Additional Instructions for Candidates

When candidates are asked to ‘show that’:

- a candidate should calculate their own answer to three significant figures and use this subsequently.

- a candidate who is unable to determine the required value should use the value given by the examiner in subsequent questions.

For Marker Use Only

SECTION A

This section assesses **Criterion 1.**

Answer **ALL** questions in this section.

Question 1

In Australia, household mains electricity is at 240V (rms) relative to earth. Touching the mains can be lethal if resistance is low enough to allow a fatal current to pass through the body. Humans are at danger of death if more than about 50 mA of electrical current passes through the heart.

(a) Explain why insulation around a mains conductor must allow for at a voltage of 340V. (1 mark)

.....

.....

(b) Show that the **minimum** insulation for safe operation is approximately 7 000Ω. [Of course, a much greater margin of safety would be required.] (1 mark)

.....

.....

(c) Electricians use fibreglass ladders rather than aluminium ones. Explain why. (1 mark)

.....

.....

Two protective devices used in the mains (240V) system are the residual current device (rcd) and the fuse. The rcd is designed to protect humans from electric shock or electrocution. A fuse protects an appliance, or wiring in general, against excess current.

(d) Describe in general terms how the rcd works. (2 marks)

.....

.....

.....

.....

(e) Why is a mains fuse unlikely to provide personal protection? (1 mark)

.....

.....

/6

Question 2

For Marker Use Only

(a) Two types of resistor in common use are: carbon film and wire-wound. Wire wound resistors are a wire wound in a spiral on an insulating core.

(i) When would a wire-wound resistor be preferable? (1 mark)

.....

.....

(ii) At high frequencies, a simple wire-wound resistor may have undesirable side effects. Explain why and give a possible solution. (2 marks)

.....

.....

.....

.....

(b) Two types of capacitor are ceramic and tantalum. In what circumstances would each be suitable? (2 marks)

.....

.....

.....

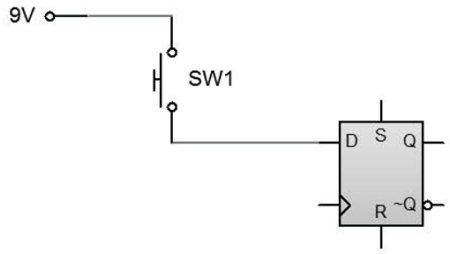
.....

/5

Question 3

For Marker Use Only

In a counting circuit, a push-button switch was used to input data. Assume S and R inputs are grounded and a suitable input is provided to the clock input.



However, the circuit did not function correctly, giving many 'false' counts.

(a) State **two** possible faults in the circuit causing it to not function correctly. (2 marks)

Reason 1: .....

.....

.....

Reason 2: .....

.....

.....

(b) Sketch a circuit that will overcome both faults identified in part (a), if you can. Otherwise, sketch a circuit overcoming a single fault. Explain how your circuit overcomes the fault(s). (3 marks)

.....

.....

.....

.....

.....

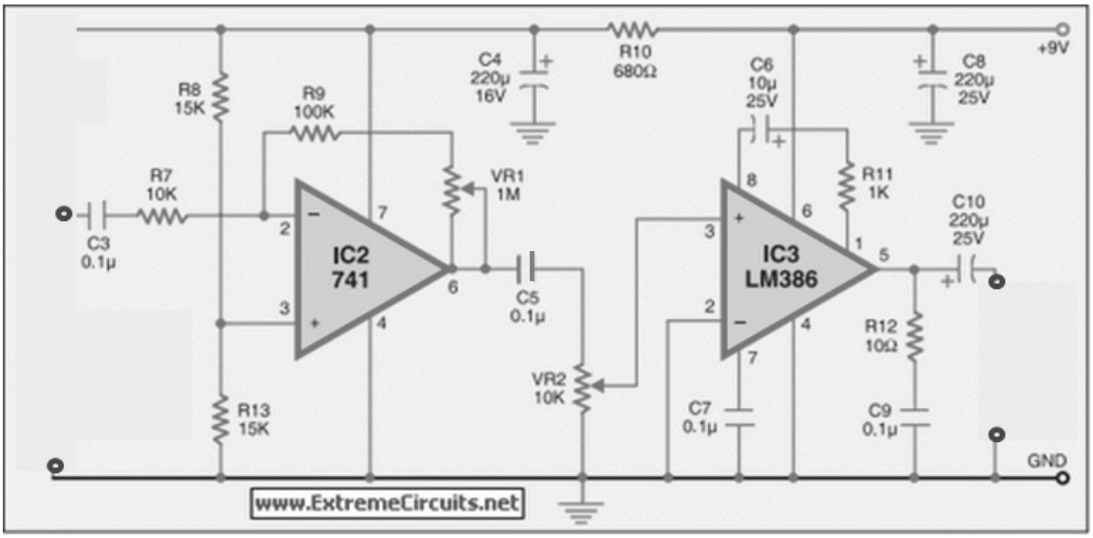
.....

