[ENG21]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG(HONS) BIOMEDICAL ENGINEERING

SEMESTER ONE EXAMINATIONS 2022/2023

BIOMECHATRONICS AND MEDICAL DEVICES

MODULE NO: BME5008

Date: Wednesday 11th January 2023 **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.

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.

Formula sheet follows questions for your reference.

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SECTION A – answer TWO questions from this section

1. (a) Identify, with the examples, how digital technologies make a significant impact on modern biomechatronic systems and devices (four areas with examples).

(13 marks)

(b) Analyse and Discuss two communication technologies are used for biomechatronic devices and systems, which include the following aspects:

- typical application cases
- advantages and challenges
- future developments

(12 marks)

Total 25 marks

2. A brushed DC motor is needed for a medical system. The nominal torque required is 5 mNm at a speed of 3500 rpm. A DC supply voltage of 15V is available. Referring to the SA catalogue, the smallest motor to achieve this power rating is the BR20 series. The 20V version has the closest operating voltage to the 15V available. Some of the motor specifications are reproduced in Table Q2 below

TABLE Q2 SA BR20 Series Motor Catalogue

No-load speed @ 20V n_0 (rpm)	6400
No-load current I_0 (mA)	1.95
The starting current I_a (mA)	189
Terminal resistance R (Ω)	40
Torque constant Km (mNm/A)	38.8
Speed constant Ke (rpm/V)	274
Output power P_0 (W)	4.0
Maximum winding temperature, Tmax (°C)	60
The ambient air temperature T_{amb} (°C)	25
Thermal resistance: housing ambient, R_{th1} (°C/W)	35
Thermal resistance: winding housing, R_{th2} (°C/W)	8.5

QUESTION 2 CONTINUES OVER THE PAGE
Please turn the page…

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QUESTION 2 CONTINUED…

(a) Check if the BR20 motor meets the requirement of the design specifications of the Power and Speed. (10 marks)

(b) Check the efficiency of the motor. (3 marks)

(c) Make comments on the using of brushed DC motor for this application. (4 marks)

(d) Suggest, with reasons, two alternative actuators which can be used for the application. (8 marks)

Total 25 marks

3. (a) Explain the features of pneumatic actuators, analyse why they are preferred in biomedical devices and provide three typical applications. (8 marks)

(b) Design a simple pneumatic lift system by using valves, and explain its operation sequences. (8 marks)

(c) Using block diagram reduction techniques to analyse a prosthetic limb control system shown in Figure Q3(c). (9 marks)

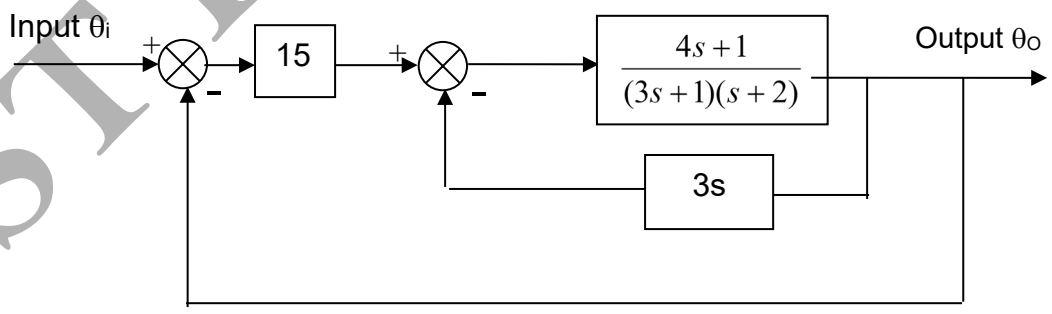

Figure Q3(c) A prosthetic Limb Control System

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

Over 200,000 joint replacement procedures were carried out in the year 2015/2016. The materials used can depend on the requirements of the particular joint.

a) Discuss the materials commonly used for replacement joint implants and the properties of each.

(10 marks)

b) The properties that need to be considered when selecting the correct materials can depend on the mechanical properties of the joint being replaced. Discuss the properties of the following joints which would need to be considered when choosing the correct materials

   i. Knee replacement

   ii. Shoulder replacement

(10 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.

