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	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2011

Electronics ELEC4

Unit 4 Programmable Control Systems

Wednesday 8 June 2011 9.00 am to 10.30 am

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

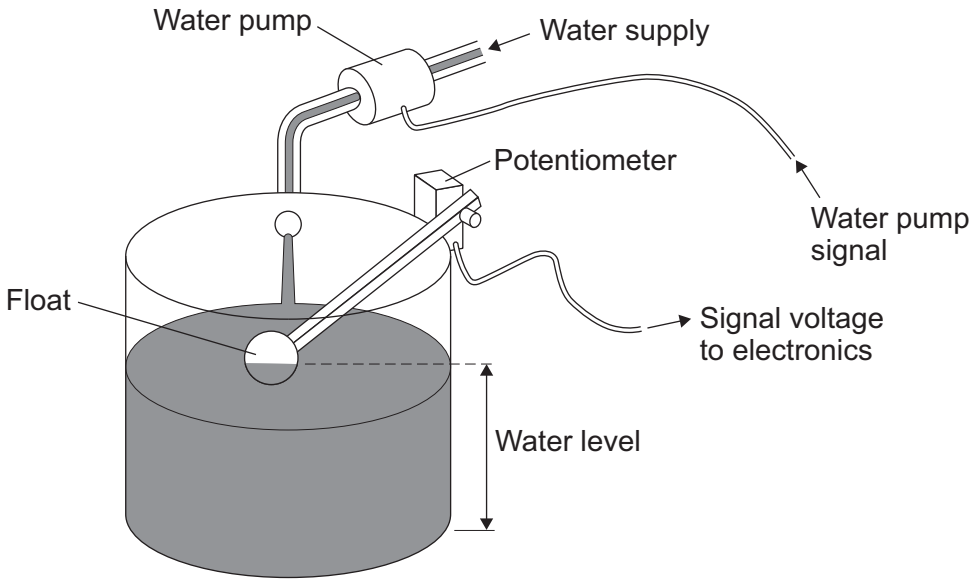
Time allowed
- 1 hour 30 minutes

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 book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

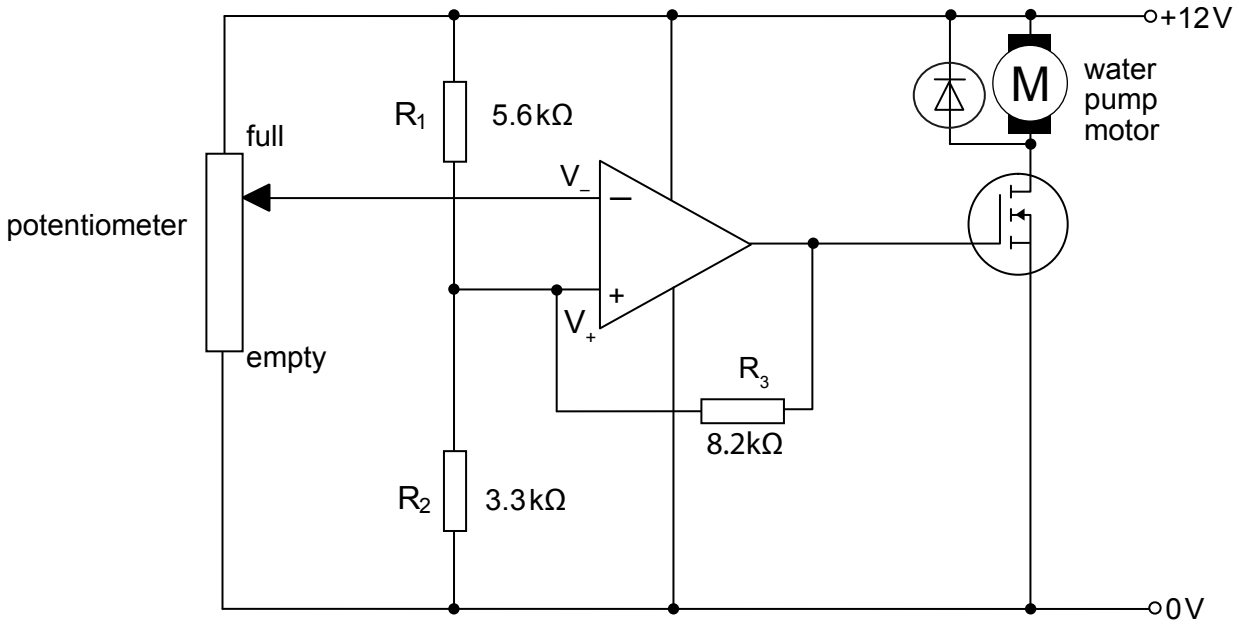
Answer **all** questions in the spaces provided.

