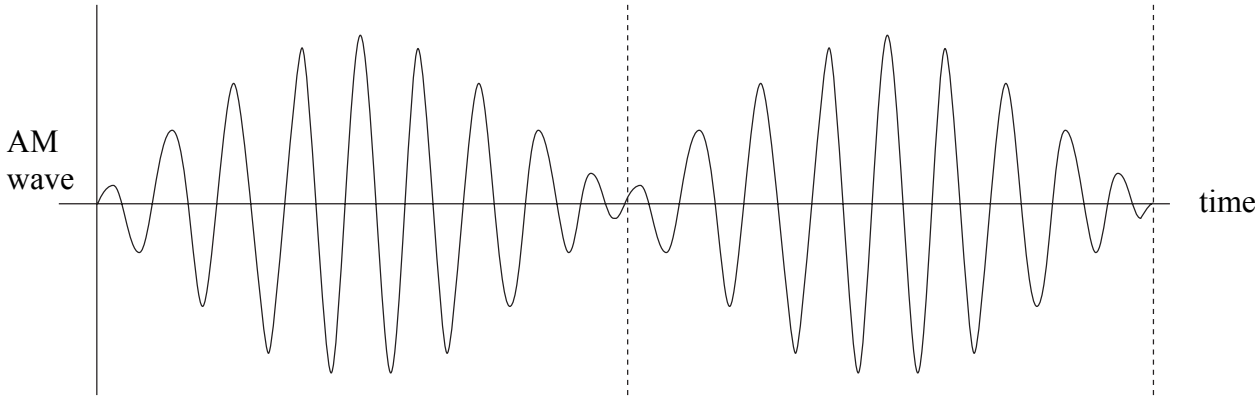
(d) State **two** advantages of frequency modulation (FM) over amplitude modulation (AM) when broadcasting music.

1 .....

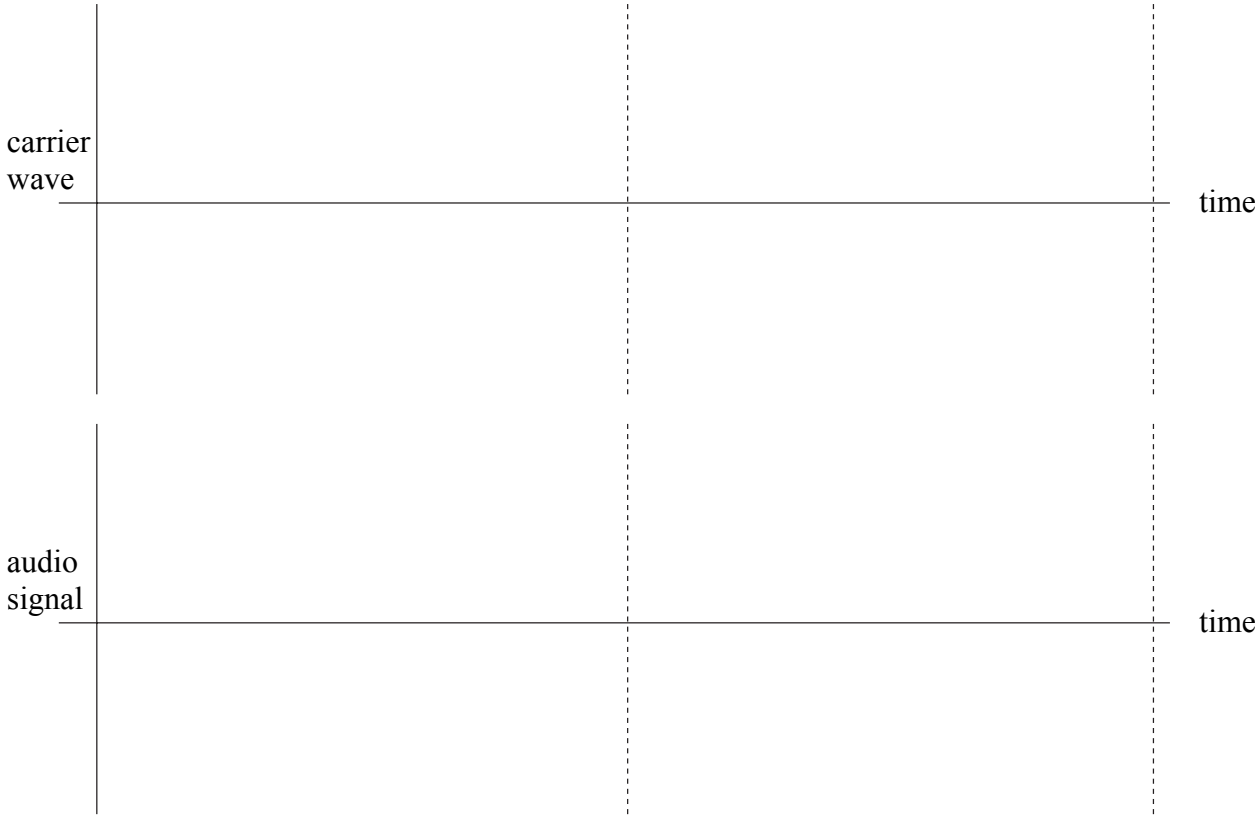
2 .....

