TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY EXAMINATION 2013/2014

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

(FOURTH YEAR SECOND SEMESTER)

(FIFTH YEAR SECOND SEMESTER)

EMG 2505 : MEASUREMENT AND INSTRUMENTATION

TIME: 2 HOURS **SERIES:** DECEMBER, 2013

INSTRUCTIONS TO CANDIDATES

1. You are required to have the following for these examinations:
   - Answer Booklet
   - Non-programmable Calculator

2. This paper has **FIVE** Questions.
3. Answer Question **ONE** and any other **TWO** Questions.
4. This paper consists of **FIVE** ***Printed pages.***

Question ONE (Compulsory)

(a) Explain the meaning of the terms as used in measurement systems:

(i) Active instrument
(ii) Null type instrument

(4 marks)

(b) Explain with the aid of a block diagram the elements of a measuring instrument.

(6 marks)

(c) Define the following terms with respect to measurement:

(i) Working standards
(ii) Primary standards

(4 marks)

(d) The expected value of the voltage to be measured is 150V. However, the measurements gives a value of 149V. Calculate:

(i) Absolute error
(ii) Percentage error
(iii) Relative error
(iv) percentage accuracy
(v) Error expressed as percentage of full scale reading. If the scale range is 0 – 200V

(5 marks)

(e) Two quantities x_1 and x_2 have errors of $\pm \delta x_1$ and $\pm \delta x_2$ respectively. Derive the expression for the error in x when:

(i) $x = x_1 x_2$

(ii) $x = x_1 / x_2$

(5 marks)

(f) Show that the gauge factor of a strain gauge can be written as:

$$G_f = 1 + 2\nu + \frac{\Delta\rho/\rho}{\Delta L/L}$$

(6 marks)

Question TWO

(a) Define the terms as used in measurements:

(i) Accuracy
(ii) Resolution
(iii) Fidelity

(3 marks)

(b) The dead zone in a certain pyrometer is 0.125% of span. The calibration is 400°C. What temperature change might occur before it is detected? **(2 marks)**

(c) A measuring instrument consists of a mass-spring system with the following parameters:

Stiffness = k N/m
Mass = mkg
Damping coefficient = kd Ns/m
For a force input, F(t) and an output movement x(t):

(i) Derive the characteristic equation of the system
(ii) Identify the order

(5 marks)

(d) Differentiate between Gross errors and Random errors. **(4 marks)**

(e) The output power of a rotating shaft is measured a dynamometers.
The relationship for output power is:

$$P = \frac{2\pi \times 9.81FLR}{t \times 10^6} kW$$

The test data are:

$F = 4.58 \pm 0.02kg, \qquad L = 397 \pm 1.3mm$
$R = 1202 \pm 1.0 \ \ revolution, \quad t = 60 \pm 0.50 \sec$

Determine the magnitude of the error in the computed power.

(6 marks)

Question THREE

(a) State **THREE** advantages of electrical transducers. **(3 marks)**

(b) Explain with the aid of a diagram, the different between a primary and secondary transducer.

(c) State **TWO** advantages and disadvantages of thermistors. **(2 marks)**

(d) A platinum thermometers has a resistance of 100Ω at 35°C.

(i) Find its resistance at 75°C if the platinum has a resistance temperature coefficient of 0.004/°C.
(ii) If the thermometer has a resistance of 150Ω. Calculate the temperature.

(4 marks)

(e) Explain with the aid of a diagram, the operation of a LVDT. **(5 marks)**

Question FOUR

(a) Define the following terms:

(i) Johnson noise
(ii) Shot noise

(4 marks)

(b) At the input an amplifier has a signal voltage level of 3μV and a noise voltage level of 1μV.

(i) Calculate the signal to noise ratio at the input.
(ii) If the voltage gain of the amplifier is 20, calculate the S/N ratio at the output.
(iii) If the amplifier adds 5Mv of noise, determine the S/N ratio at the output.

(6 marks)

(c) State **THREE** properties of an ideal operational amplifier. **(3 marks)**

(d) For a high pass filter, show that the transfer function:

$$\frac{E_o}{E_i}(s) = \frac{SRC}{1+SRC}$$

(3 marks)

(e) An inverting OPAMP has a resistance of 100kΩ in its feedback path and a resistance of 1kΩ at its input terminals.

(i) Calculate the gain
(ii) If an operational amplifier is to be built with its input resistance 10kΩ, what should be the value of feedback resistance if it acts as a multiplier with a factor of 10.

(4 marks)

Question FIVE

(a) State **ONE** advantage and **ONE** limitation of LCD displays. **(2 marks)**

(b) With the aid of a diagram, explain the operation of an LCD display. **(4 marks)**

(c) The coil of a recording ammeter is 6.5cm long and 2.5cm wide. The rated current of the coil is 10mA. The flux density in the air gap is 4.6×10^{-3}wb/m^2. The damping constant is 8×10^{-3}Nm/rad-s^{-1}. The moment of inertia is 8×10^{-3}kgm^2. The spring constant is 16×10^{-3}Nm/rad. The coulomb friction is 0.2×10^{-6}Nm. Determine, for 100^o deflection at rated current:

(i) The number of turns on the coil.
(ii) The current required to overcome Coulomb friction.

(6 marks)

(d) State **THREE** advantages of using microprocessors in measurement systems. **(3 marks)**

(e) With the aid of a sketch explain the main elements of a Cathode Ray Oscilloscope (C.R.O) tube. **(5 marks)**