The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: DMX4409 Sensors**
Academic Year	: 2019/20
Date	: 02nd August 2020
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Six (6)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answers for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear handwriting.
7. Do not use Red colour pen.

Question 01

a) Explain the differences between *error* and *uncertainty*. What are *systematic* and *random* errors? [*5 marks*]

b) What is meant by *two wire* and *three wire* sensors? Give a typical example of each type of sensor. [*5 marks*]

c) How do you perform signal conditioning for self-generating sensors? [*5 marks*]

d) Brief the working principle of the ultrasonic sensor. [*5 marks*]

Question 02

a) Describe advantages of using *digital transducers* over *analogue transducers*. [*5 marks*]

b) Describe methods of improving the *displacement resolution* and the *velocity resolution* in an encoder. [*5 marks*]

c) Compare the potentiometer circuit with the Wheatstone bridge circuit for strain gage measurements, with respect to the following considerations:

i. Sensitivity to the measured strain [*2 marks*]

ii. Error due to ambient effects (e.g., temperature changes) [*2 marks*]

iii. Signal-to-noise ratio of the output voltage [*2 marks*]

iv. Circuit complexity and cost [*2 marks*]

v. Linearity [*2 marks*]

Question 03

A strain gage tension sensor for a belt-drive system is shown in Figure Q3. Two identical active strain gages, G_1 and G_2, are mounted at the root of a cantilever element with rectangular cross-section, as shown in Figure Q3. A light, frictionless pulley is mounted at the free end of the cantilever element. The belt makes a 90° turn when passing over this idler pulley.

a) Briefly describe a situation in which tension in a moving belt or cable has to be measured under transient conditions. [*10 marks*]

b) What are some of the difficulties associated with measuring tension in a moving member? [*10 marks*]

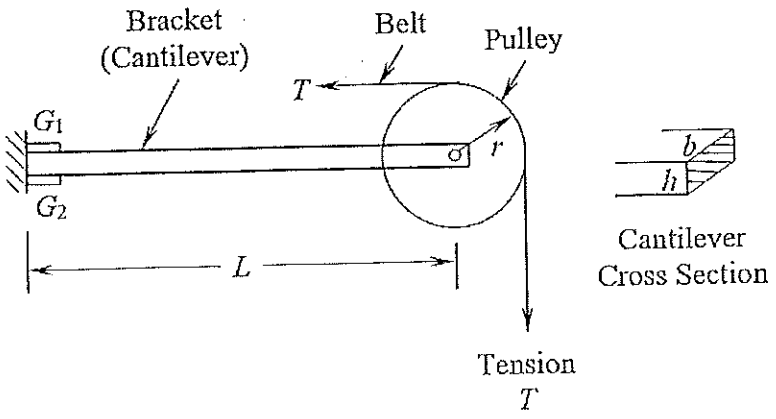

Figure Q3

Question 04

Consider the natural gas home heating system given in Figure Q4.

a) Describe the functions of various components in the system and classify them into the function groups: controller, actuator, sensor, and signal modification device.

[*10 marks*]

b) Explain the operation of the overall system and suggest possible improvements to obtain more stable and accurate temperature control. [*10 marks*]

