Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Regular Examination, 2022
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 nuclei that can be used for MRI? Briefly explain the concept of magnetic resonance in MRI. (15)
   b) What is the significance of external permanent magnetic field in MRI? What is Larmor frequency? How it relates with external magnetic field strength? (10)
   c) Briefly explain Zeeman interaction and its effects in magnetic resonance. (10)

2. a) Discuss mathematically the quantum mechanical approach of obtaining MRI signal. (15)
   b) What is saturation? Discuss the phenomenon of continuous application of the resonant frequency, preventing relaxation processes from occurring in both microscopic and macroscopic scales. (10)
   c) What is fringe field? Discuss the radio frequency system of a typical MRI. (10)

3. a) Explain the physics of spatial localization in MRI using three different gradient fields. (15)
   b) How can we improve spatial resolution of MRI? Classify MR image on the basis of image contrast. (10)
   c) Briefly describe the safety issues related to magnet system of MRI. (10)

4. a) Define gradient echo sequence. Illustrate the timing diagram of a three-segment echo-train spin echo sequence and describe it in brief. (15)
   b) Explain the principle of BOLD fMRI using appropriate illustrations. (10)
   c) What are the biological effects of static and time-varying magnetic fields in MRI? Differentiate between T_1-weighted and T_2-weighted imaging. (10)

Section B

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

5. a) What is Gamma ray? How does Gamma ray interact with matter? Briefly describe the interaction of Gamma rays that are important in nuclear medicine. (15)
   b) Develop the mathematical model for the effect of thickness of the absorber on attenuation of Gamma rays. (10)
   c) Define radioisotope, radiotracer, and radiopharmaceuticals. Enumerate a few applications of radioactive tracers. (10)

6. a) What is cyclotron? Describe the operating principle of a cyclotron. (15)
   b) Describe the quality control of $99^{m}Tc$ eluate. (10)
   c) What is collimator? Discuss the features of Geiger-Muller counter. (10)

7. a) What is radiation detector? Describe the operating principle of scintillation detector. (15)
   b) Briefly describe single photon emission computed tomography (SPECT). Write down the features of SPECT over the planar imaging. (10)
   c) Briefly describe the applications, benefits, and limitations of PET scan. (10)

8. a) Why do we need to follow the rules and protocols of radiation protection? What is ALARA? Illustrate how ALARA is achieved in nuclear imaging facility. (15)
   b) What are the generally used nuclear medicine blood volume studies? Briefly describe the blood volume analysis (BVA) procedure. (10)
   c) What is radiobiology? Briefly describe how the radiation exposure interacts with living cell. (10)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Regular Examination, 2022
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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) Draw the flowchart of typical communication system in WBAN and explain how adaptive power control is maintained during data transmission. (13)

b) Write short notes on physical layer and transport layer of an OSI model. (10)

c) Explain necessary factors to be considered for designing an implantable IoT based patient monitoring system. Illustrate the design process incorporating a flowchart. (12)

2. a) Define body area network (BAN). Compare BAN with wireless sensor network (WSN). Can these two networks be interoperable? If so, how it can be possible? (10)

b) Briefly explain the cluster tree network and also write down the advantages and disadvantages of this network. (08)

c) Draw and explain the wireless communication path when a mobile station 'X' from Khulna city wants to communicate another mobile station 'Y' in Rajshahi city. Explain the modules used in the communication path. (12)

d) Which IEEE standard is used for BAN? What are the properties of this standard? (05)

3. a) What is pervasive computing? What are the challenges of pervasive computing? (08)

b) Define wireless sensor network (WSN). Describe the operational challenges of WSN. (09)

c) What is network lifetime? Briefly explain the mobility of WSNs. (06)

d) The distance between a source node and a sink node is 200 m. If the energy consumption for processing the data in the intermediate node is 250 J, determine the energy consumption considering $\alpha = 1.65$ for the following cases: (12)
(i) in a single hop transmission and
(ii) in 3-hope transmission.

