Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Secondary Education
June 2007

ELECTRONICS
Written Paper
Higher Tier

3432/H

H

Thursday 24 May 2007 1.30 pm to 3.30 pm

For this paper you must have:
- a pencil and a 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			
Question	Mark	Question	Mark
1		5	
2		6	
3		7	
4			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Information Sheet

The following information may be useful in answering some of the questions in this examination paper.

1. **Power**
   Power = voltage × 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 value 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 10

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 × 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 Complete the following statements by filling in the missing words.

(a) An example of an output transducer that produces sound is a

.....

(b) An example of an input transducer that detects light is a

.....

(c) A simple electronic system has an input, a ..... and an output.

(d) An instrument which can be used to measure voltage, current and resistance is a

.....

(e) In order to measure the voltage across, and the current through, a component a voltmeter should be connected in .....with the component and an ammeter should be connected in .....with it.

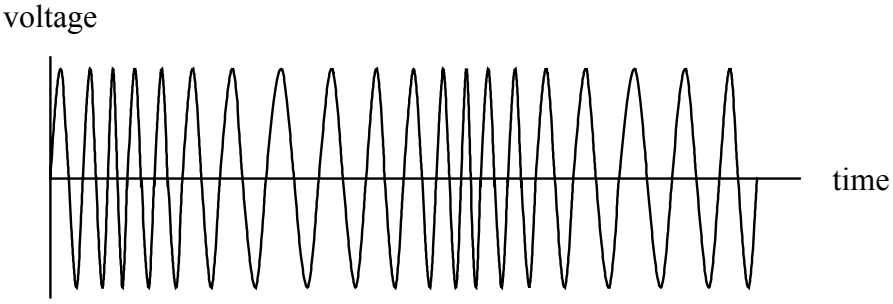
(f) Eight bits of binary data is called one .....

(g) Each memory location in a computer is identified by a number called its

.....

(h) A microprocessor can read data from memory and ..... data into memory.

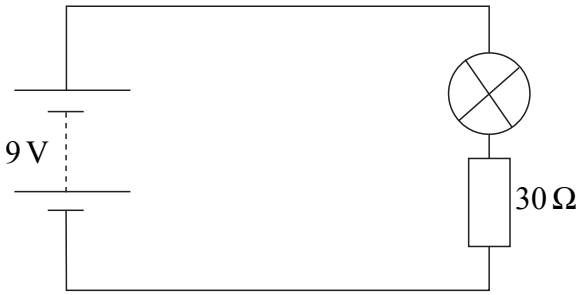
(i) The diagram below shows a carrier wave which has been ..... modulated.



(10 marks)

10

2 The lamp in this circuit is at full brightness and the current through it is 100 mA.



(a) A student needs to choose a power rating for the resistor.

(i) State the current, in amps, through the resistor.

.....

(ii) Calculate the voltage across the resistor.

.....

.....

(iii) Calculate the power dissipated by the resistor.

.....

.....

(iv) From the list draw a circle around the most suitable power rating for the resistor.

0.125 W **0.25 W** **0.5 W** **1 W**

(6 marks)

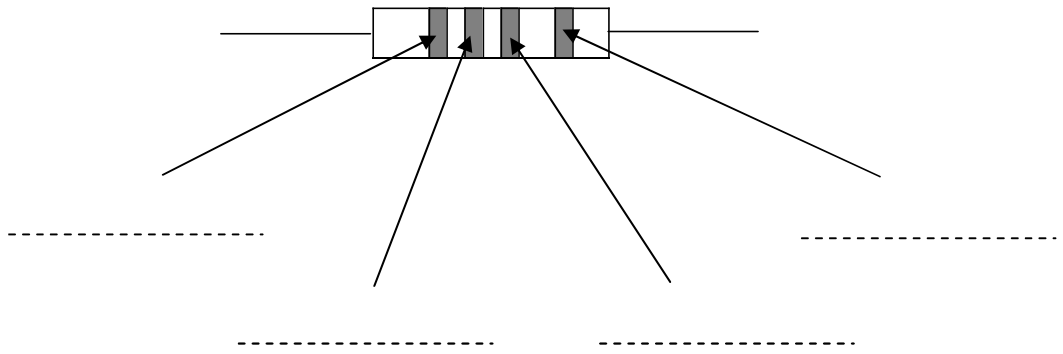
(b) (i) Calculate the voltage across the lamp.

.....

(ii) On the diagram above draw the symbol for a voltmeter connected to measure the voltage across the lamp.

(3 marks)

(c) The 30 Ω resistor has a tolerance of 5%. Label the colours of the bands on the diagram below.



(4 marks)

(d) In a circuit the lamp is to be switched using a MOSFET.

(i) Draw the symbol for a MOSFET and label its connections.

(ii) State **two** properties of a MOSFET which make it suitable for interfacing the lamp with a controlling circuit.

.....

