NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

INDUSTRIAL INSTRUMENTATION AND CONTROL 1

TIE 3114

First Semester Supplementary Examination Paper

August 2015

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Graph paper

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INSTRUCTIONS

1. Answer any five (5) questions.
2. Each question carries 20 marks.
3. Use of calculators is permissible.

Question 1

a) Describe the three sources of systematic errors that you know. [9]
b) The terms repeatability and reproducibility mean approximately the same but are applied in different contexts in regards to instruments. Explain the two terms in regards to the context they are used in. [4]
c) Explain why it is normally desirable that the output reading of an instrument is linearly proportional to the quantity being measured. [2]
d) Why it is important to understand hysteresis effects when dealing with instruments which exhibit those characteristics? [5]

Question 2

a) Explain what is meant by the following, giving examples:
   i) Active instruments, [2]
   ii) Passive instruments. [2]
b) Discuss the relative merits of these two classes of instruments. [4]
c) You work at a foundry where the temperature of the molten metal is measured by deeping a resistance temperature detector on the cupola spout when the molten metal is being poured into the ladle. There have been many instances where workers have been burnt while using the current system. The company engineer assigns you to design a new system which is safer.
   i) What instruments are you going to use? [2]
   ii) Explain using the aid of diagrams how your measurement system will function.[4]
d) You have been assigned to work on an oil rig in the Kalahari Desert that has blown up. Upon assessment of the rig you discover that the temperature measuring device was also blown up. You realise that you came with a thermistor, voltmeter, ammeter, resistors of different resistances and a torch cell. The site engineer of the rig keeps water for drinking in a fridge and has a two plate stove for cooking.
   i) Design a temperature measuring instrument using the equipment you have, [4]
   ii) Explain how you will calibrate the instrument. [2]

Question 3

a) State the three basic functional elements of an instrument and show by means of a block diagram how they are interconnected. [5]
b) An inclined tube manometer has the indicating tube at 30^{o} to the horizontal. What will be the change in level in the inclined tube that is produced by a pressure difference between the two limbs of 1000Pa if the manometric liquid has a relative density of 13.56? (Take acceleration due to gravity to be $9.81 m/s^2$). [5]
c) Calibration of industrial instruments is of great importance as far as quality control is concerned. Discuss. [10]

Question 4

a) A strain gauge which has an unstrained resistance R_o= 120Ω and a gauge factor k = 2.02, is subjected to a strain, ε = 1600μm/m where $k = \frac{\Delta R}{R\varepsilon}$

i) Determine ΔR and $\frac{\Delta R}{R}$ [3]

ii) If the gauge were initially inserted in one arm of a Wheatstone bridge, and the bridge is initially balanced at R_o, determine the output voltage, V_o, if the bridge is powered from a 10V d.c supply and the gauge is subjected to the above conditions. [5]

b) Photo-effects are classified as photo-conductive, photo-emissive and photo-voltaic.

i) Explain the meaning of each of these effects. [6]

ii) Suggest a possible practical application of each. [6]

Question 5

a) Define the term resolution. [2]

b) Given that an 8 bit microcontroller based control system is used for angular positioning for a satellite and the satellite can swipe through an angle of 360°.Calculate the possible resolution that can be achieved using such a microcontroller. [3]

c) What makes the stepper motor the most preferred actuator for microcontroller based positioning systems? [5]

d) Explain the following terms as applied to serial data communication:-

i) Simplex, [2]

ii) Half duplex, [2]

iii) Full duplex. [2]

e) Figure Q5 below shows a block diagram for the operation of a control valve.
Write an equivalent of the program in:-

i) Ladder logic. [2]

ii) Logic gate format. [2]

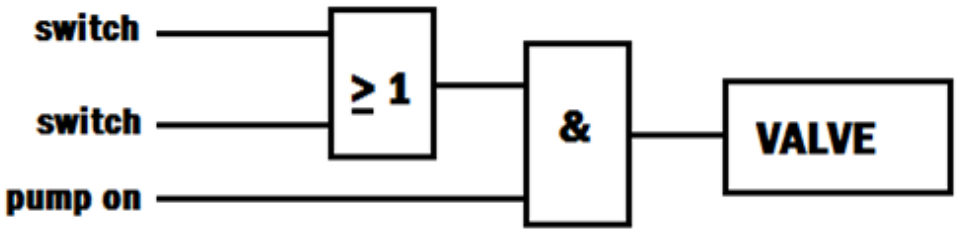

Figure Q5: Block diagram for a control valve

Question 6

a) Explain using diagrams the difference between the two groups of liquid level measuring devices. [6]
b) State three advantages of using a flow nozzle meter. [3]
c) Describe with aid of diagrams the principle of operation of a coriolis flow meter [5]
d) Zimbabwe Sugar Refineries (ZSR) operates from two plants. Sugar is loaded into the trucks using a conveyer belt in one plant and weighed on the next plant using a weighbridge. The process is time consuming as weighing is a non-value adding activity and many cases have been reported where drivers offload sugar from the trucks before they get to the weighbridge. With aid of diagrams design a weighing system which will enable sugar to be weighed as it is being loaded onto the trucks. [6]

Question 7

a) What is the difference between source code and object code? [2]
b) Shaft encoders are very useful instruments used to determine the angular velocity and the position of a shaft. Describe the principle of operation of an optical absolute encoder. [6]

c) The city of Bulawayo is experiencing problems at one of its water pumping stations. At times they experience overspills and at times the water tanks run dry due to upstream leakages. Design a PLC system based water management system for the storage tanks. In your design include a Flow Chart diagram to illustrate how the control is going to be achieved and convert that Flow Chart Diagram into a Ladder Logic program. [12]

End of examination paper