4. a) Two wearable EEG systems, both having input amplifier power consumption of 5 W have different system power consumption. 1st EEG has the sampling frequency of 1 kilo-sample/sec, net power consumption of the transmitter is 2×10^{-3} W, and system power consumption is 21 W. While the 2nd EEG has operated at 5 kilo-sample/sec, net power consumption of transmitter is 6×10^{-4} W and total system power consumption is 26 W. Find the (18)
(i) power consumed in analog to digital converter and
(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 of both EEG by 15%.

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

c) Explain the design process of medical devices with necessary figure. (10)

Section B

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

5.	a)	Show and explain the working principle of surface acoustic wave (SAW) device.	(08)
	b)	What is meant by radiation pattern and gain of an antenna?	(08)
	c)	What are the different propagation modes of electromagnetic wave? Explain	(08)
	d)	Why we use digital modulation technique? What are different types of digital modulation? Explain them with waveshapes.	(11)
6.	a)	Draw the wave shapes of 'NRZ-L', 'Bipolar', 'Biphase-L', 'Differential Manchester', and 'Delay modulation' line coding schemes for the given binary sequence data 1001010001011.	(15)
	b)	What are BioMEMS? Write down some applications of BioMEMS. How to use BioMEMS for cardiac patients?	(08)
	c)	How can you identify the DNA sequence with MEMS cell culture array? Explain.	(12)
7.	a)	Draw the block diagram of human body communication (HBC) transceiver. Illustrate the key factors for describing HBC transceiver.	(15)
	b)	What are the methods used for multi-sensor fusion? Explain elaborately the fusion rules in the context of data and/or decision.	(20)
8.	a)	What is hidden node problem? How do you overcome this problem?	(07)
	b)	Explain body effect on RF transmission. Write down the design criteria of an implant transceiver.	(10)
	c)	Design a wireless communication system to build a smart home. Give emphasis in the context of biomedical applications.	(08)
	d)	Explain the fundamental architecture of a GSM system.	(10)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Regular Examination, 2022
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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 biocompatibility? Write down a few example applications of biomaterials. (06)
b) What is probability of failure? Briefly discuss different modes of failure of a medical device (in vivo condition). (06)
c) Briefly discuss the classification of biomaterials pointing out features, advantages, and disadvantages. (15)
d) What type of materials would you consider for producing an artificial artery? Why would you consider them? Explain briefly. (08)

2. a) What is meant by toughness? Write down a comparative analysis of toughness of metals, ceramics, and polymers with necessary figures. (08)
b) Briefly discuss the brittle fractures and its microscopic features. (10)
c) Define anxetic material. Point out the reasons why strain hardening is seen in certain materials in response to tensile stress. (08)
d) Classify Ti-alloy and explain each type in brief. (09)

3. a) Write down the stages of fatigue failure with necessary figures. (07)
b) Why is standard EMF series not considered to discuss galvanic corrosion? What is the solution proposed to resolve this issue? (06)
c) What is crevice? Briefly explain crevice corrosion with necessary chemical formula. (13)
d) What is shape memory alloy? How can you exploit the shape memory property to fabricate a biomedical device? (09)

4. a) What is silicate glass? Briefly explain the commercial procedure of alumina production. (08)
b) Briefly discuss the characteristics of UHMWPE. What are the problems associated with UHMWPE in biomedical applications? How can you solve it? (07)
c) Point out the advantages and disadvantages of metals and ceramics. (10)
d) Briefly explain the polymerization process of polymethylmethacrylate in biomedical applications. (10)

Section B

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

5. a) Write the failure modes of internal fixation devices with their location and reason for failure. (06)
   b) What is the advantage of using pyrolytic carbon in preparing artificial heart valve? Explain surgically implanted synthetic graft with their design considerations and limitations. (12)
   c) Enumerate the steps involved in pyrolytic carbon molding and mention the fundamental requirements for biomaterials for long term implants. (07)
   d) What are the requirements for dialysis? Classify PD and point out the advantages and disadvantages of CAPD. (10)

