

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	



General Certificate of Secondary Education
June 2013

Electronics

44301

Unit 1 Written Paper

Wednesday 22 May 2013 9.00 am to 11.00 am

<p>For this paper you must have:</p> <ul style="list-style-type: none"> • a ruler • a pencil • a calculator.
--

Time allowed

- 2 hours

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 booklet. Cross through any work you do not want to be marked.
- Show the working of your calculations.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 150.
- A list of formulae and other information, which you may wish to use in your answers is provided on page 2.
- Any correct electronics solution will gain credit.
- You will be marked on your ability to use good English to organise information clearly and to use specialist vocabulary where appropriate.



J U N 1 3 4 4 3 0 1 0 1

Information Sheet

The following information may be useful when answering some questions in this examination.

Resistor colour code

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

BLACK	0	YELLOW	4	GREY	8
BROWN	1	GREEN	5	WHITE	9
RED	2	BLUE	6		
ORANGE	3	VIOLET	7		

The fourth band colour gives the tolerance.

GOLD $\pm 5\%$ SILVER $\pm 10\%$

Resistor printed code (BS 1852)

R means $\times 1$ K means $\times 1000$ M means $\times 1\,000\,000$

Position of the letter gives the decimal point.

Tolerances are indicated by adding a letter at the end.

J $\pm 5\%$ K $\pm 10\%$ M $\pm 20\%$

e.g. 5K6J = $5.6\text{ k}\Omega \pm 5\%$

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 their multiples of ten.

Resistance

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} \quad R = \frac{V}{I}$$

Effective resistance, R, of up to four resistors in series is given by $R = R_1 + R_2 + R_3 + R_4$

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

Power

Power = Voltage \times Current; $P = VI$

Amplifiers

$$\text{Voltage gain } G_V = \frac{V_{\text{out}}}{V_{\text{in}}}$$

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 $T = \frac{(R_1 + 2R_2)C_1}{1.44}$

ac theory

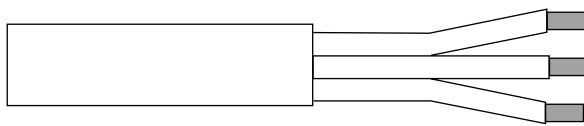
$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$f = \frac{1}{T} \quad \text{frequency, period}$$



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

- 1 (a) (i)** A mains electrical cable is shown below.
Give the name of the mains terminal each wire connects to.



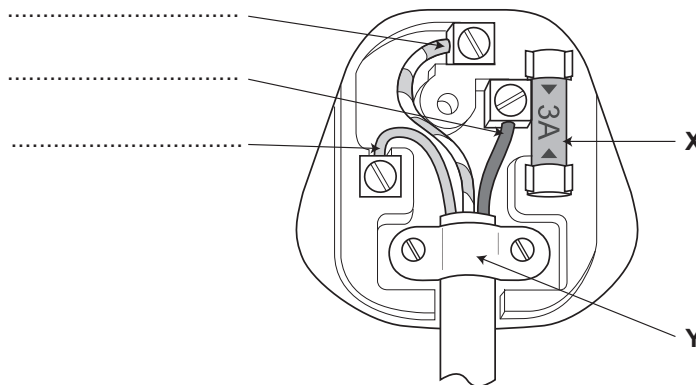
blue

brown

green/yellow.....

(3 marks)

- 1 (a) (ii)** The cable is to be fitted to the mains plug shown.
Write the wire colours on the dotted lines below.



(3 marks)

- 1 (a) (iii)** What is the name of the part labelled **X** in the diagram above?

.....
(1 mark)

- 1 (a) (iv)** What is the purpose of the part labelled **Y** in the diagram above?

.....
.....
(1 mark)

- 1 (b) (i)** The mains voltage is 230V.
What component can be used to convert this to a safe low voltage?

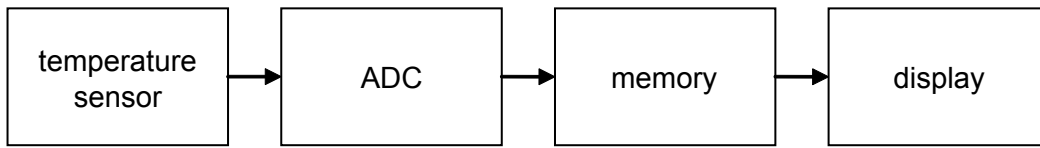
.....
(1 mark)

- 1 (b) (ii)** The mains supply provides alternating current.
What component is needed to convert this to direct current?

.....
(1 mark)



2 The system diagram below is for a digital thermometer.



2 (a) Which subsystem is

2 (a) (i) an input.....

2 (a) (ii) an output.....

2 (a) (iii) a digital process.....

2 (a) (iv) a conversion process?.....

(4 marks)

2 (b) In which subsystem could you use

2 (b) (i) a thermistor.....

2 (b) (ii) an LED.....

2 (b) (iii) an op-amp.....

2 (b) (iv) a D-type flip-flop?.....

(4 marks)

2 (c) Which subsystem

2 (c) (i) produces an analogue signal.....

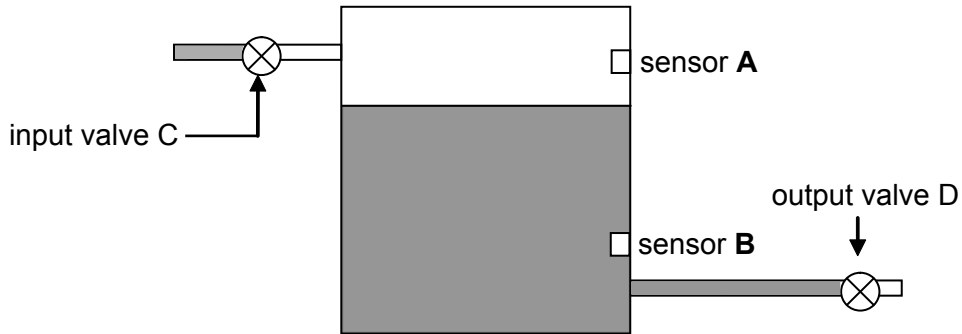
2 (c) (ii) stores a digital signal?.....

(2 marks)

10



3 An oil storage tank has two sensors **A** and **B** fitted to detect the level of oil in the tank. When a sensor is covered it gives a logic 1 output, and when it is not covered it gives a logic 0.



3 (a) A control system is used to make sure the tank is kept as full as possible but without being overfilled or running dry. Each valve is opened by a logic 1 and closed by a logic 0.

Complete the truth tables below.

sensor A	input valve C
0	
1	

sensor B	output valve D
0	
1	

(4 marks)

3 (b) Describe what is happening to the valves when sensor **A** and sensor **B** are both logic 1.

.....

.....

(2 marks)

Question 3 continues on the next page

Turn over ▶



3 (c) Name a logic gate that could control the input valve C from sensor **A**.