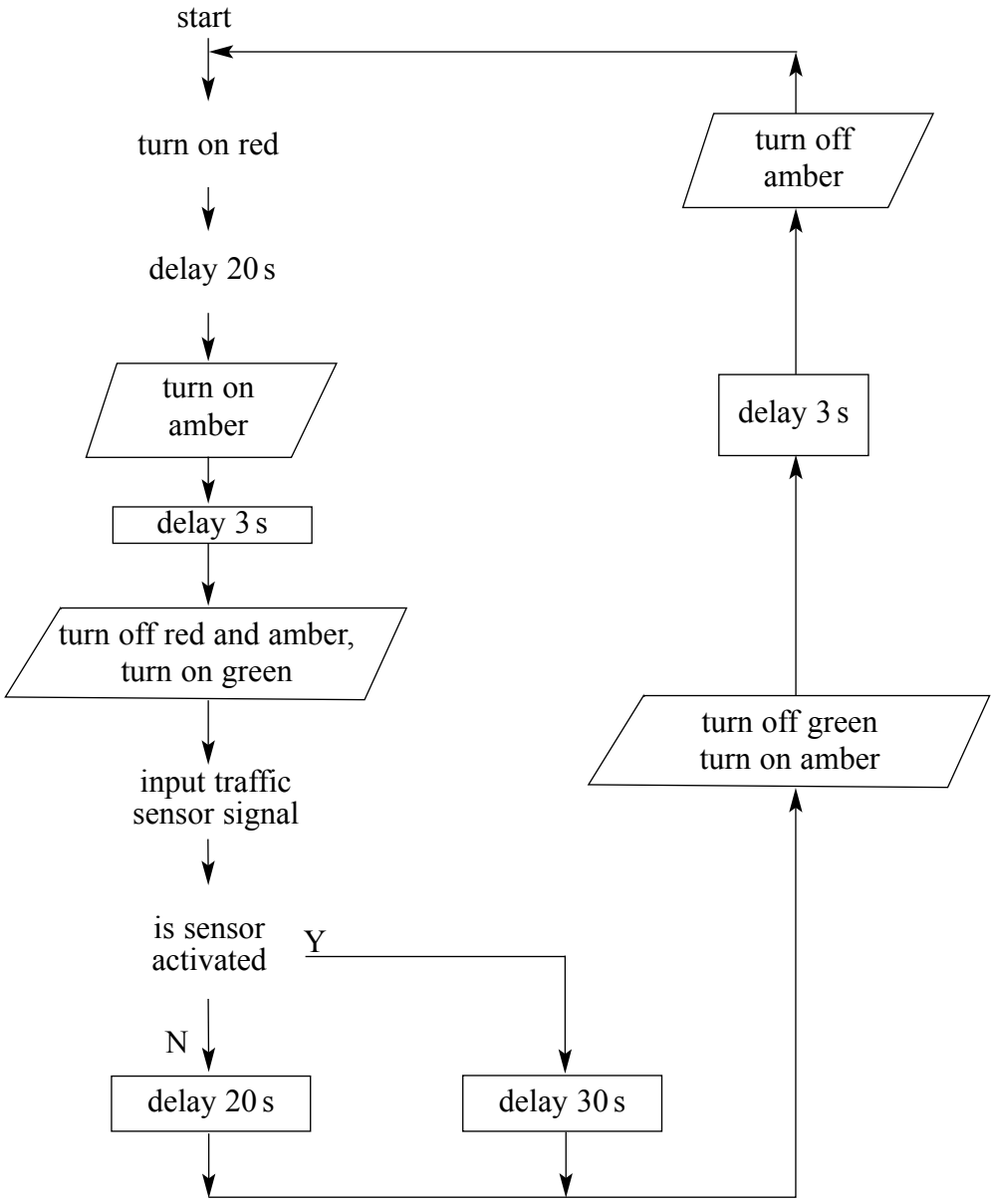
.....

.....

(5 marks)

18

3 The flowchart describes the action of a traffic light system that is capable of reacting to the length of the queue of traffic.



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

(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) (i) From **start** how long does it take before the green light turns on?

.....

(ii) The traffic sensor is activated by a long queue of traffic. How does this alter the behaviour of the traffic light system compared to a short queue of traffic?

.....

(iii) How many times in one cycle of the flowchart is the amber light switched on?

.....

(iv) What is the total length of time the amber light is switched on in one cycle of the flowchart?

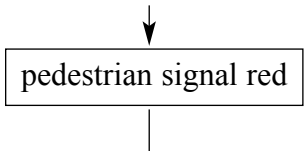
.....

(v) What is the length of time from when the red light switches on, to the next time it switches on if there is a long queue of traffic?

.....

(5 marks)

(d) A pedestrian crossing system normally shows a green light to traffic and a red symbol to pedestrians. A button is pressed by a pedestrian wishing to cross the road. After a 10s delay the traffic lights change to red and the pedestrian is shown a green symbol. The pedestrian then has 15s to cross the road before the pedestrian symbol changes back to red. Complete the flowchart to show how this pedestrian crossing system operates.



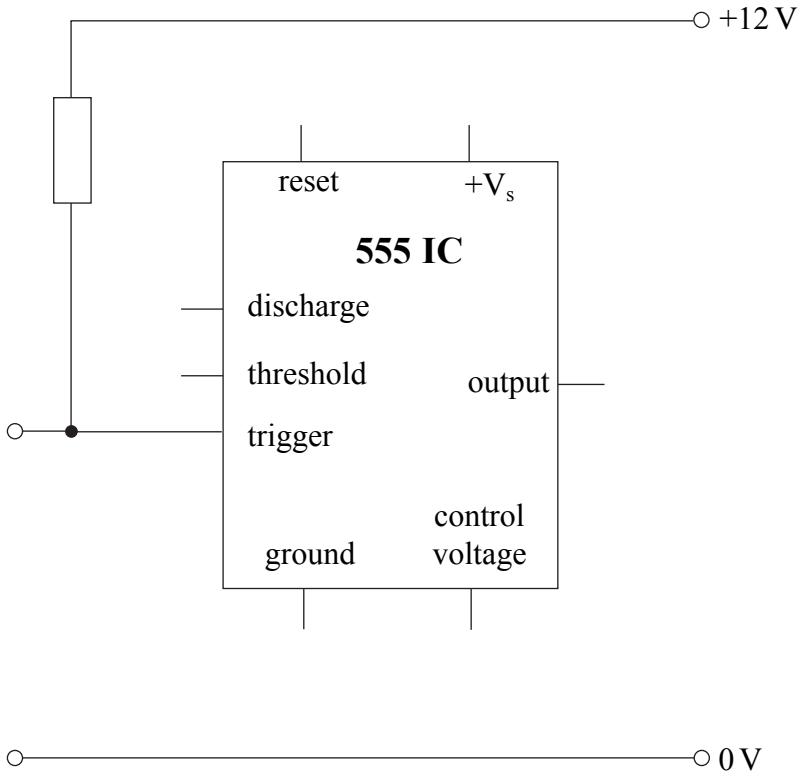
(5 marks)

20

4 A student decides to construct a traffic light system similar to that described in Question 3 part (a) and part (b), using 555 IC monostables as the timing sub-systems.

