Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2018
Department of Biomedical Engineering

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) Why the study of body sensor network is essential for biomedical engineers? (07)

b) Assume the crossover distance is 40m, E_c = 50nj/bit, e_1 = 10 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. (14)

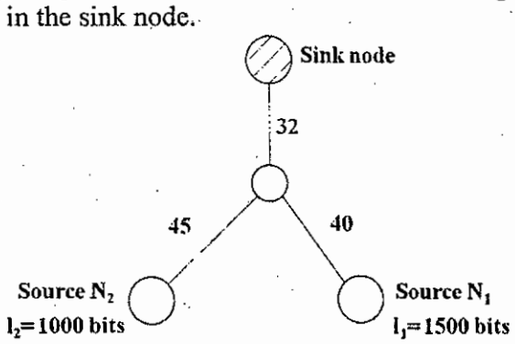

Fig 1(b)

c) Explain the IoT based modern healthcare system using body sensor network. (07)

d) What do you mean by inductive coupling regarding body sensor network. (07)

2. a) Classify the medical devices according to risk factors. Draw a design process of medical devices. (13)

b) Draw modern EEG system. How can you compute the power of this modern EEG system? (10)

c) Suppose we have two independent sensor measurements (y_1, y_2) of position x , and the sensor error may be modeled as $p(y_1/\theta) = N(\theta, {\sigma_1}^2)$ and $p(y_2/\theta) = N(\theta, {\sigma_z}^2)$, determine the MLE of x. (12)

3. a) Describe the various layers in OSI model. (06)

b) What is pervasive computing? Mention some challenges in pervasive computing environment. (11)

c) What are the pros and cons of flooding and grossiping protocols? (06)

d) Assuming accurate distance measurements between nodes of Fig 3(d), apply the trilateration technique to determine the SN coordinates (unknown) using the three BNs coordinates and the distance (known). Let BN_3 is the origin of the coordinate system. (12)

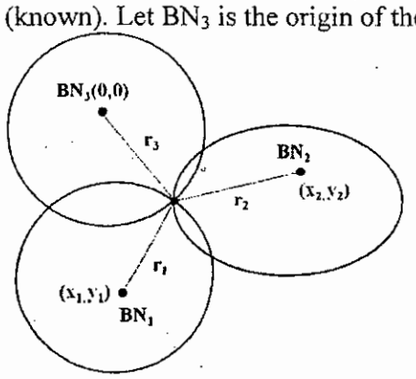

Fig 3(d)

4. a) Which IEEE standard is used for BAN? What are the properties of BAN? (09)

b) How can we improve healthcare system integration? Mention some key characteristics for this integration. (12)

c) Explain the broadband home networking by WMSN. (06)

d) What are the key differences between cluster tree and star-mesh hybrid topologies? (08)

Section B

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

5. a) What are the main features of an optical biosensor? Explain the working principle of it. (08)

b) Show and explain the operation of SAW device. (12)

c) How do you identify the DNA sequence with MEMS cell culture Array? Explain. (15)

6. a) What are the major characteristics of biological tissues considered for IBC? (10)

b) Draw the block diagram of IBC transceiver. Explain the key factors for designing IBC transceiver. (13)

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

7. a) What are the design challenges for implanted device? (09)

b) How do you monitor a patient through BAN and IoT? (14)

c) Express the effects of RF transmission on human body. (12)

8. a) What are the techniques to improve well-being and long-term health? (13)

b) Explain the fundamental architecture of a GSM system. (11)

c) What is cochlear implant? Explain the working principle of it. (11)

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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) Point out the basic criteria that must be fulfilled by biomaterials. (08)

b) What is the difference between an elastic material and a viscoelastic material? Explain how the rate of loading affects the behavior of a viscoelastic material. (07)

c) Define toughness. Based on your definition, compare the toughness of metals, ceramics and polymers using their respective stress-strain curves. (08)

d) Describe the aspects that influence the fatigue life of a material. (12)

2. a) What is stress concentration? With a schematic diagram, explain how stress concentration may arise in an inappropriately designed implant. (08)

b) What type of design feature is conducive to crevice corrosion? Explain the mechanism of crevice corrosion. (12)

c) Write short notes on: (i) fretting corrosion and (ii) stress-corrosion cracking. (08)

d) Draw an "oxidizing power vs rate of corrosion" curve and explain different zones of this curve. (07)

