

UNIVERSITY OF BOLTON
SCHOOL OF ENGINEERING
BENG (HONS) IN BIOMEDICAL ENGINEERING
SEMESTER ONE EXAMINATION 2021/2022
BIOMECHATRONICS AND MEDICAL DEVICES
MODULE NO: BME5008

Date: Monday 10th January 2022

Time: 10:00 – 12:00

INSTRUCTIONS TO CANDIDATES:

There are **TWO** sections (A and B) each containing **THREE** questions.

Answer **TWO** questions from each section.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

CANDIDATES REQUIRE:

Formula Sheets (attached following questions).

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SECTION A – answer any TWO questions from this section

- Q1** (a) Analyse and Discuss Wifi, Bluetooth and Cellular communication technologies and their typical advantages and challenges. (12 marks)
- (b) Critically identify the digital health concepts and suggest 3 digital health technologies that have been developed. (13 marks)

[Total 25 marks]

- Q2** (a) W&Z is a small biomechatronic company. Recently the senior management team intends to introduce a new type of prosthetic griper. Since this griper will have two fingers to execute relatively simple movements, the management thought that a brushed DC motor or a Blushless DC (BLDC) motor could meet the requirement.

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

- (i) Comparison between a DC motor and a BLDC motor, with reasons, in the features of
- Commutation
 - Speed/Torque
 - Cost
- (7 marks)
- (ii) The criteria used for selecting a DC motor as well as a BLDC motor.
- (6 marks)

Question 2 continues over the page

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Question 2 Continued....

- (b) A brushed DC motor needs to drive a surgical robot. The nominal torque required is 8 mNm at a speed of 3000 rpm. A DC supply voltage of 15 V is available. Referring to the TX catalogue, in Table Q2 below,

TABLE Q2 TX Motor Catalogue

Motor Specifications	TXA 22	TXD 54	TXZ 60
No-load speed @ 15V n_0 (rpm)	7800	5500	4000
No-load current I_0 (mA)	6.21	2.08	1.65
The starting current I_a (mA)	320	241	409
Terminal resistance R (Ω)	40	40	40
Torque constant K_m (mNm/A)	98.3	80.5	207.2
Speed constant K_e (rpm/V)	310	287	180
Output power P_0 (W)	10	6	12

To select a suitable motor that meets the requirement of the design specifications of the Power and Speed.

(12 marks)

[Total 25 marks]

- Q3** (a) Compare and contrast main characteristics between a hydraulic actuator and a pneumatic actuator, which include their features and their typical applications in biomechatronic systems.
- (6 marks)

- (b) Figure Q3 (b) shows a control system employing pneumatic cylinders as the actuating elements. Clearly state the sequence of operations that will occur for the cylinders A and B when the start button is pressed.

a -, a+, b -, and b+ are limit switches to detect when the cylinders are fully retracted and fully extended.

(10 marks)

Question 3 continues over the page....

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Question 3 continued....