It is not necessary to have completed your answer to Question 3 before attempting this question.

(a) Complete the circuit diagram below to show how the 555 IC should be connected to form a monostable. Include a timing resistor and capacitor, and any other components or connections required. Label the connection to the next stage.



(8 marks)

(b) The traffic light output transducers are high power LEDs which have a maximum forward voltage of 4V when conducting a maximum current of 450 mA.
Explain why they cannot be directly coupled to the logic gates or the timer in the system.

.....

(1 mark)

(c) LEDs should always be operated with a series resistor. The supply voltage for the system is 12 V.

(i) Calculate the voltage across the series resistor. .....

(ii) What current will flow through the series resistor? .....

(iii) Calculate the required value of the series resistor.

.....

(iv) What preferred value of resistor from the E24 series should be chosen here?

.....

(5 marks)

(d) It is decided to use an npn bipolar transistor to drive the LED and its series resistor. Draw the circuit diagram for the LED and its driver. Label the leads of the transistor and include a component that will limit the current to the input of the driver circuit.

(6 marks)

Question 4 continues on the next page

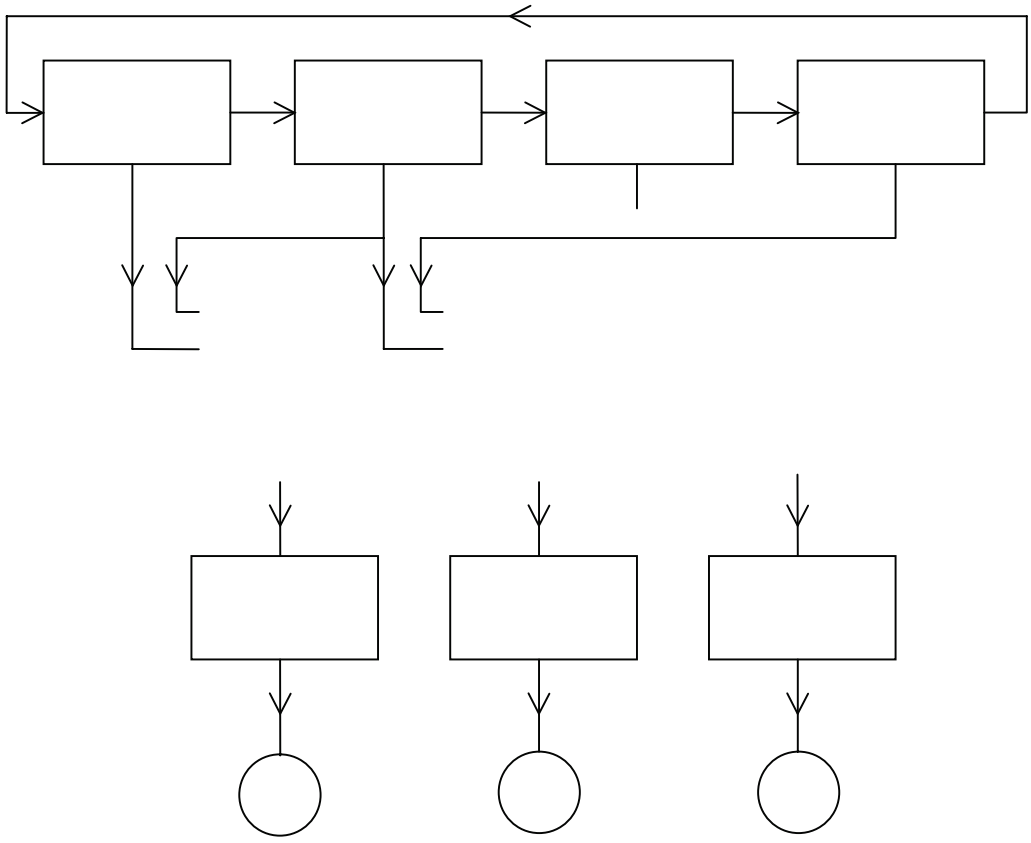
(e) When the system is first switched on, the first 555 IC monostable is triggered to provide a signal to turn on the red light for 20 s. The output from this sub-system triggers a second 555 IC monostable to turn on the amber light for 3 s and also keep the red light on during this period.

The red light driver sub-system operates when the 20 s timer or the 3 s timer is high.

At the end of the 3 s period a third 555 IC monostable is triggered for a period of 20 s to operate the green light.

A fourth 555 IC monostable is triggered at the end of this 20 s period to turn the amber light on for a further 3 s, after which the first monostable is triggered and the cycle is repeated. The amber light driver sub-system operates when either of the 3 s timers are high.

Complete the system diagram below labelling the **four** 555 timers with their respective on times; drawing in **two** logic gates; labelling **three** lamp drivers; and mark the red, amber and green lights with R, A, and G. Label each sub-system and complete the connections between them.