(2 marks)

(e) The diagram below shows an AM carrier wave.



On the axes below draw the carrier wave and the audio signal which have been combined to produce the AM wave shown above.

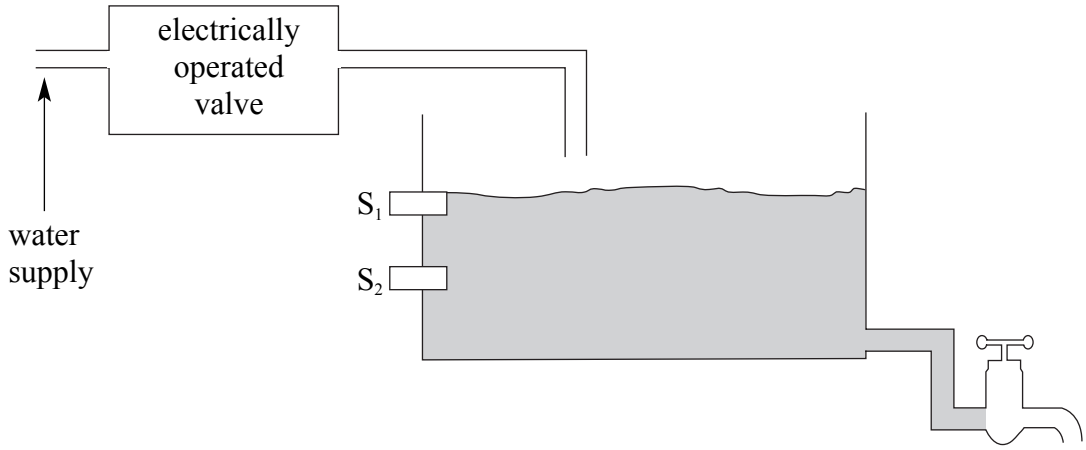


(4 marks)

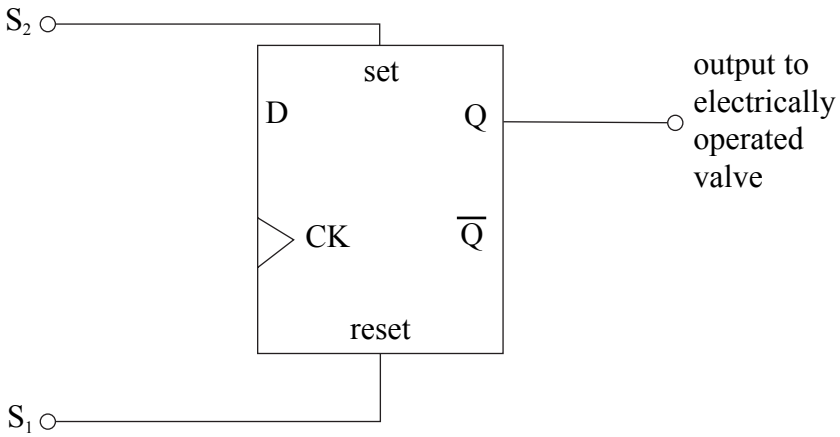
(f) On the axes below draw the FM wave after the carrier wave has been frequency modulated by the audio signal above.

(2 marks)

6 A water tank has two sensors S_1 and S_2 mounted as shown.



The signals generated by the sensors are different. S_1 gives a high output when it is in water and a low output when it is dry. S_2 gives a high output when it is dry and a low output when it is in water.
The sensors are connected to a D-type flip-flop which is used to open and close the valve.