6. a) Explain the working principle of atrial synchronous pacemaker with required diagram. (12)
   b) Define UV-ECMO. Briefly discuss the working principle of oxygenator unit in ECMO circuit with proper diagram. (08)
   c) What are the differences between the blood pumps used in ECMO circuit? Briefly describe the design construction of implantable bioartificial liver. (08)
   d) Write a short note on gas plasma treatment and mention its advantages over E+O gas sterilization methods. (07)

7. a) What is SAL? Explain gamma radiation sterilization with their setup and mention its advantages over other sterilization methods. (11)
   b) Which major problems can arise during CAPD? How would you solve them? (06)
   c) What is impression material? Explain the chemistry of calcination for gypsum product synthesis. (10)
   d) Which principal properties are sought in contact lens materials? Draw the block diagram of an artificial kidney. (08)

8. a) Provide a schematic illustration of bioartificial liver design. Explain the working principle of hollow fiber bioreactor. (10)
   b) Point out the limitations of PCF based and hemoglobin based blood substitutes. (06)
   c) Write a short note on $Zn_3(PO_4)_2$ dental elements including their composition and formation process. (07)
   d) Which steps are involved in the healing process of artificial skin? Briefly explain the manufacturing process of artificial skin. (12)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Regular Examination, 2022
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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) What are the types of bone? State the relationship between porosity and relative density of different bones. (07)

b) How do your bones "know" how big and strong to be so that they can support your weight and deal with the loads imposed on them? Name some movements in different anatomical planes. (06)

c) Why your gastroconemius can lift more weight than your bicep, even if they are equally as strong? Explain in terms of lever principle. (07)

d) Consider the position of head and neck shown in **Figure 1(d)**. The head weighs $W = 50\ N$ and its center of gravity is located at point C. F_M is the magnitude of the resultant force, which is applied on the skull at point A. The atlantooccipital joint center is located at point B. For this flexed position of head, line of action of neck muscle force makes an angle $\theta = 30$ degree and the line of action of the joint reaction force makes an angle $\beta = 60$ degree with the horizontal. Determine F_M and F_J. (15)

2. a) Why a biomedical engineering student should study biomechanics? How knowledge of vector and solid mechanics helped you to solve mathematical problems of hard tissue mechanics? (08)

b) Four forces act on bolt A as shown in **Figure 2(b)**. Determine the resultant of the forces on the bolt. (10)

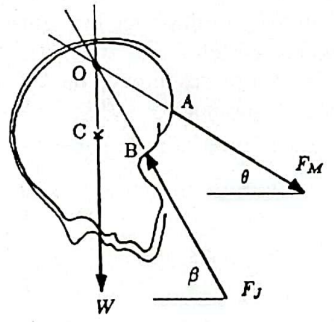

Figure 1(d)

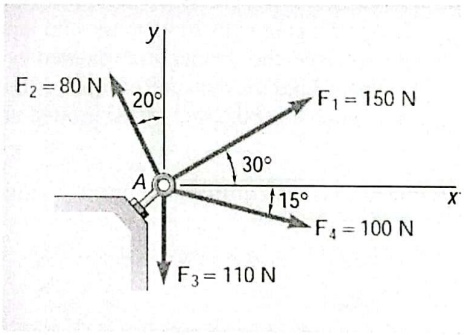

Figure 2(b)

c) The wall thickness of a 450 mm diameter spherical tank is 20 mm. Calculate the allowable internal pressure if tangential stress is limited to 60 MPa. (07)

d) A composite bar consists of an aluminium section rigidly fastened between a bronze section and a steel section as shown in **Figure 2(d)**. Axial loads are applied at the positions indicated. Determine the stress in each section. (10)

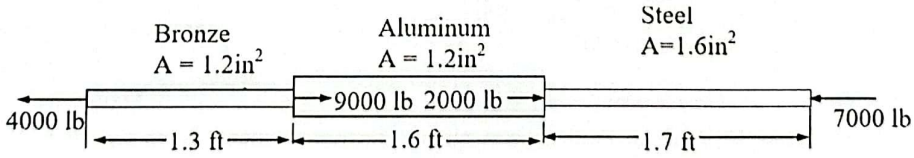

Figure 2(d)

