

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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8	
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10	
TOTAL	



General Certificate of Secondary Education
June 2011

Electronics

44301

Unit 1 Written Paper

Wednesday 8 June 2011 9.00 am to 11.00 am

For this paper you must have:

- 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 1 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

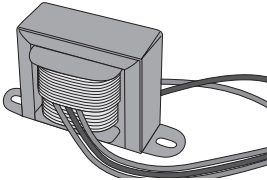
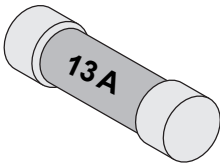
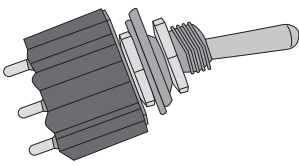
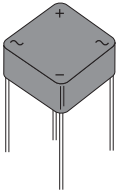
(a) Monostable mode, time period $T = 1.1 R_1 \times C_1$

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



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

1 (a) Name the components shown in the table and draw the electrical symbol for each one.

	Component	Name	Symbol
A			
B			
C			
D			

(8 marks)

1 (b) (i) What safety features does component **A** provide?

.....

1 (b) (ii) What safety features does component **B** provide?

.....

(2 marks)

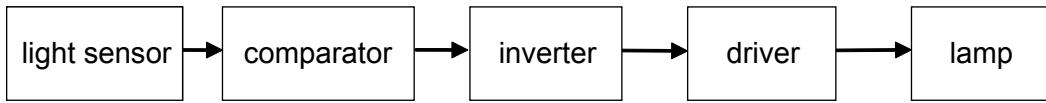
10

Turn over for the next question

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2 A lighting engineer is working on an automatic road lighting scheme. The system diagram is shown.



2 (a) In the system diagram which block represents

2 (a) (i) an input

2 (a) (ii) an output

2 (a) (iii) a logic gate? (3 marks)

2 (b) The final design uses several different types of components. In which block could you find

2 (b) (i) an LDR

2 (b) (ii) a MOSFET

2 (b) (iii) an op-amp? (3 marks)

2 (c) Which block uses a small signal to control a large current?

..... (1 mark)

2 (d) Which block converts an analogue signal to a digital signal?

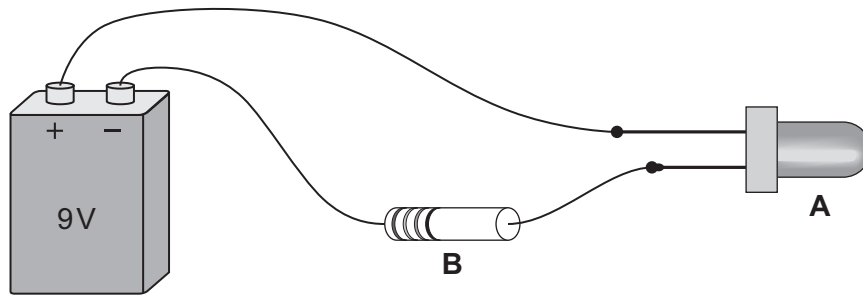
..... (1 mark)

2 (e) The light sensor produces a signal that decreases in voltage as night falls. Describe a possible sequence of operation of the next stages in response to this.

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



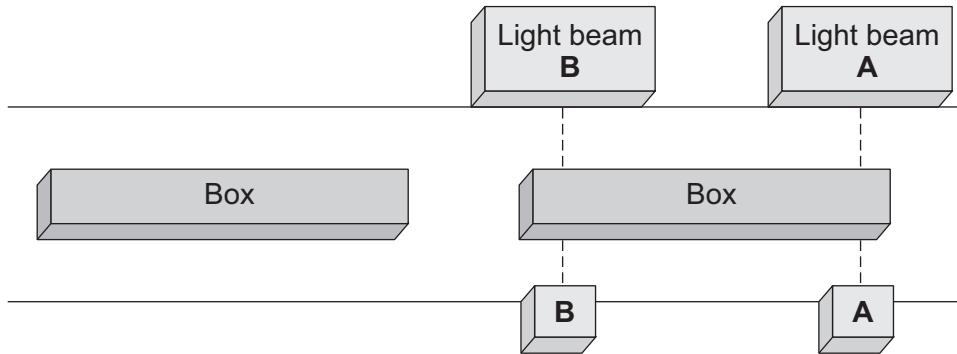
- 3** A student wants to add a visible warning to her electronic system. She carries out an experiment using the circuit shown below.



- 3 (a) (i)** Name component **A**. (1 mark)
- 3 (a) (ii)** Name component **B**. (1 mark)
- 3 (b)** Why is component **B** needed in this circuit?
..... (1 mark)
- 3 (c)** She measures the voltage across the battery and finds it is exactly 9V. She also finds there is 2.2V across component **A**.
- 3 (c) (i)** Calculate the voltage across **B**.
..... (1 mark)
- 3 (c) (ii)** She knows the current through **A** must not exceed 20 mA, (0.02 A) calculate the minimum value for **B**.
.....
..... (2 marks)
- 3 (c) (iii)** Components of this value are not available. Choose the most appropriate preferred value for **B**.
..... (1 mark)
- 3 (c) (iv)** Give the colour code for your chosen value of component **B** if it has a 5% tolerance.
..... (3 marks)



4 Boxes travel along a conveyor belt in a factory. Each box has its top printed when it is blocking both beams.



4 (a) The printer operates when a logic system connected to the beam sensors A and B gives a logic 1 from its output Q. Complete the truth table below to describe the operation of the system as a box travels along the conveyor belt.

Comment	A	B	Q
Both sensors unblocked			
Only sensor A blocked	0	1	0
Both sensors blocked	0	0	1
Only sensor B blocked			

(6 marks)

4 (b) What type of logic gate would give the function in the truth table?

