ELECTRICAL TECHNOLOGY: DIGITAL

Time: 3 hours   200 marks

**PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY**

1.   This question paper consists of 10 pages, a Formula Sheet (i) and an Answer Sheet (i–ii) for questions 3 and 4. Please check that your question paper is complete.

2.   Answer ALL the questions.

3.   Read the questions carefully.

4.   Please start each question on a new page in your Answer Book.

5.   Do not write in the margin.

6.   Number your answers exactly as the questions are numbered in the paper.

7.   You may use a non-programmable calculator.

8.   Use the attached Formula Sheet.

9.   ALL formulae and workings must be shown.

10.   Round off your final numerical answers to a MINIMUM of TWO decimal places.

11.   Write neatly and legibly.

QUESTION 1   SAFETY

1.1   Define operational equipment as contained in the OHS Act No. 85 of 1993.   (2)

1.2   What is the purpose of the Occupational Health and Safety Act? State TWO.   (2)

1.3   Each employer has duties to the employee in the workplace. State TWO duties of the employer to the employee.   (2)

1.4   Write down TWO general responsibilities of the employee in the workplace.   (2)

1.5   State TWO functions of the occupational safety representative in the Electrical Technology centre.   (2)

[10]

QUESTION 2   SEMICONDUCTORS

2.1   FIGURE 1 shows the top view of a 741-operational amplifier. Study the figure and then identify the indicated terminals of the logic chip. Write down only your answer next to the applicable number in your answer book.
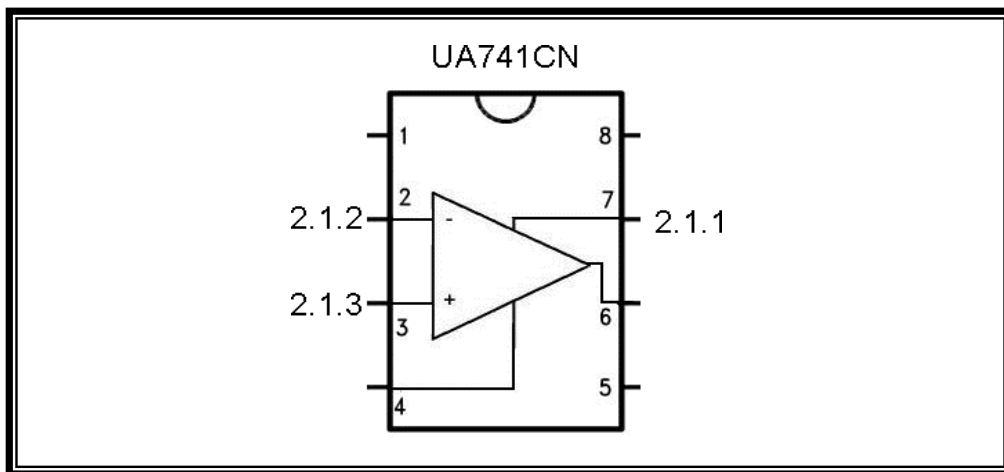
FIGURE 1

(3)

2.2   Discuss the most important difference in use between terminal 2 and terminal 3 of the 741-operational amplifier.   (2)

2.3   A 741-operational amplifier is used as a non-inverting amplifier to supply an output voltage of 8,5 V_{AC}. The value of the input resistance to the amplifier is 180 Ω.

Determine the value of the feedback resistance in the amplifier if the input voltage of the circuit is 10 mV.   (3)