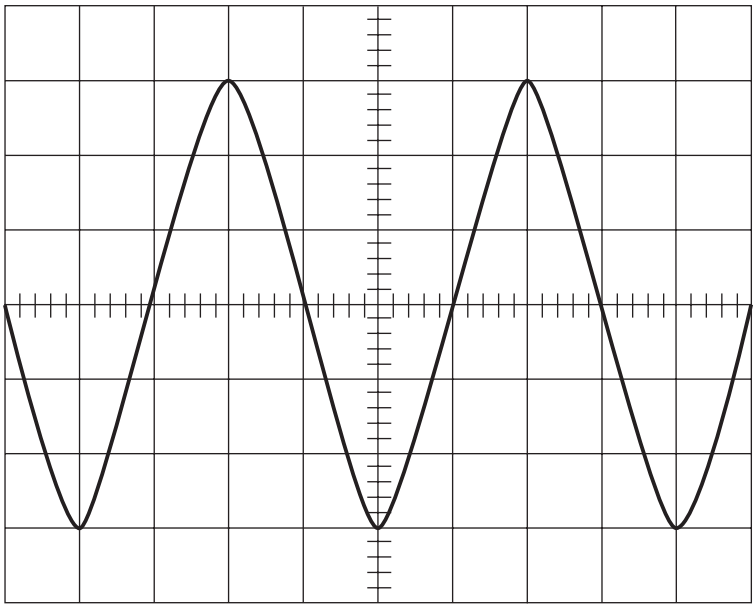
(10 marks)

30

5 A student built an audio amplifier for use with a simple radio.
He tested the amplifier's performance by connecting a signal generator to the input and an oscilloscope to the output. He obtained the following display on the screen.

Y (vertical) sensistivity is set to 2 V per division

The timebase (horizontal) is set to 0.5 ms per division



(a) (i) Calculate the peak output voltage.

.....

(ii) Calculate the time period of the signal.

.....

(iii) Calculate the frequency of the signal.

.....

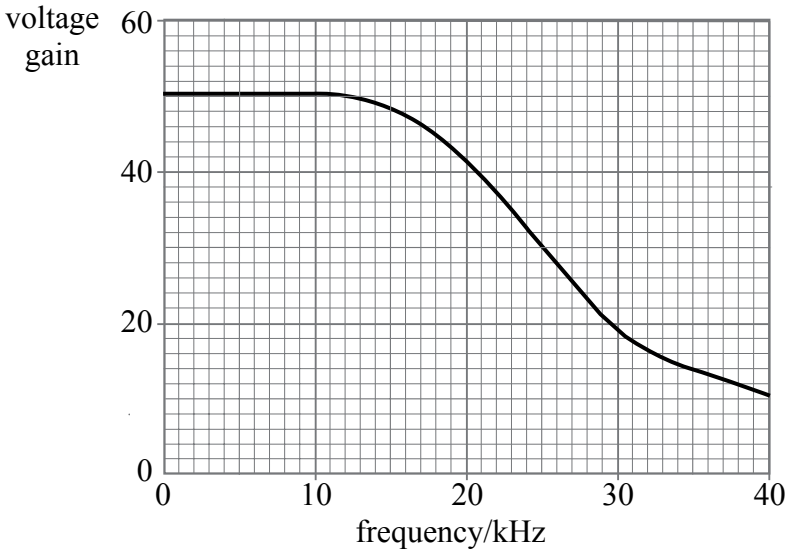
(iv) The amplifier has a voltage gain of 50. Calculate the peak input voltage supplied by the signal generator.

.....

(8 marks)

Question 5 continues on the next page

(b) The data sheet for the amplifier includes the graph below showing how the voltage gain varies with frequency.



(i) Explain what is meant by the term bandwidth when used for the amplifier.

.....

.....

.....

(ii) Use the graph above to find the maximum frequency for which a voltage gain of 30 can be obtained.

.....

(iii) Describe the effect on the performance of the amplifier as the frequency of the input signal is increased.

.....

.....

(5marks)

(c) The output voltage has a peak value of 6 V and it is connected across a loudspeaker with a resistance of 4 Ω.

(i) Calculate the rms voltage across the loudspeaker.

.....

.....

(ii) Calculate the output power.

.....

.....

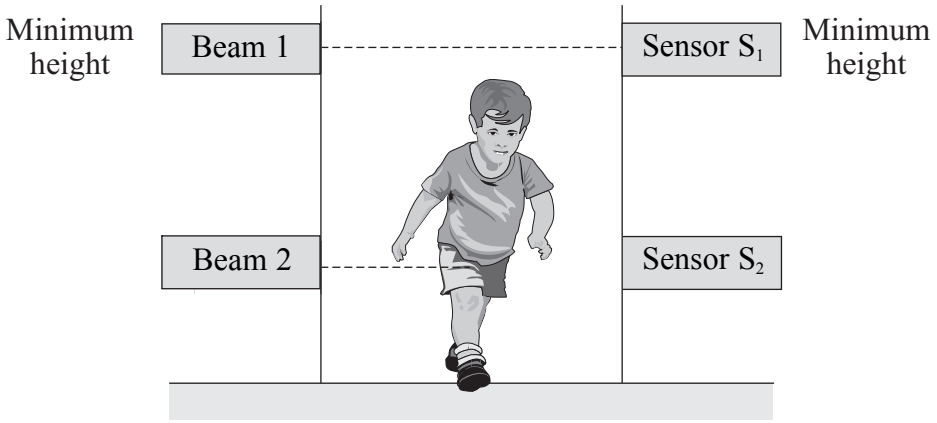
(4 marks)

17

Turn over for the next question

6 At a theme park there is a height restriction on a roller-coaster ride. A student designs a circuit which will detect a visitor who is under the minimum height.

(a) Two light beams check the height.



Each sensor gives a low output when the beam is broken. A logic system is required which gives this truth table.

