Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2019
Department of Biomedical Engineering

BME 3211

Biomaterials and Prosthetics

Time: 3 hours **Full Marks: 210**

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

Section A

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

1. a) Define Biotolerant materials. Briefly describe properties of auxetic materials. (09)

   b) Write some disadvantages of ceramics, polymers and metals. (11)

   c) Define fatigue life. Briefly explain stages of fatigue fracture with diagrams. (10)

   d) Write a short note on shot peening. (05)

2. a) State the mechanism of pitting corrosion of metal with diagram. (12)

   b) Classify Ti-alloy and explain each type in brief. Write down surface properties of Ti-alloy. (13)

   c) What is offset yield point? Describe strain hardening process of a ductile metal while applied stress. (10)

3. a) Explain stimuli responsiveness of hydrogels with examples. (10)

   b) Briefly describe commercial production process of alumina. (12)

   c) Briefly describe physical properties of hydroxyapatite that affect its solubility. Write down applications of HA. (13)

4. a) Write down the chemical formula of PMMA. Briefly describe the composition of commercial bone cement kit. (15)

   b) Briefly explain the factors affecting glass transition temperature of polymers. (10)

   c) Explain the working principle of nitinol self-expanding vascular stents. (10)

Section B

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

5. a) What is biomaterials? What features a biomaterial should have? What is the difference between prosthetics and orthotics? (08)

   b) What is meant by fracture fixation? Differentiate the cemented and cementless fracture fixation. What materials are used to make different components of total hip joint replacement? (11)

   c) Write some applications of biomaterials in prosthetics and artificial organs. (08)

   d) Write some cardiovascular system replacement devices. What are the characteristics of artificial tissue heart valve? (08)

6. a) What are the characteristics of artificial blood? (07)

   b) Describe the mechanism of urine filtration through an implantable artificial kidney. What are the materials needed to make different parts of implantable artificial kidney? (13)

   c) What design principle should be followed for making implantable devices and systems by a biomedical engineer? What are the potential clinical applications of blood substitutes? (09)

   d) Write down the properties of mechanical heart valve. (06)

7. a) A force of 20 kN is acting on the circular shaped ulna with diameter 10 mm. How much stress is applied on ulna on that time? After sometimes, it is noticed that the ulnar bone is fractured and under microscopic vision, V-shaped chevron is observed, what types of fracture occurred on ulna? Justify your answer. (10)

   b) What is perfluorocarbon? Write down the production process of PFC. What are the characteristics of PFC? (10)

   c) What is fracture? How many fracture modes are observed in a bone? Write some characteristics of ductile fracture. (10)

   d) List the differences between creep and stress relaxation. (05)

8. a) What is kidney project? What are the proposed solutions of kidney failure? (08)

   b) What materials are used to make a ventricular assistive device? Explain the mechanism of blood flow inside a VAD. (15)

   c) Compare between the PA-PA and PA-LA attachment of thoracic artificial lung. What are the disadvantages of series attachment of a thoracic artificial lung? (12)

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BME 3213

Biomechanics

Time: 3 hours **Full Marks: 210**

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

Section A

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

1. a) A model of the proposed hull is placed in a test channel and three cables are used to keep its bow on the centerline of the channel as shown in Fig. 1 (a). Dynamometer readings indicate that for a given speed, the tension is 40N in cable AB and 60N in cable AE. Determine the drag force exerted on the hull and the tension in cable AC. (15)