The valve opens when the Q output of the flip-flop is high.

(a) The water level is initially above S_1 and the valve is closed. Water is then run from the tank until the level falls below S_2. Explain the sequence of events which start with S_2 being uncovered.

.....

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.....

.....

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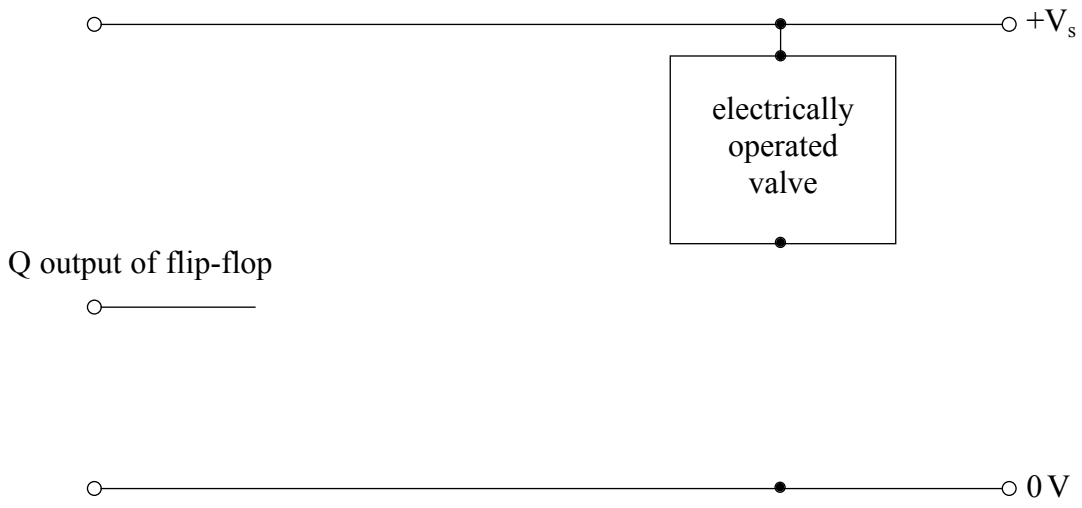
(4 marks)

(b) (i) Complete the circuit diagram to show how a MOSFET can be connected as a driver to operate the valve. Label the connections to the MOSFET.



(ii) The electrically operated valve contains a motor so a diode must be connected in parallel with it. Show this diode on the circuit diagram above.

(iii) Explain why the diode is needed.

.....

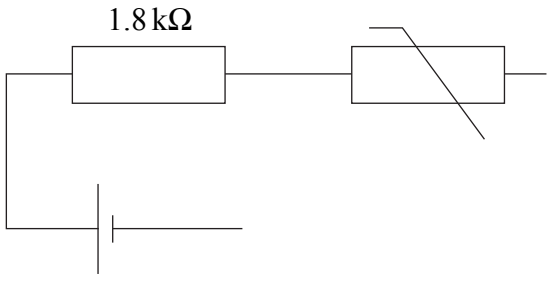
.....

.....

(8 marks)

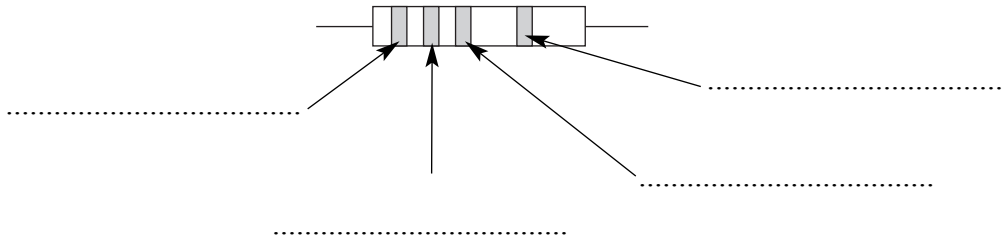
(c) The water tank is to be protected by a frost alarm. A thermistor is used as a temperature sensor and it is firstly necessary to measure its resistance at 0 °C.

(i) Complete this circuit diagram to show the position of a voltmeter and an ammeter which could be used to obtain measurements to calculate the resistance of the thermistor.



Question 6 continues on the next page

(ii) The 1.8 kΩ resistor has a tolerance of 5%. Label the coloured bands on this diagram of the resistor.



(iii) The ammeter reads 0.5 mA. What is this current expressed in amps?