2.4   The IEC symbol of a 555-timer is shown in FIGURE 2. Study the figure and then provide the labels of the indicated terminals of the component by writing down only your answer next to the relevant number in your answer book.
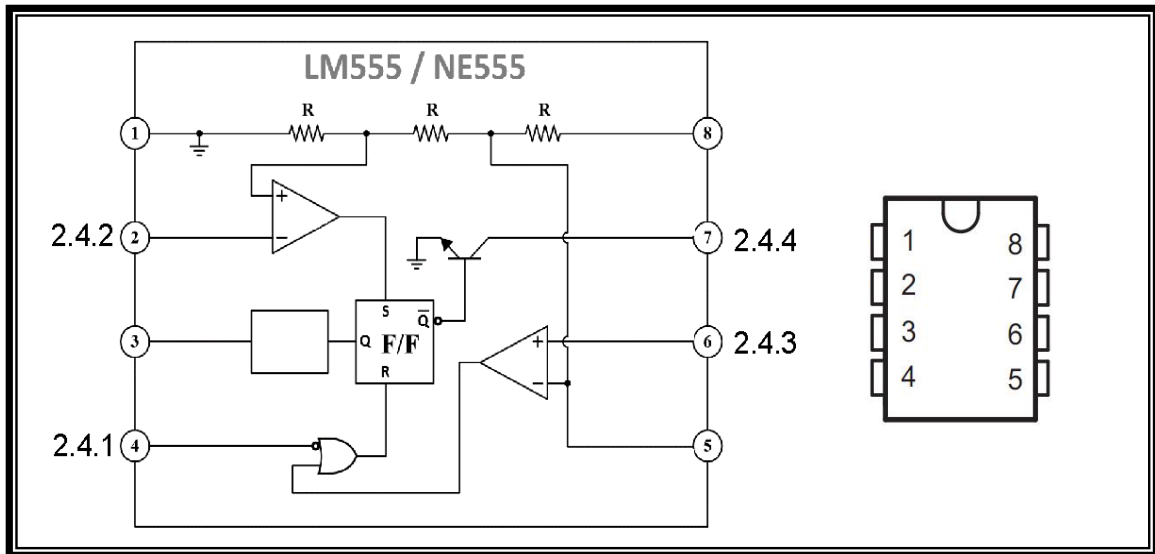

FIGURE 2

(4)

2.5   Explain the relationship between terminal 3 and terminal 7 while the 555-timer is working.   (4)

2.6   One of the functions of the 555-timer is to prevent switch debounce.

    2.6.1   What is meant by the concept of *switch debounce*?   (1)

   2.6.2   Explain the negative implication of switch debounce for a digital circuit.   (2)

    2.6.3   Identify the correct multivibrator circuit that is used to prevent switch debounce.   (1)

[20]

QUESTION 3   SWITCH AND CONTROL CIRCUITS

3.1   Draw a neatly labelled astable multivibrator using a 741-operational amplifier.   (5)

3.2   Study FIGURE 3 of the 741-operational amplifier that is used as a bistable multivibrator and then answer the questions that follow.
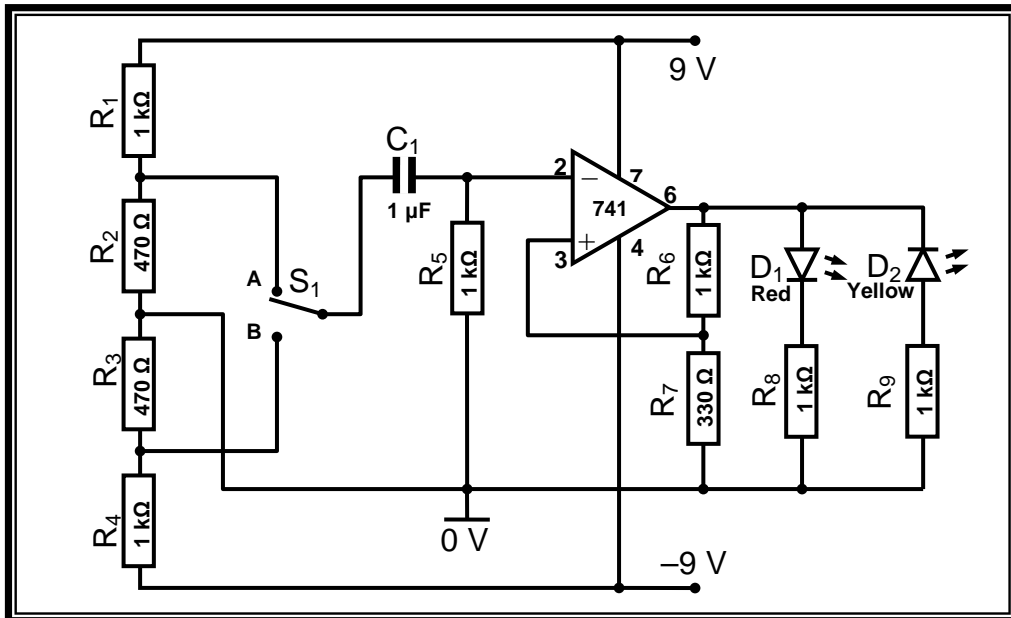
FIGURE 3