.....
.....

(1 mark)

3 (d) Draw the symbol of the logic gate that is named in **part (c)**.

Label its input and output signals.

(3 marks)

10

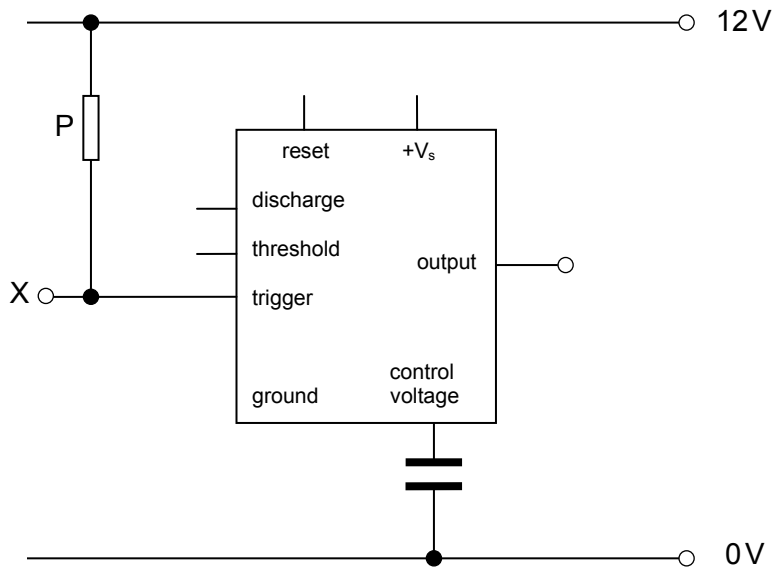


4 A technician designs a circuit to give an output pulse of a fixed length of time when it is triggered by an input signal.

4 (a) (i) What type of 555 timer circuit is needed for this function?

.....
(1 mark)

4 (a) (ii) Complete the circuit diagram below by drawing wire links, a resistor, and the timing capacitor. Label the resistor R_1 and the capacitor C_1 .



(5 marks)

4 (a) (iii) What is the function of resistor P?

.....
(1 mark)

4 (a) (iv) Describe the input signal at X that would trigger the circuit.

.....
.....
(1 mark)

Question 4 continues on the next page

Turn over ►



- 4 (b)** Calculate the value of capacitor C_1 required to produce a pulse length of 10s when R_1 is 300 k Ω .

.....

.....

.....

.....

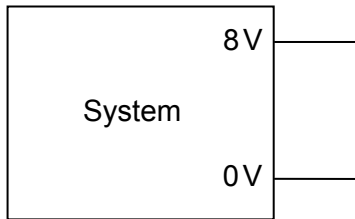
(3 marks)

11



- 5** A power LED is to be used as a warning light.
The system shown below can supply more current than is safe for the LED.

- 5 (a) (i)** Draw the circuit of the LED and a resistor needed to protect it.



(2 marks)

- 5 (a) (ii)** How does the resistor protect the LED?

.....
(1 mark)

- 5 (b)** The LED operates at a current of 300 mA and a forward voltage drop of 2.4 V. The system gives an output of 8 V when switched on.

- 5 (b) (i)** Calculate the voltage across the resistor.

.....
(1 mark)

- 5 (b) (ii)** Calculate the resistor's value.

.....
.....
(2 marks)

- 5 (b) (iii)** Select the most appropriate preferred value for this resistor.

.....
(1 mark)

- 5 (b) (iv)** Calculate the power dissipated by the resistor assuming a current of 300 mA flows through it. Use the value calculated in **5 (b) (ii)**.

.....
(1 mark)

- 5 (b) (v)** The chosen resistor in **5 (b) (iii)** could be a ceramic cased type. State the BS1852 printed code that would be marked on it, if it had a 5% tolerance.

.....
(3 marks)



- 6 (a) (i)** Draw a labelled system diagram to show how the following subsystems should be connected together to form an audio entertainment system.

tuner MP3 player/recorder amplifier loudspeaker

(4 marks)

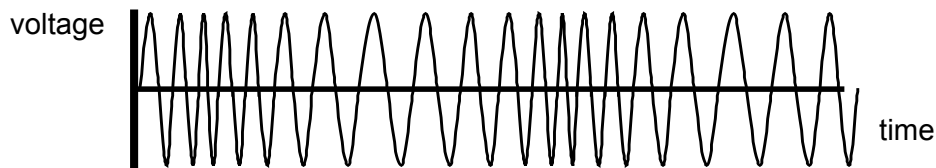
- 6 (a) (ii)** A microphone could be included so the MP3 recordings can be made. Add to your diagram a subsystem representing a microphone, and show how it would be connected.
(1 mark)

- 6 (b)** The tuner is able to receive AM and FM radio signals.

- 6 (b) (i)** What do the letters AM stand for?

.....
(1 mark)

- 6 (b) (ii)**

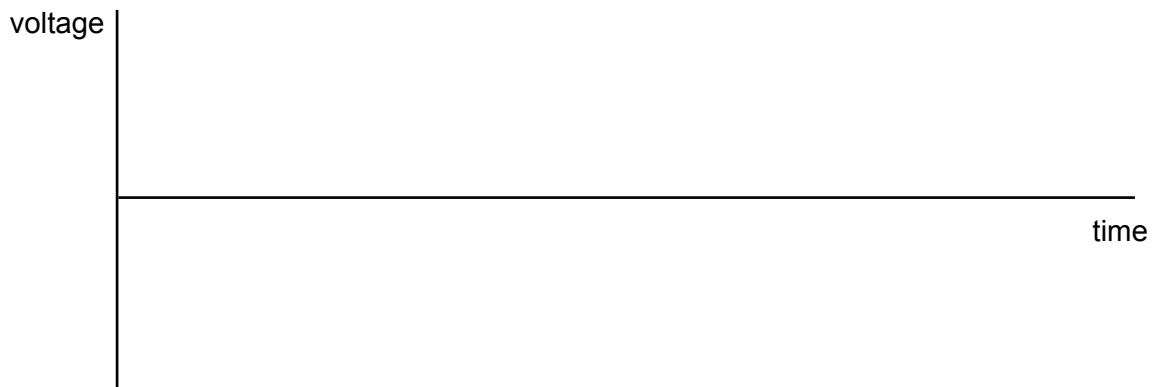


What type of radio signal is shown in this diagram?

.....
(1 mark)



6 (b) (iii) Draw the other type of radio signal that the tuner can receive.



(2 marks)

6 (b) (iv) Which subsystem in a simple radio receiver selects the required station?

.....