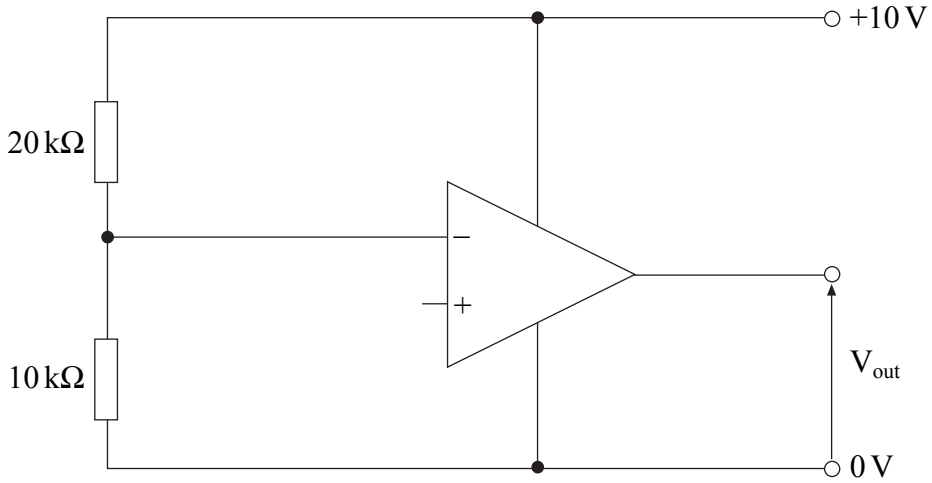
.....

(iv) The voltmeter reads 0.4 V. Calculate the resistance of the thermistor.

.....

.....

(v) A comparator circuit, as shown in the diagram below, is used to generate the alarm signal. On the diagram draw the thermistor and a fixed resistor connected so that V_{out} will be high when cold and low when hot.



(vi) Calculate a suitable value for the fixed resistor if V_{out} is to go from low voltage to high voltage when the temperature falls below 0 °C.
Use the value for the resistance of the thermistor from part (c)(iv)

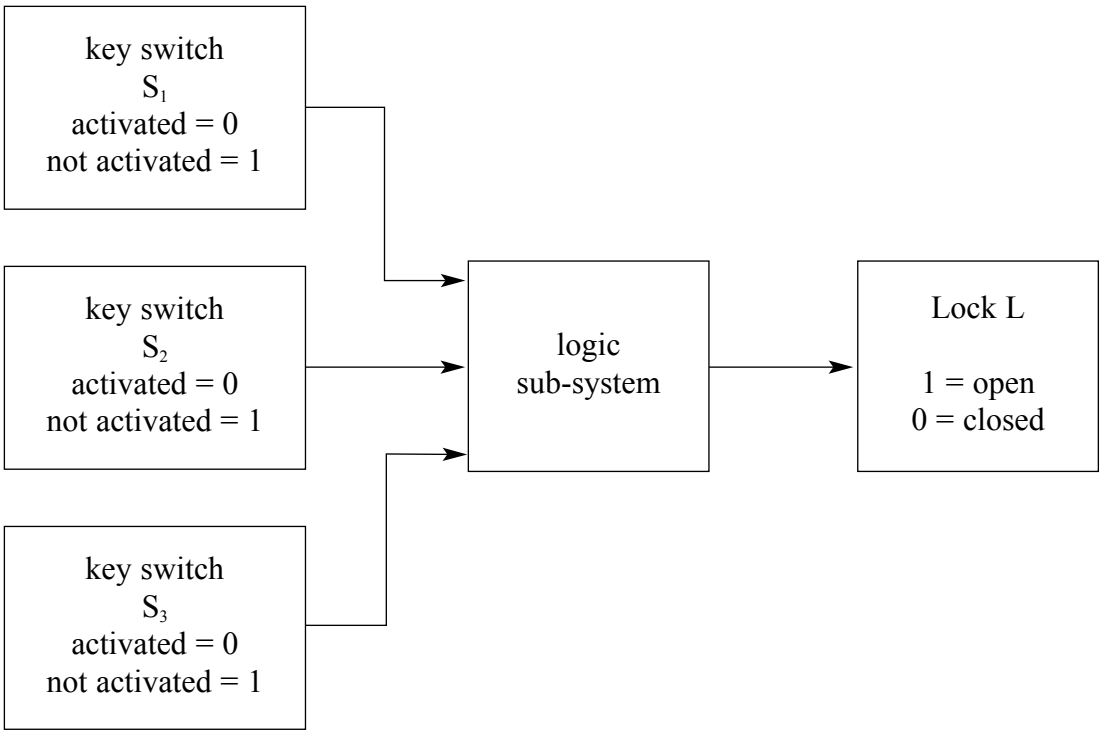
.....