3.2.1 Calculate the value of the feedback voltage in the circuit.   (3)

3.2.2 The relevant input waves for the multivibrator are shown on the Answer Sheet. Draw the correct voltage waves that will be obtained for the multivibrator on the Answer Sheet.   (5)

3.3   A 741-operational amplifier is used as an adder in FIGURE 4. Input voltages $V_1 = 100$ mV, $V_2 = 150$ mV and $V_3 = -120$ mV are placed on the inputs of the adder. Calculate the output voltage.   (3)
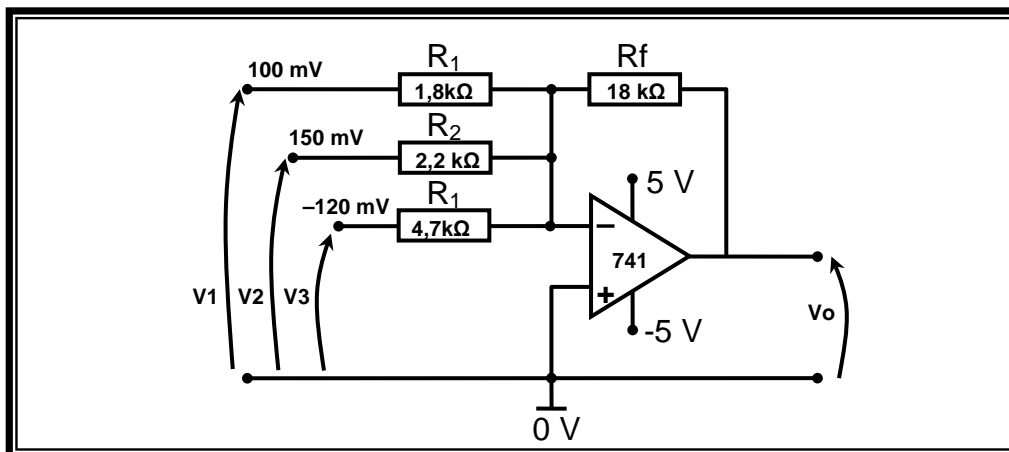
FIGURE 4

3.4   Calculate the output frequency of an astable multivibrator which uses a 741-operational amplifier if the value of the feedback resistance is 680 kΩ and the capacitor is 12 nF.   (3)

3.5   A 741-operational amplifier, shown in FIGURE 5, is used to slow down the conversion between two extreme values. Study the amplifier and then answer the questions that follow.
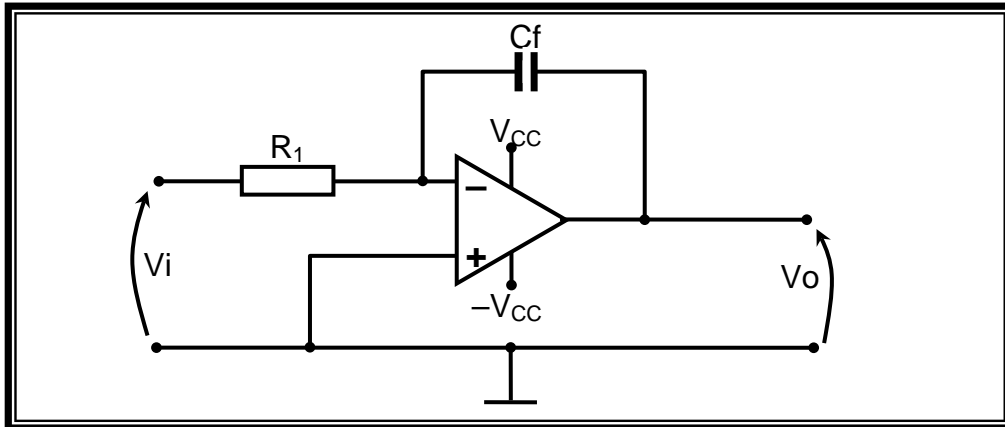