.....
(1 mark)

4 (c) Draw the logic symbol for this type of gate. Label its inputs A and B and its output Q.

(2 marks)

4 (d) Describe how the printing system would operate if the conveyor belt moved the boxes in the opposite direction.

.....
.....

(1 mark)

10



5 A 9V battery is considered to have reached the end of its useful life when it has discharged to 6V. A project circuit is designed to monitor the battery's voltage.

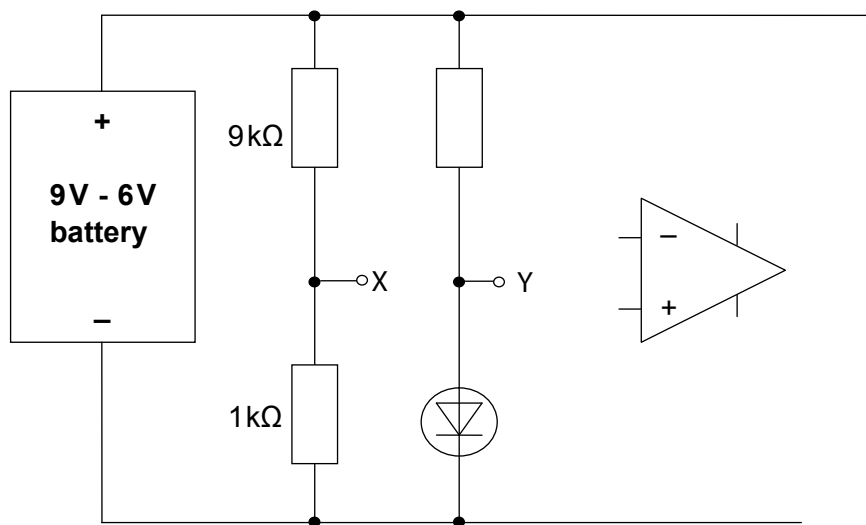
5 (a) A component, which is shown in the diagram below, can have a particular function so that it will produce an output signal when the input voltage goes below a set level.

Name the component

Name the function

(2 marks)

5 (b) Complete the circuit diagram below to show how this component can be connected to have this function. Label the output of your circuit.



(4 marks)

5 (c) Calculate the voltage at X when the battery is discharged to 6V.

.....

(3 marks)

5 (d) The voltage at Y is 0.7V when the battery is connected. State the output voltage of the circuit when the battery is at 6V.

.....

(1 mark)



- 6 (a)** Label the system diagram of a simple radio receiver using the correct name for each subsystem in the list below.

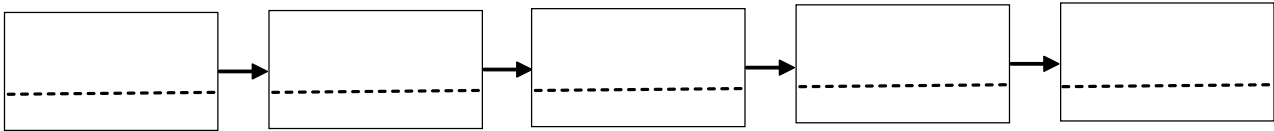
af amplifier

loudspeaker

aerial

demodulator

rf tuned circuit



(5 marks)

- 6 (b) (i)** What is a typical frequency range for an af (audio frequency) amplifier?

.....
(1 mark)

- 6 (b) (ii)** Which of these types of integrated circuits could be used to make the af amplifier? Draw a circle around the correct answer.

4017

555

4013

LM386

(1 mark)

- 6 (b) (iii)** What maximum power output would be typical of an af amplifier made from the integrated circuit? Draw a circle around the correct answer.

3 mW

20 mW

0.6 W

20 W

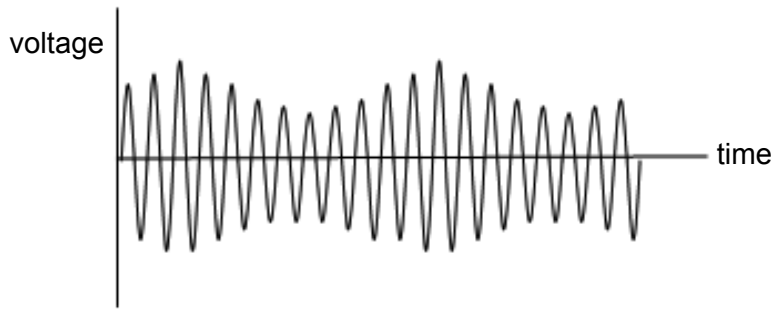
(1 marks)

- 6 (c)** Explain what is meant by the term bandwidth when applied to an af amplifier.

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

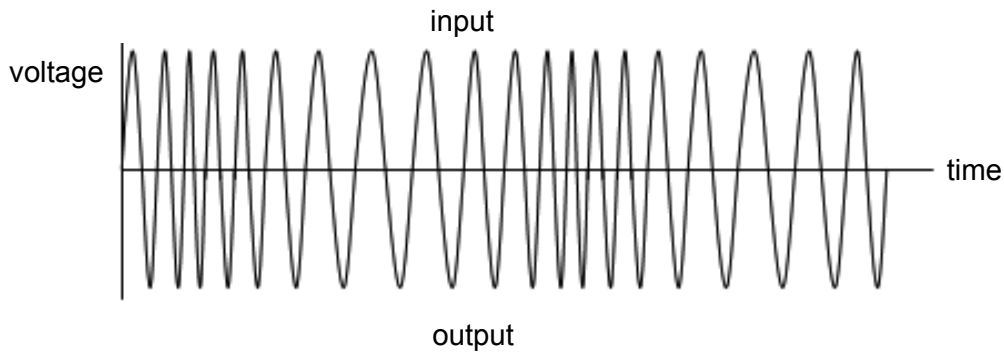


6 (d) (i) Name the type of modulation shown in this diagram.