3. a) Which method is used for manufacturing ASTMF75 Co-Cr alloy? Describe the method. (10)

b) Discuss the working mechanism of nitinol vascular stents. (10)

c) Why is pure magnesium not suitable for biomedical implants? What is the potential counter measure to tackle this problem? (08)

d) Differentiate between alpha and alpha-beta titanium alloys. (07)

4. a) Discuss the effects of grain size, porosity and sintering aid on the mechanical properties of alumina. (10)

b) Discuss the factors which determine the degradation of hydroxyapatite. (10)

c) What are biological activities which bioactive glass performs? Write down the steps of the formation of an apatite layer or bioactive glass. (15)

Section B

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

5. a) Define polydispersity index and degree of polymerization. Provide a classification of polymers based on their molecular structures. (10)

   b) What is glass transition temperature? Describe the controlling factors for glass transition temperatures of polymers. "Glass transition is important for polymeric biomaterials"- provide an example to justify this statement. (10)

   c) What is hydrogel? Write down some potential applications of hydrogels. Explain the working principles of temperature-responsive and p^H-responsive hydrogels. (15)

6. a) What is an artificial cell? Write down the prospective applications of artificial cell. (10)

   b) Write down the classification of impression materials with examples. (10)

   c) Enumerate the design criteria of artificial Lungs. (10)

   d) Write short note on Gypsum Product. (05)

7. a) What is fracture? Enumerate different stages of bone healing. (10)

   b) What is biodegradable polymer? Write down the application of carbon fibers. (10)

   c) Write down the advantages and disadvantages of Titanium alloy. (10)

   d) Write short note on PMMA. (05)

8. a) What are the features of an ideal implant material? Write down the advantages of stainless steel. (10)

   b) What is heart valve? Enumerate the types of heart valves. Explain the properties of biological heart valves. (10)

   c) What is cell membrane? Discuss about the materials of artificial cell membrane. (10)

   d) Write short note on Defibrillator. (05)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 2nd Term Examination, 2018
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) Briefly discuss how living cells of the human body is organized to form complex physiological systems. (12)

b) Discuss contribution of physiological systems to maintain homeostasis. Also give an example of positive feedback system in human body. (13)

c) Describe the working principles of Pneumotachometer to measure volume of air flow during respiration. (10)

2. a) Explain windkessel model of aortic blood pressure. And hence find the transfer function of two and three element windkessel model. (13)

b) What is meant by Linearization of system dynamics? Give an example. (10)

c) Find the range of gain K for the system of Fig. 2(c) that will cause the system to be stable, unstable and marginally stable. Assume $K > 0$. [Use Routh table] (12)

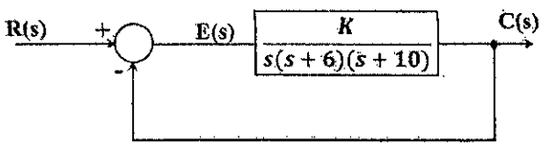

Fig. 2(c)

3. a) What is meant by root locus? What are the criteria for root locus? Outline basic rules for sketching root locus. (13)

b) Define system type, static error constants and actuating signals. What is meant by $K_a = 100$? (10)

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

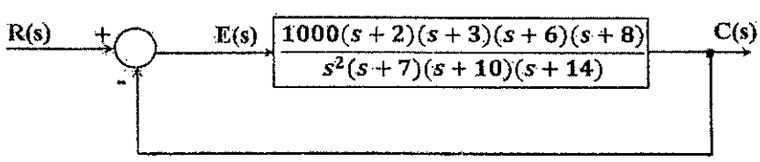

Fig. 3(c)

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

b) Discuss physical realization of a PID controller having (10)

$$G_{PID} = \frac{(s + 70)(s + 0.5)}{s}$$

c) Briefly discuss how PID controllers can be used in the field of Biomedical Engineering. (05)

d) Briefly discuss Hill model of muscle contraction. (10)

Section B

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

5. a) Mention some parameters of present and future patient monitoring system. (05)

b) How many types of PMS? What are the main functions of ECG used in PMS? (10)

c) Draw the block diagram of NIBP module. Explain each of them. (15)

d) Write down the importance of ICU. (05)

