National Exams May 2012

07-Mec-B13 – Biomechanics

3 hours duration

Notes

1. If doubt exits 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 an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Five (5) questions constitute a complete exam paper.

4. Each question is of equal value.

5. Clarity and organization of the answer are important.

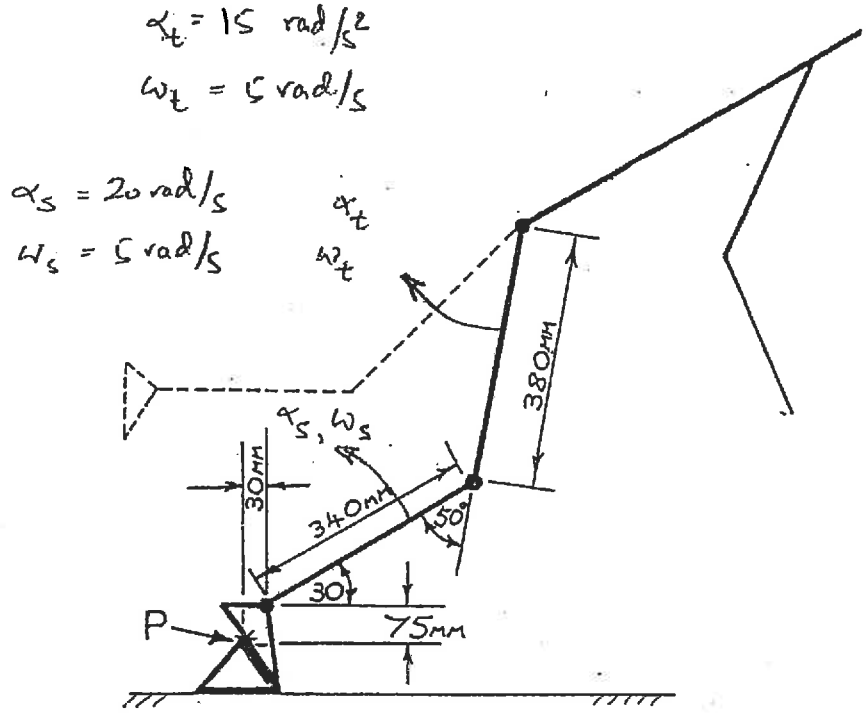
1. An 80 kg sprinter takes off from the starting blocks in the position shown. A force platform mounted below the starting block for the forward foot records a vertical force of 1120N and a forward force of 860N applied at point P on the foot. At the instant shown, the shank segment is rotating backward about the ankle with angular velocity 5 rad/s and angular acceleration 20 rad/s^2 and the thigh is rotating forward about the knee with angular velocity of 5 rad/s and angular acceleration 15 rad/s^2. Ignore the inertia effects <u>of the foot only</u>.

a) Draw the free body diagram of the shank segment (including all forces and moments). Assume the shank segment center of mass is midway between the knee and ankle, has a mass of 4 kg and a radius of gyration of 130 mm. **(4 marks)**

b) Calculate the orthogonal components of acceleration at the shank center of mass. **(4 marks)**

c) Calculate the joint resultant moment acting at the knee joint. **(4 marks)**

d) Speculate on which muscle(s) will be active to produce the observed moment. **(3 marks)**



2. A gymnast of mass 70 kg performs an "iron cross" position on the rings as shown. At the glenuhumeral (i.e. the shoulder) joint three muscles may be active. Consider the following conditions (Figure 2b):

   i) The rotator cuff muscle has a combined line of action parallel to the shaft of the humerus that passes through the joint center.

   ii) The deltoid muscle has a line of action at 10 degrees to the shaft of the humerus and an effective lever arm of 40 mm.

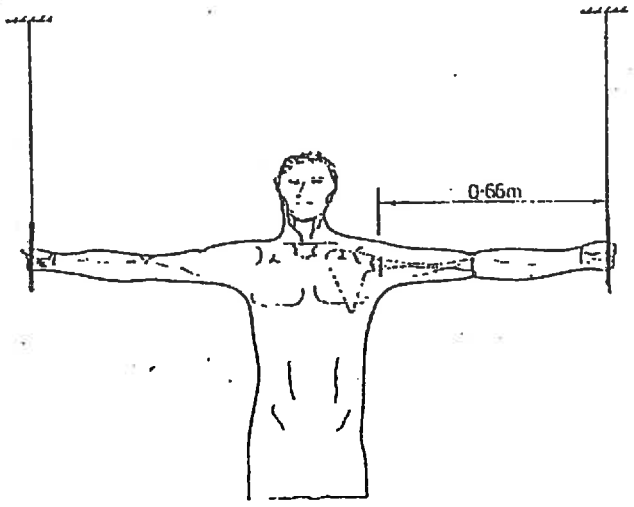
   iii) The pectoral and teres minor muscles have a combined effect that is equivalent to a line of action at 45 degrees to the shaft of the humerus. The position of their insertion on the long axis of the humerus is 100 mm distal to the joint center.