.....

(13 marks)

25

7 In a security system a lock is opened only when three key operated switches S_1, S_2 and S_3 are activated. The switches give a low output when they are activated.



(a) The logic sub-system has the following truth table.

S_1	S_2	S_3	L
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

Draw a diagram showing how this sub-system can be constructed using only NOT gates and 2-input AND gates.

(5 marks)

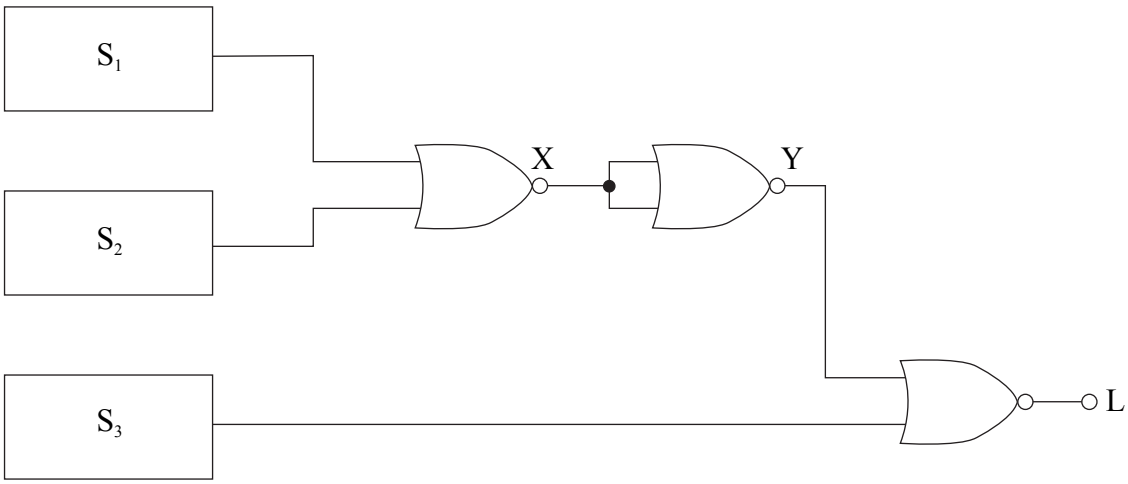
Question 7 continues on the next page

(b) The system could also be made using only NOR gates.

(i) Complete this truth table for a NOR gate with inputs A and B and output Q.

A	B	Q
0	0	
0	1	
1	0	
1	1	

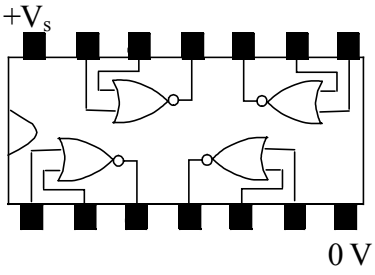
(ii) Complete the truth table below to show that this network of gates performs the required function.