6. a) What is surgical diathermy? Describe the electrodes that are used in surgical diathermy. (10)

b) Describe the modes of shock wave generation. (15)

c) Why the Gold membrane used in microchip for drug delivery system? (05)

d) What are the operating frequencies and wattage of ESU? (05)

7. a) What are the principles of shock wave therapy? (08)

b) Discuss Electrohydraulic Lithotripter shockwave machine. (12)

c) Describe the operations of Ultrasonic Therapy Unit. (10)

d) What is EMI? How many types of EMI sources? (05)

8. a) What is bone density? How many methods used for bone mineral density (BMD)? (06)

b) Describe the procedures of BMD scan. (12)

c) Discuss the differences between T-scores and Z-scores used for bone mineral density (BMD) analysis. (08)

d) Describe the TMS waveforms. (09)

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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? Briefly describe the characteristics of nuclei that can be used for MRI. (08)

b) "Production of net magnetization of human body is zero in general states". Justify this statement. (06)

c) What do you mean by Larmor frequency or precession frequency? How it relates with external magnetic field strength? (06)

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

e) Briefly explain the concept of magnetic resonance in MRI. (07)

2. a) What do you mean by laboratory frame and rotating frame? (06)

b) What is meant by relaxation in MRI? Why T1 and T2 relaxation are also known as spin-lattice and spin-spin relaxation respectively. (08)

c) What happens after turn off the excitation? Explain. How we can record MRI signal from human body after turn off the excitation? (12)

d) What is the condition for saturation that results no relaxation? Briefly explain your justification. Why T2 relaxation process is irreversible? (09)

3. a) Explain about the components of MRI systems. (20)

b) What is gradient field? Why we need this field in MRI? (07)

c) What do you mean by spatial resolution of MRI? What are the relationship among spatial resolution, field of view and voxel size? (08)

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

b) Briefly explain the manufacturing process of superconductive electromagnet. What do you mean by magnet quality? How can you compensate magnetic field distortions? (10)

c) What do you mean by BOLD effect in fMRI? Write down applications, advantages and disadvantages of fMRI. (11)

d) Briefly explain the biological effects of static magnetic field in MRI. (05)

Section B

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

5. a) What is electromagnetic spectrum? Sketch the electromagnetic spectrum and indicate the NMR, X-ray and Gamma-ray window. (08)

b) How gamma ray is generated? What is the basic difference of gamma ray and X-ray? (06)

c) Explain decay scheme with a suitable example: (06)

d) Write short notes on: (08)
   i) Equivalent dose
   ii) Inverse square law of radiation

e) The half-life of ^{99m}Tc is 6 hours. After how much time will 1/16th of the radioisotope remain? (07)

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

b) What is Radioactive tracer? Mention some applications of radioactive tracer. (08)

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

d) How much lead (Pb) is required to reduce the intensity of a 200 keV gamma-ray beam to 10% of its incident intensity? Assume that the Half Value Layer for 200 keV gamma-rays in Pb is 0.068 cm. (07)

7. a) What is radiation detector? Describe the operating principle of a gas filled radiation detector. (12)

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

c) Compare the radionuclide production processes. (08)

8. a) What is Positron Emission Tomography (PET)? Briefly explain the methodology of PET. (12)

b) Briefly describe the image reconstruction procedure using Iterative Reconstruction. Apply the Iterative Reconstruction method to estimate the pixel values whose detected projection at P1, P2, P3 and P4 detector arrays are as shown in Fig 8(b). (11)

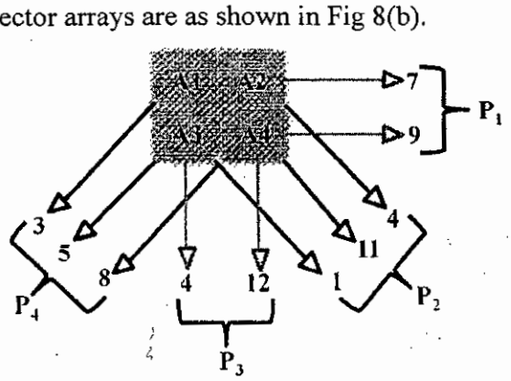

Fig 8(b)

c) Write short notes on: (12)
   i) Nuclear Medicine Imaging Systems
   ii) Collimator
   iii) Radioactive iodine uptake test (RAIU)