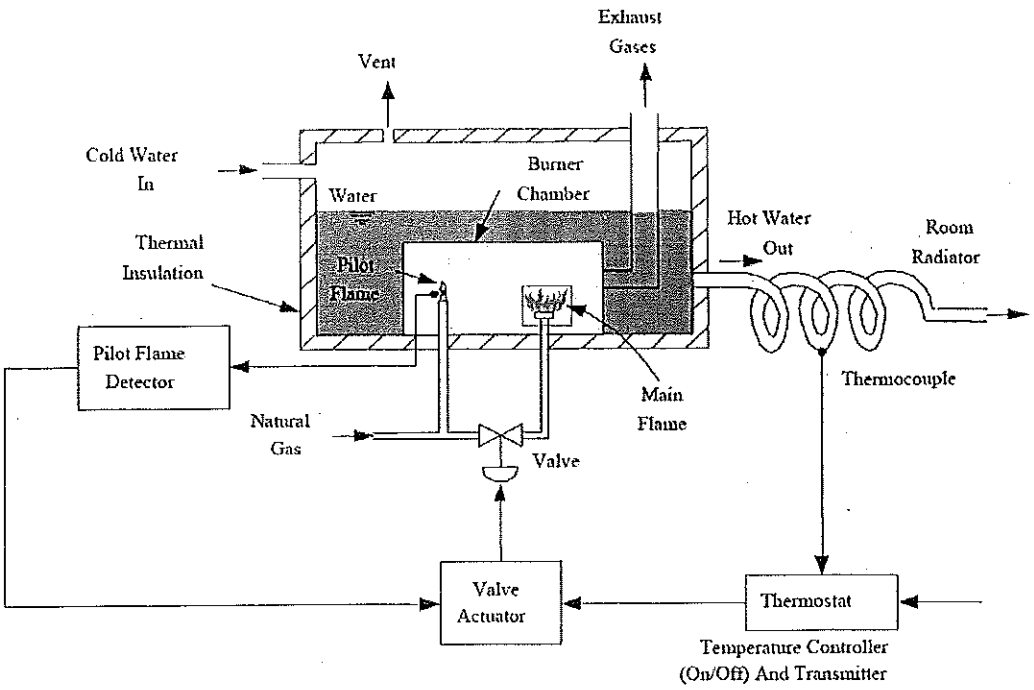

Figure Q4

Question 05

a) A particular sensor has its unit step response $y(t)$ given by following equation. Determine the rise time, delay time and the percentage overshoot of the sensor.

[*10 marks*]

$$y(t) = 1 - e^{-2t} - 2te^{-2t}$$

b) A particular sensor has its transfer function given by the following. The input $r(t)$ is the measurand, and the sensor output is $c(t)$.

$$\frac{C(s)}{R(s)} = \frac{1000}{s^2 + 45s + 1000}$$

i. Determine the resonance frequency, useful frequency range and bandwidth of the sensor. [*5 marks*]

ii. If the measurand is sinusoidal with a frequency of $4Hz$, calculate the amplitude gain and phase lead in its response? [*5 marks*]

Question 06

An automated quality grading system is shown in the following Figure Q6. The objects, which need grading, move horizontally along a conveyor. The size, the color, and the shape of the object are computed using a vision system, and the quality grade of the objects are determined based on values computed by an intelligent decision making system: A vertical positioning platform directs graded objects on to corresponding conveyors, as shown in the following Figure Q6. The positioning platform is driven by a motor which is controlled by a drive system. The positioning trajectory of the drive system of the motor is such that it uniformly accelerates to the desired speed, starting from rest, during the first half of the positioning time, and uniformly decelerates to rest during the second half. Positioning always starts at the feeder conveyor level (the top of the platform aligned with feeder conveyor) and will return to the same position after feeding the object on to the corresponding conveyor.

a) Identify suitable sensors, actuators, controllers and other vital components for the above design. Elaborate on the significant characteristics of the selected components in the component selection stage. [*10 marks*]

b) Discuss any drawbacks of your design and propose ways of enhancing its performance.