.....
(1 mark)

6 (d) (ii) The diagram below shows a different type of modulation. Sketch the signal which would be obtained from the demodulator when the waveform below is the input.



(2 marks)

6 (e) (i) Explain what is meant by the term selectivity when applied to a radio receiver.

.....
.....

6 (e) (ii) Explain what is meant by the term sensitivity when applied to a radio receiver.

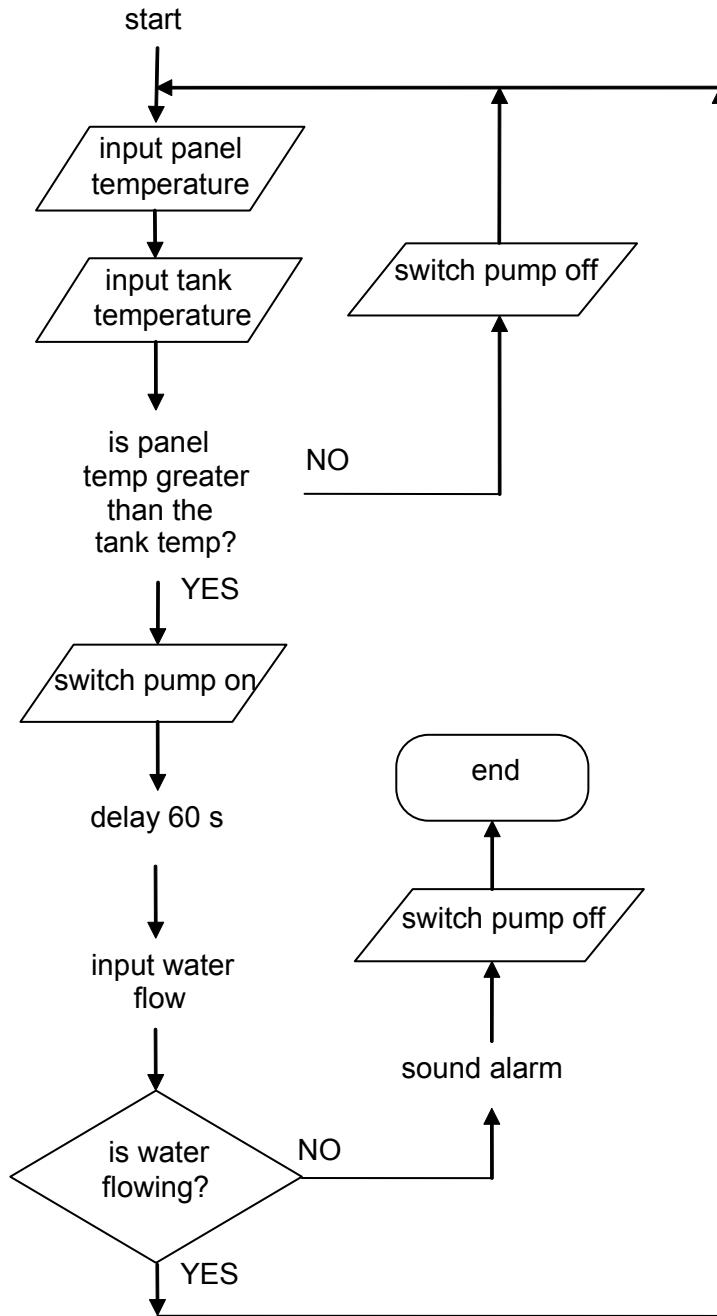
.....
.....

(4 marks)

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7 A heating engineer draws a flowchart that describes the action of a solar panel control system that he is designing. This system pumps water through the panel to a storage tank only when the Sun's energy is enough to heat the water in the panel.



7 (a) On the flowchart draw the correct flowchart symbols at **five** places where they are missing. (5 marks)

7 (b) Label on the flowchart
 a decision box an input box a loop an output box a process box
 (5 marks)



7 (c) (i) What condition must apply to the temperatures of the solar panel and storage tank to make the pump switch on?

.....
(1 mark)

7 (c) (ii) Weak sunshine on a winter's day eventually causes the pump to switch on, filling the solar panel with cold water. For how long does the pump then run?

.....
(1 mark)

7 (c) (iii) What part of the flowchart prevents the pump from continuously switching on and off?

.....
(1 mark)

7 (d) Describe in your own words the operation of this control system starting from it being switched on when the panel is at a higher temperature than the tank, and then the pump failing after 1 minute and 30 seconds.

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

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(5 marks)

