

**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY  
FACULTY OF INDUSTRIAL TECHNOLOGY  
BACHELOR OF ENGINEERING (HONS) DEGREE**

Final Examination August 2013

TEE 1241

Electrical Measurements

Duration of the Examination 3 hours

Instructions to candidates:

1. Answer any **FIVE** questions out of **EIGHT**.
2. Each question carries 20 marks
3. Show all your steps clearly in any calculation.
4. Start the answers for each question on a fresh page.

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**Question 1**

- a) Describe briefly with the aid of a diagram the operation of a stepper motor. *[8 marks]*
- b) Describe the construction of a dot-matrix printer, and show the connections needed for data transfer and control signals. Explain the purpose of each line and the direction of information flow on it. *[6 marks]*
- c) An Ohmmeter uses a 1.5 volt battery and a d'Arsonval meter movement with a resistance of 200 Ohms. The variable series resistor of the Ohmmeter is adjusted to 1053 Ohms to cause a full-scale deflection when the probes are shorted together. When the probes are placed across a test resistor, the deflection is 64% of full scale. What is the value of this test resistor? *[6 marks]*

**Question 2**

- a) Describe the mechanical construction of the d'Arsonval meter movement, using a fully labelled diagram. *[6 marks]*
- b) A dynamometer movement produces a full-scale deflection when the product of the currents in the two coils is  $10^{-3} \text{ A}^2$ . If a load of 100 Ohms across a supply voltage of 50 volts produces a half-scale deflection, what is the value of the series resistance in the series resistance in the voltage-measuring part of the circuit? *[6 marks]*
- c) A meter has an internal resistance of 500 Ohms and a full-scale deflection of 1 mA. Design suitable circuits to make this into:
  - i. A voltmeter reading from 0-10 volts, and
  - ii. An ammeter to read 0-2 amps. *[8 marks]*

### Question 3

- a) Describe with the aid of a diagram the construction of an oscilloscope. [10 marks]
- b) Two signals of the same frequency are applied to the X and Y plates of an oscilloscope. Sketch the Lissajous figures that would result when the X input lags the Y input by the following phase shifts:  $0^\circ$ ,  $45^\circ$ ,  $90^\circ$ ,  $120^\circ$  and  $180^\circ$ . [5 marks]
- c) A common-cathode 7-segment display is driven by means of a decoder connected to the 7 segments, as shown in Figure Q3. If line "a" is connected to the MSB and "g" to the LSB of the binary number from the decoder, what will be the values of these binary numbers from the decoder for display of 1, 2, 3, 4, 5 by the module? [5 marks]

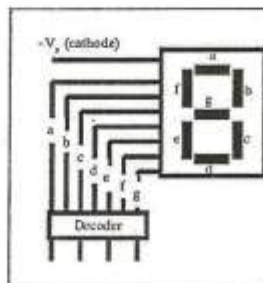


Figure Q3

[5 marks]

### Question 4

- a) It is required to produce a voltage which is the composite of three voltages,  $V_1$ ,  $V_2$ ,  $V_3$  according to the equation:  
$$V_{out} = -2V_1 - 5V_2 - 2V_3$$
  
Design a circuit using operational amplifiers to achieve this, giving realistic values for any resistors used. [8 marks]
- b) Define the term "telemetry" and give one example of technologies used in telemetry. [2 marks]
- c) What are some of the advantages of using telemetry compared to sending researchers to remote sites to make measurements? [4 marks]
- d) How would you classify the following measuring systems? A speed trap meter, a d'Arsonval DC ammeter, and a soil pH data logger connected to a computer? [6 marks]

**Question 5**

- a) Define a sensor.

[2 marks]

- b) Four strain gauges are used to measure the bending of a beam. The mechanical arrangement and the electrical connections are shown below in Figure Q5a. The supply voltage across the bridge is 12 volts. The gauges have sensitivity factors of 2.5. What would be the voltage  $V_o$  at the centre of the bridge when all the gauges are mechanically strained by 3%. Indicate which gauges are in tension and which under compression.

[8 marks]

- c) The Schmidt Trigger circuit shown in Figure Q5b receives an input in the form of a sinewave of frequency 10 kHz and peak-to-peak value of 24 volts. If the supply voltages of the op amp are  $\pm 12$  V, draw a graph of output voltage  $V_o$  against time. Show clearly the voltage values, and the times at which the output voltage crosses the zero axis.

[10 marks]

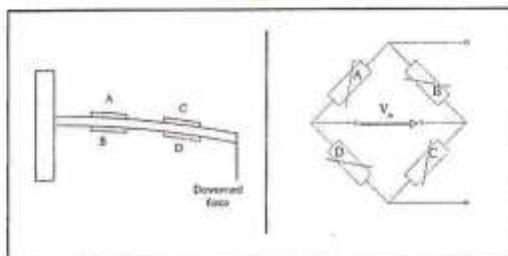


Figure Q5a

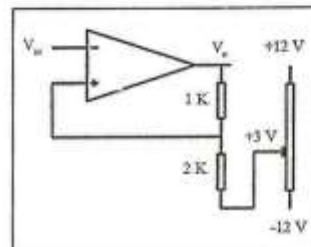


Figure Q5b

**Question 6**

- a) Describe **briefly** three types of transducers for measuring light intensity.