FIGURE 5

3.5.1   Identify the circuit shown in FIGURE 5.   (1)

3.5.2   The input wave to the circuit is shown on the Answer Sheet. Draw the expected output waves of the circuit if the RC time constant is longer than the pulse duration of the input wave.   (2)

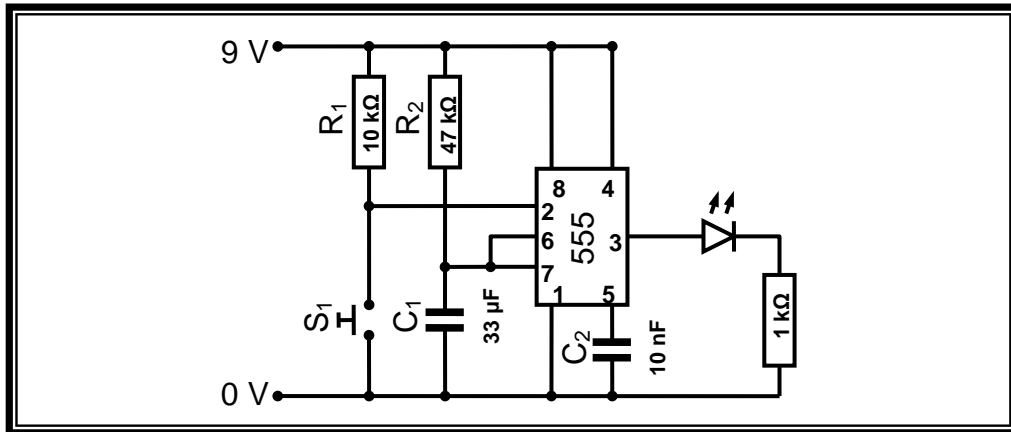3.6   The circuit in FIGURE 6 uses a 555-timer. Study the figure and then answer the questions that follow.

FIGURE 6

3.6.1 Identify the 555-circuit that is shown in FIGURE 6.   (1)

3.6.2 Calculate the time that the LED is on.   (3)

3.6.3 Describe how the circuit will switch off the LED.   (5)

3.6.4 Discuss the function of resistor R_1 in the circuit.   (3)

3.7   An astable multivibrator that is constructed using a 555-timer consists of a 220 nF capacitor, a discharge resistor of 47 kΩ and a 3,3 kΩ resistor. The multivibrator is supplied with a 9 V input voltage.

3.7.1 Draw a neatly labelled circuit diagram to show the construction of the multivibrator.   (8)

3.7.2 Draw the relevant capacitor and output waveforms of the circuit on the Answer Sheet in the space that is provided. Label your sketches properly.   (4)

3.7.3 Explain the working principle of the astable multivibrator 555-timer.   (9)

[55]

QUESTION 4   DIGITAL AND SEQUENTIAL DEVICES

4.1   Explain the basic construction of a liquid crystal display (LCD).   (4)

4.2   State and explain the difference between the two types of 7-segment LEDs that are available.   (4)

4.3   State TWO maximum values that should be considered when working with an LED display unit.   (2)

4.4   Draw a neatly labelled logic-gate diagram to show the composition of a full adder.   (5)

4.5   Study FIGURE 7 of a clocked RS-latch and then answer the questions that follow. Refer to the numbering as it is used in the figure to structure your answer.
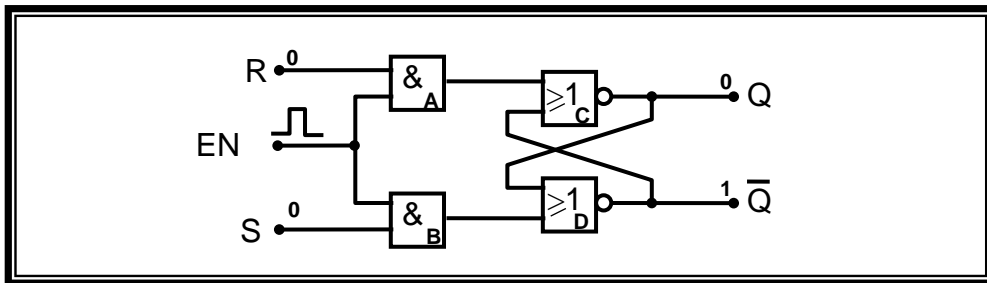
FIGURE 7