Khulna University of Engineering & Technology
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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 do you mean by fatigue fracture? Explain the importance of Wohler's curve in fracture mechanics. (05)

b) The rigid bar AB, attached to two vertical roads as shown in Fig. 1(b), is horizontal before the load 'P' is applied. Determine the vertical movement of 'P' if its magnitude is 50 kN. (15)

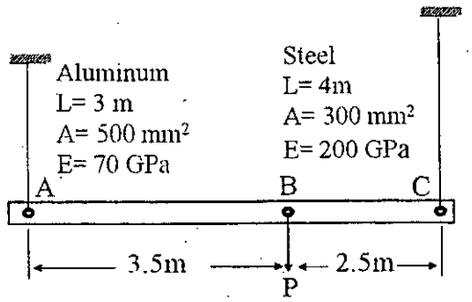

Fig. 1(b)

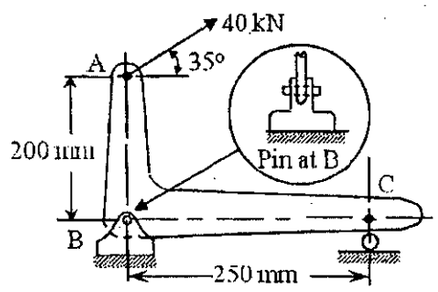

Fig. 2(a)

c) The mass of a turbine rotor of a ship is 8 tones and has a radius of gyration 0.6m. It rotates at 1800 r.p.m. clockwise when looking from the stern. Determine the gyroscopic effects in the following cases: (15)

i. If the ship travelling at 100 Km/hr steers to the left in a curve of 75 m radius,
ii. If the ship is pitching and the bow is descending with maximum velocity. The pitching is simple harmonic, the periodic time being 20 seconds and the ship pitches 10^o above and below the horizontal position,
iii. If the ship is rolling and at a certain instant has an angular velocity of 0.03 rad/s clockwise when looking from stern.

2. a) Complete the shearing stress in the pin at B for the member supported as shown in above Fig. 2 (a). The pin diameter is 20 mm. (12)

b) A cylindrical steel pressure vessel 400 mm in diameter with a wall thickness of 20 mm, is subjected to an internal pressure of 4.5 MN/m^2. (12)

i) Calculate the tangential and longitudinal stresses in the steel.
ii) To what value may the internal pressure be increased if the stress in the steel is limited to 120 MN/m^2?
iii) If the internal pressure were increased until the vessel burst, sketch the type of fracture that would occur.

c) The two blocks shown in Fig. 2(c) are originally at rest. Neglecting the masses of the pulleys, determine : (11)
(i) The acceleration of each block, (ii) The tension in the cable; Assuming that the coefficient of friction between block A and incline are $\mu_s = 0.25$ & $\mu_k = 0.2$.

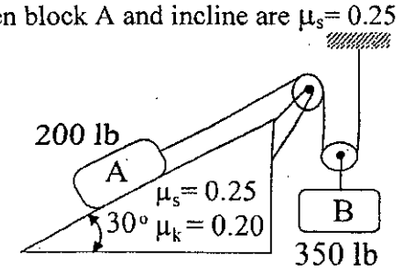

Fig. 2(c)

3. a) If an automobiles braking distance from 90km/h is 45m on level pavement, determine the automobiles braking distance from 90km/h when it is (i) going up a 5° incline, (ii) going down a 3-percent incline. Assume the braking force is independent of grade. (12)

b) A helicopter is flying with a constant horizontal velocity of 180km/h and is directly above point A when a loose part begins to fall. The part lands 6.5s later at point B on an inclined surface as shown in Fig. 3(b). Determine: (i) the distance d between points A & B, (ii) the initial height *h*. (11)

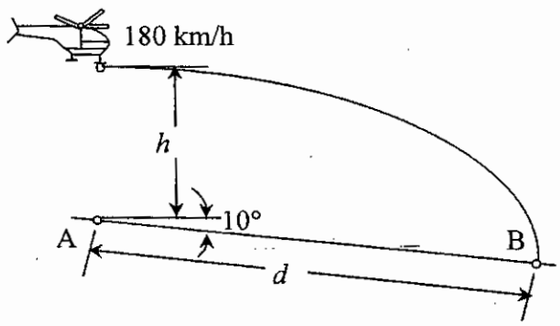

Fig. 3(b)

