INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 25-04-2012 (AN) **Spring End-Semester 2012** **Time:** 3 hrs **Full Marks:** 100

Department: **Mechanical Engg** Subject: **Mechanics of Human Body** Subject No: **ME 60430, ME 41612**

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

(b) Briefly describe the procedure of determining mechanical properties of bone from a CT-scan image. What is Hounsfield Units?

(c) How are mechanical properties of bone related to its structure and apparent density?

(4 + 8 + 8= 20)

(2) (a) What are the stress components acting at a point in three-dimension? Write the stress tensor.

(b) The state of stress at a point on the implant-bone interface is, σ_x = 10 MPa, σ_y = –5 MPa, σ_z = –5 MPa, $\tau_{xy} = \tau_{yz} = \tau_{zx}$ = 2.5 MPa. Determine the normal and shearing stresses at the implant-bone interface on a plane that is equally inclined to all the three axes.

(6 + 14 = 20)

(3) (a) What are the techniques for fixation of implant with bone?

(b) Discuss briefly the major failure mechanisms of orthopaedic implants.

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

(d) Using the data of Problem 2(b), evaluate failure at the implant-bone interface, assuming adjacent bone density ρ = 0.5 gm. cm^{-3}. Take interfacial strengths as: $S_t = 14.5\ \rho^{1.71}$, $S_c = 32.4\ \rho^{1.85}$, $S_s = 21.6\ \rho^{1.65}$.

(3 + 5 + 6 + 6 = 20)

(4) (a) What is meant by 'bone remodelling'?

(b) Considering bone remodelling caused by joint replacement, state the mathematical formulation of the 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) What are the joints and bones that constitute a 'Knee Joint'?

(b) What are the major muscles acting on the knee joint and the range of movements offered by the joint?

(c) With the help of a graphical representation, explain the variation of knee-joint reaction force in terms of body weight during a normal walking cycle.

(d) What are the biomechanical functions of the 'Patella' in the knee joint?

(4 + 6 + 6 + 4 = 20)