3. a) Why should you study biofluid mechanics? Describe the flow of newtonian fluid. (10)

b) Th 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 behavior, calculate the strain at UCS. [mass = 70 kg, Y = 179× 10^2 Nmm^{-2}, and UCS = 170 Nmm^{-2}] (12)

c) Consider stress-strain graph shown in **Figure 3(c)**. Which line in the graph is valid for cortical bone and which one for trabecular bone? Define levels of strength, ductility, toughness, and stiffness for each bone considering the graph. (13)

4. a) What is blood rheology? Draw the viscosity vs. shear-rate graph and show that blood viscosity decreases as shear rate increases. (10)

b) Derive and draw stress and velocity profile for flow of viscous fluid through tube. (15)

c) Write a short paragraph describing the differences between laminar and turbulent flow and also name two physiological conditions under which turbulent flow might arise in the body. (10)

Section B

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

5. a) Briefly explain viscoelastic properties of tissue. (10)

b) What is pennation angle? Discuss muscle force production with appropriate diagram. (12)

c) How is mechanical load distributed in human body? How much compressive stress is present on L1 and L2 vertical discs of a 500 N man? Given that approximately 50% of body weight is supported by the disc when he stands in anatomical position. (the disc is oriented horizontally with a surface area of 25 cm^2) (13)

6. a) Explain Hill Muscle Model with proper diagram. (07)

b) If a muscle has a pennation angle of 20° and the length of muscle fibers is 10 cm, calculate the effective length of the muscle fibers. (08)

c) Explain the generation of AP in muscle cell with appropriate diagram. How is muscle force generated for muscle contraction? (20)

7. a) Edward was involved in a car accident resulting in whiplash injury. The cervical ligaments, particularly the anterior longitudinal ligament (ALL) were subjected to tensile loading during the sudden deceleration. Sketch the long-elongation curve for the ALL until failure, considering the impact of accident. (08)

b) How does tendon and ligament heal after an injury? (07)

c) Consider a man with 70 kg mass who injured his left foot, as illustrated in **Figure 7(c)**. As a consequence, the contact force exerted by the ground on his left foot is 200 N. His feet are 30 cm apart. Find the distance of injured foot to the line that passes through the C.G. Calculate the contact force exerted by the ground on the healthy right foot. (10)

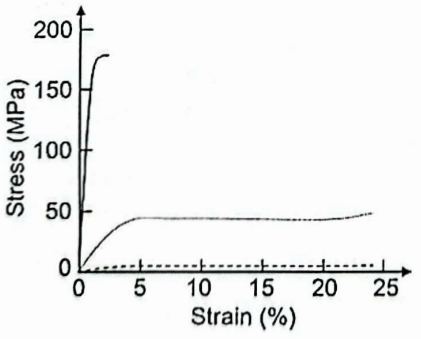

Figure 3(c)

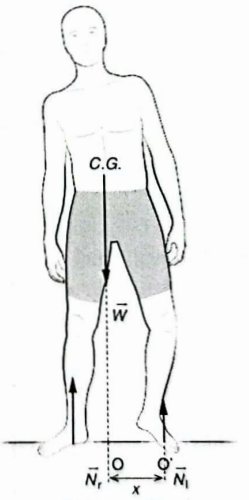

Figure 7(c)

d) Which device is used for limb angular movement measurement? State the types of that particular device. (10)

8. a) What is gait cycle? What are the phases of gait cycle? Describe the complete gait cycle of a human with appropriate diagram. (20)

b) Why is it necessary to perform clinical gait analysis? How is kinematic data analysis performed? Given the following marker coordinate data of a patient-Lateral femoral condyle marker $LK = -0.881i - 0.858j + 0.325k$, Medial femoral condyle marker $MK = -0.855i - 0.767j + 0.318k$, Hip center location $H = -0.906i - 0.763j + 0.593k$. Compute an anatomical coordinate system for the thigh. (15)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Regular Examination, 2022
Department of Biomedical Engineering