1 The diagram shows the system for maintaining water in a tank at a preset level.



The water level is monitored by a float attached to a potentiometer, so that as the water level rises the voltage from the potentiometer increases.

The diagram below shows the control electronics for the system.



1 (a) What is this type of op-amp circuit called?

.....

(1 mark)

1 (b) What type of feedback has been applied to the op-amp?

.....

(1 mark)

1 (c) Assume that the tank is empty, so that the op-amp output is at +12 V and the water pump is on. By describing how the voltages at the op-amp's inputs, V_+ and V_-, change, explain what happens as the water level rises and reaches the preset level.

.....

.....

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.....

.....

(4 marks)

1 (d) Calculate the voltage on the V_- input at which the pump switches off.

.....

.....

.....

(3 marks)

1 (e) Calculate the voltage on the V_- input at which the pump switches back on.

.....

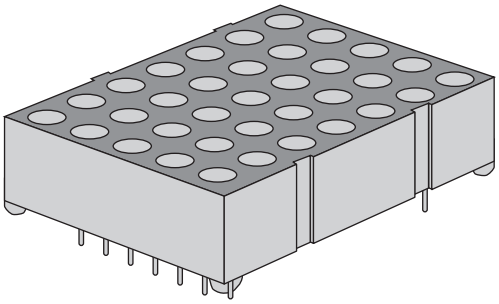
.....

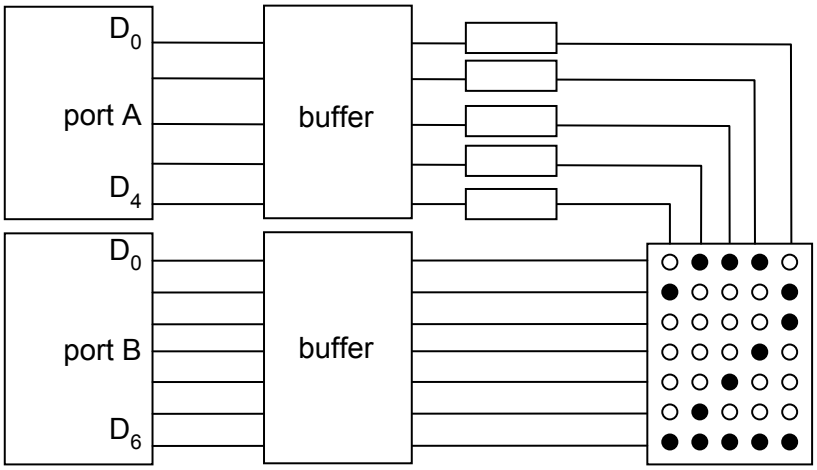
(2 marks)

11

Turn over for the next question

2 A microcontroller is being used as a multiplexer to drive a 5×7 dot matrix display. When a column is made positive and a row is at 0 V, the corresponding LED is lit. Port A (bits 0–4) of the microcontroller is connected to the columns, and port B (bits 0–6) is connected to the rows.





2 (a) State the main advantage of having the LEDs mulitplexed rather than having each LED connected separately.

.....

(1 mark)

2 (b) State the purpose of the resistors in the circuit.

.....

(1 mark)

2 (c) Complete the following table to show the sequence of data which should be repeatedly sent to the ports to display the number '2', as shown.

step	port A	port B
1	00010000	10111101
2		
3		
4		
5		

(4 marks)

2 (d) The buffer outputs are 5.0 V for a high level and 0 V for a low level, respectively. Each LED has a forward voltage of 2.0 V at a normal current of 20 mA.

2 (d) (i) Calculate the value of resistor needed to give a current of 20 mA through an LED when lit.

.....

.....

.....