4.5.1   The truth table for the RS-latch is shown on the Answer Sheet. Complete the truth table for the given latch.   (4)

4.5.2   Explain how the RS-latch will react when a logic 1 is placed on the S input and the clock pulse of the circuit changes from logic 0 to logic 1.   (6)

4.6   A JK-latch is shown in FIGURE 8. Study FIGURE 8 and explain step by step how the JK-latch will react when a logic 1 is placed on both inputs J and K.   (10)
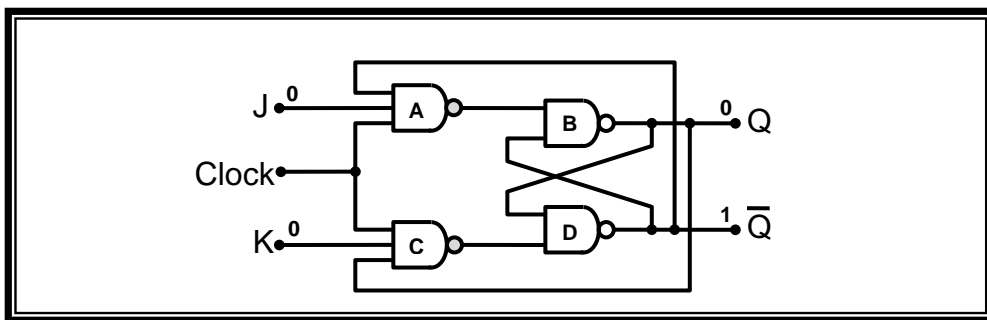
FIGURE 8

4.7   Discuss the difference in working principle between a synchronous and an asynchronous ripple counter. (4)

4.8   A MOD16 synchronous ripple counter is shown in FIGURE 9. Study the figure and then answer the questions that follow. Refer to the numbering as it is used in the figure to structure your answer.
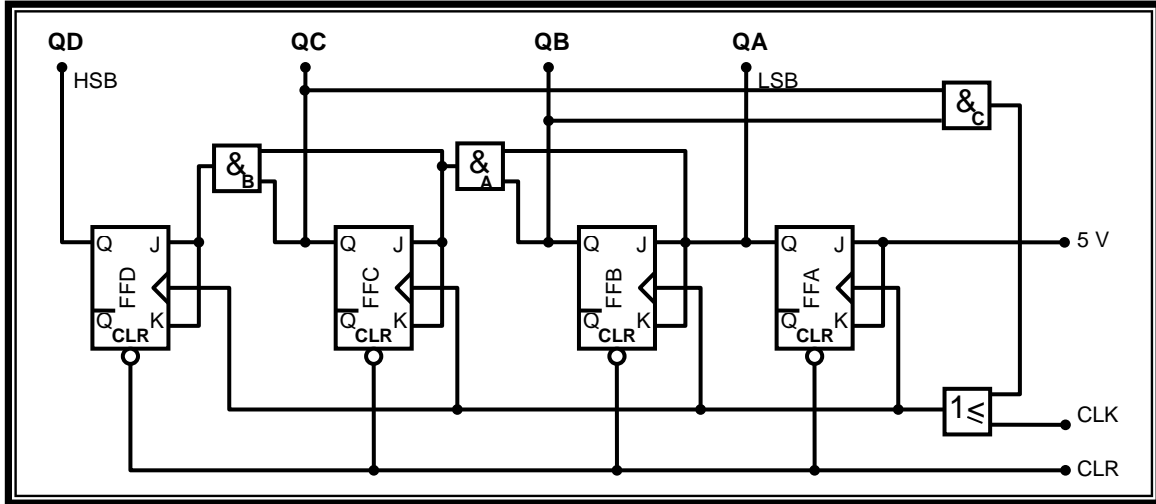