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 biomedical device. Show the converging technologies for the development of biomedical devices. (08)

b) What is patient monitoring? What are the long-term objectives and parameters of patient monitoring? (10)

c) What is ICU? Who are admitted to ICU? What are the common equipment in ICU? (07)

d) What is oximeter? Classify it. What are the advantages and limitations of oximeter? (10)

2. a) What is CTG? What are the commonly employed methods for CTG monitoring? (08)

b) What is electrosurgery? Briefly explain different techniques of electrosurgery with block diagrams. (12)

c) What is electrosurgery unit? Calculate the power dissipated in 0.2 m^3 of tissue that has a resistivity of 1.6×10^3 Ωm if the current density is 0.36 A/m^2. (07)

d) Classify EMI. How can you reduce EMI? (08)

3. a) What is lithotripsy? Briefly explain extracorporeal shock-wave lithotripsy with figure. (20)

b) Describe the operation of ultrasonic therapy unit. (07)

c) Define drug delivery. Briefly explain the working of an automated drug delivery system. (08)

4. a) What is electrotherapy? Mention some uses of electrotherapy. Who are not eligible for this therapy? (08)

b) What is electrical brain stimulation? Classify it. (06)

c) Describe the operation of transcranial magnetic stimulator. (11)

d) Write short notes on: (i) peripheral nerve stimulator and (ii) Vagus nerve stimulator. (10)

Section B

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

5. a) Deduce the differential equation of linearized model of lung mechanism. (10)

   b) Given the pole plot shown in Figure 5(b), find ζ, W_n, T_p, %OS, and T_s. (10)

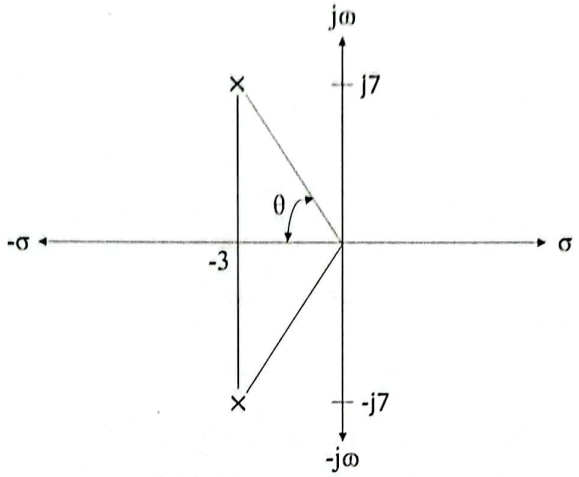

Figure 5(b)

   c) Summarize the steps taken to linearize a nonlinear system. (10)

   d) What pole locations characterize the underdamped systems, the overdamped systems, and the critically damped systems? (05)

6. a) Define homeostatic control system. Give examples of positive and negative feedback systems in human body. (10)

   b) What does the Routh-Hurwitz criterion tell us? Determine the stability of the closed-loop transfer function via Epsilon Method. (12)

$$T(s) = \frac{10}{s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3}$$

   c) Explain steady-state error in terms of $G(s)$. Take standard step, ramp, and parabolic inputs and evaluate its effect on steady-state error. (13)

7. a) What information is contained in the specification $K_a = 500$? If a system has $K_p = 4$, what steady-state error can be expected for inputs of $70u(t)$, $70tu(t)$, and $70t^2u(t)$? (12)

   b) How can you improve the transient response of an existing plant? Explain. (07)

   c) Sketch the root locus and its asymptotes for a unity feedback system that has the forward transfer function (10)

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

   d) What is meant by FEF 25-75%. Explain using spirometry graph. (06)

8. a) Briefly state and explain the Nyquist criterion. (10)

   b) Describe windkessel effect of the cardiovascular system. Hence deduce the differential equation of two and three element windkessel models. (15)

   c) From lung volume vs. time graph, describe obstructive and restrictive lung disorder with examples. (10)