Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021
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) What is bioactive materials? Write down a comparative analysis on classification of biomaterials in terms of structure to identify the appropriate type of material to fabricate a synthetic meniscus. (15)

b) What is bone plate? Write down the methods to determine yield points of a metallic bone plate and a polymeric vascular graft. (08)

c) Discuss the working mechanism of nitinol vascular stents. (12)

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

b) Describe the mechanism of crevice corrosion with chemical reactions and figures. (14)

c) Write down the advantages and disadvantages of Mg when used in vivo condition. (08)

3. a) Mention the polymorphism of Zirconia. Explain the transformation toughening mechanism of zirconia. (12)

b) Briefly describe the factors that affect the solubility of hydroxyapatite. (13)

c) Write down some applications of PSZ. (10)

4. a) Mention the chemical formula of polysterene repeat unit. Briefly explain the factors that affect the glass transition temperature. (10)

b) Write the differences between polymer and ceramics. (05)

c) What is hydrogel? State the working mechanism of temperature-responsive and pH-responsive hydrogel. (12)

d) State the production and degradation process of PLA and PGA. (08)

Section B

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

5. a) What is the main difference between prosthetics and orthotics? Explain the chronological development of biomaterials. (15)

b) What is atherosclerosis? Classify and write short notes on each types of artificial circulatory support. (10)

c) How could the artificial cells be used in cancer therapies? (10)

6. a) What are the types of permanent pacemaker? Write the construction and design requirements of pacemaker electrodes. (07)

b) What are the most common types of vascular access used in extracorporeal blood purification? Explain each of them with required illustration. (13)

c) Write the differences between venoarterial and venovenous ECMO. (07)

d) Illustrate the bioartificial liver design and write the working principle of hollow fiber bioreactors. (08)

7. a) Draw the schematic diagram of EtO sterilization chamber. Explain the EtO sterilization with it's advantages and limitations. (15)

b) Write down the names of the heart valves. Briefly describe different types of stents used in biomedical applications with their general compositions. (10)

c) Classify hydrogel. Write short notes on the uses of hydrogel in contact lenses. (10)

8. a) A cardiac pacemaker delivers 5 V pulses of 2 ms duration to bipolar electrodes that can be approximated as being a 2 kΩ resistive load. The mean pulse rate of the pacemaker is 70 per min. The pulse represents 25% energy consumed by the pacemaker. The pacemaker is powered by two lithium cells connected in series to give a voltage of 5.6 V. As the designer of the circuit you are called upon to specify a battery capable of operating the pacemaker for 10 years. What is the minimum acceptable capacity for each cell? (10)

b) Mention some tissue-implant responses and complications. (08)

c) Write short notes on oxygen based blood substitutes. (05)

d) Illustrate the standard ECMO circuit. (07)

e) Write a short note on tilting disc valve prosthesis. (05)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021
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? What are the characteristics of a nuclei that can be used for MRI? (07)
   b) What is Larmor frequency? How does it relate with external magnetic field strength? (06)
   c) Explain the Zeeman interaction for producing net magnetization. (10)
   d) What is magnetic resonance? Describe its concept from the perspective of quantum and classical physics. (12)
2. a) Summarize the events that occur when the RF transmitter is turned off. How the MR signal is recorded? (10)
   b) What is flip angle? List the parameters that regulate the steady-state. (07)
   c) What is meant by relaxation in MRI? Briefly discuss different relaxation process. (08)
   d) Sketch the block diagram of an MRI system. Why shimming is necessary in MRI? (10)
3. a) Explain spatial resolution and image contrast of MRI? What are the relationship among spatial resolution, field of view, and voxel size? How can we improve spatial resolution of MRI? (14)
   b) What is timing diagram? Draw the timing diagram of a four-segment echo-train spin echo sequence and explain it in brief. (12)
   c) Classify MR image based on image contrast. What are the key features of MR angiography? (09)
4. a) What is fMRI? How does fMRI work? Discuss the advantages and disadvantages of fMRI. (13)
   b) Discuss the contraindications to MRI scanning for implanted medical devices. (13)
   c) List some biological effects of time-varying magnetic fields. Analyze fMRI with other neuroimaging modalities graphically. (09)

