Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2020
Department of Biomedical Engineering

BME 3231
Biomedical Devices and Control

Time:1 Hour 30 Minutes **Full Marks: 120**

N.B. i) Answer **ANY TWO** questions from each section in separate script.
ii) Figures in the right margin indicate full marks.

Section A

(Answer **ANY TWO** questions from this section in Script A)

1. a) Give examples of homeostatic control system in the human body. (10)

b) Find the transfer function, $G(s) = V_0(s)/V_i(s)$, for each circuit shown in figure Q1.b(i) and Q1.b(ii). (10)

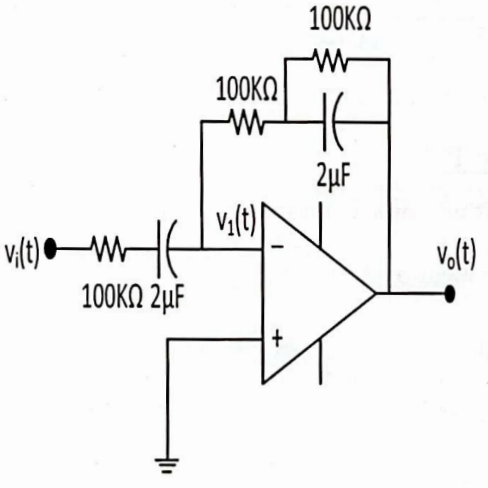

Figure Q1.b(i)

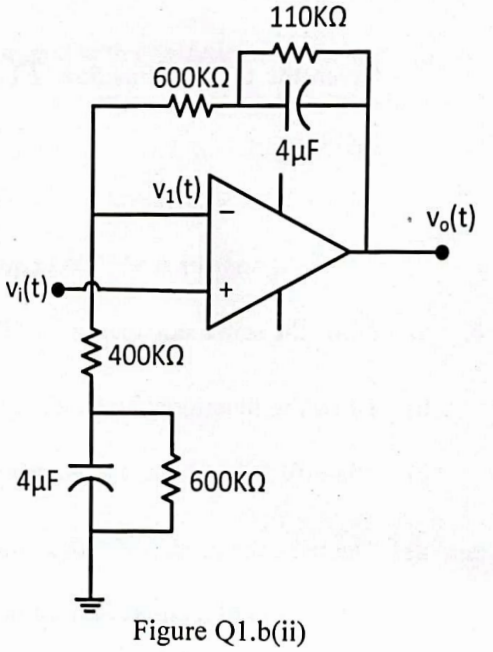

Figure Q1.b(ii)

c) Describe the working principles of (10)
(i) Ultrasonic type spirometer
(ii) Turbine type spirometer.

2. a) Sketch the root locus and its asymptotes for a unity feedback system that has the forward transfer function: (12)

$$G(s) = \frac{k}{(s+2)(s+4)(s+6)}$$

What are the effects of adding open loop poles and zeros on Root Locus?

b) Briefly discuss three-elements Hill model of muscle contraction. (10)

c) What is meant by compensator? How can you improve steady state error and transient response of an existing plant? Explain. (08)

3. a) Write short notes on: (06)

(i) Contour

(ii) Phase Margin

(iii) Gain Stability Margin.

b) Deduce the differential equation of linearized model of lung mechanics. (12)

c) Given the transfer function $T(s) = \frac{0.04}{s^2+0.02s+0.04}$ find $\zeta, \omega_n, T_s, T_p$ and %OS. (12)

Section B

(Answer **ANY TWO** questions from this section in Script B)

4. a) Draw the schematic diagram of DMS and mention each module of it. (10)

b) Draw the functional block diagram of ESU, explain them in briefly. (12)

c) Classify JCU. Explain them briefly. (08)

5. a) Describe the modes of shock wave generation. (10)

b) Why the gold membrane used in microchip for drug delivery system? (05)

c) What is Cardiotocography (CTG)? Describe the operational block diagram of CTG. (15)

