**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, σx = 10 MPa, σy = 15 MPa, σz = –5 MPa, τxy = τyz = τzx = 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): *St =15ρ1.71, Sc=32ρ1.85, Ss = 22ρ1.65 (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)*