Section B

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

5. a) What is diagnostic imaging? Why nuclear imaging is used in medical diagnosis? (07)
   b) Define and illustrate decay scheme with suitable examples. (07)
   c) How radioactive decay occurs? Derive the expression of half life time of radioactive decay. Graphically represent the typical decay pattern and also show the influence of decay constant on half life time. (14)
   d) What is the minimum mass of ^{99m}Tc that can have a radioactivity of 2 MBq? Assume the half-life is 6 hours and the Avogadro's number is 6.023×10^{23}. (07)
6. a) What is meant by absorbed dose? Define SI and traditional units of absorbed dose. (07)
   b) Explain interaction and attenuation of gamma rays with matter. Briefly describe the interaction of gamma rays that are important in nuclear medicine. (10)
   c) Briefly describe the features of half value layer and significance of mass attenuation coefficient? (06)
   d) Why the production of radioisotopes is required? How much Aluminium (Al) is required to reduce the intensity of a 200 keV gamma ray beam to 10% of its intensity? Assume the half value layer for 200 keV gamma ray in Al is 2.14 cm. (12)
7. a) Define radioisotope, radio tracer, and radiopharmaceuticals? Write some applications of radioactive tracers. (10)
   b) What is cyclotron? Describe the operating principle of cyclotron. (15)
   c) What is dose calibrator? Discuss the features of the Geiger-Muller counter. (10)

8. a) What is Gamma camera? Briefly describe the working principle of a Gamma camera. (10)

b) Briefly describe the image reconstruction procedure using filtered back propagation of the Fig. 8(a). (12)

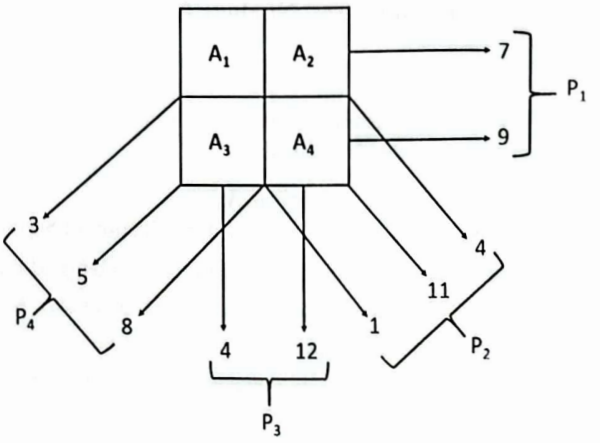

Fig. 8(a).

c) What is ALARA? Illustrate how ALARA is achieved in nuclear imaging facility. (13)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021
Department of Biomedical Engineering
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) What is shear stress? A 250 kg cylinder is hung by means of two cables PQ and PR, which are attached to the top of a vertical wall as shown in Fig. 1(a). A horizontal force M perpendicular to the wall holds the cylinder in the position shown. Determine the magnitude P of M and the tension in each cable. (13)

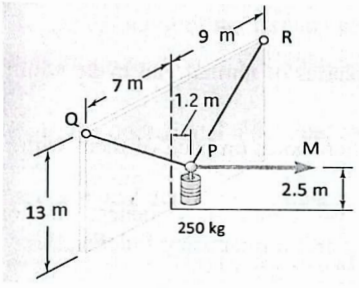

Fig. 1(a)

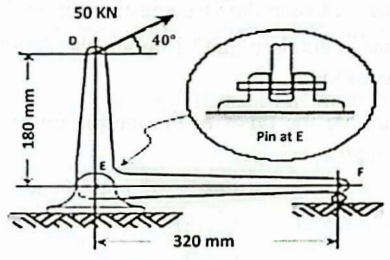

Fig. 1(b)

b) Compute the shearing stress in the 20 mm diameter pin at E for the member supported in the above Fig. 1(b). (12)

c) Prove that the tangential stress, σ_t, in a thin walled cylindrical shell subjected to internal pressure, p, is given by: $\sigma_t = \frac{pd}{2t}$, where the symbols have their usual meanings. (10)