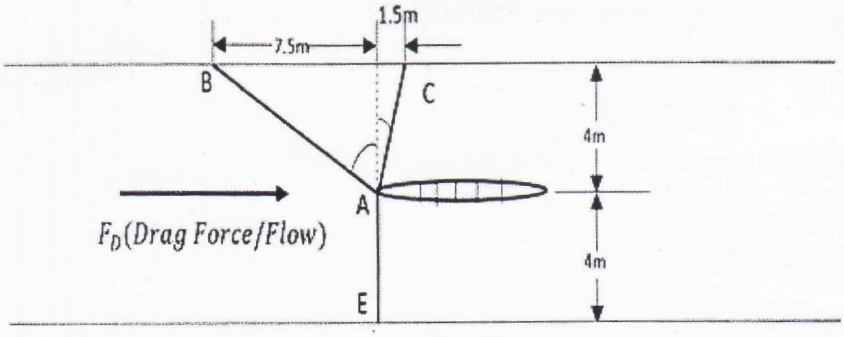

Fig. 1(a)

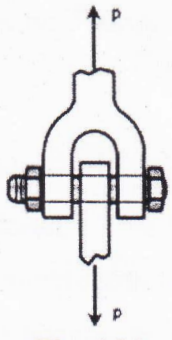

Fig. 1(b)

b) In the clevis shown in the above Fig. 1 (b), find the minimum bolt diameter and minimum thickness of each yoke that will support a load P = 14KN without exceeding a shearing stress of 12MPa and bearing stress of 20MPa. (13)

c) Write down design criteria of bone. (07)

2. a) Show that the tangential stress in a thin walled cylindrical shell of diameter, D and wall thickness, t subjected to internal pressure P is given by $\sigma_t = \frac{PD}{2t}$. (15)

b) A bronze bar is fastened between a steel bar and an aluminum bar as shown in the Fig. 2 (b). Axial loads are applied at the positions indicated. Find the largest value of P that will not exceed an overall deformation of 3.0 mm, or the following stresses: 140 MPa in the steel, 120 MPa in the bronze and 80 MPa in the aluminum. Assume that assembly is suitably braced to prevent buckling. Use E_{St} = 200 GPa, E_{Al} = 70 GPa, and E_{Br} = 83 GPa. (20)

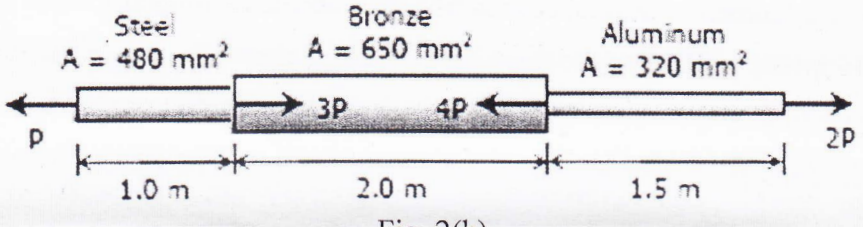

Fig. 2(b)

3. a) A rigid block of mass M is supported by three symmetrically spaced rods as shown in Fig. 3 (a). Each copper rod has an area of 900 mm^2; E = 120 Gpa; and the allowable stress is 70 MPa. The steel rod has an area of 1200 mm^2; E = 200 GPa; and the allowable stress is 140 MPa. Determine the largest mass M which can be supported.

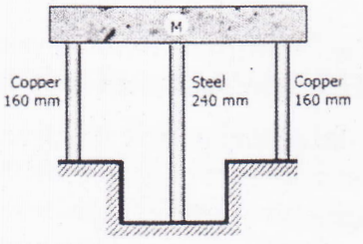

Fig. 3(a)

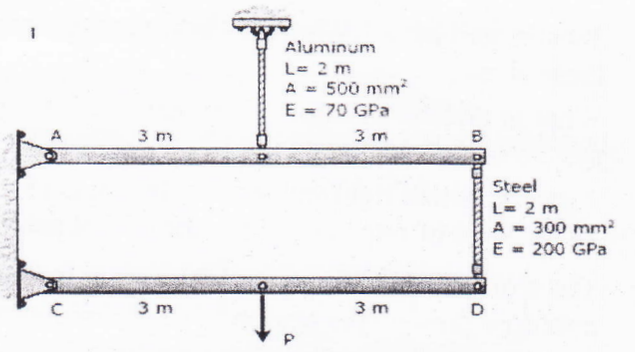

Fig. 3(b)

b) The rigid bars AB and CD shown in the above Fig. 3(b) are supported by pins at A and C and the two rods. Determine the maximum force P that can be applied as shown if its vertical movement is limited to 5 mm. Neglect the weight of all members.