(1 mark)

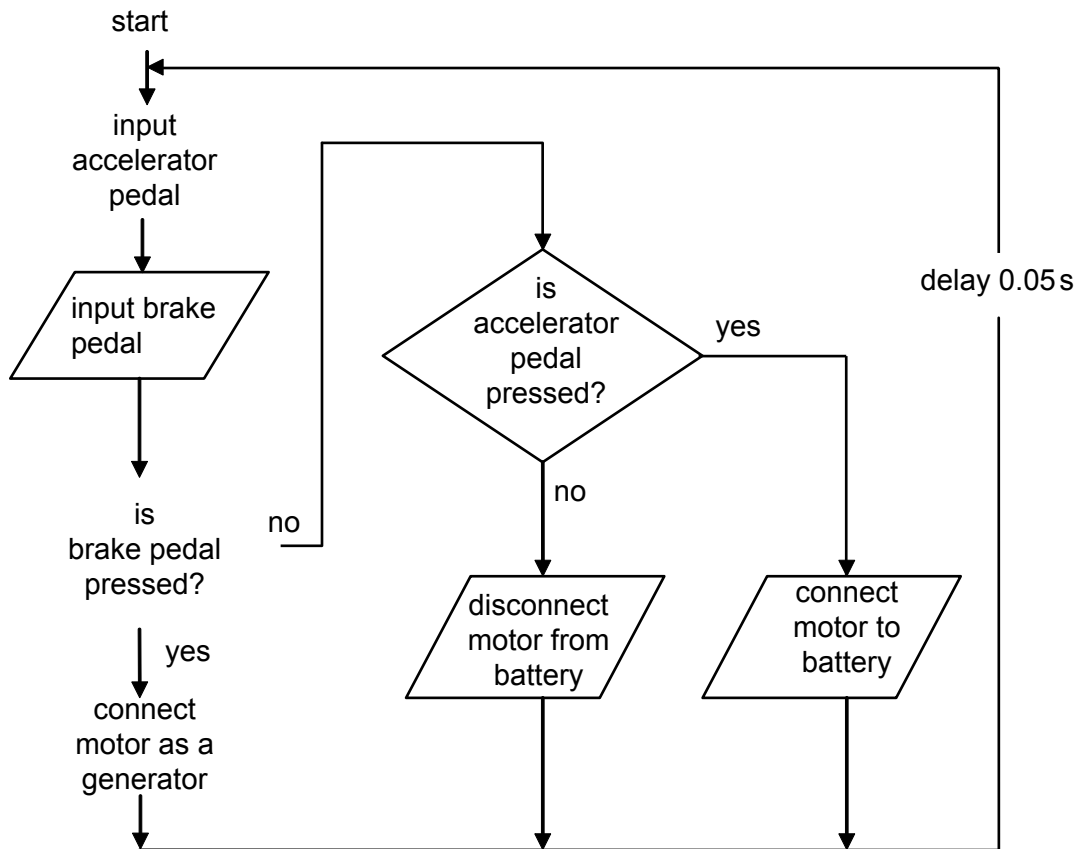
10

Turn over for the next question

Turn over ▶



- 7 A student designs a flowchart for a motor controller in an electric car. Pressing the accelerator pedal causes the motor to drive the car forwards. Pressing the brake pedal causes the motor to act as a generator to slow the car by returning charge to the battery.



- 7 (a) Draw the correct flowchart symbols at five places where they are missing on the diagram. (5 marks)

- 7 (b) Label on the flowchart:

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

(5 marks)



- 7 (c)** Use the space below to design a flowchart to control the recharging of the car's battery when it is parked at a charging point. It must detect the presence of the charger when connected; measure the amount of charge remaining in the battery, and charge the battery if needed until it is fully charged. After this it must switch the charger off and indicate that the battery is now fully charged.

(8 marks)

18

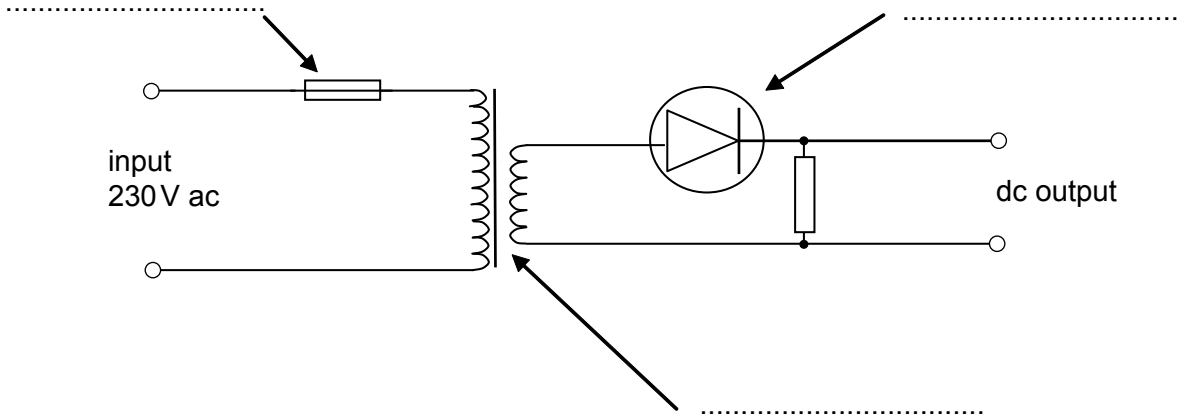
Turn over for the next question

Turn over ▶



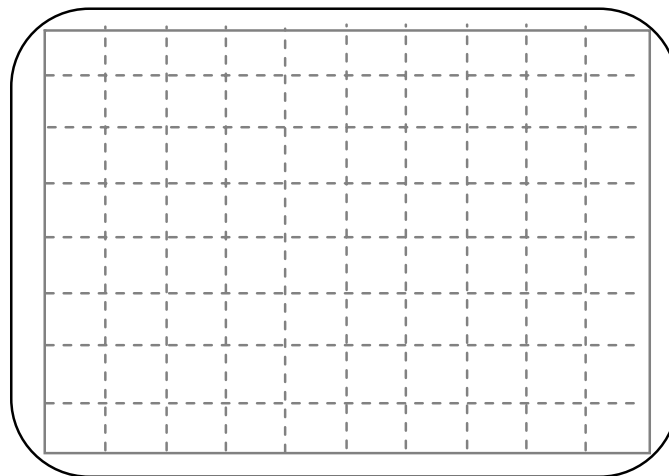
8 A student designs a system to protect the contents of a freezer by sounding an alarm if the power to the freezer fails.

8 (a) (i) The system uses a 5V mains power supply. Label the three components indicated by the arrows.



(3 marks)

8 (a) (ii) Draw the trace that the student would see if the signal from the power supply dc output was connected to the input of a correctly adjusted oscilloscope.