FIGURE 9

4.8.1   Discuss the reason for the addition of the OR-logic function on the clock-pulse input of the counter. (2)

4.8.2   Explain in chronological steps how the counter will reach one binary count upwards from 101_2 to 110_2. (8)

4.9   Draw a neatly labelled circuit diagram in which you use a D-flip-flop to change a 4 Hz clock pulse into a 1 Hz clock pulse. (6)

[55]

QUESTION 5   MICROCONTROLLERS

5.1   Give TWO advantages of the use of microcontrollers in IC format.   (2)

5.2   Give ONE disadvantage of microcontrollers.   (1)

5.3   FIGURE 10 shows a block diagram of a microcontroller. Study the diagram and then answer the questions that follow.
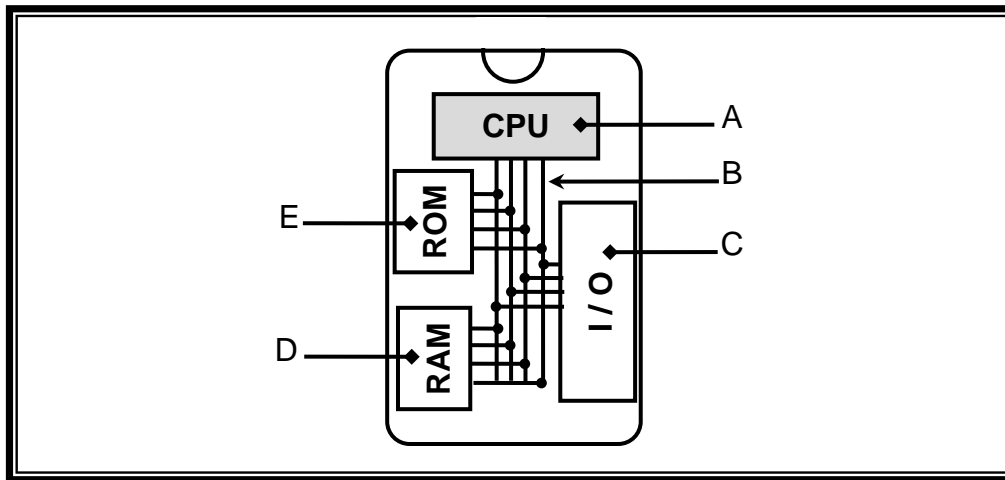
FIGURE 10

5.3.1   Explain the difference in function between items E and D of the PIC.   (2)

5.3.2   Discuss the function of item C in the PIC.   (2)

5.3.3   Describe the purpose of item A in the PIC.   (2)

5.3.4   Identify item B and provide its purpose in the construction of the PIC.   (2)

5.4   List the THREE types of buses that are found in a PIC bit.   (3)

5.5   Explain the basic difference between a microcontroller and a microprocessor.   (4)

5.6   Describe an analogue to digital converter.   (2)

5.7   Draw a labelled block diagram to show the basic layout of a full-duplex data communication system.   (6)

5.8   Discuss the main difference between a synchronous and an asynchronous series communication system.   (2)

5.9   Give TWO advantages of synchronous data communication.   (2)

5.10   Draw a neatly labelled block diagram to show how an asynchronous communication system would transmit data in a simplex system.   (8)

5.11   Explain the term "UART" as an asynchronous communication peripheral.   (4)

5.12   Discuss how an Inter-Integrated Circuit (I²C) communication system would transmit 8 data bits to the receiver.   (8)

5.13   Consider the following scenario and develop a flow diagram to program a PIC:

A water pump supplies extra water to a watering trough for animals.

The pump should switch on for ten minutes when the water flow from the storage tank is high and the water level in the watering trough is low or if the ambient temperature is high.

Let the water level be input A, the flow from the storage tank input B and the temperature input C, with F for the water pump.

The Boole equation of the function is $F = (\overline{A} + C)B$.   (10)

[60]

Total: 200 marks