(2 marks)

2 (d) (ii) When this value of resistor is used the multiplexed display is too dim. State why this is so and calculate a more suitable value of resistor.

.....

.....

.....

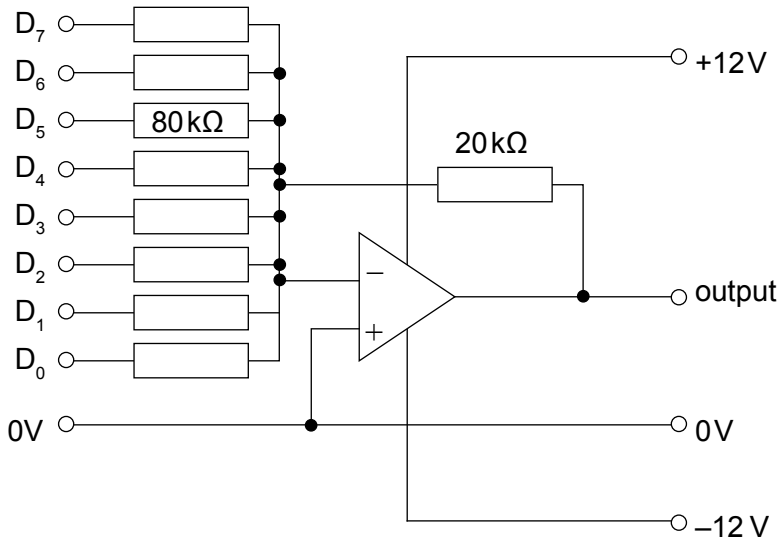
.....

(3 marks)

11

Turn over for the next question

3 Part of the circuit diagram for a DAC is shown below.



3 (a) What is the mode of operation of the op-amp in this circuit?

.....

(1 mark)

3 (b) Calculate the values for the resistors for the D_6 and D_1 inputs.

.....

.....

(2 marks)

3 (c) If a logic 1 input to the DAC is +5 V and a logic 0 is 0 V, calculate the output voltage from the DAC when D_5 is logic 1 and all of the other inputs are logic 0.

.....

.....

.....

(2 marks)

3 (d) Port A of a microcontroller operating with a 1 MHz clock provides the input to the DAC. The microcontroller runs the assembler code shown below.

```
MOVW 0x00
MOVWR TRISA
MOVWR PORTA
loop1:
INC PORTA
JPZ loop1
```

What do the following statements do.

3 (d) (i) MOVWR TRISA ……..... *(1 mark)*

3 (d) (ii) INC PORTA ..... *(1 mark)*

3 (e) In the code above calculate how long it takes to complete one loop.

.....

..... *(1 mark)*

3 (f) Calculate the period of the output signal of the DAC.

.....

.....

.....

..... *(2 marks)*

Question 3 continues on the following page

3 (g) On the axes below sketch the shape of the waveform that will be produced from the DAC.

(2 marks)

12

Turn over for the next question

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4 (a) Two conventional motors are used to move a robot buggy.
State **one** advantage and **one** disadvantage of using conventional motors for this purpose compared to stepper motors.

Advantage .....

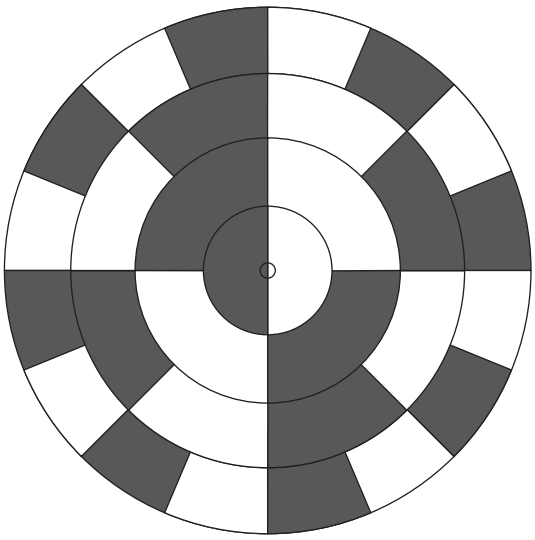
.....

Disadvantage .....

.....

(2 marks)

To monitor how far it has travelled and its position, a binary coded optical disc is fitted to each wheel. One of the optical discs is shown below.