(3 marks)

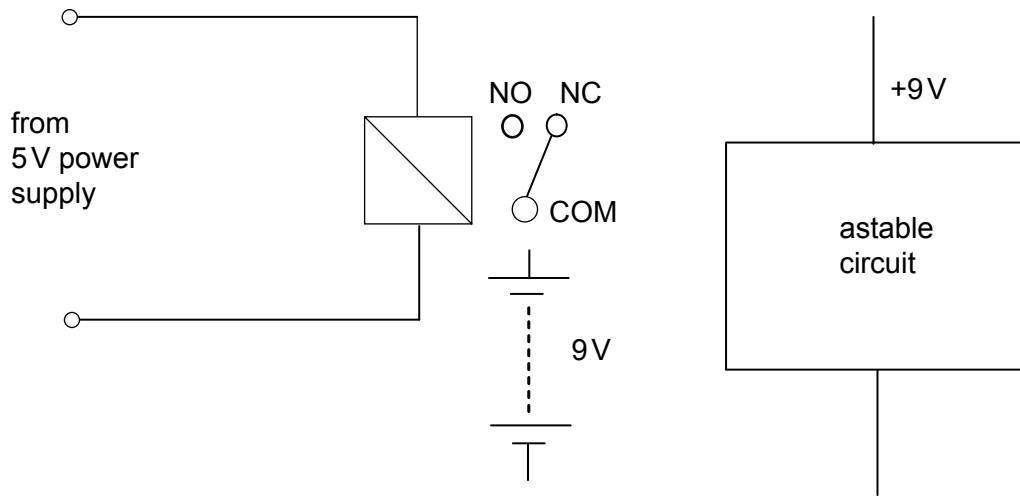
8 (a) (iii) State the name of this type of rectified signal.

.....
(1 mark)

8 (a) (iv) The student thinks the output of the power supply needs to be 'smoothed'. Draw on the diagram in **part (a)(i)** the symbol for a component which would perform this 'smoothing' process.
(2 marks)



- 8 (b)** The power supply from the mains power supply is connected to a relay subsystem as shown below.



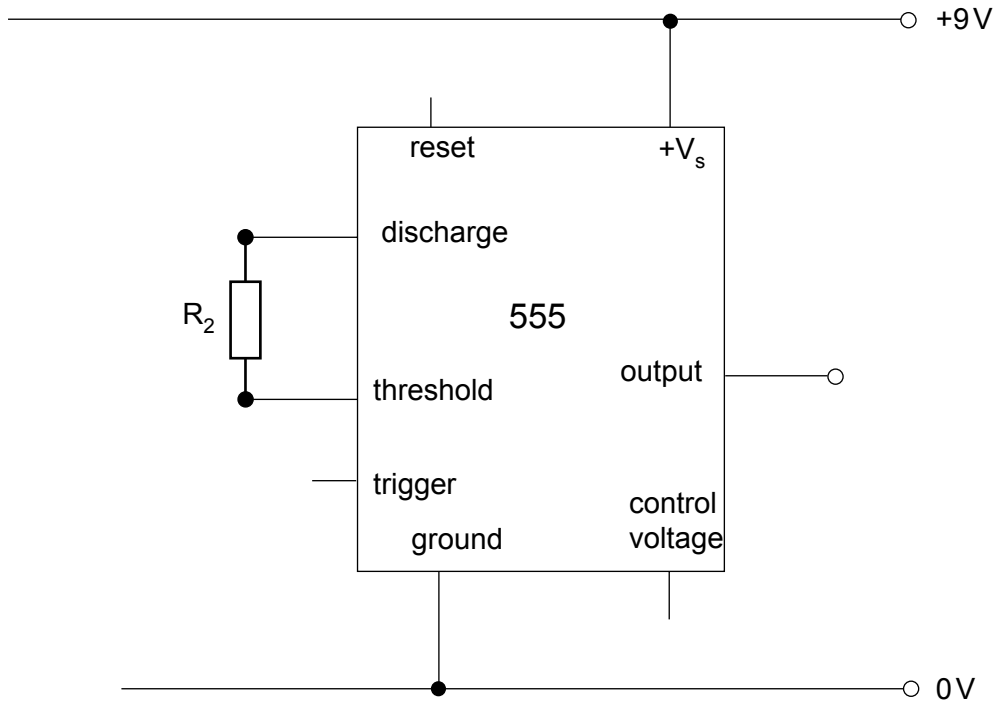
On the diagram draw the connection wires so that an astable will be connected to the 9V battery if the 5V power supply fails. (3 marks)

Question 8 continues on the next page

Turn over ▶



8 (c) (i) Complete this diagram of the astable circuit by drawing resistor R_1 , two capacitors C_1 and C_2 and wire links. Include a loudspeaker to produce an audible signal.



(6 marks)

8 (c) (ii) Calculate the period of the pulses produced using the formula on the data sheet. The timing components have the values $R_1 = 1\text{ k}\Omega$, $R_2 = 12\text{ k}\Omega$ and $C_1 = 0.1\text{ }\mu\text{F}$.

.....

(3 marks)

8 (c) (iii) Calculate the frequency of the pulses.

.....

(2 marks)

8 (c) (iv) State whether this is a suitable audio frequency. Give a reason for your answer.

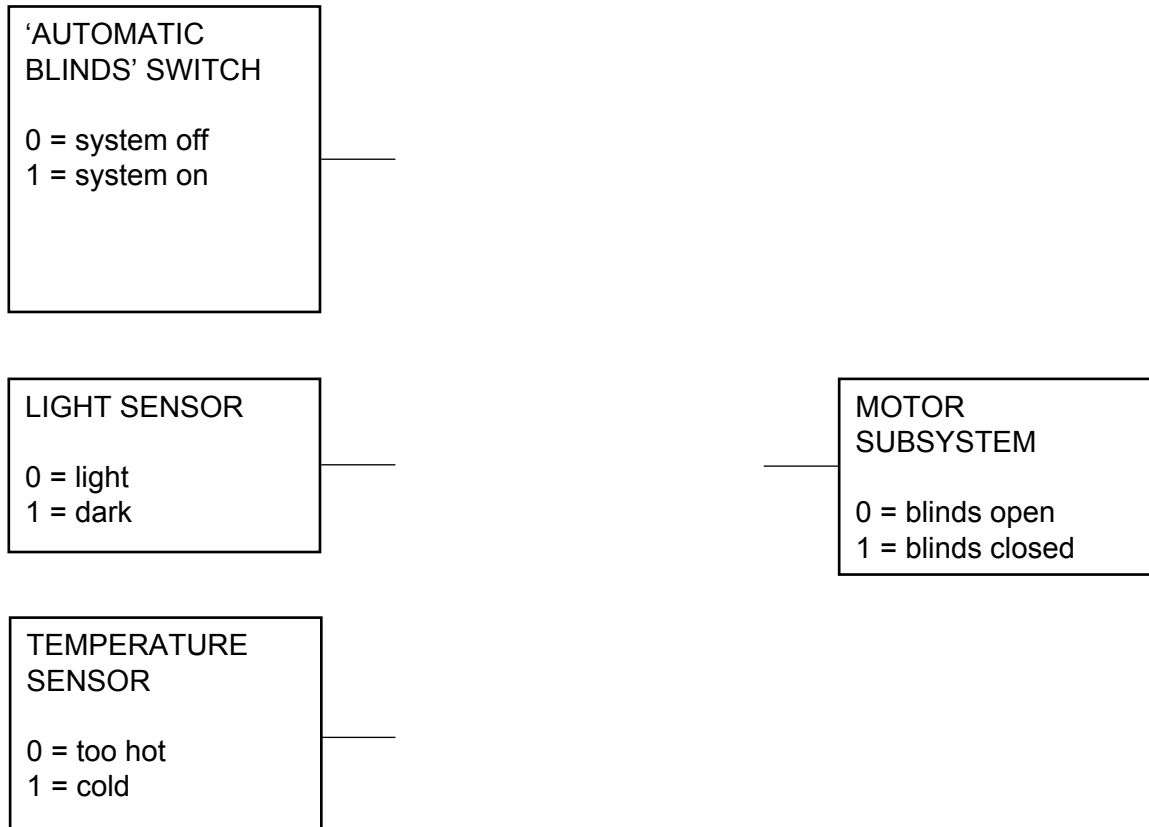
.....