[*10 marks*]

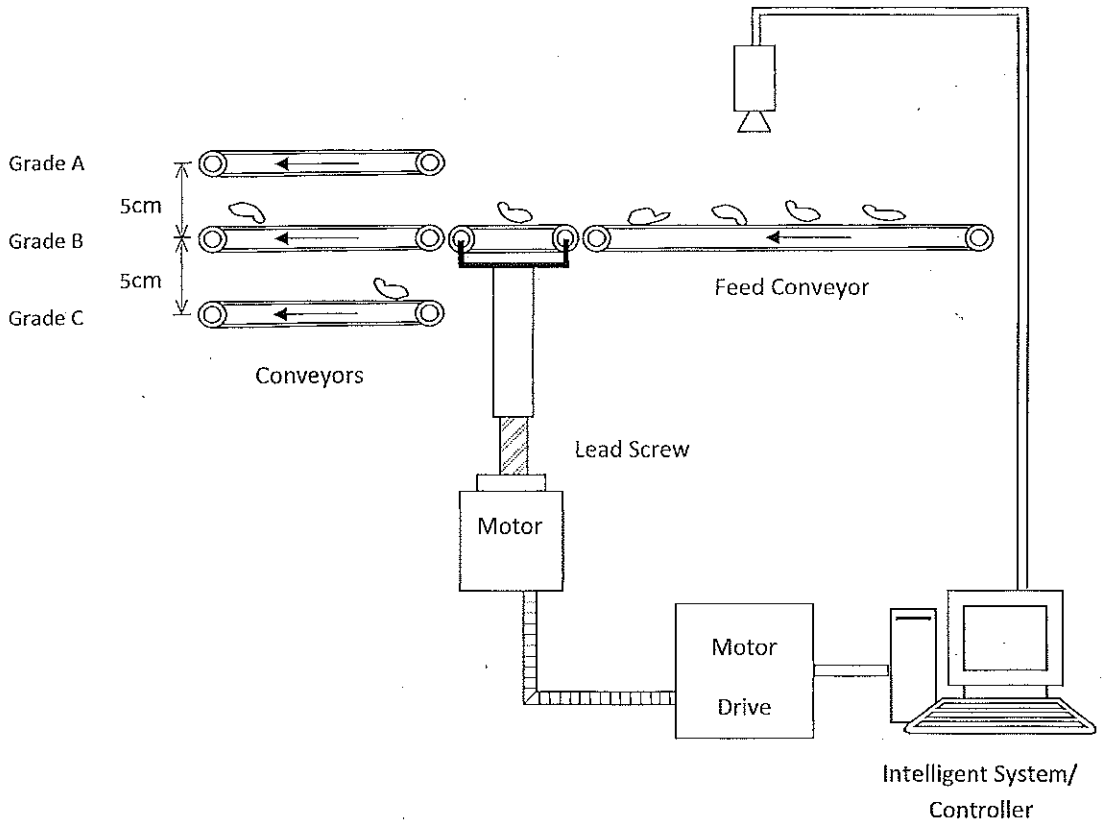

Figure Q6

Question 07

a) Draw the block diagram and explain of typical measuring/data acquisition system. [*5 marks*]

b) Describe the classification of sensors based on signal characteristics. [*5 marks*]

c) Describe the selection criteria of the sensors for a particular application. [*5 marks*]

d) Describe the five advantages of LVDTs. [*5 marks*]

Question 08

a) What is a "smart-sensor" and what are the advantages and disadvantages? [*5 marks*]

b) Figure Q8 is shown a diagram of a river running past a chemical factory. The same types of sensors, connected to a computer in the factory are placed at *A* and *B* to monitor pollution of the river by the factory. Name 3 sensors and its specification that would need to be placed at both *A* and *B*. [*10 marks*]

c) Describe how the computer would monitor levels of pollution in the river in Q8(b). [*5 marks*]

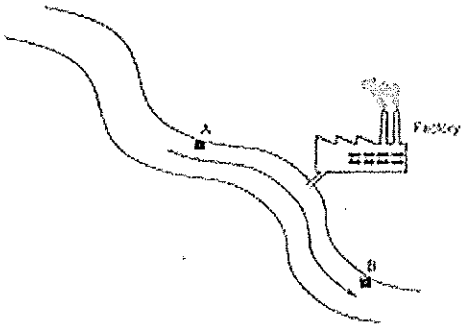

Figure Q8

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