(5 marks)

Total 25 marks

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Q5

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

Q6

a) Smart devices respond to an external stimulus to activate them. Examples of stimuli include pH (chemical) and thermal (physical). Identify three other stimuli that will activate the smart medical device

(5 marks)

b) Cardiac pacemakers are often used to regulate the heart. Summarise what a pacemaker is and describe how it works.

(10 marks)

c) Discuss the important material properties that could have to be considered in the manufacturing of a stent product.

(5 marks)

d) Hydrogels are used in many different healthcare applications including medical devices. Compare the properties of natural versus synthetic hydrogels giving advantages and disadvantages of both.

(5 marks)

Total 25 marks

END OF QUESTIONS

Please turn the page for formulae sheet and valve symbols

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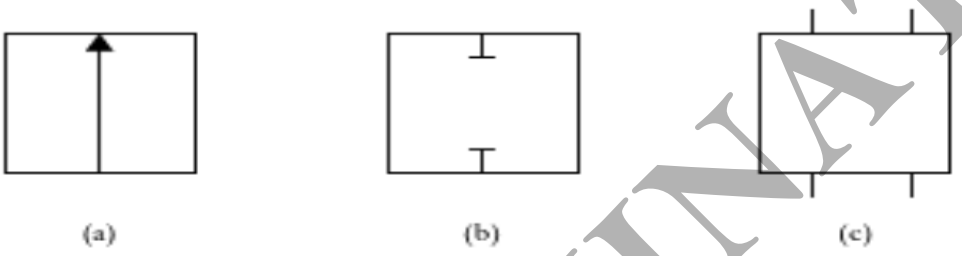
FORMULAE SHEET

Blocks with feedback loop

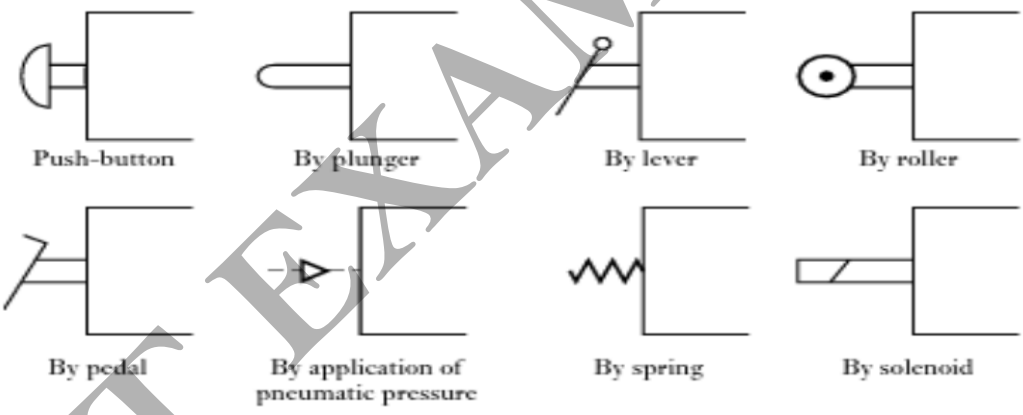
G(s) = $\frac{Go(s)}{1+Go(s)H(s)}$ (for a negative feedback)

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

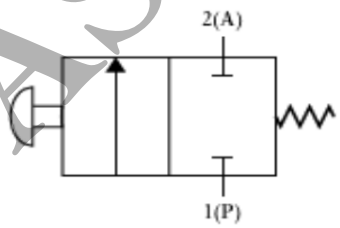
VALVE SYMBOLS



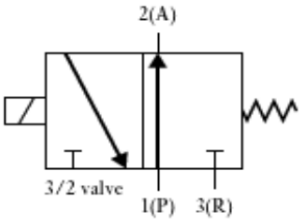
(a) Flow Path (b) Flow Shut-Off (c) Initial Connection



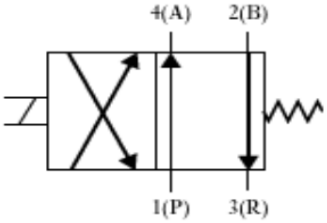
Valve Actuation Symbols



Two-Port, Two-Position Poppet Valve 2/2



Three-Port, Two-Position Poppet Valve 3/2



Four-Port, Two-Position Poppet Valve 4/2

END OF PAPER