/5

Question 4

For Marker Use Only

The audio amplifier represented below was constructed on a PCB and is being tested.



The following range of test equipment is available:

Microphone, signal generator, music player (e.g. iPod), oscilloscope (CRO), speaker, multimeter, logic probe

(a) The first part of testing involves passing a signal through the circuit and examining the output signal. Student 1 proposes testing the circuit using an iPod, a microphone and a speaker. Student 2 proposes testing the circuit using a signal generator, an oscilloscope and a multimeter. Which method is better? Justify your choice. (3 marks)

.....

.....

.....

.....

.....

.....

.....

Question 4 continues.

For Marker Use Only

(b) No signal is found at the output when a signal is input. The student now decides to test PCB tracks, solder joints and voltage levels. Outline five steps (in order) that the student should follow to identify and overcome any fault. (5 marks)

(i) .....

.....

(ii) .....

.....

(iii) .....

.....

(iv) .....

.....

(v) .....

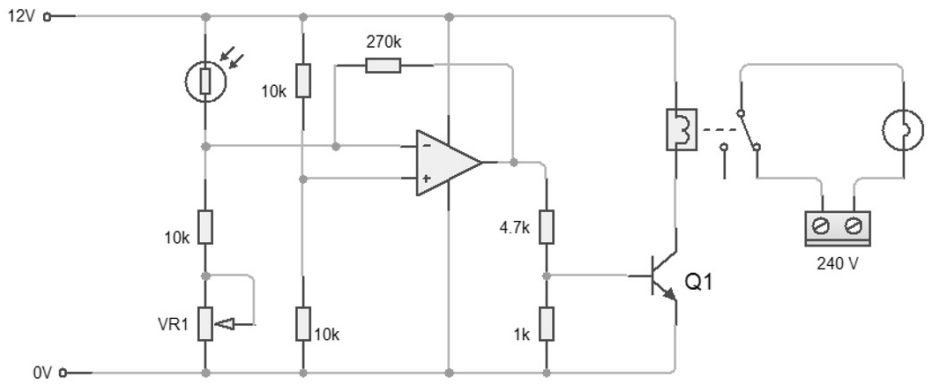
.....

/8

Question 5

For Marker Use Only

Below is a circuit diagram for a light-activated switch.



Back emf has the potential to damage one of the components in the above circuit.

(a) Which component is most at risk? (1 mark)

.....

.....

(b) Describe the effect of back emf. (2 marks)

.....

.....

.....

.....

(c) Place a diode in the above circuit to reduce the risk of damage. (1 mark)

(d) Explain how the diode reduces the risk. (2 marks)

.....

.....

.....

.....

/6

Question 6

For Marker Use Only

This question is comparing two families of digital IC, CMOS and TTL.

(a) Put a cross (X) under the better choice for each characteristic. (3 marks)

	Characteristic	CMOS	TTL
1	Higher input impedance		
2	Lower output impedance		
3	Higher “fan out”		
4	More sensitive to static damage		
5	Wider supply voltage accepted		
6	Lower power requirements		
7	Higher switching speeds		

(b) For your answer to characteristic 4, give two procedures to reduce the risk of static damage to the chip. (2 marks)

.....

.....

.....

.....

(c) Characteristic 1 implies that, in a circuit, unused inputs must be tied HIGH or LOW. Explain why. (2 marks)

.....

.....

.....

.....

(d) A digital circuit that uses a small capacity battery as a power source is to be designed. Which IC family should be used in the design? What are two advantages and two limitations of your choice? (3 marks)

.....