6. a) Describe the Transracial Magnetic Stimulation operation. (10)

b) How do we assess BMD for osteoporosis? (10)

c) Write the operations of Deep Brain Simulation device. (10)

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BME 3213
Biomechanics

Time:1 Hour 30 Minutes **Full Marks: 120**

N.B. i) Answer **ANY TWO** questions from each section in separate script.
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Section A

(Answer **ANY TWO** questions from this section in Script A)

1. a) What are the anatomical reference planes? Briefly explain the ways of muscle force production with necessary diagram. (10)

   b) Briefly explain the effects of repetitive and acute loading on biological tissues with the necessary diagram. (08)

   c) The pointer in figure Q1(c) consists of a rod equipped with two reflective markers A and B. The locations of the two reflective markers are provided by a camera-based motion capture system. Given marker locations A = (629,-35,190)mm and B = (669,191,120)mm, determine the location of the pointer tip, T, if marker B is a fixed distance, D, of 127mm from the pointer tip. (12)

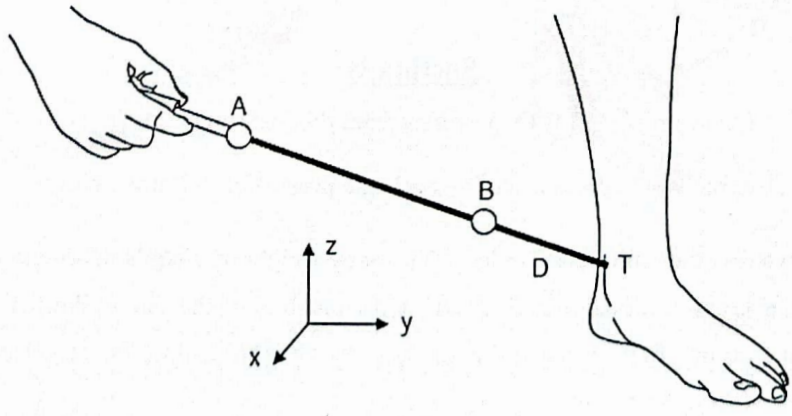

Figure Q1(c)

2. a) What is gait cycle? What are the main phases of gait cycle? Write the name of the subdivision of these phases. (10)

   b) Explain the mechanism of muscle contraction with the necessary diagram. (10)

c) Given the following 3 dimensional locations in meters for a set of pelvic markers expressed related to an initially fixed laboratory coordinate system. (10)

$$\text{Right ASIS: RASIS} = -0.85\hat{i} - 0.802\hat{j} + 0.652\hat{k}$$

$$\text{Left ASIS: LASIS} = -0.751\hat{i} - 0.831\hat{j} + 0.686\hat{k}$$

$$\text{Posterior SIS: PSIS} = -1.075\hat{i} - 0.656\hat{j} + 0.676\hat{k}$$

Compute an anatomical coordinate system for the pelvis.

3. a) What are the difference between cartilage, ligament and tendon? Explain the stress-strain curve of tendon and ligament with proper diagram. (12)

b) A person weighing 170lb has a thigh length of 15inches, find the moment of inertia of these body segment with respect to its center of mass in SI units. Given, the segment of thigh is 15% of total body weight. The proximal radius of gyration of thigh is 58% of the length of the segment of thigh and the proximal center of mass of thigh is 47.7% of the length of segment of thigh. (12)

c) The tibia is the major weight-bearing bone in the lower extremity. If 82% of body mass is proximal to the knee joint, how much compressive force acts on each tibia when a 600N person stands in anatomical position? How much compressive force acts on each tibia if the person holds a 20N sack of groceries? (06)

Section B

(Answer **ANY TWO** questions from this section in Script B)

4. a) Briefly describe any two models of viscoelastic properties of human bone. (12)

b) With no stress the femur is 0.5m long. The body weight of 70kg is distributed over the femur cross-sectional area 370mm^2. How much does the femur shorten when you stand on one foot? What is the strain at the UCS (assuming linear behavior)? Where Y=179 x 10^2 N/mm^2. (10)

c) As a biomedical engineer you have been assigned to design a replacement for a femur (Which consists of compact and trabecular bone). What materials would you use? (Would you want to use materials that match the properties of bones? Why?) (08)

