

[ESS20]

UNIVERSITY OF BOLTON
SCHOOL OF ENGINEERING
BENG (HONS) IN BIOMEDICAL ENGINEERING
SEMESTER ONE EXAMINATION 2019/2020
BIOMECHATRONICS AND MEDICAL DEVICES
MODULE NO: BME5008

Date: Monday 13 January 2020

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 Sheet (attached)
Non-programmable calculator

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SECTION A – answer ANY TWO questions from this section

Q1

(a) Using simple sketches briefly describe and explain the following data communication techniques for biomechatronics system control, and give ONE application example for each technique below:

- Serial data communication
- Parallel data communication
- USB
- Bluetooth
- Wi-Fi

(20 marks)

(b) Explain why data communication technology plays an important part in field of biomechatronic systems. **(5 marks)**

Total 25 marks

Q2

A brushed DC motor is used to drive an air pump. The nominal torque required is 2.5 mNm at a speed of 5000 rpm. A DC supply voltage of 12 V is available. Referring to the MS catalogue, the smallest motor to achieve this power rating is the TR 16 series the 16 V version has the closest operating voltage to the 12 V available. Some of the motor specifications are reproduced in Table Q2 below.

TABLE Q2 MS TR 16 Series Motor Specifications

| | |
|--|------|
| No-load speed @ 16 V n_0 (rpm) | 8000 |
| No-load current I_0 (mA) | 2 |
| The starting current I_a (mA) | 240 |
| Terminal resistance R (Ω) | 40 |
| Torque constant K_m (mNm/A) | 25 |
| Speed constant K_e (rpm/V) | 300 |
| Output power P_o (W) | 3.0 |
| Maximum winding temperature, T_{max} ($^{\circ}\text{C}$) | 70 |
| The ambient air temperature T_{amb} ($^{\circ}\text{C}$) | 20 |
| Thermal resistance: housing ambient, R_{th1} ($^{\circ}\text{C}/\text{W}$) | 30 |
| Thermal resistance: winding housing, R_{th2} ($^{\circ}\text{C}/\text{W}$) | 8 |

Q2 continues over the page....

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Q2 continued....

- (a) Check if the TR 16 motor meets the requirement of the design specifications of the Power and Speed. **(12 marks)**
- (b) Check whether the motor will be able to accommodate the heat rise in the coils. **(5 marks)**
- (c) Check the efficiency of the motor. **(3 marks)**
- (d) Make comments on the using of brushed DC motor for this application. **(5 marks)**

Total 25 marks**Q3**

- a) A prosthetic limb control system can be represented by the block diagram shown in Figure Q3(a). Using block diagram reduction techniques, find the θ_o for this control system.

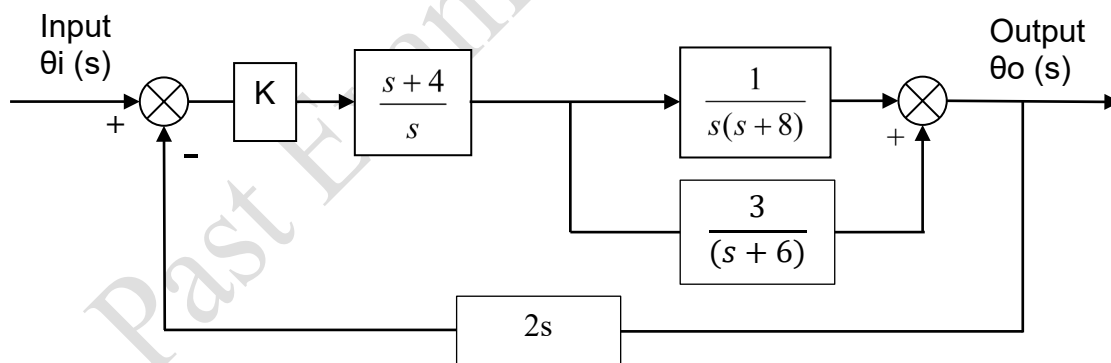


Figure Q3 (a) A prosthetic limb control system. Where $\theta_i(s)$ is an input, and $\theta_o(s)$ is the output.

(10marks)**Q3 continues over the page....****PLEASE TURN THE PAGE....**

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Q3 continued....

(b) Explain and identify following three actuation systems and their features.
Specify three applications in biomechatronic systems from each of them:

- i) Mechanical actuation system
- ii) Hydraulic actuation system
- iii) Pneumatic actuation system

(15 marks)

Total 25 marks

END OF SECTION A

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.

a) 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)

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

(5 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)

d) Outline five potential applications of hydrogels.

(5 marks)

Total 25 marks

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Q5

Over 97,000 Percutaneous Coronary Interventions (previously called 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.

(10 marks)

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

(10 marks)

- c) Explain why biomedical devices need coating?

(5 marks)

Total 25 marks

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 also any disadvantages.

- i. X ray /CT scan

(8 marks)

- ii. Ultrasound

(7 marks)

- b) One of the most commonly used devices is an endoscopy. Explain in detail how an endoscope works and how it can be used in three different ways to diagnose and treat patients.

(10 marks)

Total 25 marks

END OF QUESTIONS

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Blocks with feedback loop

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

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

Motor Selection

$$I = \frac{T}{Km} + I_0$$

$$n = n_{\text{volt}} - IRK_e$$

$$P_{\text{dis}} = I^2R$$

$$\Delta T_{\text{emp}} = P_{\text{dis}}(R_{\text{th1}} + R_{\text{th2}})$$

$$T_{\text{emp/motor}} = T_{\text{emp/amb}} + \Delta T_{\text{emp}}$$

END OF FORMULAE SHEETS