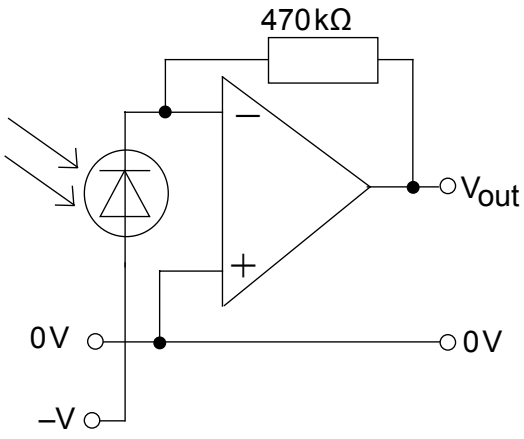
4 (b) Calculate the angular resolution of this disc.

.....

.....

(2 marks)

4 (c) Light passing through the optical disc is detected by photodiodes. Part of the photodiode circuit is shown below.



When the photo diode is illuminated the current passing through it is 10 µA and when it is in the dark the current is zero.

4 (c) (i) Mark clearly on the diagram in part (c) the direction of the current flow through the photo diode when it is illuminated. *(1 mark)*

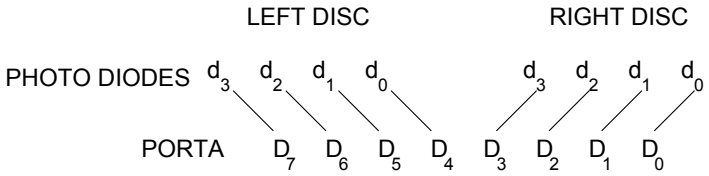
4 (c) (ii) Calculate the output voltage, V_{out}, when the photo diode is illuminated.

.....

.....

(2 marks)

4 (d) The outputs from the photodiode circuits from each optical disc are connected to port A of the microcontroller, as shown in the diagram below.



Write the assembler instructions for the microcontroller to read the data from the optical discs into the working register and then isolate the data from just the left optical disc.

.....

.....

.....

(3 marks)

Turn over ▸

4 (e) When the data from one optical disc changes from a binary output of 1111 to 0000, the microcontroller reads instantaneous values of 1101, 1001, 1000 during the change.

4 (e) (i) Suggest a reason for this.

.....

.....

(1 mark)

4 (e) (ii) Explain why a Gray coded optical disc eliminates this problem.

.....

.....

(1 mark)

12

5 Below is a list of terms associated with microcontrollers.
Explain the meaning of each term.

5 (a) (i) Register .....

.....

(1 mark)

5 (a) (ii) Flag .....

.....

(1 mark)

5 (a) (iii) Program Counter .....

.....

(1 mark)

5 (b) (i) Working Register .....

.....

(1 mark)

5 (b) (ii) Stack .....

.....

(1 mark)

5 (b) (iii) Clock .....

.....

(1 mark)

5 (c) TRISA .....

.....

(1 mark)

5 (d) (i) RISC .....

.....

(1 mark)

5 (d) (ii) Harvard architecture .....

.....

(1 mark)

5 (e) (i) Interrupt .....

.....

(1 mark)

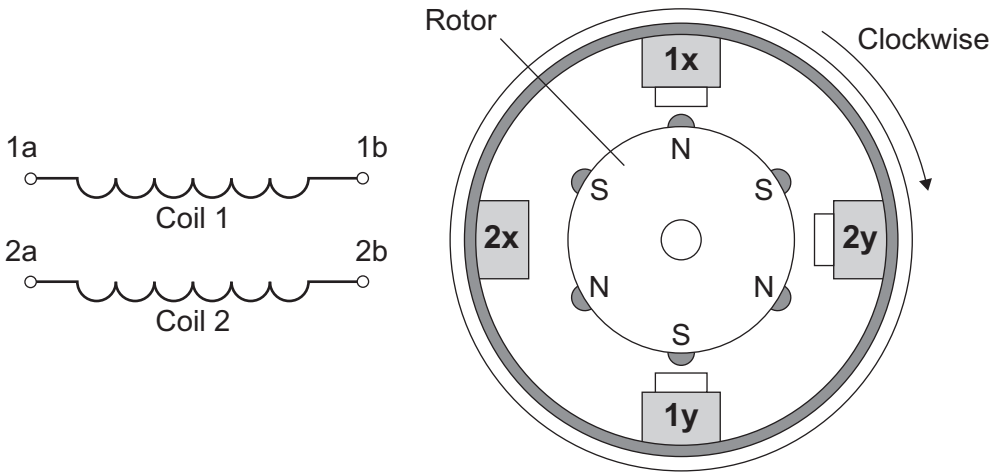
5 (e) (ii) Subroutine.....