4. a) During a rough hockey game, an athlete is slashed in the tibia, creating a 0.01mm defect as shown in Fig. 4 (a-1). He plans to run a marathon tomorrow. Stress distribution during running upon tibia is shown in Fig. 4 (a-2). Critical stress intensity factor of cortical bone is $K_C = 2.2 - 6.3\, MN/m^{3/2}$. Cortical bone constants are $C = 2.5 \times 10^{-6}$ m $(MN/m^{3/2})^{-2.5}$, m = 2.5. If each stride length is 2m, determine steps required to cause a tibia fracture during marathon. (18)

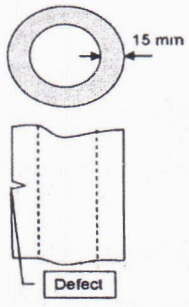

Fig. 4(a -1)

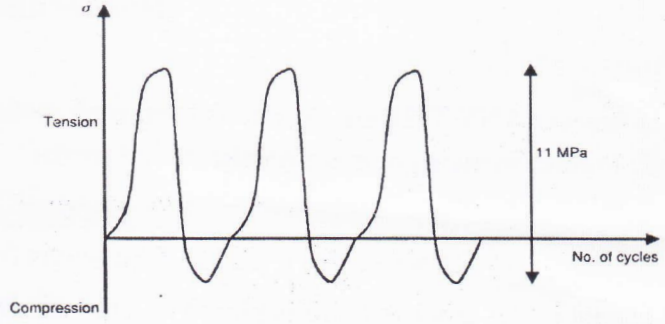

Fig. 4(a -2)

b) Explain ductile/brittle transition of bone depending on strain rate during fast fracture. (10)

c) Write down biomechanical differences between tendon and ligament. (07)

Section B

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

5. a) What are the functions of tendon and ligament? (07)

b) Show stress-strain relationship of skin. (08)

c) What is skeletal joint? Write down some name of synovial joints. For a rectangular bone plate attached with muscle shown in Fig. 5 (c), find the resulting moment of the forces acting about the corner marked 0. (13)

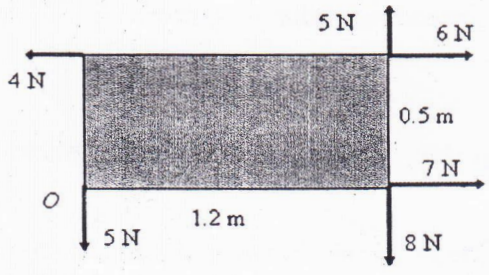

Fig. 5 (c)

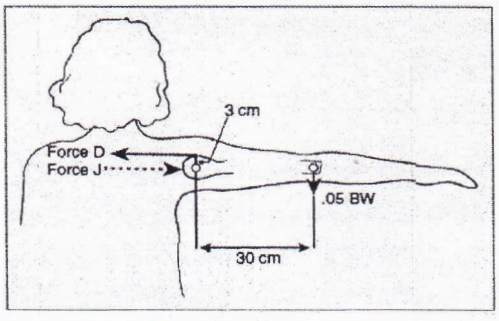

Fig. 8 (d)

d) Describe the load-elongation curve of tendon. (07)

6. a) Explain the mechanism of muscle contraction with necessary diagram. (16)

b) What is goniometer? What are the function of skeletal muscle? (08)

c) Why we need a hand dynamometer? What are the criteria used in recording muscle strength? (11)