2. a) Enumerate the assumptions and limitations for applying principles of statics to analyze the mechanics of human joints. Fig. 2(a) illustrates a person doing lower limb exercise from sitting position wearing a weight boot. If OA = 12 cm, OB = 23 cm, and BC = 26 cm; determine F_m and F_j. (15)

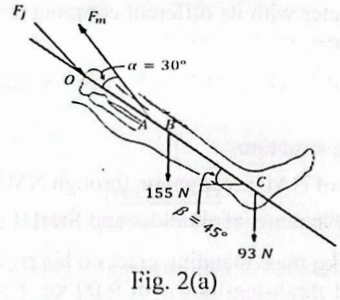

Fig. 2(a)

b) Tabulate the mechanical properties of human cortical bone. Explain the structure of cortical bone with appropriate diagram. (15)

c) Why is it important to study biofluid mechanics? (05)

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

b) What is a perfect dashpot? Discuss the time-independent deviations in Hookean materials. (13)

c) Define UCS. The length of femur is 500 mm and the cross-sectional area is 370 mm^2. How much does it shorten when you stand on one foot? Assuming linear behaviour, calculate the strain at the UCS. (12)
[$mass = 70\ kg$, $Y = 179 \times 10^2\ Nmm^{-2}$, and $UCS = 170\ Nmm^{-2}$]

4. a) What is meant by thixotropic fluid? Briefly describe the different types of pressure measurements in the human body. (10)

b) What property of blood is described by the Fahraeus-Lindquist effect? Derive the Moens-Korteweg equation. (13)

c) Name one part of the body in which the static pressure is sub-atmospheric. Show that the flow through an orifice is directly proportional to the discharge coefficient. (12)

Section B

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

5. a) Consider a horizontally outstretched arm, a3 shown in Fig. 5(a). In this posture the arm is supported by the muscle force F, exerted by the deltoid muscle attached at 12 cm from the shoulder articulation at an angle of 15° to the Humerus. The weight force W of the arm-forearm-hand with magnitude of 44 N is exerted at center of gravity at 30 cm from the shoulder articulation. There is a third force, of contact N, applied to the Humerus at shoulder articulation to equilibrate the arm. Determine F and N. (10)

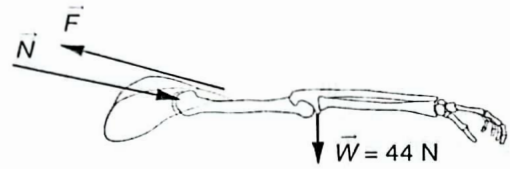

Fig. 5(a).

b) Briefly explain the viscoelastic properties of tissue. (10)

c) What is antalgic gait? Explain the major and sub-phases of normal gait cycle with proper illustration. (15)

6. a) What are the types of ergonomic injuries? Write short notes on each of them with proper examples. (07)

b) Fig. 6(b) shows the 'xyz' coordinate axis with a y-x-z rotation sequence. Find out the equations of x''', y''', z''' with respect to x, y, z in matrix format using Euler angles. (13)

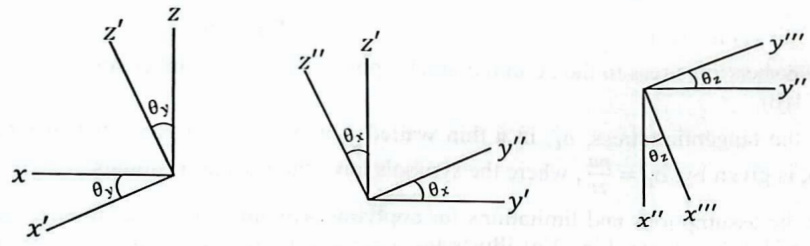

Fig. 6(b)

c) What is meant by gait? Illustrate the time periods of gait cycle. (08)

d) Illustrate a typical torsiometer with its different components and briefly explain each of the types of electro goniometer. (07)

7. a) Draw and describe the load vs elongation and stress vs. strain curves of a tendon-ligament structure. (13)

b) Illustrate individual muscle structure. (07)

c) Briefly explain the process of NAP propagation through NMJ. (10)

d) Show the sagittal plane movements of shoulder and foot. (05)

8. a) Consider a person with 60 kg mass standing erect on his right foot. The mass of each set thigh-leg-foot is of 9.00 kg. Use Fig. 8(a) and determine the intensities: (15)

(i) of the hip abductor muscle which makes an angle of 70° to the horizontal on the great trochanter of the femur, and

(ii) of contact (reaction) force C, exerted by the acetabulum on the femur head, as well as the direction of the contact force in relation to the horizontal.