Question 7 continues on the next page

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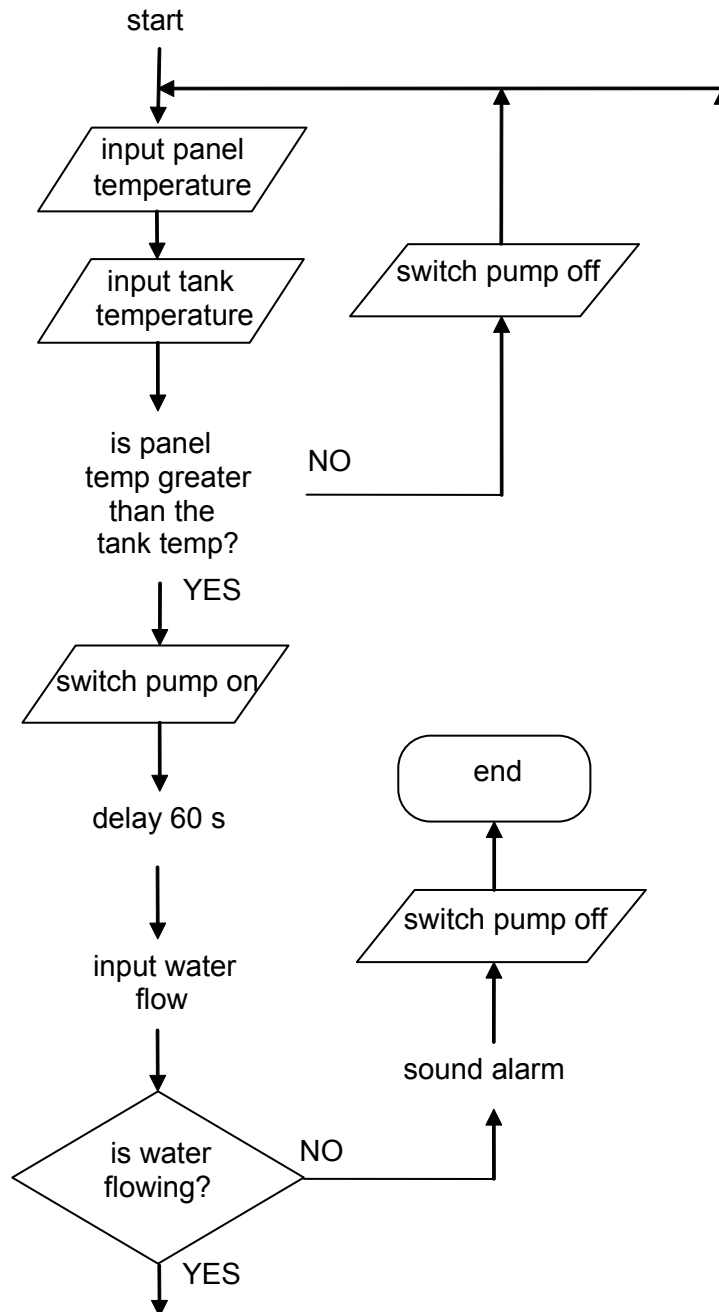


7 (e) (i) Add to the flowchart below, in the correct place, where you would switch on a green LED when water is flowing.

(1 mark)

7 (e) (ii) Add to the flowchart below, in the correct place, where you would switch on a red LED when the water is not flowing.

(1 mark)



- 8** A chicken farmer asks a student to design and build an audible alarm system which will detect intruders, such as foxes, after nightfall. The student uses a light sensor to detect when it is dark, an infrared sensor to detect movement and he includes a switch for disabling the system.

The states of the sensors and the audible alarm are shown in the logic diagram below.

- 8 (a)** Add two AND gates, and another NOT gate to the diagram to show how the system could be made to operate as described above.

light sensor

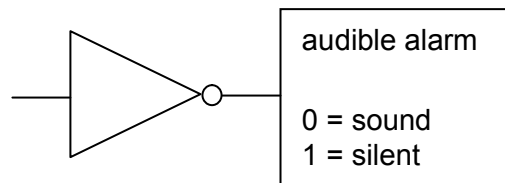
0 = dark
1 = light

infrared sensor

0 = no movement
1 = movement

switch

0 = system off
1 = system on



(5 marks)

Question 8 continues on the next page

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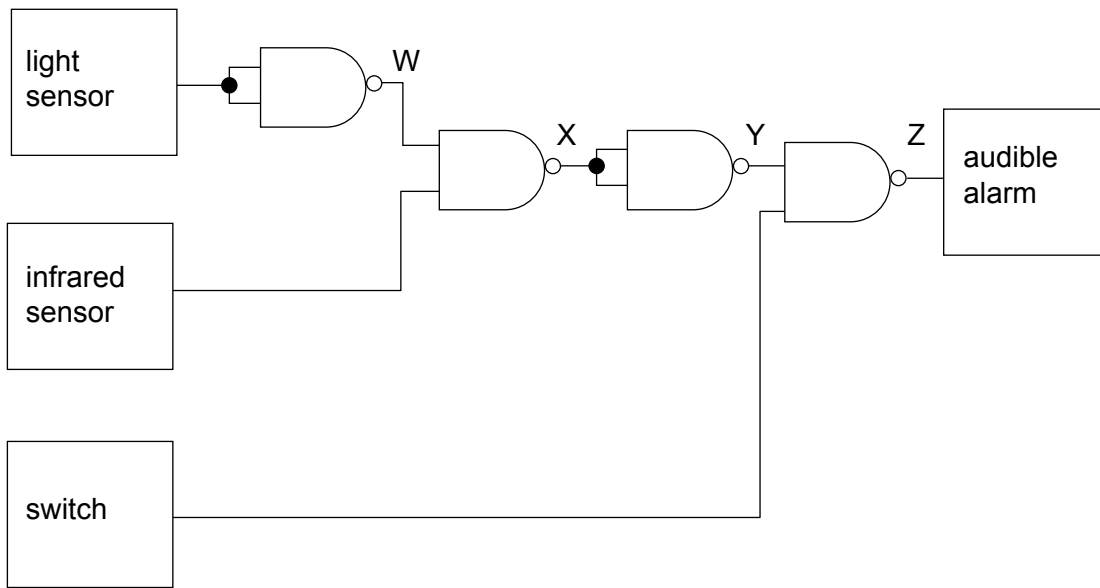


8 (b) (i) The system could also be made using only NAND gates. Complete the truth table for a NAND gate.

A	B	Q
0	0	
0	1	
1	0	
1	1	

(1 mark)

Part of the NAND gate system is shown below.