5. a) What is meant by bone fracture? Explain different types of bone fractures resulting from different types of loading. (09)

b) Write down the differences between tendon and ligament. (06)

c) A 240kg cylinder is hung by means of two cables AB and AC which are attached to the top of a vertical wall. A horizontal force P perpendicular to the wall holds the cylinder in the position shown. Determine the magnitude of P and the tension in each cable. (15)

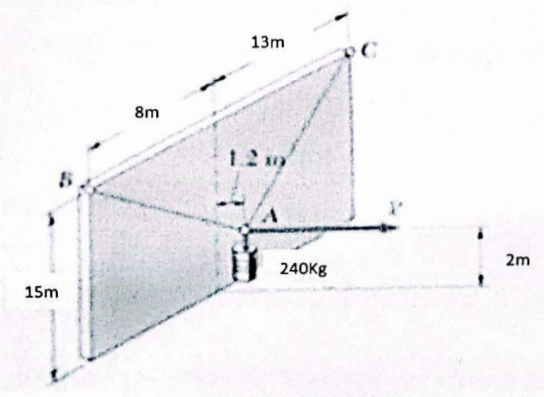

Figure: Q.5(c)

6. a) A cylindrical pressure vessel is fabricated from steel plating that has a thickness of 20mm. The diameter of the pressure vessel is 450mm and its length is 3.0m determine the maximum internal pressure that can be applied if the longitudinal stress is limited to 145mPa, and the circumferential stress is limited to 67mPa. (15)

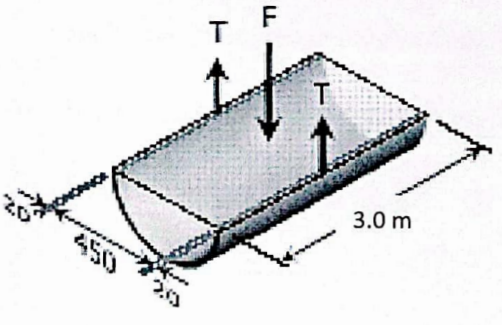

Figure: Q.6(a-i)

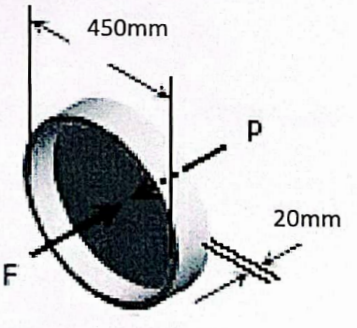

Figure: Q.6(a-ii)

b) A homogenous bar with a cross section area of 560mm^2 is attached to rigid supports. It carries the axial loads P_1= 25 KN and P_2= 50 KN, applied as shown in figure Q6(b). Determine the stress in segment BC. (15)

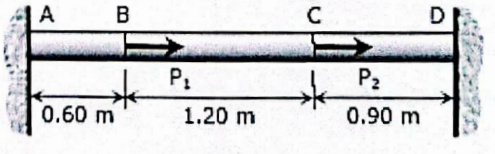

Figure Q6(b)

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BME 3241

Magnetic and Nuclear Imaging

Time:1 Hour 30 Minutes **Full Marks: 120**

N.B. i) Answer **ANY TWO** questions from each section in separate script.
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Section A

(Answer **ANY TWO** questions from this section in Script A)

1. a) What is MRI? What are the characteristics of nuclei that can be used for MRI? (08)

b) What is Larmor frequency or precession frequency? How it relates with external magnetic field strength? (06)

c) Draw and explain the microscopic and macroscopic scenario of a collection of protons in the presence of an external magnetic field. (08)

d) Briefly explain the concept of magnetic resonance in MRI? (08)

