

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG(HONS) BIOMEDICAL ENGINEERING

SEMESTER ONE EXAMINATION 2023/2024

BIOMECHATRONICS AND MEDICAL DEVICES

MODULE NO: BME5008

Date: Thursday 11th January 2024

Time: 10:00 – 12:00

INSTRUCTIONS TO CANDIDATES:

There are 2 sections (A and B) each containing 3 questions.

Answer 2 questions from each section.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Q1.

(a) Use block diagram reduction techniques to find the transfer function of the control as shown in Figure 1. **(9 marks)**

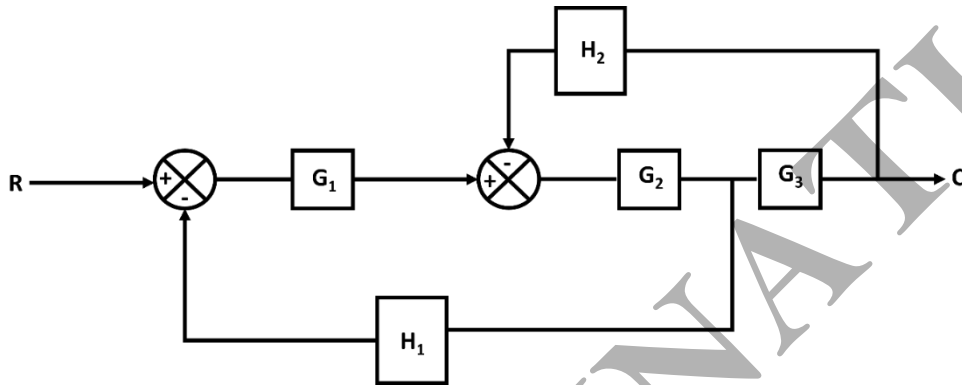


Figure 1. Block diagram of a closed loop feedback control system.

(b) A capacitive transducer/sensor consists of two parallel plates of diameter 2 cm each and separated by an air gap of 0.25 mm. Calculate the displacement sensitivity of the capacitive transducer. How would the displacement sensitivity of the transducer be affected when the separation distance between the plates is increased to 0.5 mm? Please elaborate on your answer with examples of Biomechatronics systems where capacitive transducers/sensors can be used.

(9 marks)

(c) Calculate the gauge factor for a strain gauge sensor that has a resistance of 152 Ω . The resistance changes by 5 Ω for 5000 micro strains. In your answer discuss the applications of strain gauge-based sensors in Biomedical systems.

(7 marks)

Total 25 marks

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Q2.

(a) A separately excited 200 V, DC motor runs with the speed of 1500 RPM at no load current of 5A. When operated at full load current is found to be 50 A. Assuming constant flux operation with armature resistance of 0.2 Ω , calculate the full load speed.

(8 marks)

(b). DC shunt motor runs at 600 rpm on a 240 V supply while drawing a line current of 30A. Its armature and field resistances are 0.5 ohm and 120 ohm respectively. (Viedor, 21018) resistance should be placed in series with the armature circuit in order to reduce the speed to 400 rpm. Assume no changes in the armature or field current.

(8 marks)

(c). W&Z is a small biomechatronic company. Recently the senior management team intends to introduce a new type of prosthetic gripper. Since this gripper will have two fingers to execute relatively simple movements, the management thought that a brushed DC motor or a Brushless DC (BLDC) motor could meet the requirement.

You are asked by the management to investigate these two types of motors and provide the following information to them:

Comparison between a DC motor and a BLDC motor, with reasons, in the features of

- Commutation
- Speed/Torque
- Cost

(9 marks)

Total 25 marks

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Q3.

The following are two biomechatronic systems:

1. An artificial Foot
2. A smart wheelchair

a) Identify THREE basic elements for both systems above.

(3 marks)

b) Specify four types of sensors that could be applied to the above two biomechatronic systems and describe the functions of these sensors applied to the systems.

(12 marks)

c) If closed-loop control systems would be applied to these two systems, draw two control block diagrams for each of them. In the diagrams, you need to clearly indicate the elements and their input and output signals for each block.

(6 marks)

d) Using block diagrams explain the differences between an open-loop control system and a closed-loop control system.

(4 marks)

Total 25 marks

END OF SECTION A

Please turn the page for Section B

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SECTION B – answer TWO questions from this section

Q4

Thousands of joint replacement operations are carried out each year on knees, hips, ankles, shoulders and elbows. The implants are manufactured from a variety of materials.

a) Discuss the different materials that are used for joint implants and the properties that make them suitable for replacement joints.

(5 marks)

b) Discuss the mechanical properties of joints that need to be considered when selecting the material for the implant. Take into consideration how the joint works.

(10 marks)

c) All types of materials used for joints have problems that can occur with use. Discuss the problems that can arise over the lifetime of the joints made from each of the materials.

(10 marks)

Total 25 marks

Q5

Cardiovascular disease is very common in the Western world.

a) Demonstrate the use of angioplasty as treatment for treating blocked blood vessels. Explain how the device is introduced into the blocked vessel and the materials used to make the balloon and the stent. Explain how the stent is not rejected by the body.

(10 marks)

b) Discuss the different types of artificial heart valves that could have to be considered in the replacement of the heart valve.

(7 marks)

a) Rotablation and Atherectomy are two different methods that can be used to remove the deposited plaque on coronary artery wall. Summarise what these devices are and describe how they work.

(8 marks)

Total 25 marks

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Q6

Bioimaging has transformed diagnostic medicine over the past century and made medical diagnosis more accurate. Discuss how information is collected and the images produced in the following machines. Give the advantages of each technique and also any disadvantages.

- a) X ray/CT scan (7 marks)
 - b) Ultrasound (7 marks)
 - c) Nuclear medicine (5 marks)
 - d) MRI (6 marks)
- Total 25 marks**

END OF QUESTIONS

Formulae sheet follows over the page

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FORMULAE SHEET

Blocks with feedback loop

$$G(s) = \frac{G_0(s)}{1+G_0(s)H(s)} \text{ (for a negative feedback)}$$

$$G(s) = \frac{G_0(s)}{1-G_0(s)H(s)} \text{ (for a negative feedback)}$$

$$C = \frac{A\epsilon}{x}$$

$$A = \pi r^2$$

$$E1 = v - I_a R_a$$

$$\frac{E1}{N1} = \frac{E2}{N2}$$

$$N2 = \frac{E2}{E1} \times N1$$

END OF PAPER