S_1	S_2	output
0	0	0
0	1	0
1	0	1
1	1	0

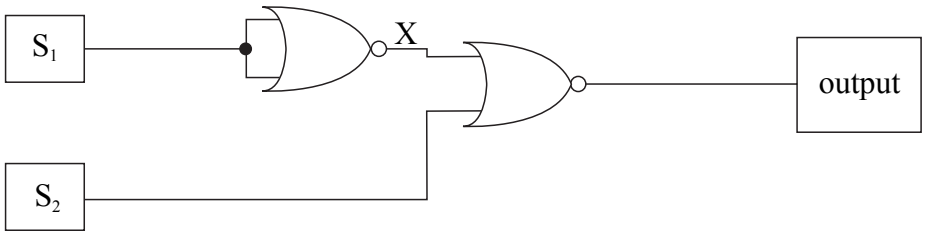
(i) Draw a diagram to show how this system could be built using only AND and NOT gates.

S_1

output

S_2

This system could also be built using only NOR gates.



(ii) Complete this truth table for the system including the logic state of the point marked X.

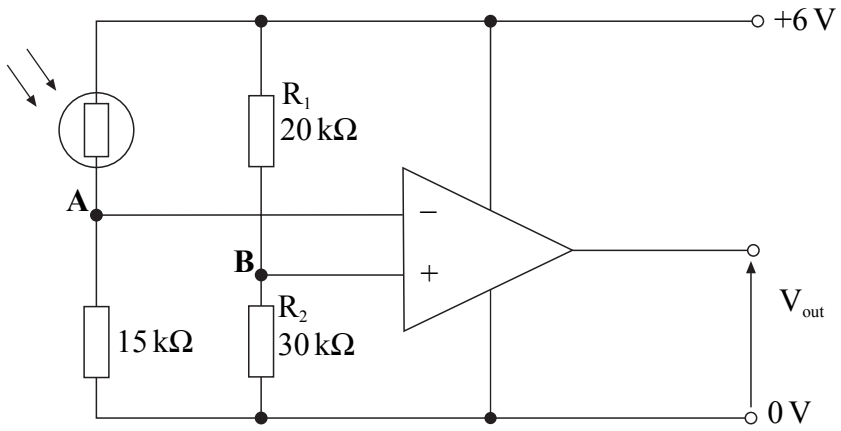
S_1	S_2	X	output
0	0		
0	1		
1	0		
1	1		

(iii) Draw a diagram showing how **three** NOR gates can be connected together to make an AND gate.

(8 marks)

Question 6 continues on the next page

(b) The circuit for one of the light beam sensors is shown below.



(i) Explain the behaviour of the op-amp in terms of its input voltages at the points **A** and **B**.

.....

.....

.....

(ii) Calculate the voltage at point **B**.

.....

.....

(iii) Calculate the resistance of the LDR when the voltage at point **A** is equal to the voltage at point **B**.

.....

.....

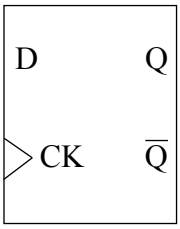
(iv) What is the approximate output voltage when the LDR is brightly lit?

.....

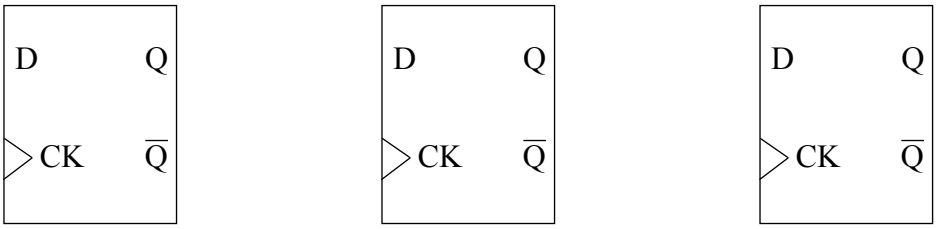
(7 marks)

(c) The maximum number of people allowed in the roller-coaster car is eight. The student adds a frequency divider to his system which gives a pulse when the car is full.

(i) Complete the diagram to show how a D-type flip-flop should be connected to make a divide by two circuit. Label the input and output.



(ii) Complete and label the diagram to show how three D-type flip-flops should be connected together to divide the input frequency by eight.



(iii) Complete this table of binary and denary (decimal) numbers.

Denary	Binary
0	0000
1	0001
2	
3	
4	
5	
6	
7	

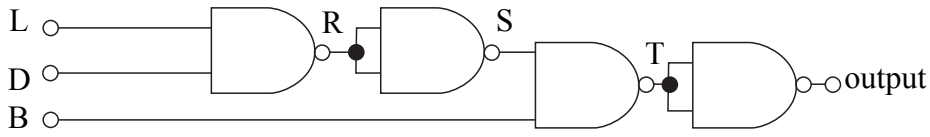
(9 marks)

Question 6 continues on the next page

(d) Before a car may leave, three separate safety sensors must give logic 1.

Load sensor L gives logic 0 if the car is overloaded.
Door sensor D gives logic 0 when the door is open.
Brake sensor B gives logic 0 if the braking system is faulty.

This arrangement of NAND gates combines these three inputs:



(i) Complete the truth table for this arrangement of NAND gates.

L	D	B	R	S	T	output
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) What does an output of logic 1 from this circuit mean?

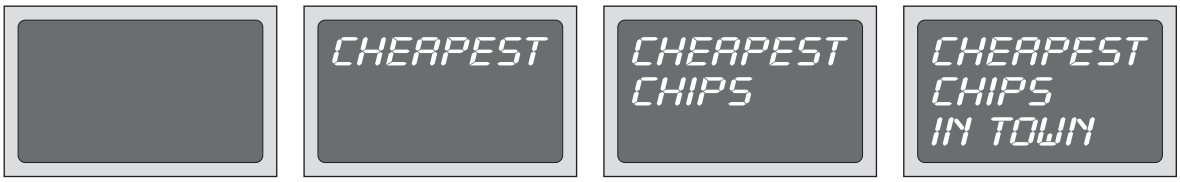
.....