.....

.....

.....

.....

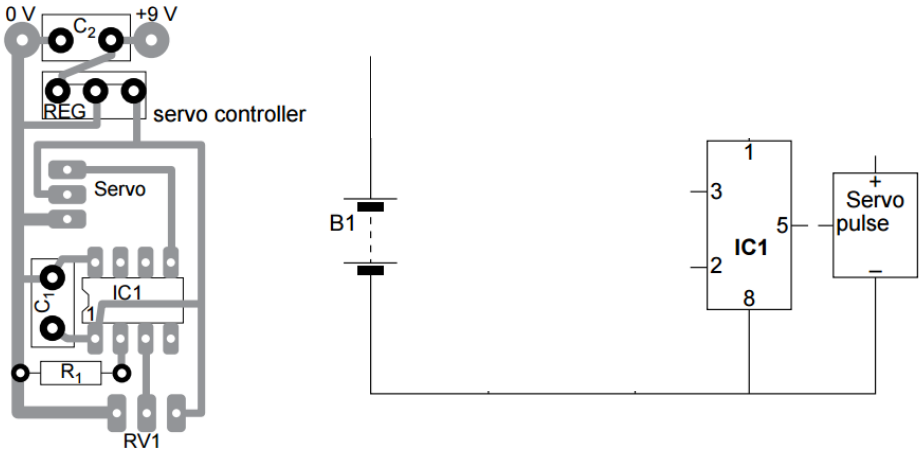
.....

/7

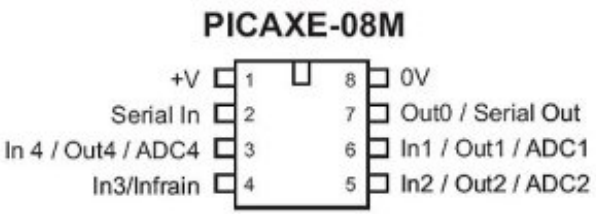
Question 7

For Marker Use Only

The diagram shows the printed circuit board design of a Servo Motor Controller. The circuit is design to send controlled pulses to the Servo Motor. The parts list is shown in the table.



Part number	Description
R_1	10 k ohm 0.25W resistor
C_1	100 nF polyester capacitor
C_2	470 nF polyester capacitor
RV1	10 k linear potentiometer
REG1	7805 regulator
IC1	PICAXE 08M microcontroller
SERVO	mini servo motor
B1	9 V battery



(a) Using the PCB design as a guide, complete the circuit diagram. (3 marks)

(b) What is the main function of the component REG1 and what voltage is being fed from it to the microcontroller (IC1)? (1 mark)

.....

.....

(c) With RV1 in the halfway position, what voltage would you measure at pin 3 on IC1? (1 mark)

.....

.....

Question 7 continues.

Question 7 (continued)

For Marker Use Only

(d) Discuss the merits of using a microcontroller in this circuit in preference to a switching circuit based on transistors and logic gates. (3 marks)

.....

.....

.....

.....

.....

.....

/8

BLANK PAGE

For Marker Use Only

SECTION B

This section assesses **Criterion 4.**

Answer **ALL** questions in this section.

Question 8

(a) Complete this table of capacitor values. (2 marks)

pF Code	nF	µF
155		
	39	
		0.47
	2n2	

(b) In the process of designing a circuit, a student obtained the following **calculated** resistor values. Determine the closest E12 value and then give its colour code.
(2 marks)

Resistor Value	Closest E12 Value	Colour code of E12 resistor
71R		
365 000 Ω		

/4

Question 9

For Marker Use Only

The operational amplifier (op-amp) is a versatile, widely-used amplifier.

(a) An **ideal** op-amp has certain characteristics which should either be **zero** or **infinite**. In the appropriate column indicate either **zero** or **infinite**. (2 marks)

Characteristic	Zero	Infinite
Open loop gain		
Output impedance		
Input impedance		
Bandwidth		

Negative feedback reduces the gain of an amplifier, yet negative feedback is used in most practical amplifiers.

(b) Give **two** advantages of negative feedback. (2 marks)

(i) .....

.....

.....

(ii) .....

.....

.....

Question 9 continues.