(2 marks)



9 An energy efficient house has a system of motor-operated reflective blinds that close over the windows. These stop the house losing heat at night or becoming too hot when the sun is shining. When the 'automatic blinds' switch is operated AND it is either too hot in the house OR it is night time the blinds should close.

9 (a) Show how an AND gate, an OR gate and a NOT gate should be connected to make this system operate.



(5 marks)

9 (b) (i) The system above could also be made using only NAND gates.

Complete this truth table for a NAND gate.

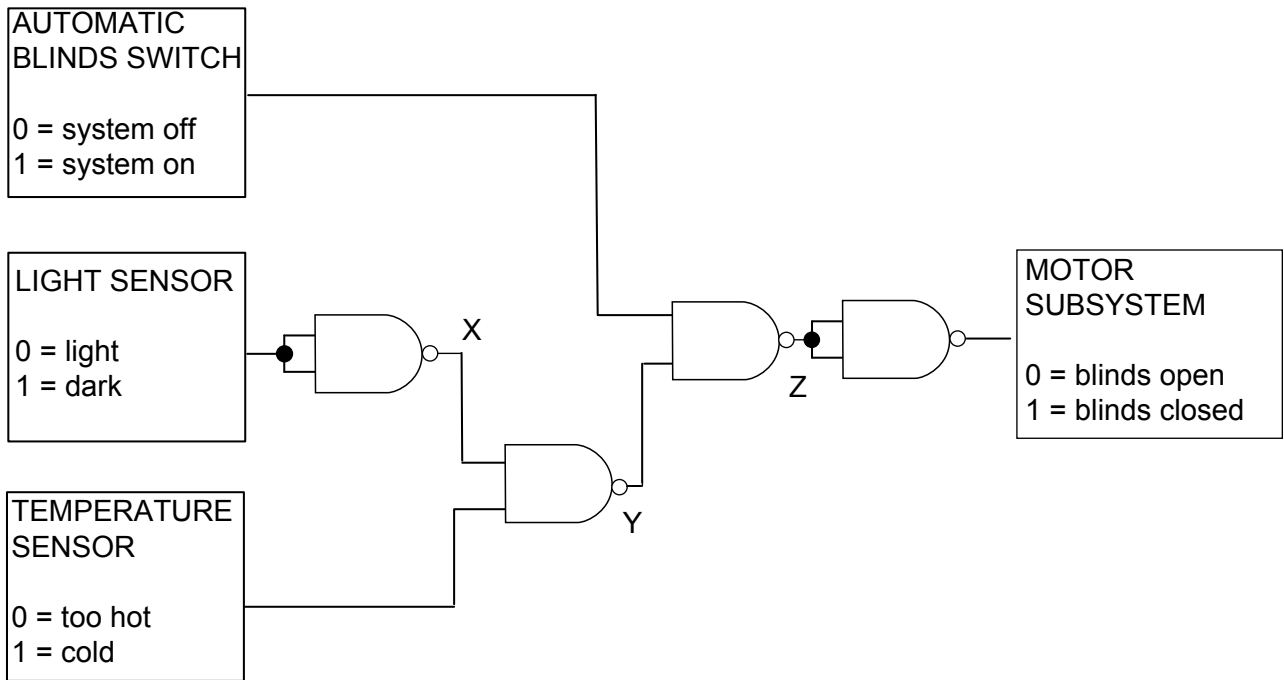
A	B	Q
0	0	
0	1	
1	0	
1	1	

(1 mark)

Turn over ►



9 (b) (ii) Complete the truth table below for this NAND gate system.

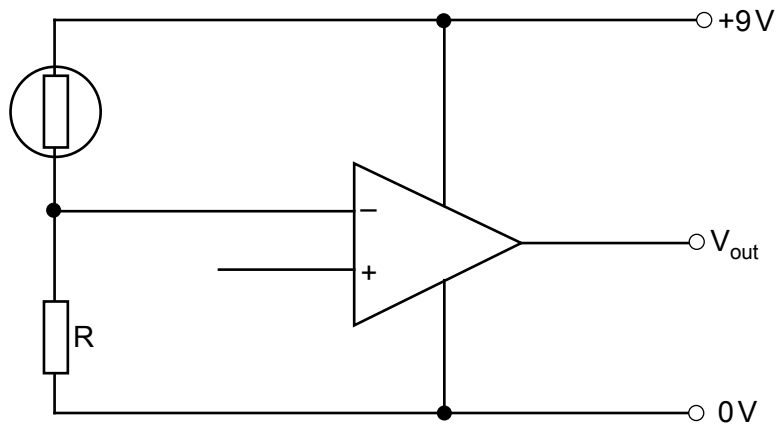


auto blinds switch	light sensor	temp. sensor	X	Y	Z	motor subsystem
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

(4 marks)



9 (c) (i) Part of the circuit for the light sensor contains an op-amp, connected as a comparator, and is shown below. Complete the circuit by adding two 10 kΩ resistors.



(2 marks)

9 (c) (ii) Using the correct names of the two op-amp inputs, explain how an op-amp comparator circuit works in terms of the input and output voltages.

Answer this question in continuous prose. The quality of written communication will be assessed in your answer.

.....

.....

.....

.....

.....