(5 marks)

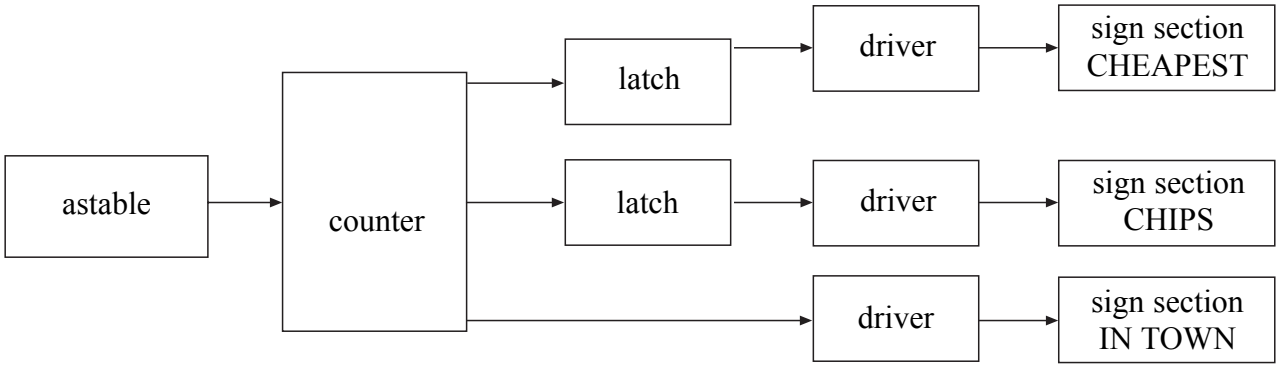
29

Turn over for the next question

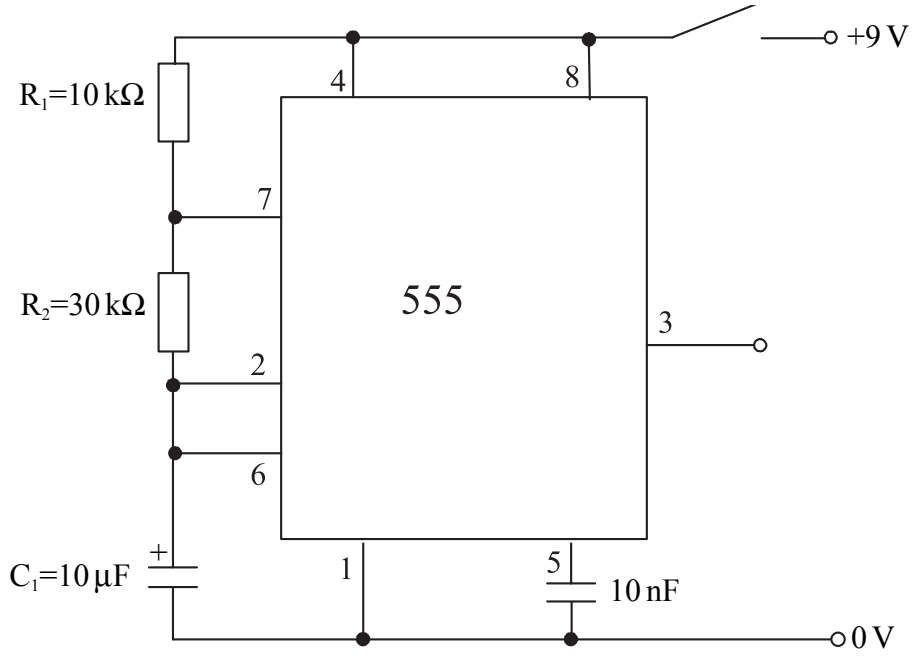
7 An advertising sign in a shop window lights up in stages to say 'Cheapest Chips in Town'.



This is the system diagram for the sign.



A 555 timer is connected as the astable.



(a) Calculate the period of the pulses produced by the astable.

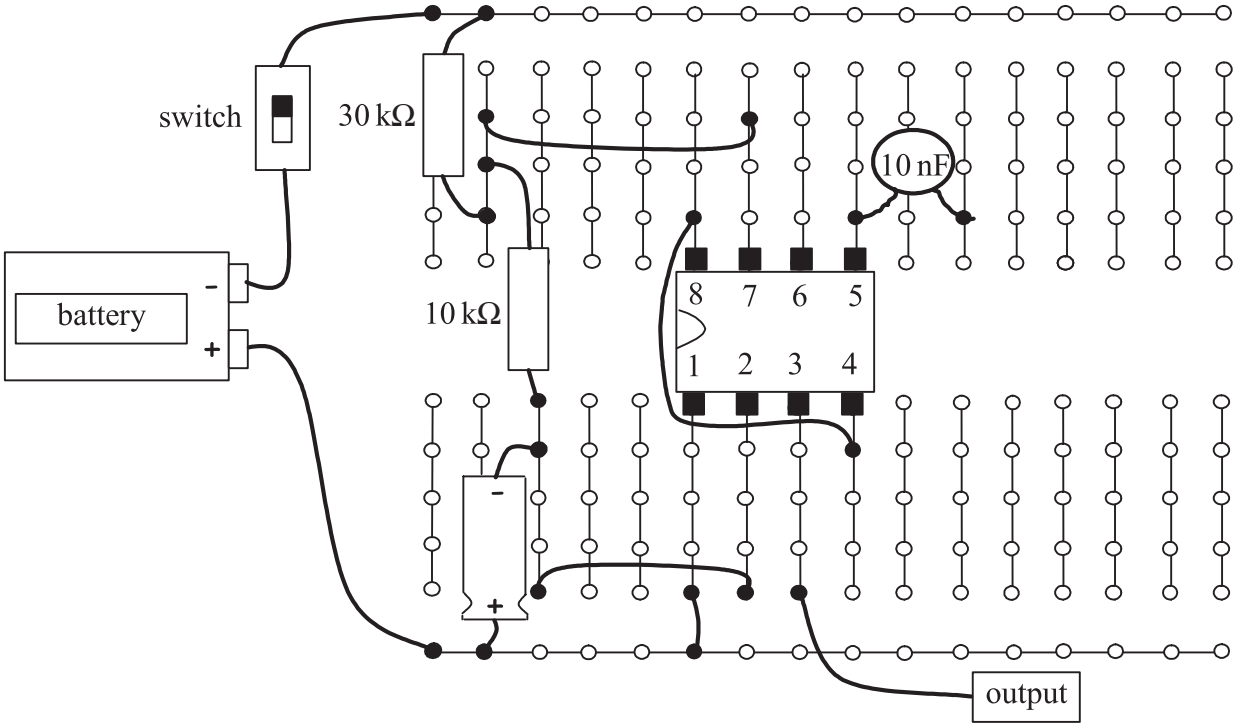
.....