7. a) What is active and passive tension muscle? Describe a model of muscle. (10)

b) A person weighing 150 lb has a thigh length of 17 inches. Find the moment of inertia of this body segment with respect to its center of mass in SI unit. Assume the segment of thigh is 0.100 of total body weight. The proximal radius of gyration of thigh is 0.540 of the length of the segment of thigh. And the proximal center of mass of thigh is 0.433 of the length of the segment of thigh. (18)

c) What is ergonomics? Why ergonomics is important? (07)

8. a) What is gait cycle? What are the major phases of gait cycle? Write the name of the subdivision of these phases. (07)

b) What is pedobarograph? Write down the main requirements of implemented sensors in in-shoe system of pedobarograph. (10)

c) A patient whose right and left step length is 18 inches and 20 inches respectively. A physician counts 20 numbers of steps in one minute of that patient. What was the speed of patient in SI unit? (09)

d) The arm is in 90° of abduction, and it is assumed that only the deltoid muscle is active. The force produced through the tendon of the deltoid muscle (D) acts at a distance of 3 cm from the center of rotation of the joint. The force produced by the weight of the arm is estimated to be 0.05 time of body weight (BW) and acts at a distance of 30 cm from the center of rotation. Determine the value for D when a weight equal to 0.025 times of body weight is held in the hand with the arm in 90° of abduction shown in the above Fig. 8 (d). (09)

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BME 3231
Biomedical Devices and Control

Time: 3 hours **Full Marks: 210**

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

Section A

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

1. a) Define MVV, PEFR. (04)

b) What is meant by feedback? Give examples of positive and negative feedback system in human body. (12)

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

d) Describe the working principles of bellows type spirometer. And hence what are the limitations of this type? (07)

2. a) Define natural frequency, damping ratio. (04)

b) What is meant by transfer function of a system? Find the transfer function of human leg between output angular rotation about hip joint and input torque supplied by the leg muscle. (15)

c) What is necessary condition for stability, instability and marginal stability of a system? (06)

d) What is meant by linearization of system dynamics? Give an example. (10)

3. a) Find the number of poles in the left half-plane, the right half-plane, and on the $j\omega$-axis for the system of Fig. 3(a). Draw conclusions about the stability of the closed-loop system. (15)

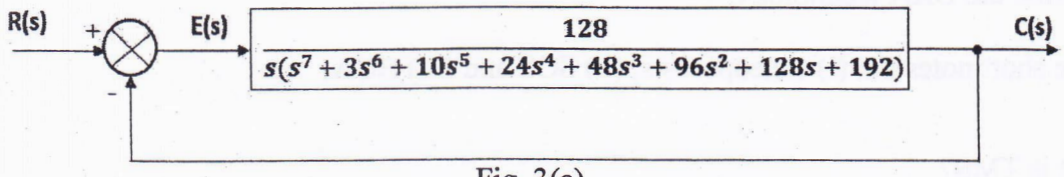

Fig. 3(a)

b) For system of Fig. 3(b), evaluate the static error constants and find the expected error for the standard step, ramp and parabolic inputs. (12)

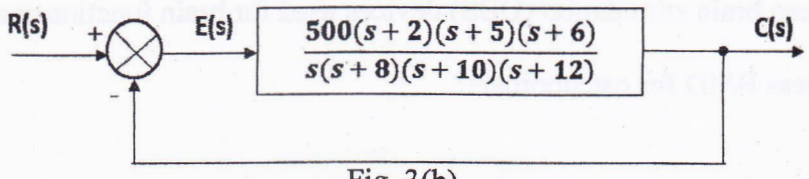

Fig. 3(b)

c) Briefly state the Nyquist criterion. (08)

4. a) Elaborate design steps for PID controller. (10)

b) Implement a PID controller through an electric device, the transfer function of the PID controller is (10)

$$G_{PID} = \frac{(s + 60.92)(s + 0.5)}{s}$$

c) Describe second order underdamped response specifications. (10)

d) What is K in control system? (05)

Section B

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

5. a) What is surgical diathermy? Described the surgical tissue effect on electrosurgical machine. (13)

b) Draw the schematic diagram of PMS and mentions each module of it. (07)

c) What are the operating frequencies and watt used in ESU? (05)

d) Draw the functional block diagram of ESU. Explain them. (10)