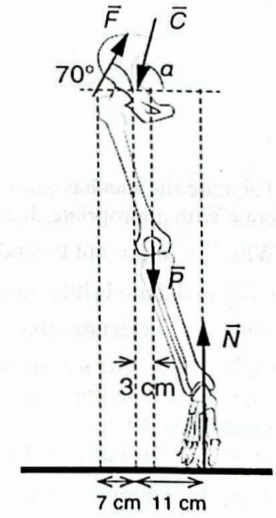

Fig. 8(a)

b) Briefly describe different types of ligament injuries and healing process including the phases. (15)

c) Define ergonomics. What are the advantages of applying ergonomic principles? (05)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021
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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) What is biomedical device? "Biomedical devices are developed from converging technologies", Explain the statement with suitable illustration. (11)

b) Define patient monitoring. Explain patient monitoring system with necessary diagram. (13)

c) What is meant by oximetry? Explain the working of a typical pulse oximeter with appropriate figure. (11)

2. a) Describe the operational block diagram of ultrasonic Doppler-shift based FHR measurement circuit. (12)

b) What is surgical diathermy? Explain the basic principle of surgical diathermy machine. (12)

c) Calculate the current flowing through the active electrode during surgery if $V_{OC} = 10$ kV, $R_1 = 0.1\ \Omega$, $R_E = 100\ \Omega$, $R_B = 1$ kΩ, $R_R = 0.5\ \Omega$. Also calculate the power dissipated in tissue (04 m × 0.4 m × 1.25 m) that has a resistivity of $1.6 \times 10^3\ \Omega$m. The symbols have their usual meanings. (11)

3. a) What is EMI? What are the effects and sources of EMI? Briefly explain different types of EMI with neat sketch. (16)

b) Define lithotripsy. What are the components of lithotripter? (06)

c) What is diathermy? Explain the operation of SWD. Also explain the common forms of SWD applications. (13)

4. a) Why implantable devices for drug delivery? What are the risks of targeted drug delivery? (10)

b) What is EBS? Explain deep brain stimulation (DBS) method. What are the applications and risks of DBS? (11)

c) Explain transcranial magnetic stimulation method with its associated applications and risks. What types of pain that can be treated by spinal cord stimulation? (14)

Section B

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

5. a) What is Homeostasis? Briefly explain homeostatically regulated factors. (12)

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

c) How do you get linear approximations to nonlinear systems in order to obtain transfer functions? (11)

6. a) Explain the working principle of Pneumotachometer. What are the disadvantages of it? (10)

b) Define transfer function. Find the capacitor voltage in the network shown in Fig. 6(b), if the switch closes at $t = 0$. Assume zero initial conditions. Also find the time constant, rise time, and setting time for for the capacitor voltage. (15)

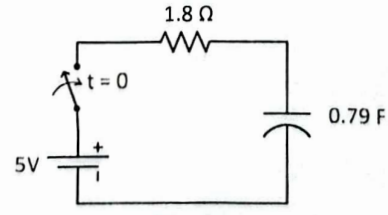

Fig. 6(b)

c) How do you determine the stability of a root locus? What are the effects of adding open loop poles and zeros on root locus? (10)

7. a) What information is contained in specification $k_p = 210$? If a system has $k_a = 105$, what steady state error can be expected for inputs of $85u(t)$, $85tu(t)$, and $85t^2u(t)$? (12)

b) Find the range of gain k for the system of Fig. 7(b) that will cause the system to be stable, unstable, and marginally stable. Assume $k > 0$. [use Routh table] (15)