2. a) What is relaxation in MRI? Why T1 and T2 relaxation are also known as spin-lattice and spin-spin relaxation respectively? (09)

b) Briefly explain the manufacturing process of super conductive electromagnet. (07)

c) What is shim coil? Why do we need this in magnet system? (05)

d) What is slice selection gradient? Explain the slice selection process. (09)

3. a) What is meant by spatial resolution of MRI? What are the relationship among spatial resolution, field of view and voxel size? (08)

b) What is pulse sequence? Briefly describe the spin echo and gradient echo pulse sequences. (10)

c) What is meant by BOLD effect in fMRI? Write down applications, advantages and disadvantages of fMRI. (12)

Section B

(Answer **ANY TWO** questions from this section in Script B)

4. a) Sketch the electromagnetic spectrum and indicate the NMR, X-Ray and Gama-Ray window. (05)

b) How Gamma ray interact with Matter? Briefly describe the interaction of gamma rays that are important in nuclear medicine. (10)

c) Briefly describe the relations of the attenuation of an absorber with atomic number, density and thickness. (15)

5. a) Describe the principle of radionuclide generator. (13)

b) Describe the operating principle of a gas filled radiation detector. (12)

c) A gas filled detector with capacitance of 100pF required 30 eV to produce one pair ion. Determine the voltage generated interaction with a beta particle of 2.0 MeV. (05)

6. a) Briefly describe the applications, benefits and limitations of PET scan. (10)

b) Briefly describe thyroid function test. (12)

c) Briefly describe the molecular effect of radioactivity and how molecular oxygen influence it. (08)

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BME 3211
Biomaterials and prosthetics

Time:1 Hour 30 Minutes **Full Marks: 120**

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Section A

(Answer **ANY TWO** questions from this section in Script A)

1. a) What is meant by biocompatibility? (02)

b) You have been asked to examine a broken bone plate and determine the reason for failure. If the surface shows a wave-like, what kind of failure would you suspect? Explain the reason of failure with necessary figures? (14)

c) If you have to produce an artificial artery, what are the essential properties will you incorporate in your design? Which type of material would you first consider? Why? (14)

2. a) Classify stainless steel based on microstructure. Which type of stainless steel is mostly used in biomedical implants and why? Give an example. (08)

b) Briefly explain the investment casting with necessary diagrams. (12)

c) Write down some applications of PSZ. (05)

d) Give a short note on: Silicate glass. (05)

3. a) Briefly describe the factors influencing degradation of calcium phosphates. (13)

b) How can we improve the mechanical properties and hardness of silicones? (06)

c) Briefly discuss stimuli-responsive hydrogels with example. (11)

Section B

(Answer **ANY TWO** questions from this section in Script B)

4. a) Enumerate at least five disinfection and sterilization methods of biomaterials. Describe three of them with an example of each method. (06)

b) Why Bileaflet Heart valve is advantageous over caged-ball and tilting disc implants? Describe the common problems with mechanical heart valves. (10)

c) What is VAD? As a Biomedical Engineer which category of artificial circulatory support would you suggest to a patient with advanced stages of cardiomyopathy? Justify your answer. (07)

d) Why polymeric biomaterials are used to construct synthetic graft? Explain the reason for preferring balloon-expandable stents over self-expanding stents in some cases. (07)

5. a) Classify impression materials and enumerate a casting technique for dental restorations. (10)

b) What are the basic differences between transcutaneous and transvenous pacemaker? Explain the requirement and working principle of a rate responsive pacemaker. (10)

c) What is VV-ECMO? What are the basic components of ECMO circuit? Write down the working principle of oxygenator unit in ECMO circuit with proper diagram. (10)

6. a) What is artificial blood? What are the characteristics of PFC? Write down the production process of hemoglobin based blood substitutes. (10)

b) What is artificial skin? What are the design considerations of artificial skin? Enumerate at least six biomaterials used for total joint replacement and mention the application and properties of each biomaterial. (10)

c) Explain the purification process of blood in extracorporeal artificial kidney with required block diagram. (10)