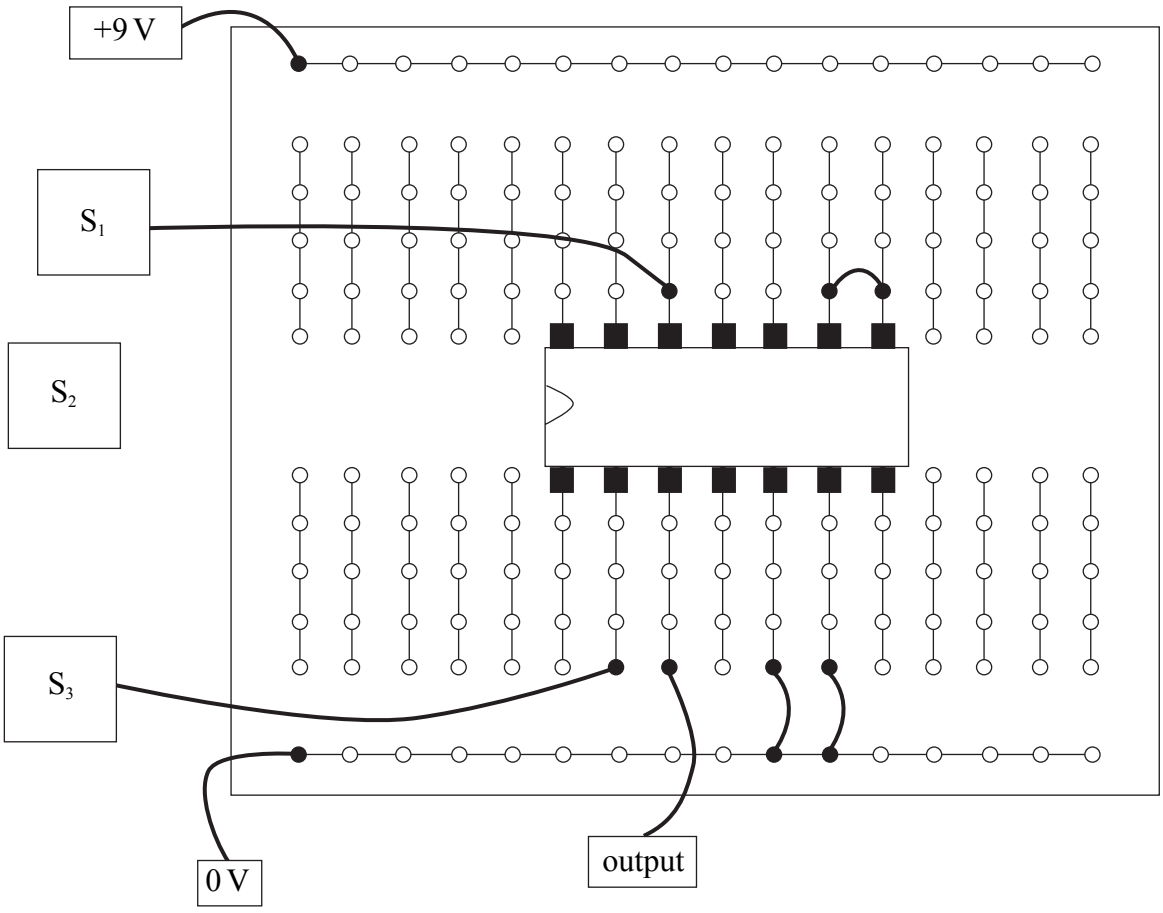
S_1	S_2	S_3	X	Y	L
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

(4 marks)

(c) This diagram shows the pin connections for an IC suitable for making the network of gates on **page 16**.



The network of gates is to be made on prototyping board. Complete the circuit below by adding the **five** wire links needed.



(5 marks)

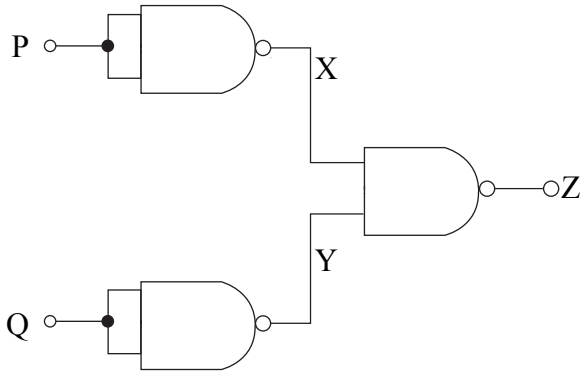
Question 7 continues on the next page

(d) NAND gates can be used to make any other type of logic gate.

(i) Complete this truth table for a NAND gate with inputs A and B and output W.

A	B	W
0	0	
0	1	
1	0	
1	1	

(ii) Complete the truth table for the network of gates shown below.



P	Q	X	Y	Z
0	0			
0	1			
1	0			
1	1			

(iii) Name the type of single gate which would perform the function of the network above.