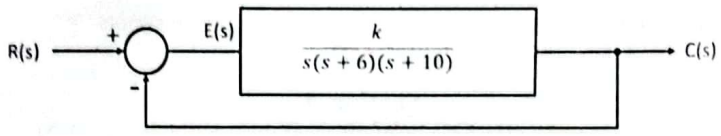

Fig. 7(b)

c) What is the dominant pole approximation? Why is a dominant pole required in control system? (08)

8. a) How can you improve transient and steady state error of an existing plant? (11)

b) Given the unity feedback system of Fig. 8(b), find the angle of departure from the complex poles and sketch the root locus. (13)

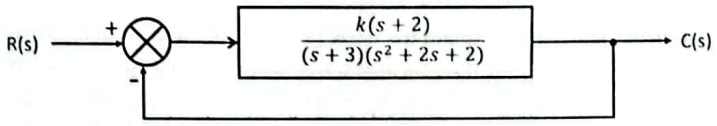

Fig. 8(b)

c) Elaborate design procedures for PID controllers. (11)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2021
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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 Sensor Network or BSN? What are the technical differences between BSN and WSN? (10)

b) Explain necessary factors to be considered for designing an implantable IoT based patient monitoring system. Illustrate the design process using a flow chart. (12)

c) Classify the types of sensors used in BSNs based on the deployment positions of sensor nodes. (07)

d) Differentiate between physical and logical topologies. (06)

2. a) Compare BAN with Wireless Sensor Network (WSN). Can this two network be interoperable? If so, illustrate it with appropriate example. (08)

b) What are the advantages and drawbacks of optical biosensor? (09)

c) Suppose you are sending a data containing text message from PC 'A' to PC 'B'. Draw the entire path of this data flow along with subsequent changes that occurs throughout the path. (14)

d) Mention some examples of Implantable medical devices. (04)

3. a) Which IEEE standard is used for BAN? What are the properties of this standard? (06)

b) Describe the design challenges of WSN. (09)

c) Explain the network lifetime. Write down the advantages of Multihop networks with examples. (10)

d) Two wearable EEG system, both having input amplifier power consumption of 5 W have different system power consumption. First EEG has sampling frequency of 1 kHz, net power consumption of the transmitter is 2×10^{-3} W and system power consumption is 21 W. Second EEG is operating with 5 kHz sampling frequency, net power consumption of transmitter is 6×10^{-4} W and total system power consumption is 26 W. Find the: (10)

(i) Power consumed in analog to digital converter.
(ii) Resolution bits in analog to digital converter.

For both EEG systems also design an efficient EEG system having compression ratio of 0.6, which reduces total system power consumption in the both EEG by 10%.

4. a) Explain discontinuous wearable EEG system with necessary figure. (09)

b) How do you improve global healthcare system integration? What are the key features for healthcare system integration? (13)

c) What are the factors that determine how many sensors need to be deployed? (05)

d) The distance between a source node and sink node is 100 m. If the energy consumption for processing the data in the intermediate node is 200 J, determine the energy consumption for $\alpha = 1.5$: (08)

(i) In single hop transmission.
(ii) In 3-hop transmission.

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

5. a) Show and explain the operation of SAW device. (11)

b) Explain the challenges you will face while designing a multiparameter sensing body sensor network. (11)

c) What is 'closed feedback loop system' in the context of BSN? Explain the system with appropriate example. (08)

d) Explain the term 'Context awareness' in BSN. (05)

6. a) What are the elements of a biosensor? Classify biosensors based on bio receptor or bio-recognition element (12)

b) Explain the three modules of proteins in protein engineering. (09)

c) Draw a block diagram of IBC system and briefly explain the components. (07)

d) What is telehealth and what are the services of telehealth? (07)

7. a) How does cochlear implant work? Explain the stimulation and recording modes briefly. (12)

b) Explain body effect on RF transmission. Write down the design criteria of an implant transceiver. (12)

c) What are the techniques to improve well-being and long-term health? (11)

8. a) How can you identify the DNA sequence with MEMS cell culture array? Explain in brief. (13)

b) Provide the comparison between the characteristic of capacitive and galvanic coupling methods for modelling of body tissues. (10)

c) Explain the design and operational challenges of multi-sensor fusion. (12)