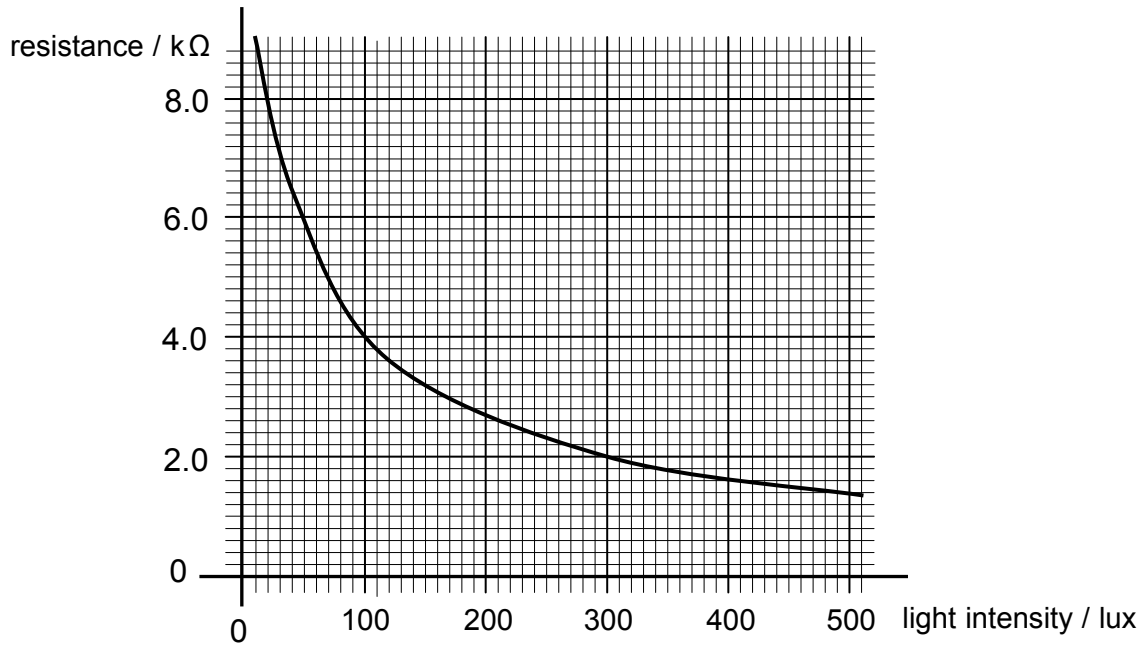
(5 marks)

Question 9 continues on the next page

Turn over ▶



9 (d) The data sheet for the Light Dependent Resistor (LDR) in the light sensor circuit includes the following graph.



9 (d) (i) State the resistance of the LDR when the light intensity is 300 lux.

.....
(1 mark)

9 (d) (ii) State the light intensity when the resistance of the LDR is 4.0 kΩ.

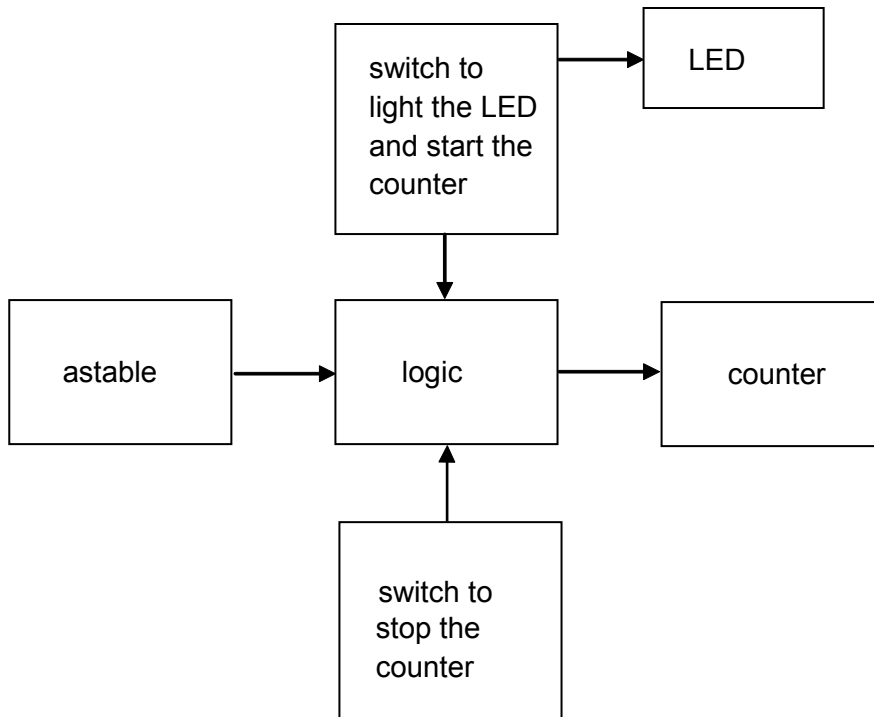
.....
(1 mark)

9 (d) (iii) The blinds should close in the evening when the light intensity on the LDR reaches the value in **part (d)(ii)**. State the value that should be used for resistor R in **part (c)(i)** and give a reason for your value.

.....
.....
(3 marks)



- 10** A student designs a reaction timer so that when a switch is pressed, an LED lights and a counter starts. When the LED lights, another switch has to be pressed as quickly as possible, which stops the counter and records the reaction time on a display. Part of the system is shown in the diagram below.



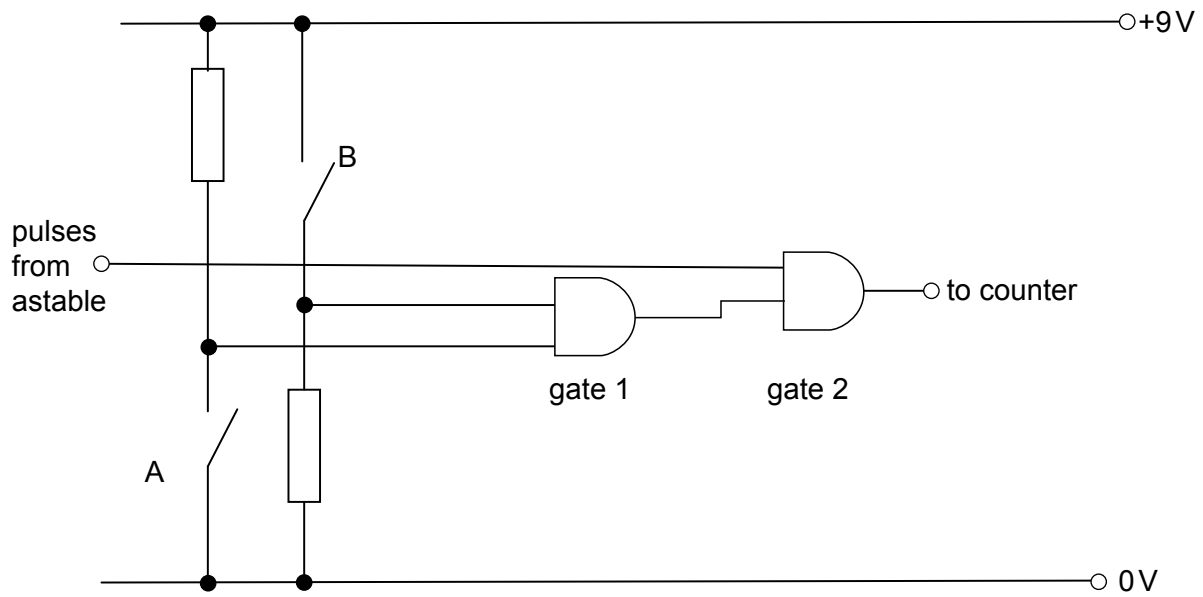
- 10 (a)** Draw on the system diagram **two** more blocks showing the display subsystem and the counter reset subsystem. (2 marks)

Question 10 continues on the next page

Turn over ▶



10 (b) The circuit for the switches and logic is shown below.