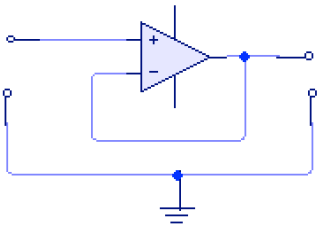
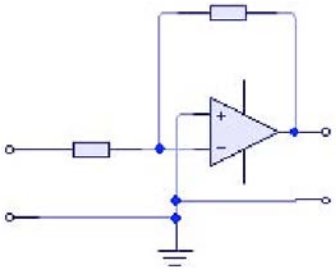
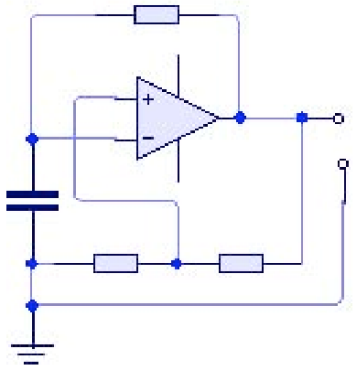
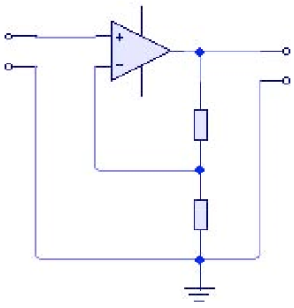
Question 9 (continued)

For Marker Use Only

(c) Below are four circuits based on op-amps. For each circuit: (4 marks)

(i) Give the usual name for the configuration.

(ii) State the features of the configuration that allowed you to identify it.

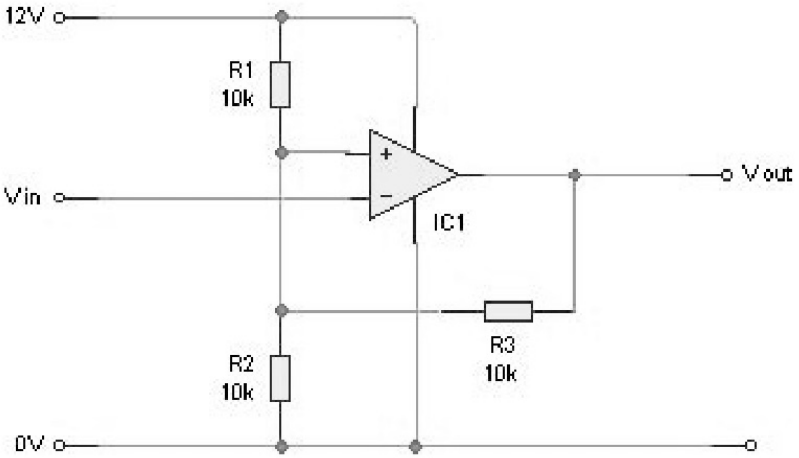
	1.	2.
		
i		
ii		
	3.	**4.**
		
i		
ii		

/8

Question 10

For Marker Use Only

The output of a simple comparator will switch from LOW to HIGH (and vice-versa) very quickly as the input changes. One problem is that small input fluctuations can cause the output to switch states repeatedly. *Hysteresis* is a useful attribute to minimise this problem.



(a) Explain how *hysteresis* functions in a comparator circuit. An appropriate voltage graph must be included as part of your answer. Show the lower and upper thresholds clearly. (3 marks)

.....

.....

.....

.....

.....

.....

(b) In the above circuit, which component causes the hysteresis? (1 mark)

.....

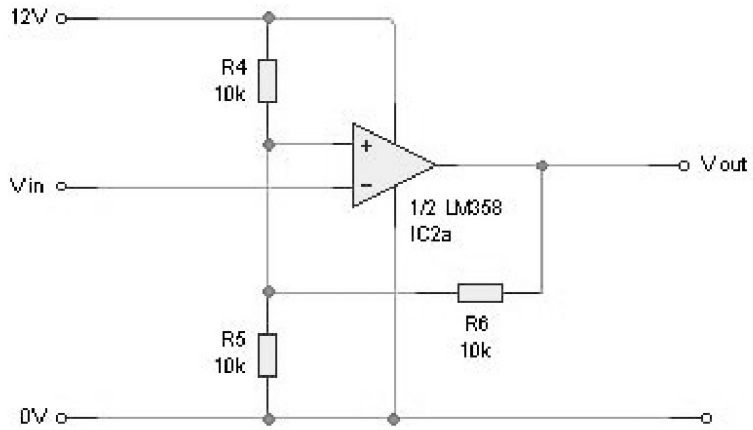
.....