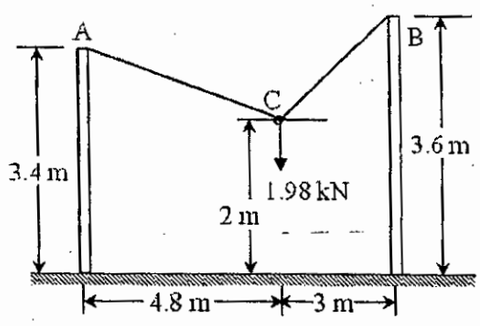

Fig. 3(c)

c) Two cables are tied together at C and loaded as shown in above Fig. 3(c). Determine the tension (i) in cable AC, (ii) in cable BC. (12)

4. a) Define: (i) Static; (ii) Dynamic; (iii) Kinematics; (iv) Kinetics; (v) Stiffness; (vi) Torque. (12)

b) Describe the viscoelastic properties of human body. (15)

c) Explain the Force-Motion principle in biomechanics. (08)

Section B

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

5. a) Why is it important to study biomechanics? What does some biomechanics do? (06)

b) Describe the nine fundamental principles of biomechanics. (14)

c) Explain how musculoskeletal tissues respond to forces on loading. (15)

6. a) What is biofluid mechanics? Describe the formula of fluid mechanics. (15)

b) Given the following three dimensional locations in meters for a set of pelvic markers expressed relative to an inertially fixed laboratory coordinate system. (10)

Right ASIS : RASIS= - 0.850i - 0.802j +0.652k

Left ASIS : LASIS = - 0.831i - 0.654j +0.652k

Compute an anatomical coordinate system for the pelvis.

c) Calculate the static fluid pressure in the cranium at the end of systole and the end of diastole. Assume that the cranium is 30 cm above the aortic valve and that the pressure at systole and diastole is120 mmHg and 80 mmHg respectively shown in Fig. 6(c). The density of blood is 1050 kg/m^3. (10)

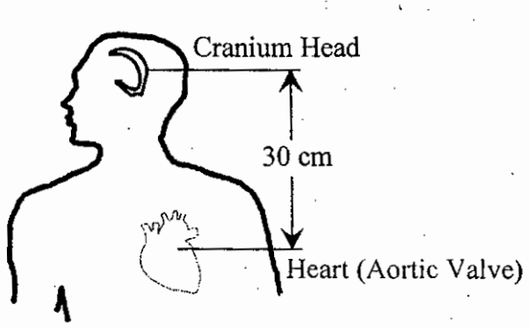

Fig. 6(c)

7. a) Discuss A.V. Hill modeled the active contraction of heart muscle using a three component model. (15)

b) Calculate the circumferential stress distribution in the left ventricle during peak systole (assuming that the ventricle is a spherical shell). The inner radius and outer radius of the sphere are 3.5 cm and 4 cm respectively. The external pressure is 23 mmHg. (10)

c) Show the Bernoulli equation. Given the following position Vector, calculate the velocity and acceleration of a fluid particle as a function of time. This particle starts at the origin of the coordinate axis at time zero. Plot the fluid particles position and velocity for times 0s, 1s, 2s and 4s. (10)

$$\vec{x}(t) = (3ms^{-1})\left(t + \left(\frac{5}{2}s^{-1}\right)t^2\right)\vec{\imath} + (2ms^{-1})t\,\vec{\jmath}$$

8. a) Determine the volumetric flow rate through the arterial system. (12)

b) Calculate the resistance to blood flow within the descending aorta and inferior venacava. Assume that the pressure difference between the distal portion of the aortic arch and the iliac arteries is 20 mmHg. The pressure difference within the inferior venacava is 3 mmHg. Assume that flow rate through both vessels is 4.5 L/min. (05)

c) What is Fick technique for measuring cardiac output? A patient's spirometer oxygen consumption is 250 mL/min while her arterial oxygen concentration is 0.2 mL/mL and her venous oxygen concentration 0.15 mL/mL. What will be patient's cardiac output? (10)

d) Write a short note on Electromagnetic flowmeter. (08)