INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date: 24-04-2014 (AN) **Spring End-Semester 2014** **Time:** 3 hrs **Full Marks:** 100

Department: **Mechanical Engg** Subject: **Mechanics of Human Body** Subject No: **ME 60407**

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) What is meant by 'Gait Cycle'? What are the different phases of gait cycle?

(b) Indicate the basic musculoskeletal loading with points of application of forces acting on a proximal femur using a 'free body diagram'.

(c) A force vector in a Cartesian coordinate system **(A)** is given as 12i + 15j + 20k. 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: +20° about y-axis, then –10° about z-axis, and then +30° about x-axis degrees.
(ii) Translations: 10 units along x, y and z-axes.

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

(5 + 5 + 10 = 20)

(2) (a) What is meant by 'apparent density' of bone? How is bone mechanical properties related to apparent density and its structure?

(b) Briefly describe how a CT-scan image is produced. State the differences between CT and MRI.

(c) What is Hounsfield Unit? How is pixel grey value related to bone apparent density?

(8 + 8 + 4= 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 = 80 MPa, σ_y = 40 MPa, σ_z = –30 MPa, $\tau_{xy} = \tau_{yz} = \tau_{zx}$ = 20 MPa. Determine the normal and shearing stresses at the implant-bone interface on a plane that is equally inclined to all the three axes.

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

(4 + 10 + 6 = 20)

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

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

(c) Suggest a computational scheme for simulating the bone remodelling process, using a flow diagram.

(4 + 8 + 8 = 20)

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

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

(c) How does 'wear' of articulating (bearing) surfaces affect failure of joint replacement? How is volumetric wear calculated?

(d) What are the different stages of fracture healing? Briefly describe the mechano-regulatory principal of fracture healing.

(4 + 5 + 5 + 6 = 20)