INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Date: 27-04-2017 (AN) **Spring End-Semester 2017** **Time:** 3 hours **Full Marks:** 100

Department: **Mechanical Engg** Subject: **Mechanics of Human Body** Subject No: **ME 60430**

Marks distribution for each question is indicated within brackets.
Assume any suitable data that may be required for solution, stating clear justifications

Answer all questions.

(1) (a) State clearly the steps and governing equations required to find out joint forces and moments in a limb segment using 'Inverse Dynamics Method'.

(b) What are the techniques for fixation of implant with bone? Discuss briefly the major failure mechanisms of orthopaedic implants.

(c) A force vector in a Cartesian coordinate system **(A)** is given as 10i + 20j + 30k. Another new coordinate system **(B)** is obtained by applying the following sequential rotation and translation with respect to the original Cartesian coordinate system **(A)**:

(i) Rotations: +60° about y-axis, then –30° about z-axis, and then +60° about x-axis degrees.
(ii) Translations: +20 units along x, y and z-axes.

Calculate the transformation matrix and transformed force vector in the new coordinate system **(B)**.

(8 + 5 + 7 = 20)

(2) (a) How is 'bone' classified, macroscopically? What is meant by 'apparent density' of bone?

(b) What is Hounsfield Unit? How is bone mechanical properties related to apparent density and its structure?

(c) State the criteria for selection of implant material for joint replacement. Name the commonly used biomaterials for load bearing implants.

(5 + 8 + 7= 20)

(3) (a) How is implant-bone interfacial failure evaluated? State and explain each term of the failure criterion.

(b) The state of stress at a point on the implant-bone interface is, σ_x = 10 MPa, σ_y = 15 MPa, σ_z = –5 MPa, $\tau_{xy} = \tau_{yz} = \tau_{zx}$ = 10 MPa. Determine the normal and shearing stresses at the implant-bone interface on a plane, which is inclined at **60° with x-axis**, **60° with y-axis** and **45° with z-axis**.

(c) Using data of Problem 3(b), evaluate Hoffman failure value at implant-bone interface, assuming adjacent bone density ρ =0.5 gm.cm^{-3}. Interfacial strengths (MPa): $S_t = 15\rho^{1.71}$, $S_c = 32\rho^{1.85}$, $S_s = 22\rho^{1.65}$

(4 + 10 + 6 = 20)

(4) (a) What is the difference between 'bone remodelling' and 'bone ingrowth'?

(b) State the mathematical formulation for the 'external' and 'internal' bone remodelling process.

(c) Design a scheme, using flow diagram, for the iterative simulation of the bone remodelling process.

(4 + 8 + 8 = 20)

(5) (a) State the differences between phenomenological and cell-phenotype specific tissue differentiation methods.

(b) Briefly describe the process of tissue differentiation from Mesenchymal Cells.

(c) Write the governing equations of phenomenological and cell-phenotype specific methods, indicating the significance of each term.

(6 + 6 + 8 = 20)