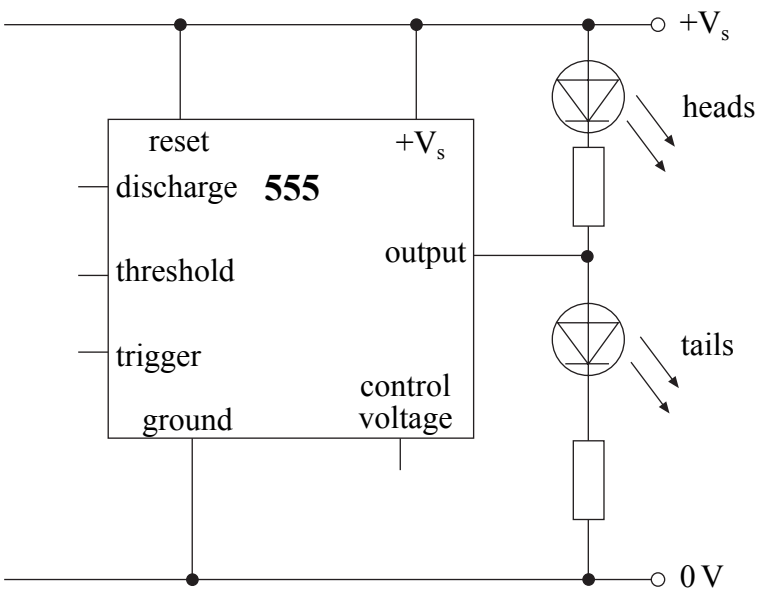
.....

(5 marks)

19

8 Instead of tossing a coin, a student wishes to build a circuit to help make decisions. He starts with a 555 timer which he connects as an astable.

(a) (i) Complete this diagram of a 555 astable by adding **two** resistors, R_1 and R_2, **two** capacitors and any wire links needed.



(ii) The LEDs light alternately, but so fast that they both appear to be on all the time. If the value of R_1 is 10 kΩ, R_2 is 15 kΩ and the timing capacitor is 0.1 μF calculate the period of the astable pulses.

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.....

.....

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.....

(iii) Calculate the frequency of the astable.

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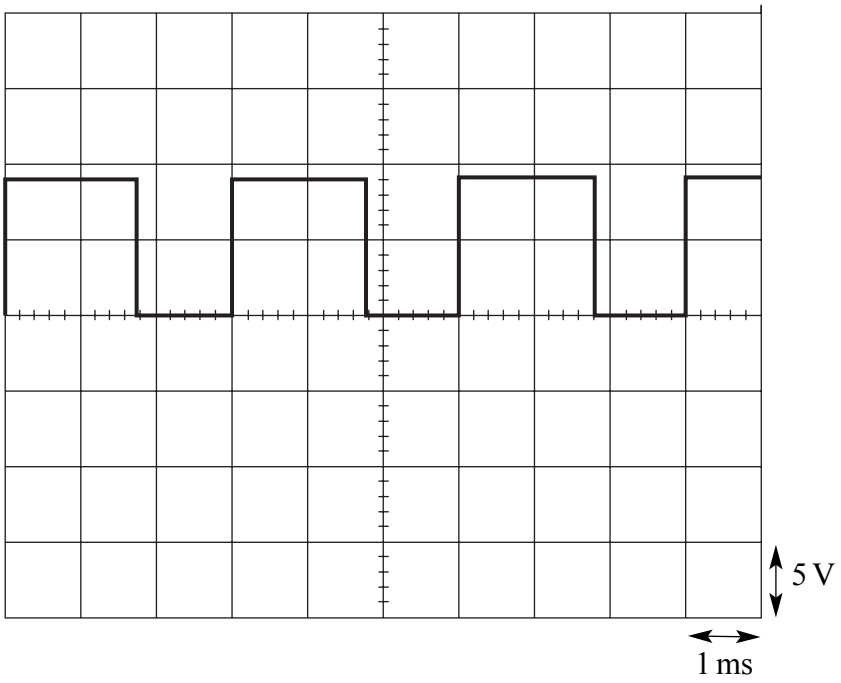
(11 marks)

Question 8 continues on the next page

(b) The student connects the output of the astable to a cathode ray oscilloscope and obtains the following trace.



(i) The timebase is set to 1 ms per division. Use the oscilloscope trace to find the period of the pulses.

.....

.....

(ii) Explain **one** of the reasons why this value is not exactly the same as the calculated value.

.....