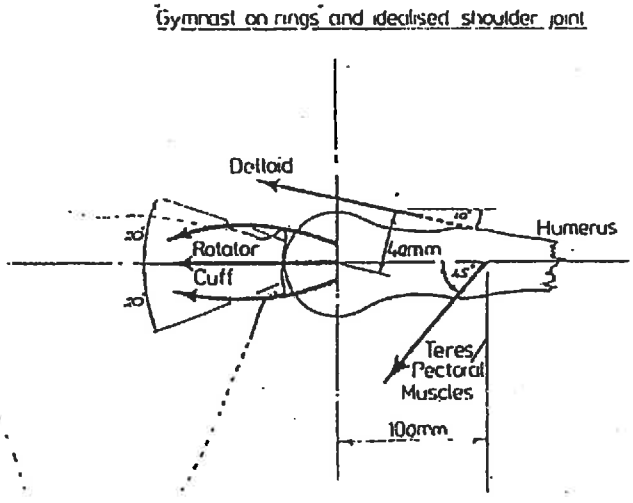
a) Calculate the tension in the pectoris/teres minor muscles needed for joint equilibrium. **(3 marks)**

b) Calculate the magnitude and direction of the joint force applied to the humeral head. **(4 marks)**

c) If the border of the glenoid cavity extends an angle from +20 to –20 degrees to the horizontal, calculate the minimum tension required in the rotator cuff muscle group in order to produce a stable joint. **(4 marks)**

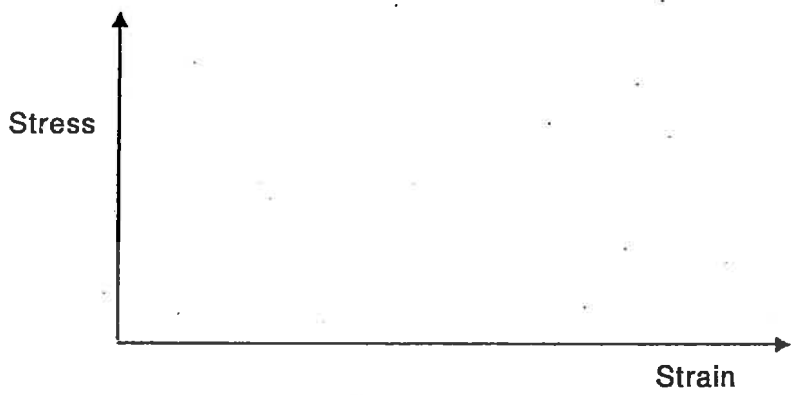
d) If the rotator cuff was torn and unable to produce tension, could the deltoid muscle provide the necessary tension to stabilize the joint? Would this change the joint force calculated in part c)? **(4 marks)**





3. a) Sketch an example of a stress-strain curve for bone using the axes below (please draw these axes in your answer booklet). Don't worry about the scale on the vertical or horizontal axes, just sketch the shape of the curve. Clearly show the following: **(5 marks)**

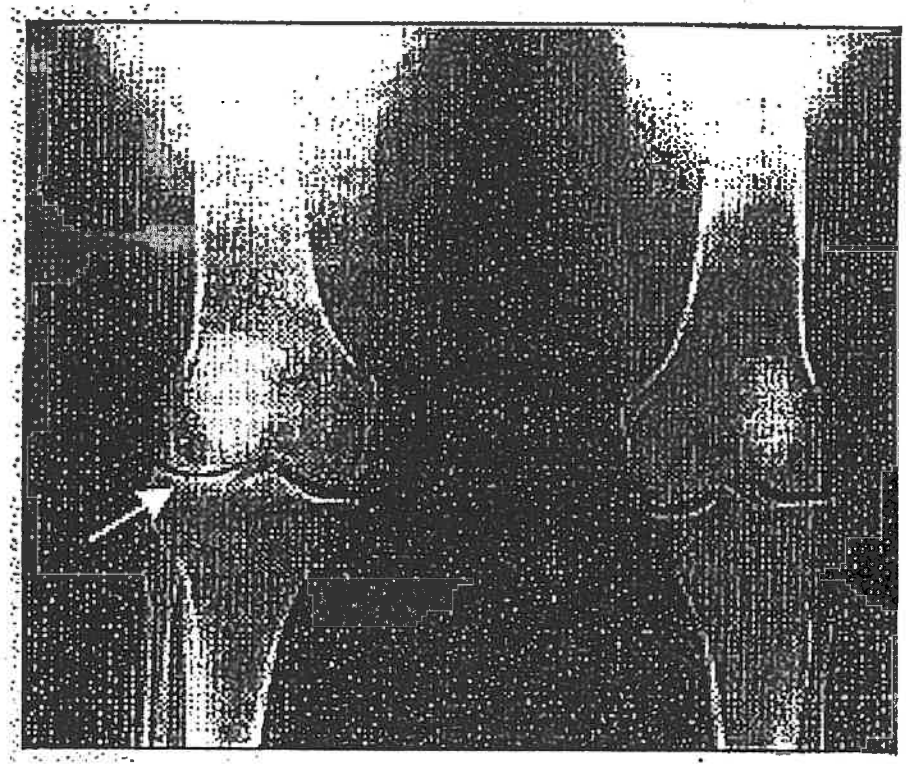
i) Failure stress
ii) Elastic region
iii) Toe region
iv) Yield stress
v) Plastic region



