National Exams **December 2008**

04-Bio-A4, Biomechanics

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

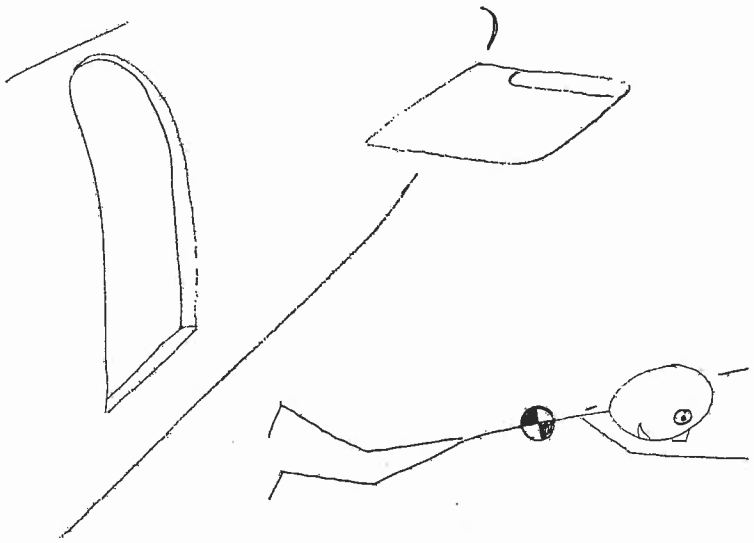
2. This is a CLOSED BOOK EXAM.
   Only approved Casio or Sharp calculators are permitted.

3. FIVE questions constitute a complete exam paper.

4. Each question is of equal value.

5. Clarity and organization of the answers are important, please draw and write clearly.

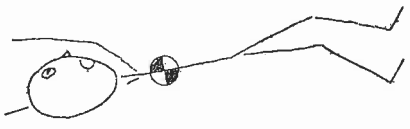
1. A skydiver has just launched themselves from an airplane traveling at 300 km/hr at 5000m. Please answer the following questions. Assume no rotational accelerations or buoyancy forces and please be accurate in your vector placements.



Please answer the following questions,

a) Draw all forces acting on the skydiver for the time period immediately following their leaving the aircraft. Please also include other accelerations or inertial forces if required. (9)

b) Later, the skydiver reached their terminal freefall velocity. Please draw all forces now acting on the subject. (9)



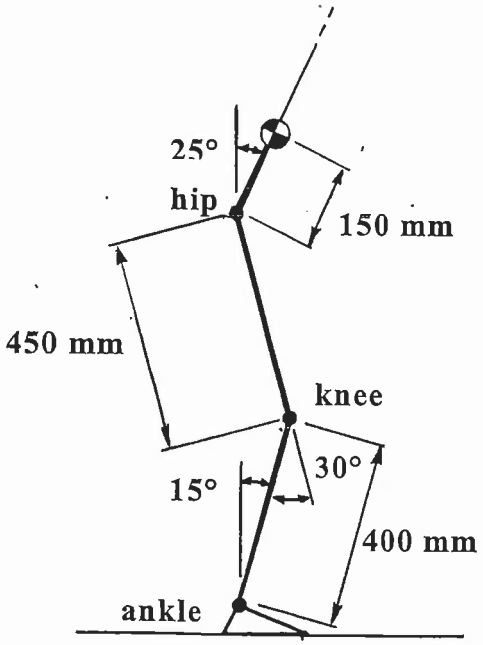
c) What piece of equipment did the skydiver forget to bring along for the test? (2)

2. A 70 kg patient with a 30 ° flexion deformity of both knees stands in an elevator. The elevator moves upward with an acceleration of 2 m/s ^{2}. Assume limb mass is negligible. The centre of gravity for the subject is shown. State clearly any further assumptions you make to answer the following questions.

   a) Calculate the ground reaction forces for the patient. Be sure to draw the required free body diagram. (8)

   b) For the limb position shown calculate the flexion/extension moments at the knee joints. Be sure to draw any additional diagrams that are required. (8)

   c) What muscles might you expect to be responsible for maintaining the 30 ° of knee flexion? (4)



3. A bewildered biomechanics student was trying to model the viscoelastic behaviour of a sample of skin. To characterise the skin's behaviour he applied an instantaneous step stress to the sample at time t_o. The corresponding strain in the sample was measured and plotted in the left graph. Four different spring and dashpot models were tried in an attempt to reproduce the behaviour of the skin. Each model was subjected to an instantaneous stress the same as that applied to the skin. The corresponding strain response in each of the four models was then calculated and plotted in the right graph. In his haste, the student lost track of the particulars of the models he had used.

   a) Knowing the strain response characteristics of simple spring and dashpot models, you offer to help sort out his problem. Clearly draw the simplest spring and dashpot models that would produce the model responses illustrated below.