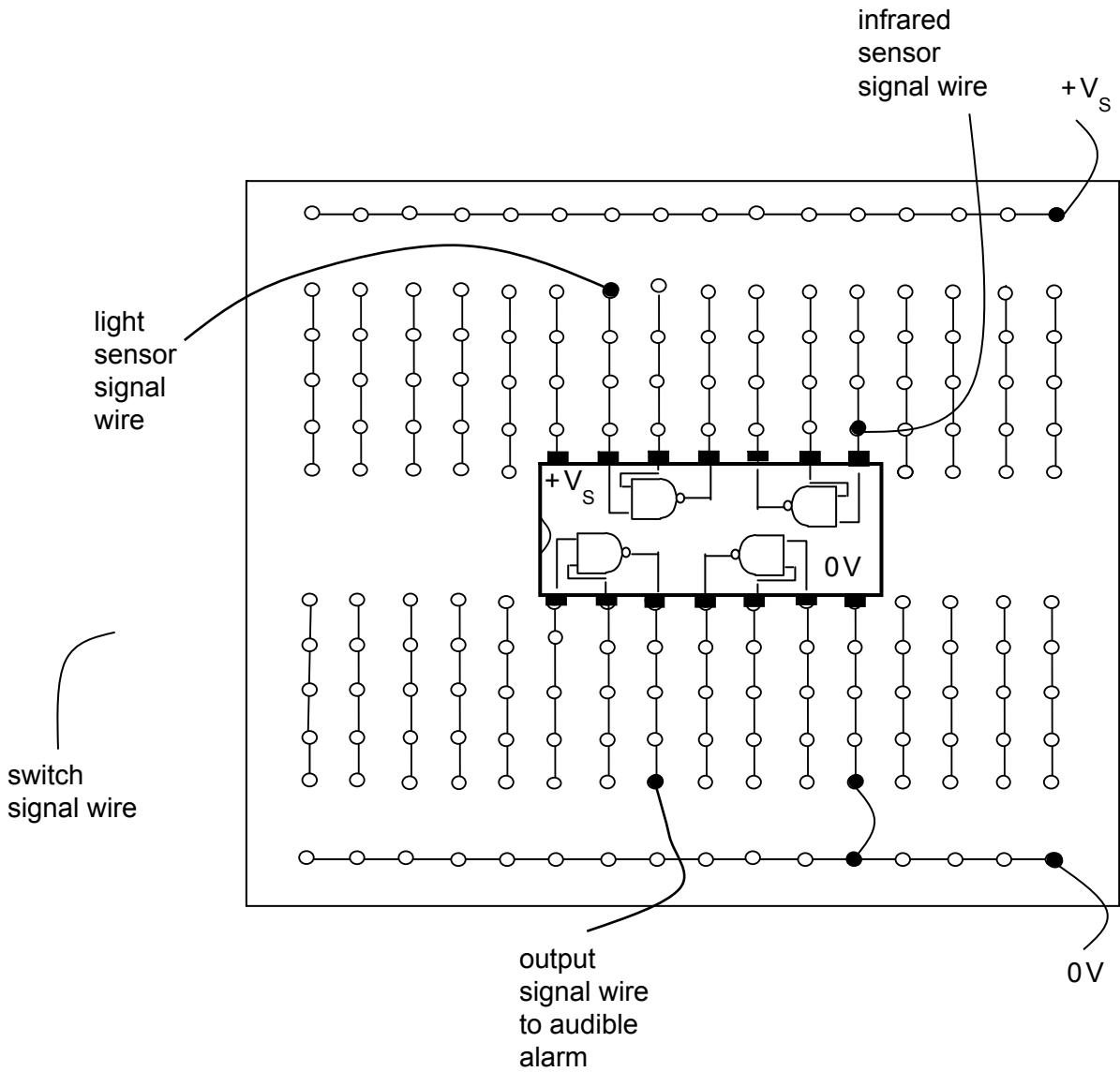
8 (b) (ii) Complete the truth table below for the NAND gate system.

light sensor	infrared sensor	switch	W	X	Y	Z
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)



8 (c) The system is to be built on prototyping board. Complete the circuit by adding seven missing connections.



(7 marks)

17

Turn over for the next question

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9 An electronic engineer asks a new trainee at her company to demonstrate his ability to use test equipment and his knowledge of circuits.

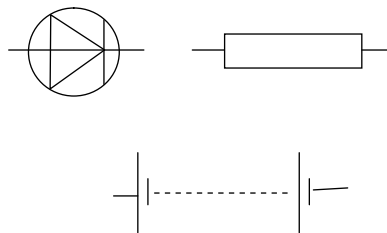
9 (a) (i) Draw the circuit symbols for an ammeter and a voltmeter.

ammeter

voltmeter

(2 marks)

9 (a) (ii) The diagram below shows an LED being powered from a battery via its current limiting resistor. Complete the diagram to include an ammeter and a voltmeter in order to measure the current through the resistor and the voltage across it when the LED is lit.



(3 marks)

9 (a) (iii) When connected correctly the ammeter reads 100 mA. Convert this value to amps.

.....
(1 mark)

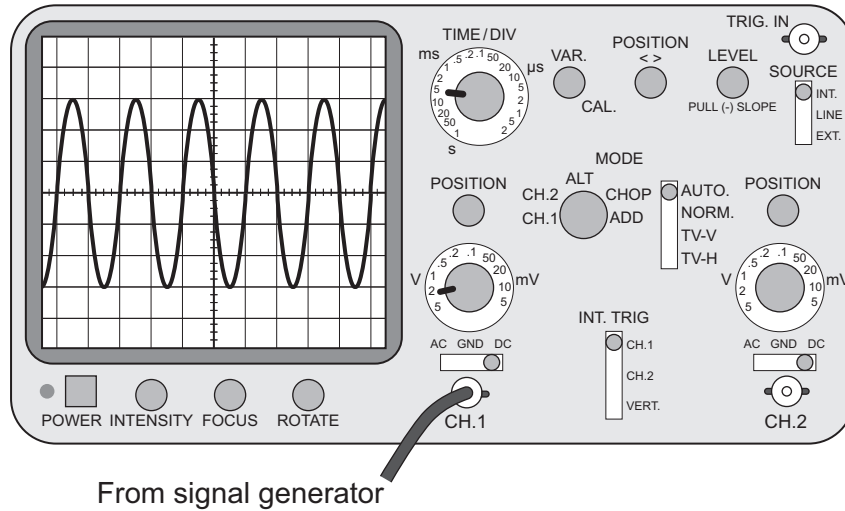
9 (a) (iv) The voltmeter reads 6.8V. Calculate the power dissipated by the resistor.