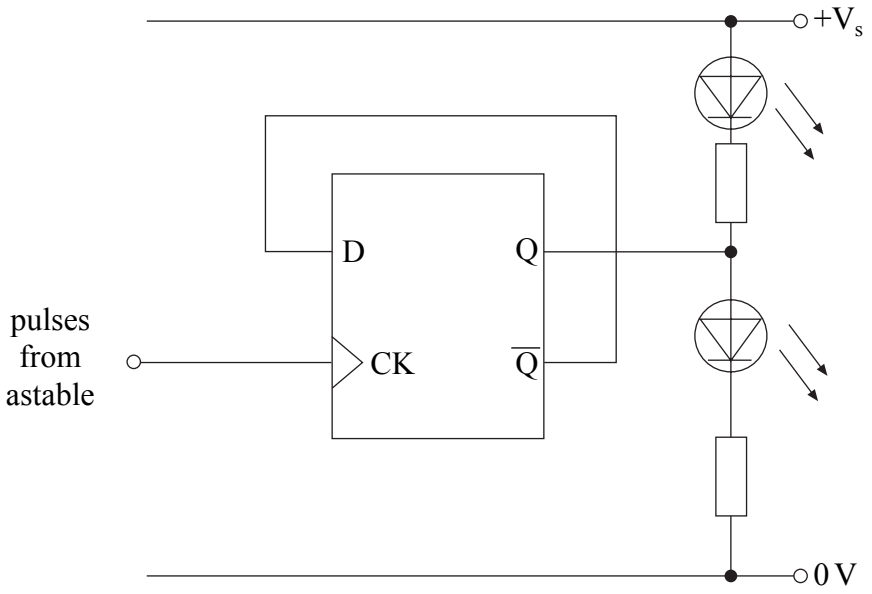
(iii) The Y (vertical) sensitivity is set to 5 V per division. Use the oscilloscope trace to find the voltage of the pulses.

.....

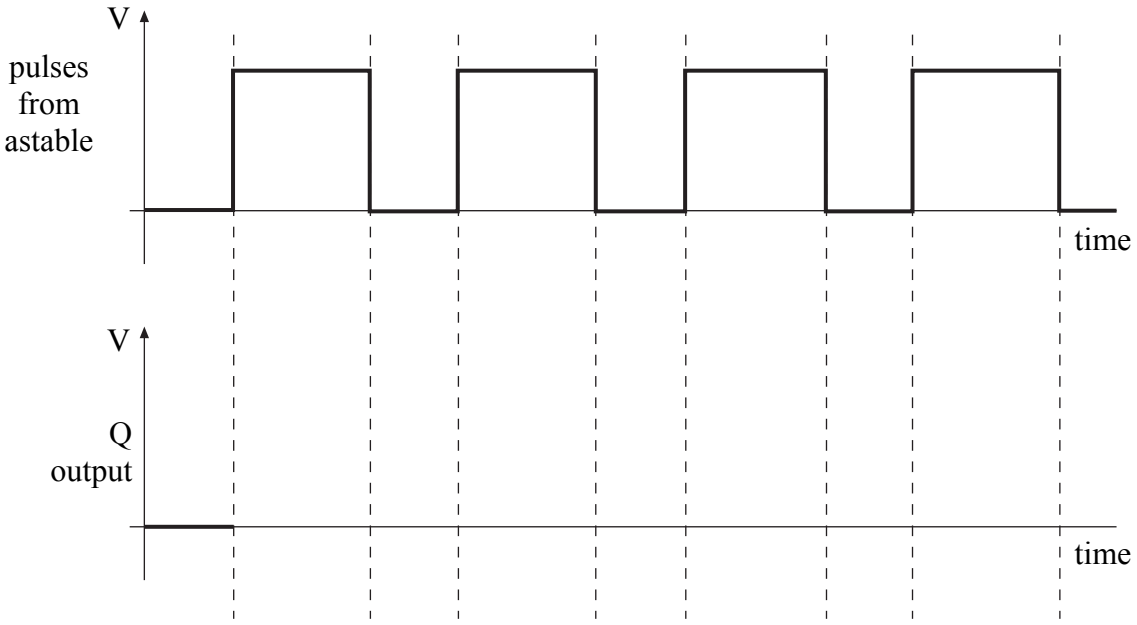
.....

(5 marks)

(c) The student notices from the oscilloscope trace that the output is high for a longer time than it is low. He decides to connect a D-type flip-flop between the astable and the LEDs as shown below.



(i) Complete the timing diagram below by showing the Q output



(ii) A push switch is added to the astable circuit and when it is released the astable stops producing pulses leaving one LED lit. Explain whether you would expect the circuit with the flip-flop to be fairer (i.e. have an equal chance of either LED being left lit).

.....

.....

(6 marks)

END OF QUESTIONS

There are no questions printed on this page

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