6. a) What is shock wave? What are the characteristics of shock wave (SW)? (10)

b) Describe the operations of stone fragmentation by SW. (13)

c) Discuss the Electrohydraulic Lithotripter machine (12)

7. a) What is short-wave diathermy? (06)

b) Describe the circuit operations of short-wave diathermy unit with necessary diagram. (10)

c) Describe the DXA technology. (10)

d) Write short notes on: (i) Osteoporosis; (ii) SOS and (iii) BUA. (09)

8. a) What is TMS? (05)

b) Discuss about the TMS-EEG working principle in brief. (13)

c) Describe the deep brain stimulation (DBS) devices used for brain function analysis. (10)

d) How do we assess BMD for osteoporosis? (07)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2019
Department of Biomedical Engineering
BME 3241
Magnetic and Nuclear Imaging

Time: 3 hours **Full Marks: 210**

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

Section A

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

1. a) What is MRI? Explain intrinsic spin angular momentum. (07)
   b) What is magnetic domain? "Production of net magnetization of human body is zero in general state". Justify this statement. (09)
   c) What is net magnetization M_0 in MRI? Illustrate the microscopic and macroscopic scenario of a collection of protons in the presence of an external magnetic field. (11)
   d) Briefly explain the concept of magnetic resonance in MRI? (08)

2. a) What is laboratory frame and rotating frame? (05)
   b) What happens after turn off the excitation? Explain. How we can record MRI signal from human body after turn off the excitation? (12)
   c) What is meant by relaxation in MRI? Briefly discuss about T1 and T2 relaxation process. Why T1 and T2 relaxation are also known as spin-lattice and spin-spin relaxation respectively? (10)
   d) What is the condition for saturation that result no relaxation? Briefly explain your justification. Why T2 relaxation process is irreversible? (08)

3. a) What is gradient field? Why we need this field in MRI? (07)
   b) What is readout gradient? Explain the readout process. (08)
   c) What is shim coil? Why we need this in magnet system? (06)
   d) Briefly describes about the components of radio frequency (rf) transmitter. (09)
   e) What happens if we avoid phase encoding step in MRI? (05)

4. a) What is meant by spatial resolution of MRI? How can we improve spatial resolution of MRI? (07)
   b) What is image contrast of MRI? Write short notes on: (10)
      i) T1-weighted imaging
      ii) T2- weighted imaging
      iii) PD- weighted imaging
   c) What is meant by BOLD effect in fMRI? Write down applications, advantages and disadvantages of fMRI. (10)
   d) Briefly explain the biological effects of static magnetic field in MRI. (08)

Section B

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

5. a) What is radioactivity and radioactive decay? Briefly describe the different radioactive decay processes with suitable examples. (12)

   b) Derive the expression for the radioactive decay and hence define the radioactive decay law. Graphically represent the typical decay pattern and influence of decay constant of radioactive decay? (12)

   c) What is absorbed dose? Define the SI and traditional units of absorbed dose. (06)

   d) How gamma ray is generated? What is the basic difference of gamma ray and X- ray? (05)

6. a) How gamma ray interact with matter? Briefly describe the interaction of gamma rays that are important in nuclear medicine. (12)

   b) A 10^5 MBq source of ^{137}Cs is to be contained in a Pb box so that the exposure rate 1m away from the source is less than 0.5 mR/hour. If the half value layer for ^{137}Cs gamma rays in Pb is 0.6 cm, what thickness of Pb is required? The specific gamma ray constant for ^{137}Cs is 3.3 R $hr^{-1}mCi^{-1}$ at 1 cm. (08)

   c) Describe the working principles of ^{99}Mo-^{99m}Tc generators. Demonstrate the quality control of ^{99m}Tc eluate. (15)