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



9 (b) (i) The trainee then demonstrates the use of the instrument below. What is it called?

.....
(1 mark)



The trainee connects the instrument shown above to a signal generator and obtains the trace shown.

9 (b) (ii) If the Y sensitivity is set to 2 volts per division calculate the peak voltage of the signal generator output.

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

9 (b) (iii) If the time base is set to 5 ms per division calculate the time period of this signal.

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

9 (b) (iv) Calculate the frequency of this signal.

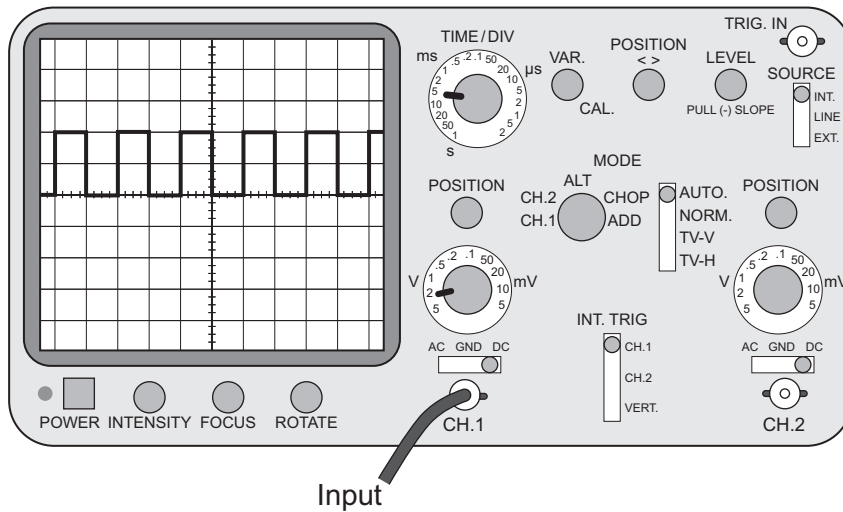
.....
.....
(2 marks)

Question 9 continues on the next page

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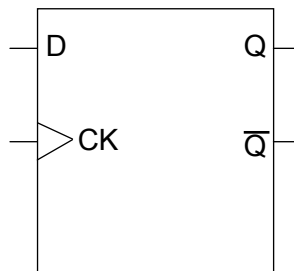


9 (c) The trainee sets the signal generator to produce square pulses.



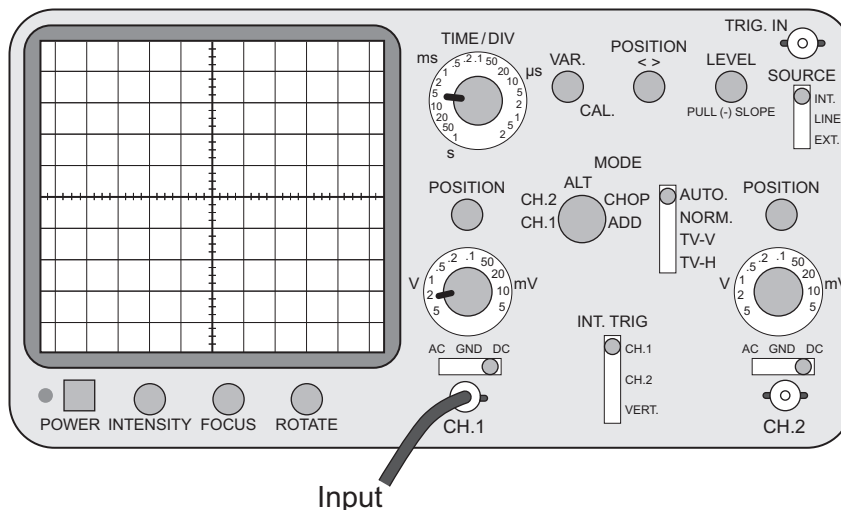
He then passes the pulses through a D-type flip-flop connected as a frequency divider.

9 (c) (i) Complete the diagram below to show how a D-type flip-flop should be connected to act as a frequency divider. Label the input and output.



(3 marks)