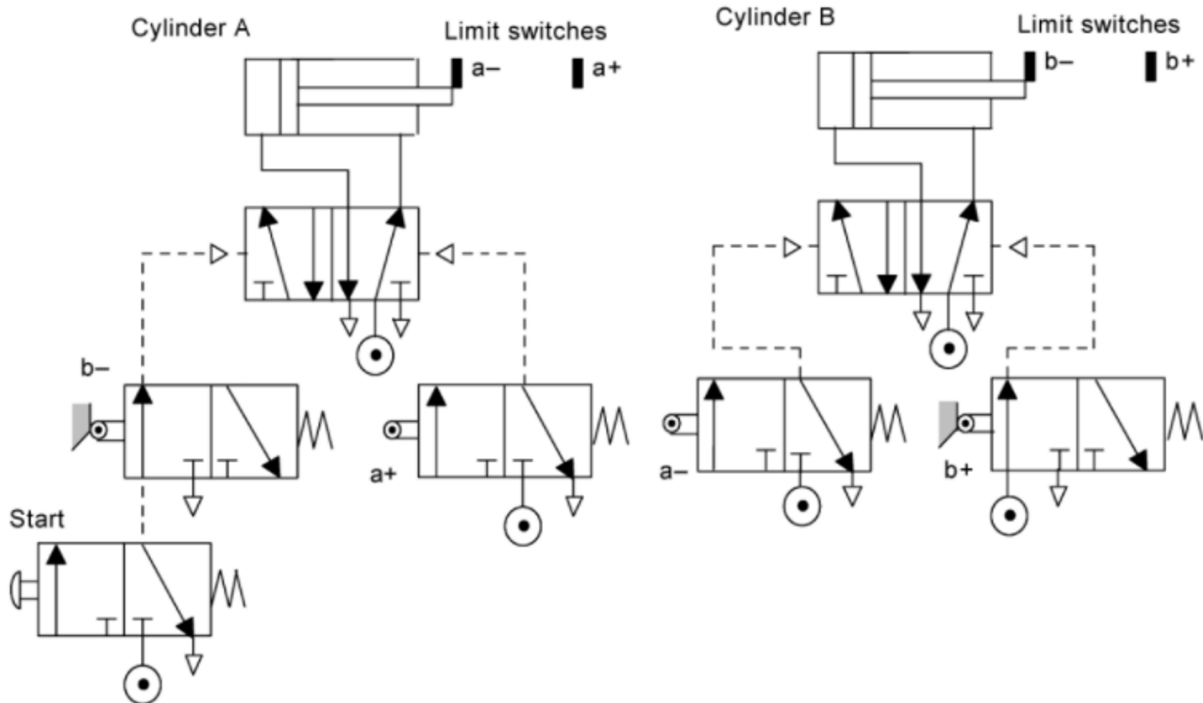


Figure Q3 (b) Two-actuator Sequential Operation

- (c) Using block diagram reduction techniques to analyse a biomechatronic control system shown in Figure Q3(c).

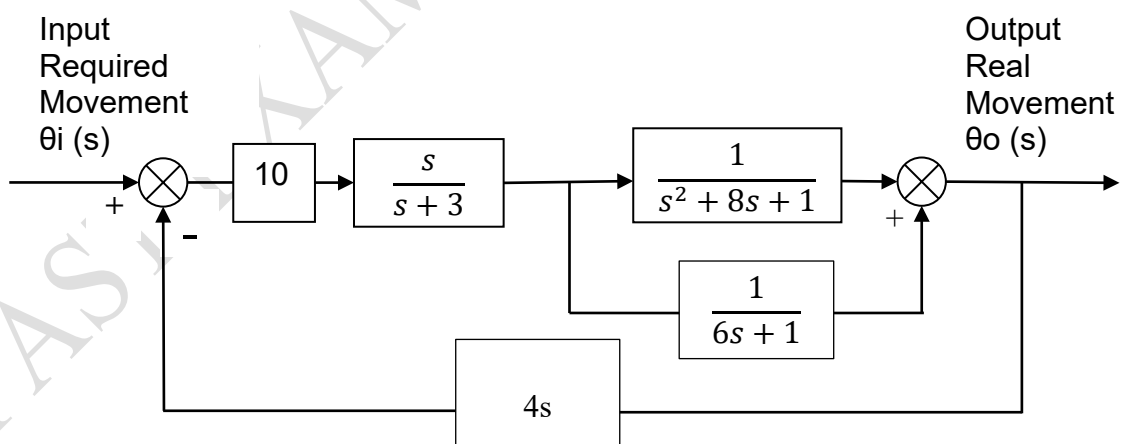


Figure Q3 (c) A biomechatronic control system.

(9 marks)

[Total 25 marks]

END OF SECTION A

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SECTION B – answer any 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. Considering a 54-year-old male patient with 78 kg weight who is an active person please answer the below questions.

- a) Discuss the mechanical properties of Knee joint that need to be considered when selecting the material for total Knee implant. Take into consideration how the Knee joint works and which materials can be used for each part of the total Knee implant.
(10 marks)
- b) Discuss the methods of fixation that can be used for joint implants and suggest the most suitable fixation method for above patient and explain why you think your chosen method is suitable.
(8 marks)
- c) Sometimes an implant can cause a negative tissue response after replacement. Describe the types of responses that can happen from any device implanted into the human body, whether temporary or permanent and estimate the life time of the Knee implant for above patient.
(7 marks)

[Total 25 marks]

Q5

Over 97,000 angioplasty are carried out every year in the UK. It is a common procedure used to open and widen blocked or narrowed coronary arteries. A stent is usually inserted and left in place.

- a) Discuss the materials can be used to make stent and explain how the stent is inserted into the body and what are the main difference between bioresorbable stent and metallic stents.
(10 marks)
- b) Cardiac pacemakers are often used to regulate the heart. Summarise what a pacemaker is and describe different type of pacemakers.
(10 marks)
- c) Explain why biomedical devices need coating? And suggest criteria that need to be considered for coating a hip replacement.
(5 marks)

[Total 25 marks]

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Q6

- a) 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 any disadvantages suggest which machine can be used for a 65-year patient with implanted metal fixture in her left femur.
- i. CT scan (8 marks)
 - ii. MRI (7 marks)
- b) One of the most used devices is ultrasonic. Explain in detail how it can be used in to diagnose and treat patients. (5 marks)
- c) Suggest a type of natural and a type of synthetic hydrogels can be used in tissue engineering and explain which synthesis methods can be used. (5 marks)

[Total 25 marks]

END OF QUESTIONS

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FORMULAE SHEET

Blocks with feedback loop

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

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

END OF PAPER

PAST EXAMINATION PAPER