Which of the switches A or B must be closed to allow pulses to the counter? Explain your answer.

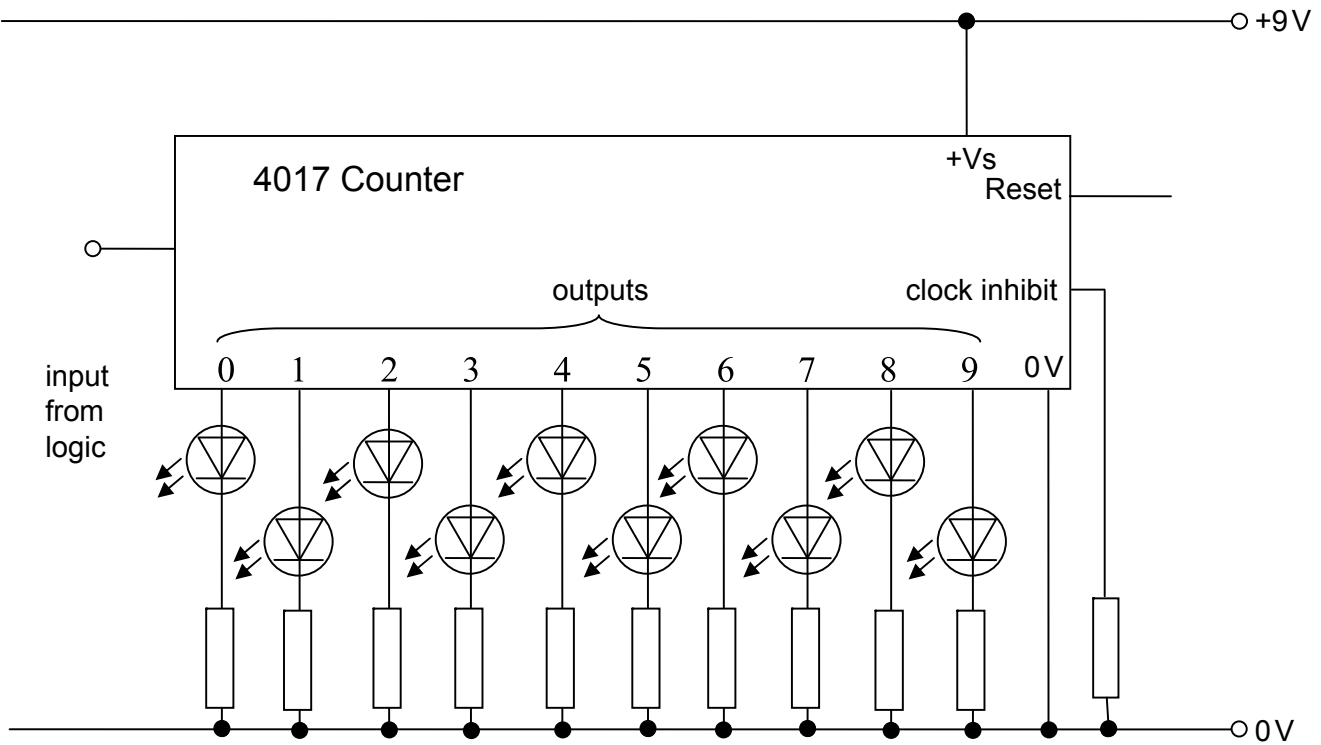
.....

.....

(2 marks)



10 (c) This diagram shows the counter and display circuit.



10 (c) (i) Draw, on the circuit above, a resistor and switch that can be used to reset the counter. (3 marks)

10 (c) (ii) Draw a connecting wire on the circuit to stop the counter when the LED connected to output 9 lights up. (1 mark)

Question 10 continues on the next page

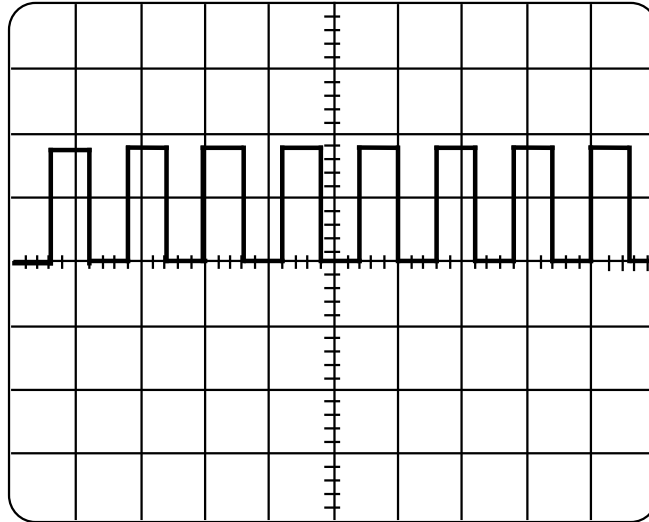
Turn over ▶



10 (d) The student uses an oscilloscope to measure the period of the pulses and obtains this trace.

Y sensitivity is set to 5V per division

Time base is set to 100 ms (0.1 s) per division



10 (d) (i) Calculate the period of the pulses from this trace.

.....
(2 marks)

10 (d) (ii) The student designed the astable to produce pulses with a time period of 0.1 s. State **two** reasons why the measured period could be different from that calculated from the values of the timing capacitor and resistors.

Reason 1

Reason 2

(2 marks)

Question 10 continues on page 26



Turn over for the next question

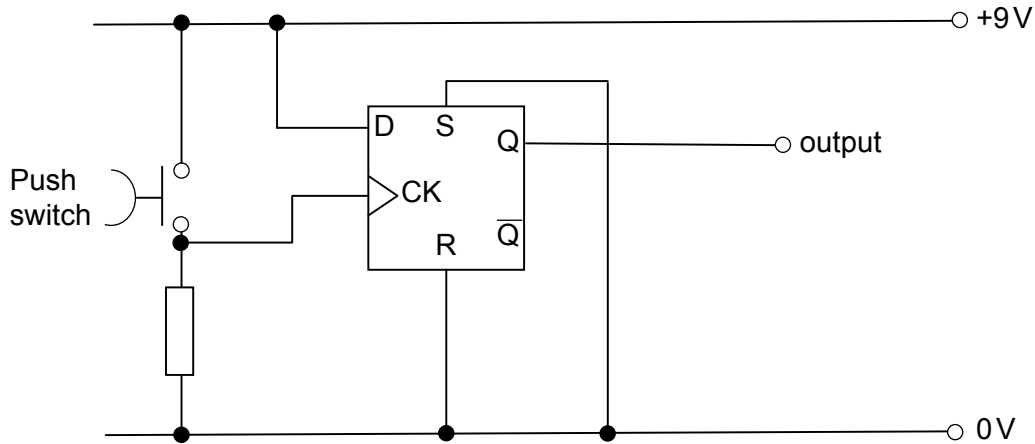
**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ▶



2 5

10 (e) After testing her circuit the student decides that it would be better to use a momentary action push to make switches and flip-flops as the inputs to her circuit instead of toggle switches. She decides to build this circuit on prototyping board.