7. a) What is radiation detector? Describe the operating principle of a gas filled radiation detector. (10)

   b) 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. (06)

   c) Write short notes on: (08)
      i) Dose calibrator
      ii) Geiger-Muller Counters

   d) What is gamma camera? Briefly describe the working principle of a gamma camera. (11)

8. a) What is Positron Emission Tomography (PET)? Briefly describe the methodology of Positron Emission Tomography. (10)

   b) What are the generally used Nuclear medicine blood volume studies? Briefly describe the blood volume analysis (BVA) procedure. (10)

   c) How radiation damage occurs in molecular level? Briefly describe the role of oxygen in radiation damage. (06)

   d) Write short notes on: (09)
      i) Equivalent dose
      ii) Effective dose
      iii) Committed dose

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ECE 3215
Body Sensor Networks

Time: 3 hours **Full Marks: 210**

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

Section A

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

1. a) Define Body Area Network. Write down the main research area of BSN with appropriate figure. (08)

   b) Let, the crossover distance is 40m, $E_c = 50nj/bit$, $e_1 = 25\,pj/bit$ and $e_2 = 0.0013\,pj/bit$. Calculate the total energy required from source to destination of Fig. 1(b). Also, calculate the number of bits received in the sink node. (12)

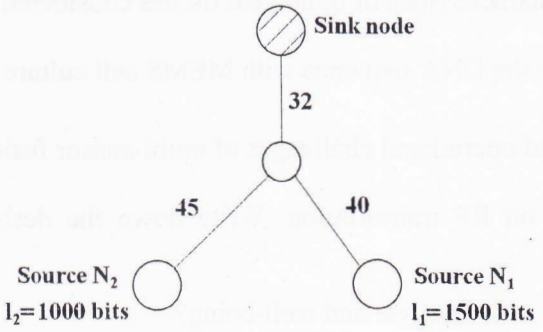

Fig. 1(b)

   c) Write down the factors that inhibit growth in the medical device wearable market. (08)

   d) Draw the figure of design process of medical device. (07)

2. a) Classify the medical devices according to risk factors. (05)

   b) What are the problems in traditional electrode technology? How it can be solved? (07)

   c) Explain the three-way tradeoff between compression achieved (c), the compression block power consumption (P_{comp}) and the device operating lifetime (T) with proper equation. (12)

   d) Classify bio-sensing technique in brief. What are the elements of a biosensor? (11)

3. a) What is pervasive computing? What are the challenges of pervasive computing? (12)

   b) Write down the advantages and drawback of multi-hop networks. (08)

   c) Explain network lifetime. How we can deploy sensor network? (08)

   d) Write short notes on application layer and physical layer of an OSI model. (07)

4. a) How do you improve healthcare system integration? What are the key features for healthcare system integration? (13)

b) Explain the fundamental architecture of a GSM system. (10)

c) Describe wireless regulatory environment with proper diagram. (12)

Section B

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

5. a) Explain the necessity of body sensor network in the field of biomedical engineering. (10)

b) Draw the block diagram of IBC transceiver. Explain the key factors for designing IBC transceiver. (14)

c) Show and explain the working principle of Surface Acoustic Wave (SAW) device. (11)

6. a) Design a BSN node for in-home health monitoring application. (10)

b) What are the major characteristics of biological tissues considered for IBC? (12)

c) How can you identify the DNA sequence with MEMS cell culture array? Explain. (13)

7. a) Explain the design and operational challenges of multi-sensor fusion. (10)

b) Explain body effect on RF transmission. Write down the design criteria of an implant transceiver. (10)

c) How do you improve your lifestyle and well-being? (07)

d) Define BioMEMS. What are the reasons for miniaturization? (08)

8. a) How do you use BioMEMS for Glaucoma management? (10)

b) How does the cochlear implant work? Explain the stimulation and recording modes briefly. (11)

c) What are the advantages of bionic eye? (08)

d) Write down the difference of capacitance coupled IBC and galvanic IBC. (06)