   (8)

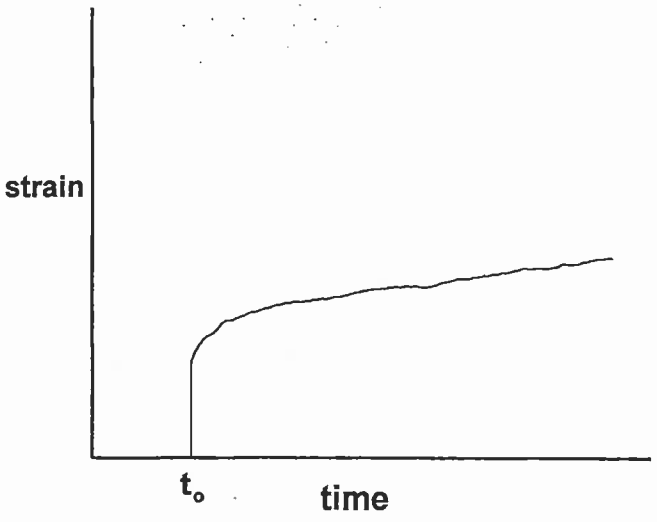
   b) State whether the response for each model is that of a linear or viscoelastic fluid or solid.

   (8)

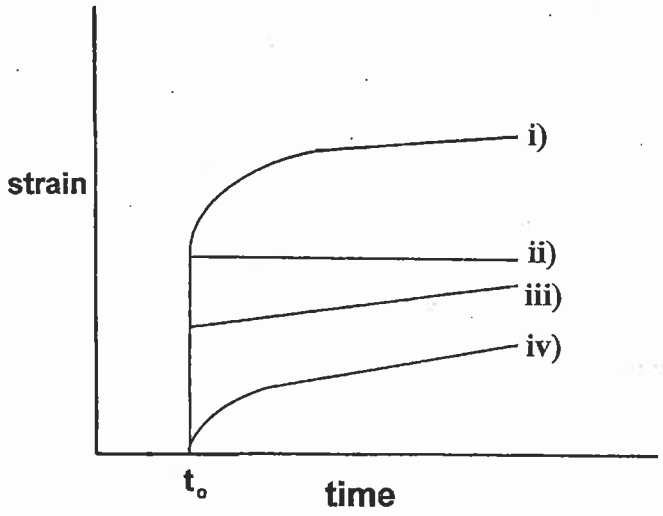
   c) State which of the four models displays strain characteristics closest to that of the skin sample. Explain the reasons for your choice. State what specific change you would recommend for this model for it to better represent the skin sample.

   (4)

Skin Sample Response



Model Responses



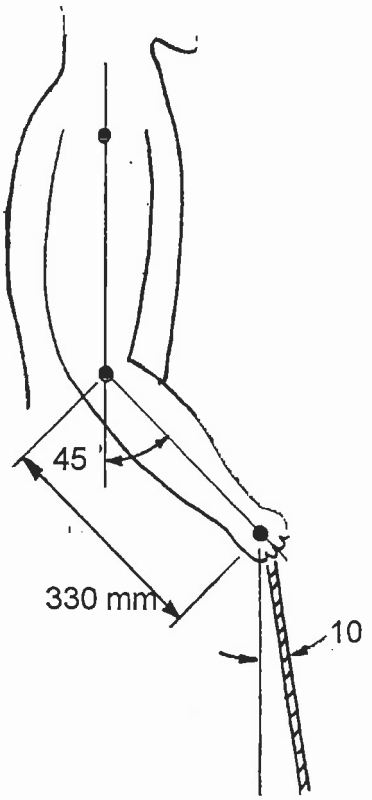
4. The left diagram below shows the position of a subject pulling on a cable attached to a sewer cover. For the instant shown, the subject is pulling on the cable with a force of 600 N. Assume arm mass is negligible.

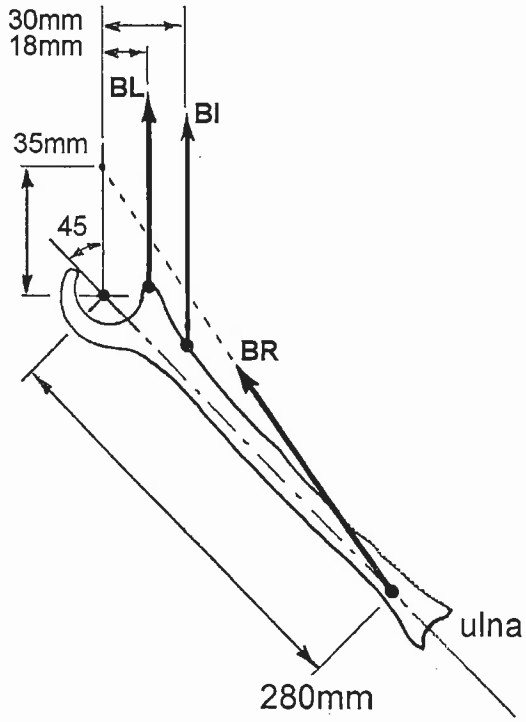
   a) For the subject position and geometry shown, calculate the magnitude and direction of the elbow moment being generated by the elbow musculature (sagittal plane only). (8)

   b) Three muscles can act as flexors for the elbow, they are biceps (BI), brachialis (BL) and brachioradialis (BR). For the instant shown, assume:
      - all three muscles are acting in tension
      - the force in biceps (BI) is equal to twice the force in brachioradialis (BR)
      - the force in brachialis (BL) is equal to twice the force in brachioradialis (BR)