10 (e) (i) Assuming that the flip-flop has been reset, explain what happens when the switch is pressed and then released.

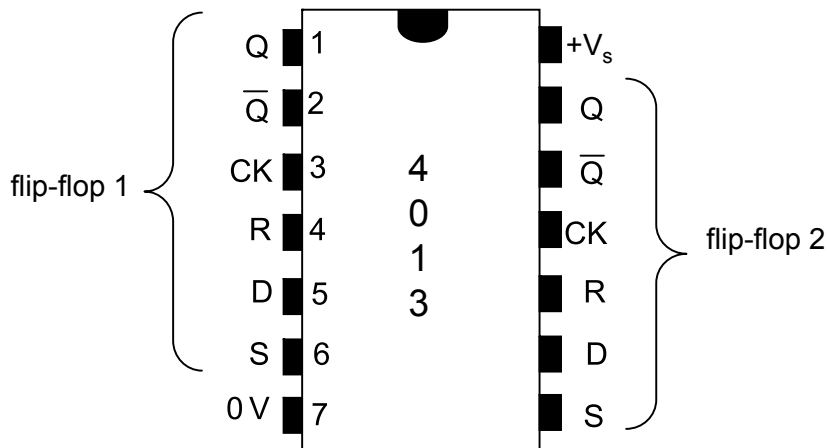
.....

.....

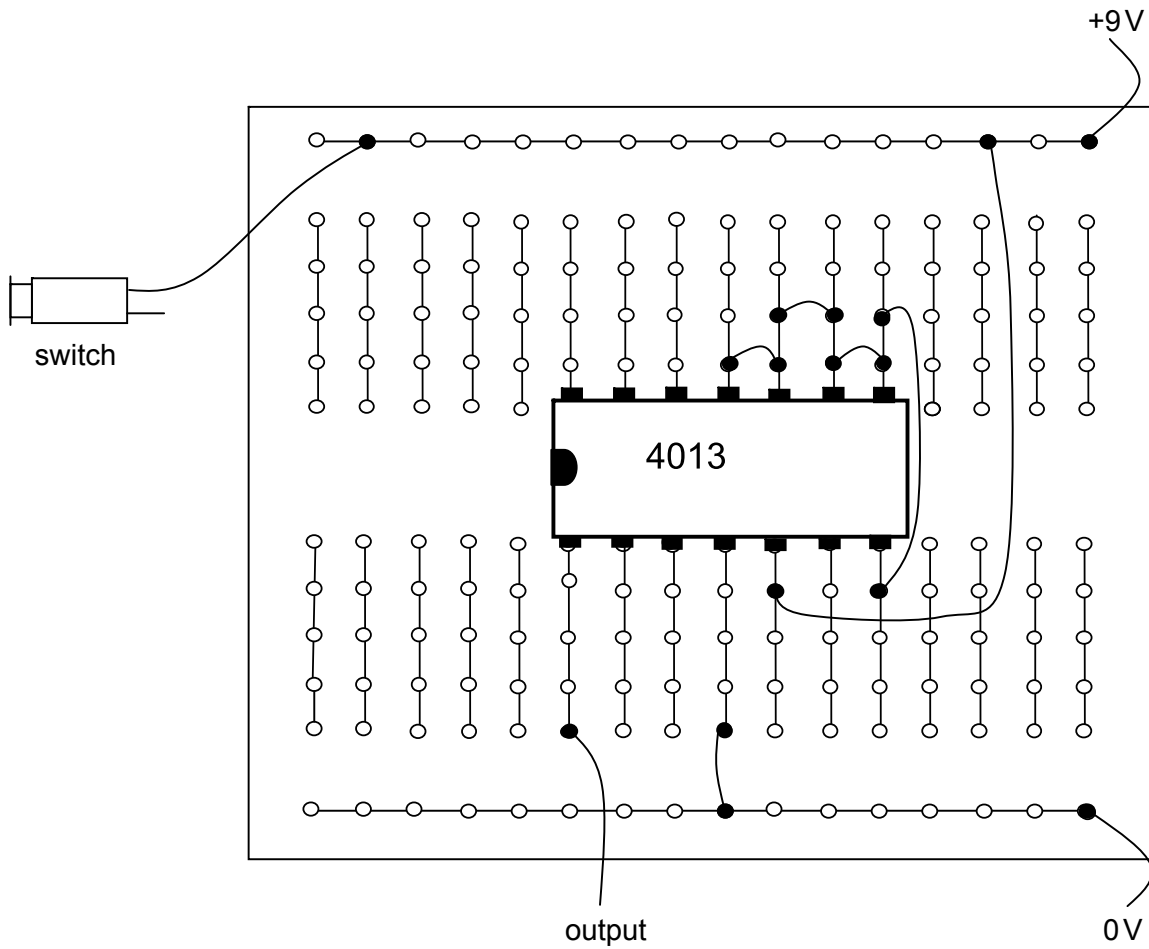
.....

(3 marks)

10 (e) (ii) The 4013 integrated circuit contains two D-type flip-flops and the pin connections for flip-flop 1 and flip-flop 2 are shown below.

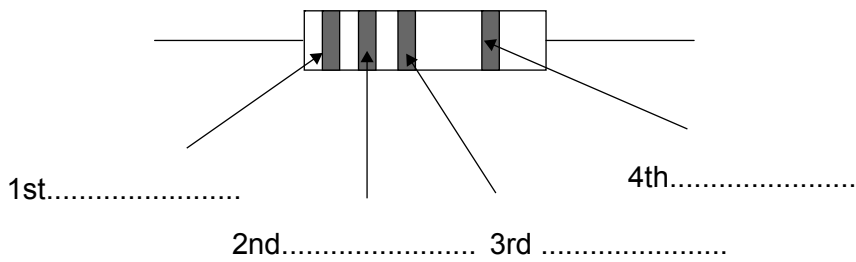


Complete the flip-flop circuit by adding the missing resistor and four wire links.



(5 marks)

- 10 (f) The resistor used in the circuit has a value of $100\text{k}\Omega$ ($100\,000\Omega$). Label the coloured bands it would have if its tolerance were 5%.



(3 marks)

23

END OF QUESTIONS



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