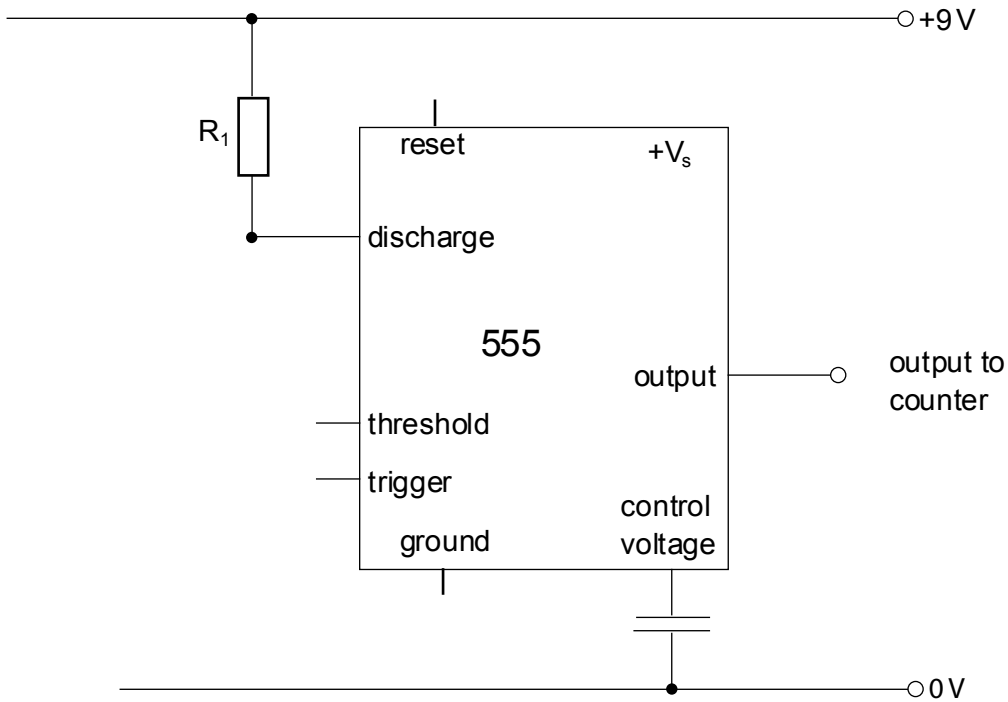
9 (c) (ii) With the signal generator connected to the input of the frequency divider and the output to his test instrument, the trainee obtained a trace on the screen. Draw on the screen below the output he would obtain.



(2 marks)



10 (a) (i) A 555 timer is used to produce pulses for a control system. Complete this diagram to show how a 555 timer can be used as an astable.



(6 marks)

10 (a) (ii) Show that if the value of the timing components are $R_1 = 10\text{ k}\Omega$, $R_2 = 100\text{ k}\Omega$ and $C = 100\text{ }\mu\text{F}$ then the time period of the pulses is about 15 s.

.....

.....

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(3 marks)

Question 10 continues on the next page

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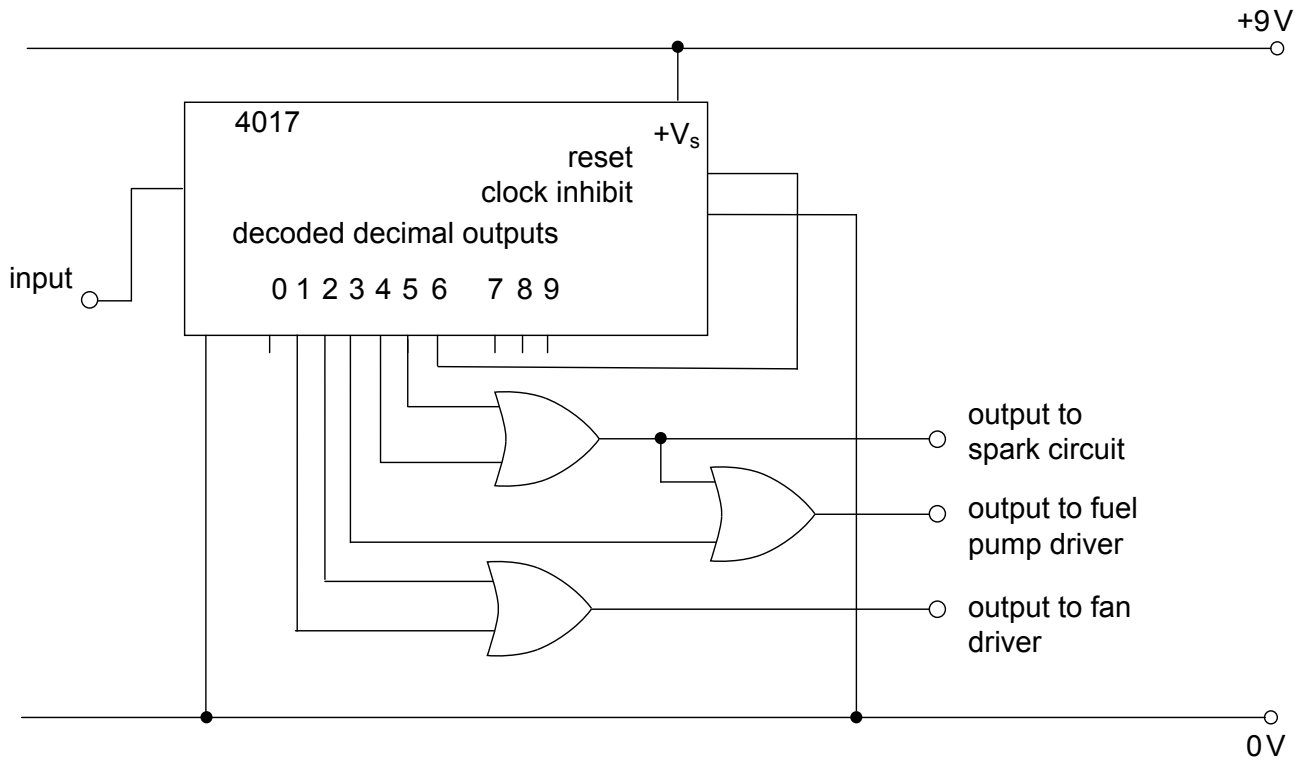


10 (b) A control system is needed to ignite an industrial oil heater. A sequence of three operations is required.

- A fan must switch on to blow any unburnt gases out of the heater.
- A fuel pump must switch on.
- A circuit must operate to produce a spark to ignite the fuel.

An engineer decides to use a 4017 counter for this system.

The sequence of operations is controlled by the counter and logic system shown below.