.....

(1 mark)

11

6 The diagram below represents a bipolar stepper motor.



The table below shows the relationship between the current flow through the coils and the magnetic fields created. For example, in the first row, if current passes from terminal a to terminal b in coil 1, then the electromagnet 1x becomes South and electromagnet 1y becomes North.

Coils		**Electromagnets**	
1a +	1b –	1x: S	1y: N
1a –	1b +	1x: N	1y: S
2a +	2b –	2x: S	2y: N
2a –	2b +	2x: N	2y: S

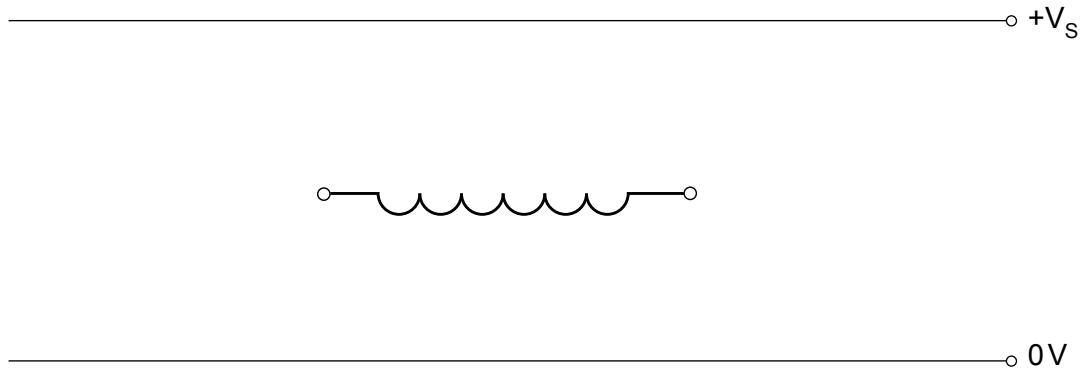
6 (a) Complete the table below, indicating the current flow through each coil, in order to make the rotor turn clockwise, starting with the conditions given in which no current passes in coil 2 and current passes from terminal a to terminal b in coil 1.
The first line has been completed for you.

COIL 1		COIL 2	
1a	1b	2a	2b
+	–	0	0

(4 marks)

6 (b) In order to control a bipolar stepper motor, an H-bridge circuit is needed to operate each coil. Draw the circuit diagram for an H-bridge circuit, using two p-channel MOSFETs and two n-channel MOSFETs and any other components you need, which could be used to control one of the coils.

Show where the coil is connected and the inputs to your circuit.



(6 marks)

6 (c) When writing the control program for an H-bridge, state **one** safety precaution that should be taken.

.....

.....

(1 mark)

11

Turn over for the next question

7 (a) Give a reason why a robotic system needs sensors.

.....

.....

(1 mark)

7 (b) Sensors can be

- active (generate a voltage or current) or
- passive (give a change of resistance).

They can also be

- analogue (give a wide range of output values) or
- digital (only give two different outputs).

Complete the table below giving **one** example of each type.

	Active	**Passive**
Analogue		
Digital		

(4 marks)

7 (c) Robotic systems can be controlled by either a conventional computer system or an Artificial Neural Network. Give one example of a robotic system that is better controlled by a computer system and one that is better controlled by an ANN. Explain your choice for each.

Conventional PC .....

.....

.....

.....

ANN .....

.....

.....

.....

(4 marks)

7 (d) Using the headings below explain how an ANN differs from a conventional computer.

Processors .....

.....

.....

Memory .....

.....

.....

Programming .....

.....

.....

(3 marks)

12

END OF QUESTIONS

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