      Using the geometry of the elbow musculature as shown below on the right, calculate the three muscle forces required to generate the 600 N cable tension. (8)

   c) Do your solutions for parts a) and b) make sense? Explain why or why not. (4)



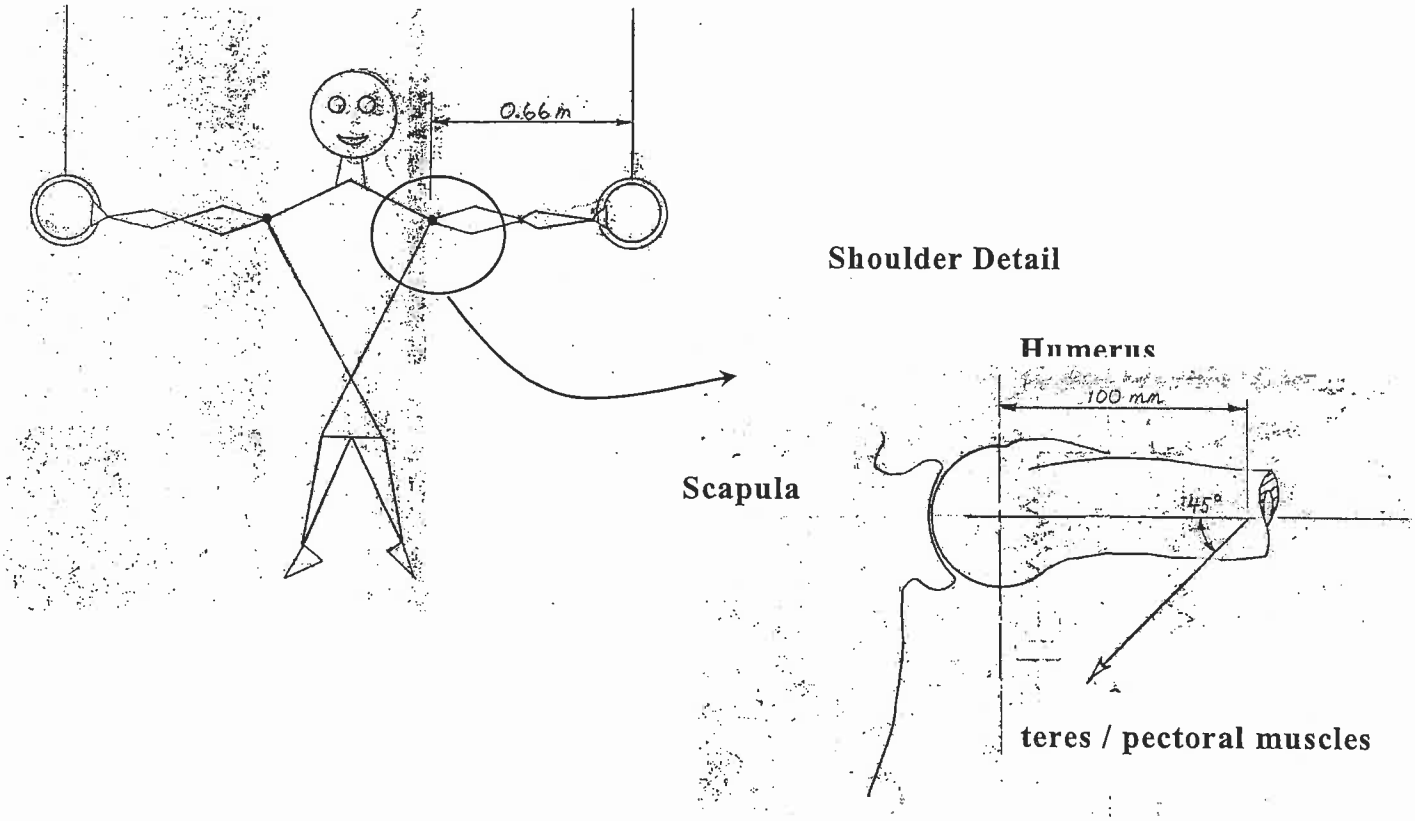


5. An 80 kg gymnast performs a "cross" position on the rings, where all their weight is supported on their outstretched arms, as shown below. Assume the necessary shoulder moment is generated by the teres / pectoral muscles acting together, as shown in the shoulder detail. State clearly any other assumptions that you make.

   a) **Draw** a free body diagram of the arm / humerus showing all necessary information. (4)

   b) **Calculate** the force in the teres / pectoral muscles for joint equilibrium. (6)

   c) **Calculate** the resulting vertical and horizontal joint forces on the head of the humerus (10)



Marking Scheme

1. 20 marks total (3 parts- 9, 9 & 2 marks respectively)
2. 20 marks total (3 parts- 8, 8 & 4 marks respectively)
3. 20 marks total (3 parts- 8, 8 & 4 marks respectively)
4. 20 marks total (3 parts- 8, 8 & 4 marks respectively)
5. 20 marks total (3 parts- 4, 6 & 10 marks respectively)