10 (b) (i) If the period of the astable is 15s for how long does the fan switch on?

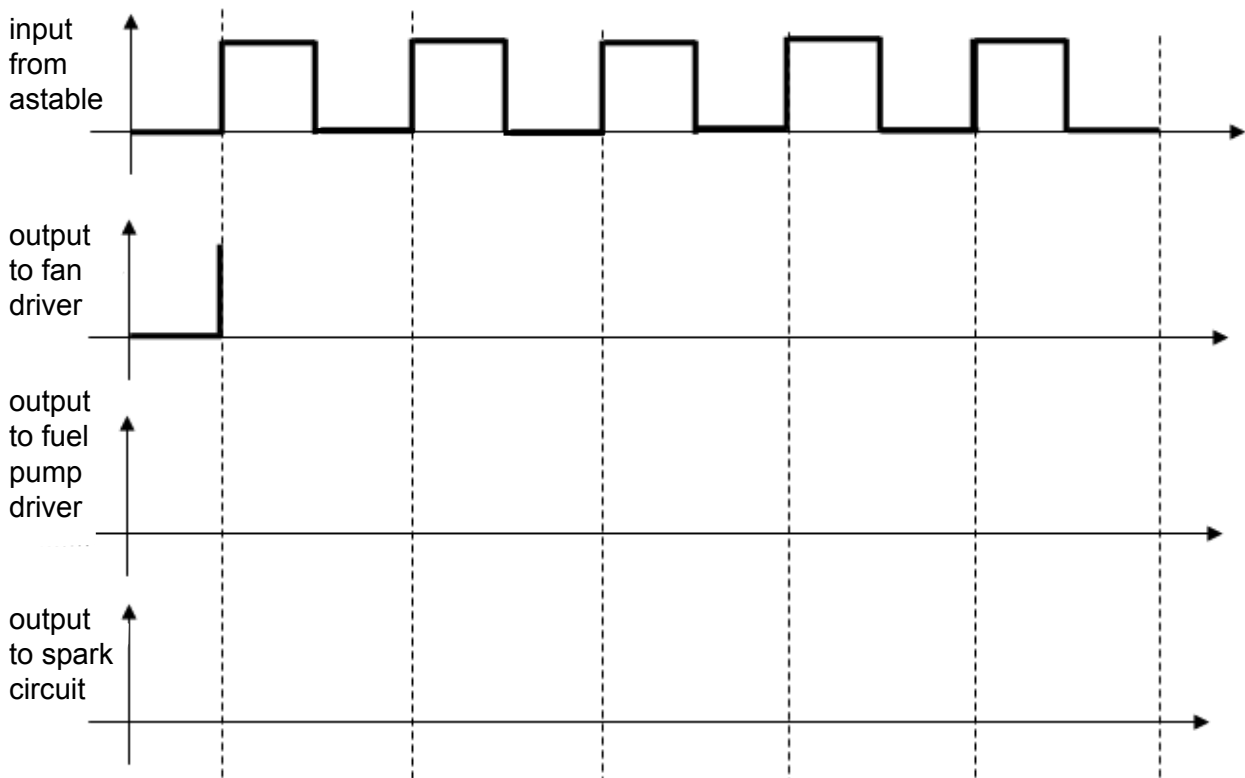
..... (1 mark)

10 (b) (ii) For how long is the pump on before the spark circuit operates?

..... (1 mark)

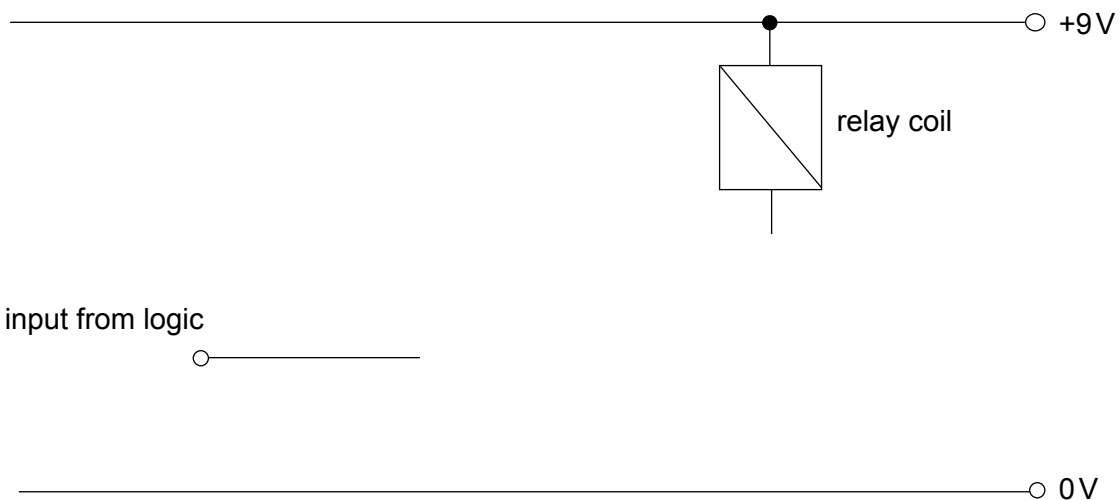


10 (b) (iii) Complete these timing diagrams for the system.



(5 marks)

10 (c) (i) The fuel pump is operated by a relay which is switched by a MOSFET. Complete this diagram to show how the MOSFET should be connected to switch the relay and label the three connections of the MOSFET.



10 (c) (ii) Add to the diagram a diode which would protect the MOSFET.

(5 marks)

Turn over ▶



10 (d) A microcontroller could be used instead of using the counter and logic circuit.
Explain the advantages of using a microcontroller system over the counter and logic circuit.

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

.....

.....

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(5 marks)

26

END OF QUESTIONS



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