Question 10 continues.

Question 10 (continued)

For Marker Use Only

The LM358 is a useful comparator. In the circuit shown, its output will be either 0V or 12V depending on the value of V_{in}.



(c) What does the ½ indicate in the ½ LM358? (1 mark)

.....

.....

In the above circuit, the upper and lower thresholds are 8V and 4V.

(d) By referring to the circuit, explain why the thresholds have these values (8V & 4V). (2 marks)

.....

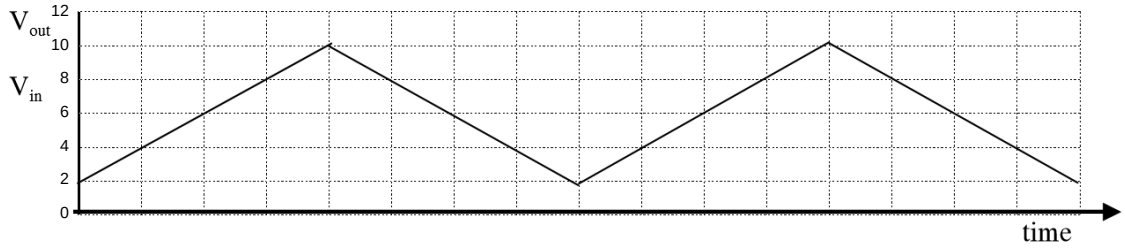
.....

.....

.....

A triangular wave is fed into the above circuit. V_{in} varies from 2V and 10V as shown below.

(e) On the same axes, show the output (V_{out}) you would expect to see on an oscilloscope. (2 marks)



/9

Question 11

For Marker Use Only

(a) What are **two** significant differences between a **passive** filter and an **active** filter? (2 marks)

(i) .....

.....

.....

(ii) .....

.....

.....

(b) Sketch a circuit diagram for a simple low-pass active filter. (3 marks)

A low-pass filter with a cut-off frequency of 150 Hz has an input signal of 2.0V and variable frequency. At low frequencies, the voltage gain is 1 and 750 mW of power is delivered from the filter.

(c) Sketch a V_{out} ~ frequency graph for this filter showing all relevant features. (2 marks)

Question 11 continues.

Question 11 (continued)

For Marker Use Only

(d) At the cut-off frequency, what is:

(i) The output voltage? (1 mark)

.....

.....

(ii) The output power? (1 mark)

.....

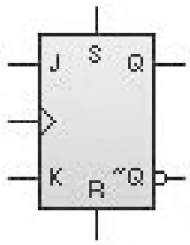
.....

/9

Question 12

For Marker Use Only

(a) A block diagram for a JK flip-flop and its logic table are given.



J	K	CLK	Q
0	0	↑	No change
1	0	↑	1
0	1	↑	0
1	1	↑	Toggles
0 or 1	0 or 1	↓	No change

(i) Explain the difference between *synchronous* and *asynchronous* inputs. (2 marks)

.....

.....

.....

.....

(ii) Which pair J, K or S, R is asynchronous? (1 mark)

.....

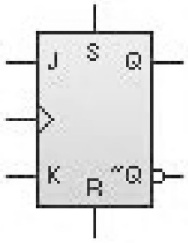
.....

(iii) By referring to the table above, explain the mode of operation of this input: (1 mark)

.....

.....