.....

.....

(3 marks)

(b) A very inexperienced student builds the astable on prototyping board using the diagram on **page 20**. The pin connections are numbered for you on the diagram.



Describe **six** mistakes which should be corrected before the circuit is switched on.

(i) .....

(ii) .....

(iii) .....

(iv) .....

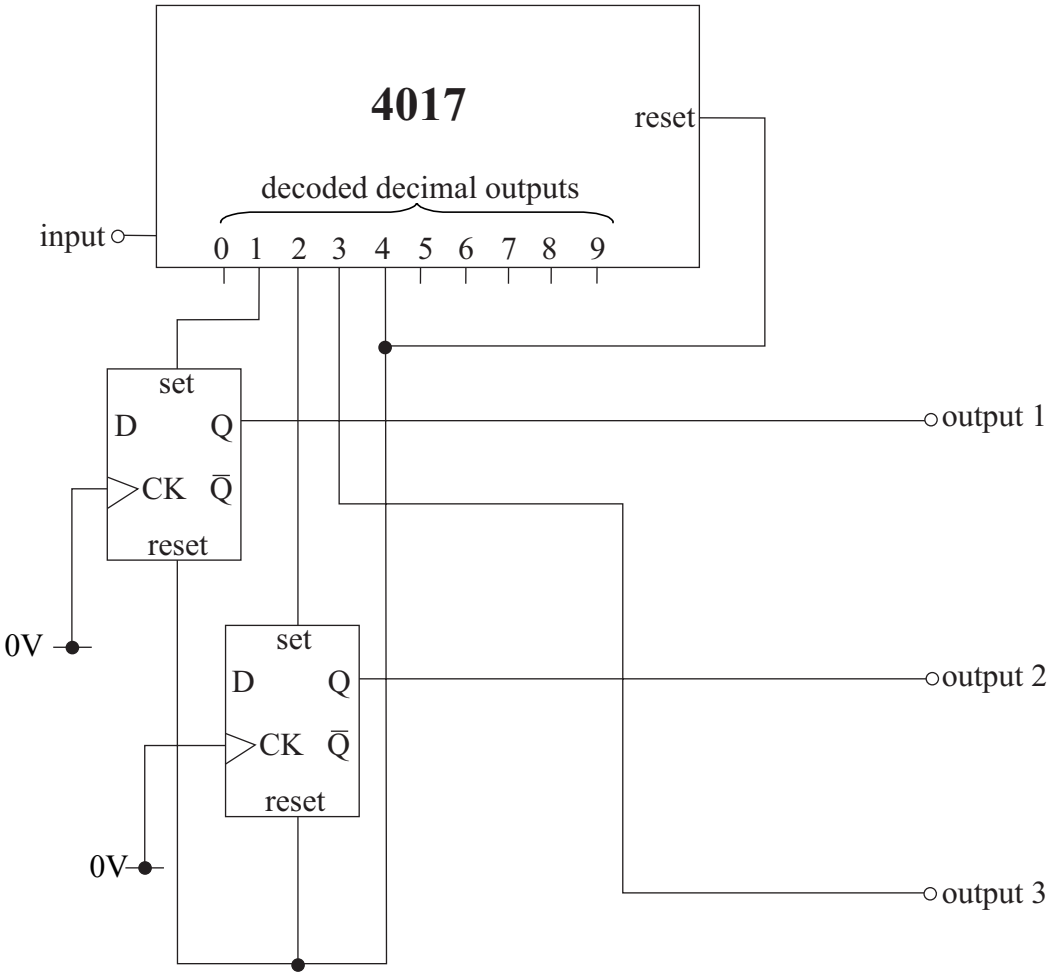
(v) .....

(vi) .....

(6 marks)

Question 7 continues on the next page

(c) The astable pulses are used as the input to this counter.