[6 marks]

- b) A photo-transistor having the characteristics shown in Figure Q6 is connected in series with a load of 2.5 kOhms across a supply of voltage of 25 volts. What would be the voltages across the transistor when the light intensities are 100, 200, and 400  $W/m^2$ ?  
Mark the load line and the operating points on the Figure Q6 in page 5.

GRAPH OF FIGURE Q6 SHOULD BE ATTACHED TO YOUR ANSWER BOOK.

[6 marks]

- c) **Briefly** describe the four main levels of a Virtual Instrumentation system.

[8 marks]

### Question 7

- a) A resistive temperature transducer of resistance 1500 ohms at 20°C and temperature coefficient 0.004 is connected in series with a resistor of 2500 ohms across a 12 volt supply. The voltage across the transducer is passed to the input of an op amp integrator circuit with input resistor of 100 kohm and feedback capacitor of 1000 uF. The transducer is placed in an electric oven at temperature 20°C and the integrator switch is opened. The oven heats linearly with time to a temperature of 300°C in a time of 100 seconds. What would be the output voltage of the op amp at the end of the time?

*[9 marks]*

- b) **Briefly** describe 4 terms that describe measurement system reliability and errors that can occur in measurement systems, indicating briefly how these can be reduced in each case.

*[8 marks]*

- c) State the sources of measurement errors.

*[3 marks]*

### Question 8

- a) Describe and explain the operation of an Analogue-to-Digital Converter, using a circuit diagram.

*[10 marks]*

- b) An Analogue-to-Digital Converter produces an output of 10 bits. The analogue input range is 0-10 volts. What would be the binary number at the output when the input is 4.7 volts?

*[4 marks]*

- a) State the number of lines that a General Purpose Interface Bus (GPIB) has, and with the aid of a diagram show how they are divided according to their functions.

*[6 marks]*



The Graph for Question 6 – It must be attached to the answer book if this question is attempted.

Student No. ....

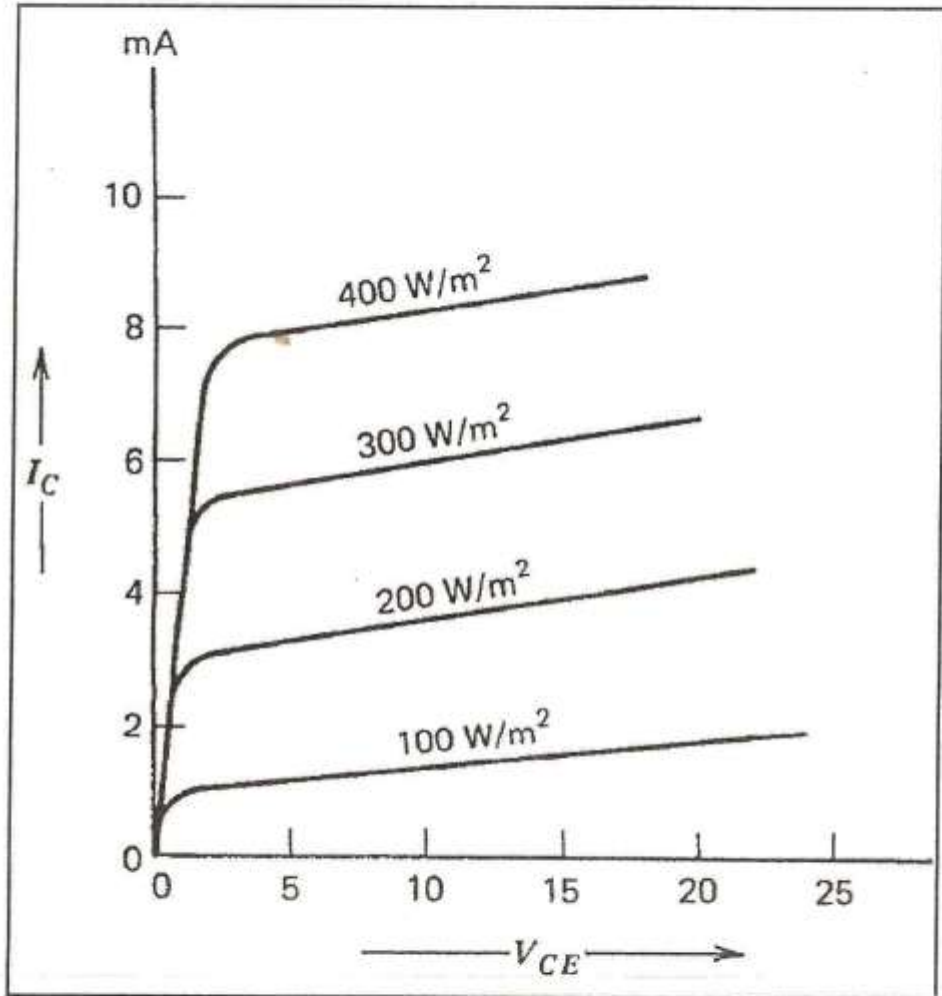


Figure Q6