(b) Show how to connect all the input pins of a JK flip-flop to convert it into a reliable T-type flip-flop and label the inputs. (2 marks)



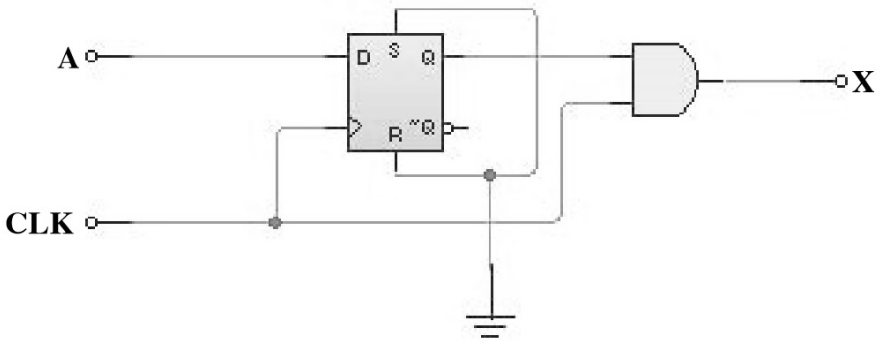
Question 12 continues.

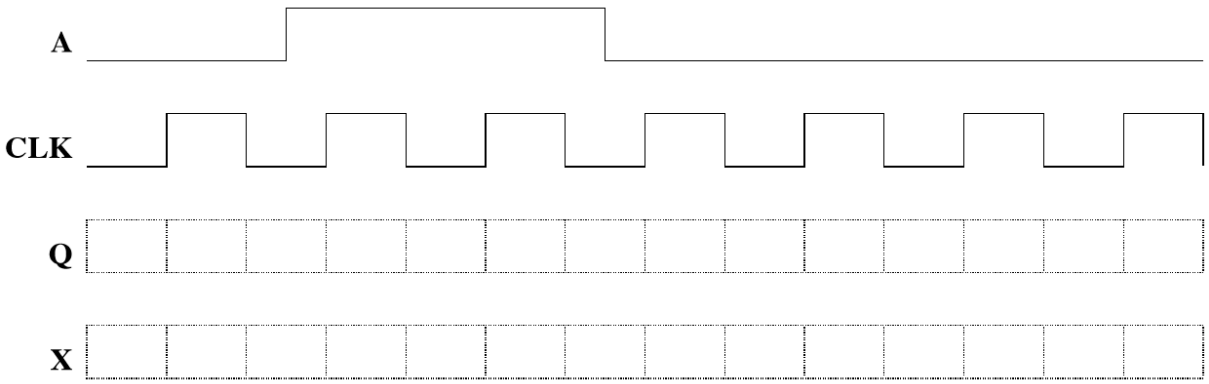
Question 12 (continued)

For Marker Use Only

(c) The circuit below uses a D-type flip-flop to synchronise a debounced switch with clock pulses. The signal from the switch is shown as **A** on the diagram.

Complete the timing diagram for the **Q** and **X** outputs. (2 marks)



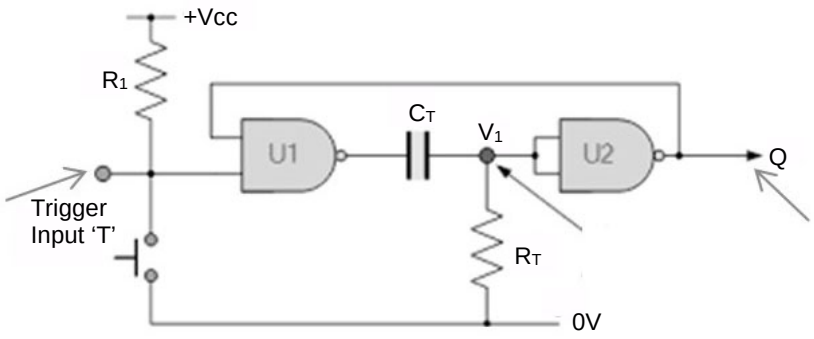


/8

Question 13

For Marker Use Only

This is a circuit diagram for a monostable multivibrator (sometimes called a 'one-shot').



(a) (i) What are the components U1 and U2? (1 mark)

.....

.....

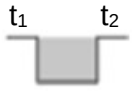
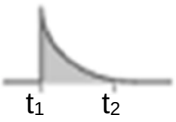
(ii) How would U1 and U2 usually be packaged? (1 mark)

.....

.....

(b) On the table below, match the graphs to show how the voltage changes with time at the following points on the diagram. (3 marks)

(i) Trigger input
(ii) V_1
(iii) Q

I	II	III
		

(c) Describe how you could determine the time for which the one-shot is active. No actual calculations are required. (2 marks)

.....

.....

.....

.....

/7

BLANK PAGE