When a D-type flip-flop is connected, as in the circuit above

(i) what must happen to make its Q output go high,

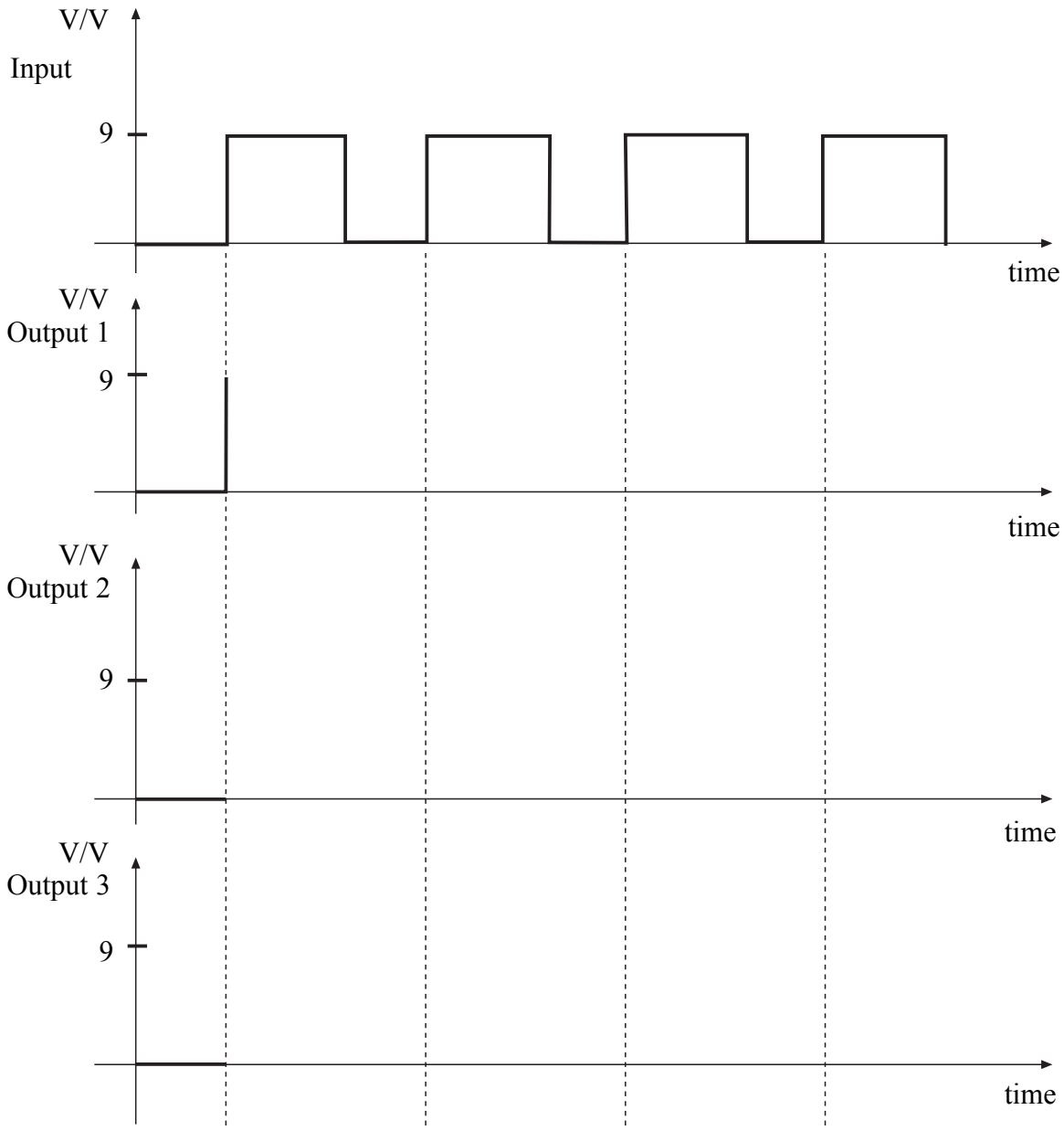
.....

(ii) what must happen to make the Q output go low again?

.....

(2 marks)

(d) Complete the timing diagram for the outputs from the flip-flop latches and counter.



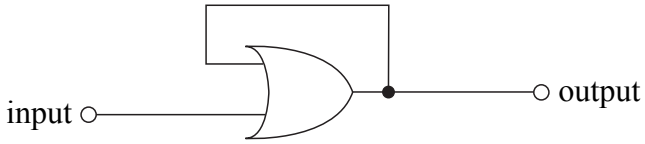
(7 marks)

Question 7 continues on the next page

The student investigated alternative latch circuits.

(e) The output of the circuit below is logic 0.

(i) Explain what happens to the output of the circuit when the input goes from low to high and then low again.



.....

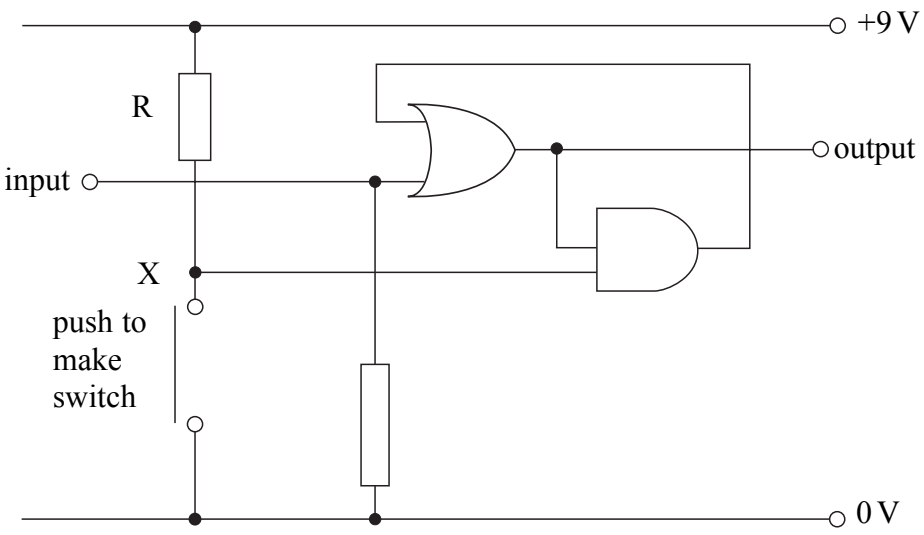
.....

(ii) Explain why this circuit is **not** suitable for use in the advertising sign system.

.....

(3 marks)

(f) Another alternative latch circuit is shown below.



(i) In the circuit above what is the voltage at X when the switch is pressed?

.....

(ii) What is the purpose of the resistor R?

.....

(iii) Initially the output of this circuit is logic 0.
Explain the operation of this circuit after the input goes high and the effect of pushing the switch.

.....

.....

.....

(5 marks)

26

END OF QUESTIONS

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