b) What <u>condition</u> is arrow pointing to in the lateral compartment? **(3 marks)**

c) What surgical procedure might have lead to this happening? **(3 marks)**

d) What musculoskeletal disorders is this patient now at risk for? **(4 marks)**

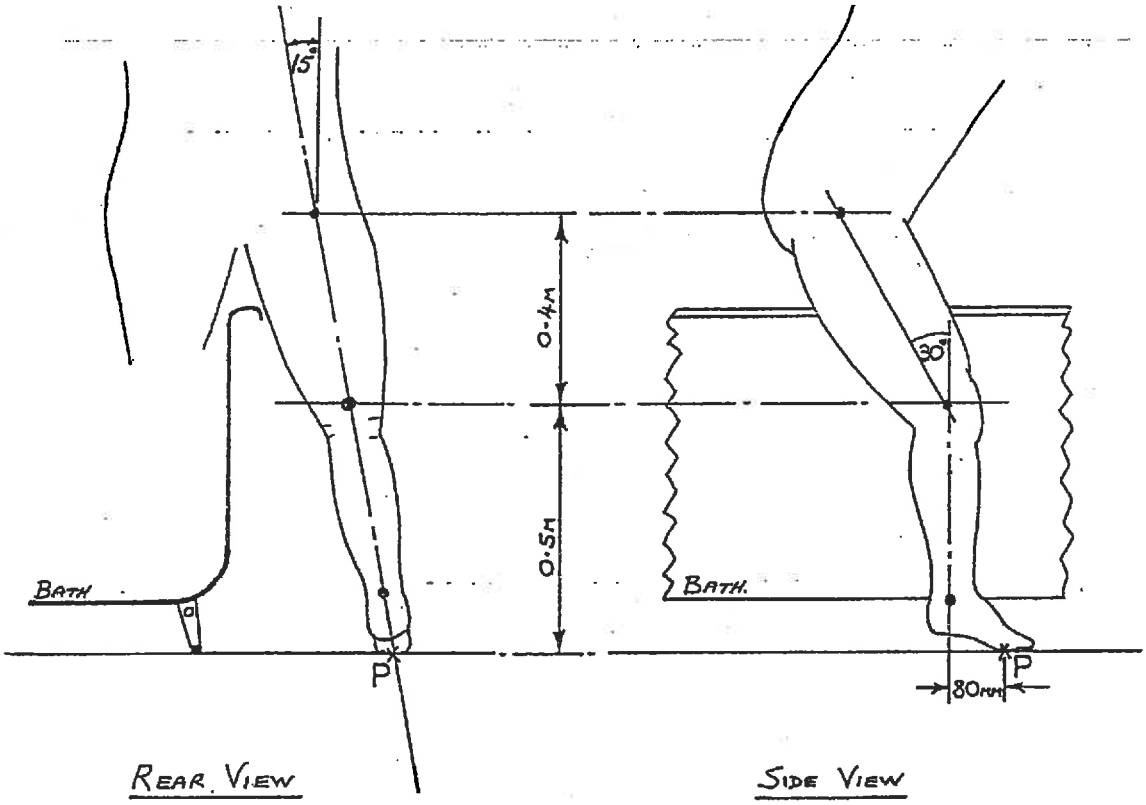


4. An elderly subject of mass 60 kg exits from a bath as shown below where the right root contacts the ground and experiences a vertical ground reaction force component of 400 N, a side-to-side force component of 45 N directed towards the bath and a backwards force of 20 N. If these forces can be considered to act at the centre of pressure, P, then:

a) Calculate the joint resultant moments at the knee and the hip joints in the sagittal plane. Ignore inertial effects. **(5 marks)**

b) Calculate the joint resultant moments at the knee and the hip joints in the frontal plane. Ignore inertial effects. **(5 marks)**

c) Calculate the joint resultant moments at the knee and the hip joints in the transverse plane. Ignore inertial effects. **(5 marks)**



5. Consider the runner in the photo to the right.

a) What has this person injured at this instant? **(4 mark)**

b) Suggest the biomechanical mechanism by which this structure became injured. **(5 marks)**

c) How long would you expect the healing process to take before this person can return to sport? What <u>three</u> criteria would you use? **(4 marks)**

d) Give two possible complications during healing. **(2 marks)**

Marking Scheme

1. 15 marks total; a) 4, b) 4, c) 4, d) 3 marks
2. 15 marks total; a) 3, b) 4, c) 4, d) 4 marks
3. 15 marks total; a) 5, b) 3, c) 3, d) 4 marks
4. 15 marks total; a) 5, b) 5, c) 5 marks
5. 15 marks total; a) 4, b) 5, c) 4, d) 2 marks