

National Exams May 2019

04-Bio-A4, Biomechanics

3 hours duration

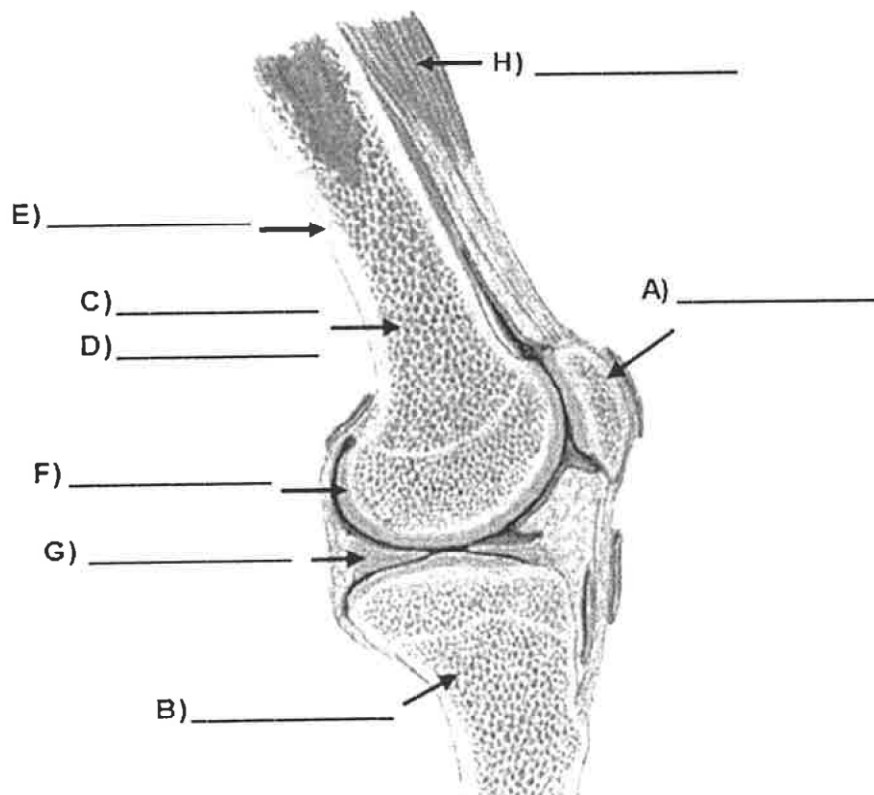
NOTES:

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 an OPEN BOOK EXAM.
Any non-communicating calculator is permitted.
3. FOUR (4) questions constitute a complete exam paper.
4. Each question is of equal value.
5. Clarity and organization of the answer are important.

Marking Scheme

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

1. Consider the diagram of the knee joint below shown in a cross-section along the sagittal plane.
- Identify the bones in A), B) and C). Also identify which is the cortical bone and the trabecular bone in D) and E). (5 marks)
 - Identify the connective tissue structures at F) and G) and the muscle at H). (3 marks)
 - If the muscle H) is contracted, what motion occurs at the knee? (4 marks)
 - Speculate on biomechanical purpose of the connective tissue structure at F). (3 marks)



2. A gymnast of mass 60 kg performs an “iron cross” position on the rings as shown (Figure 2A). At the glenohumeral (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 muscle needed for joint equilibrium. (5 marks)
 - b) Calculate the magnitude and direction of the joint force applied to the humeral head. (5 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. (5 marks)

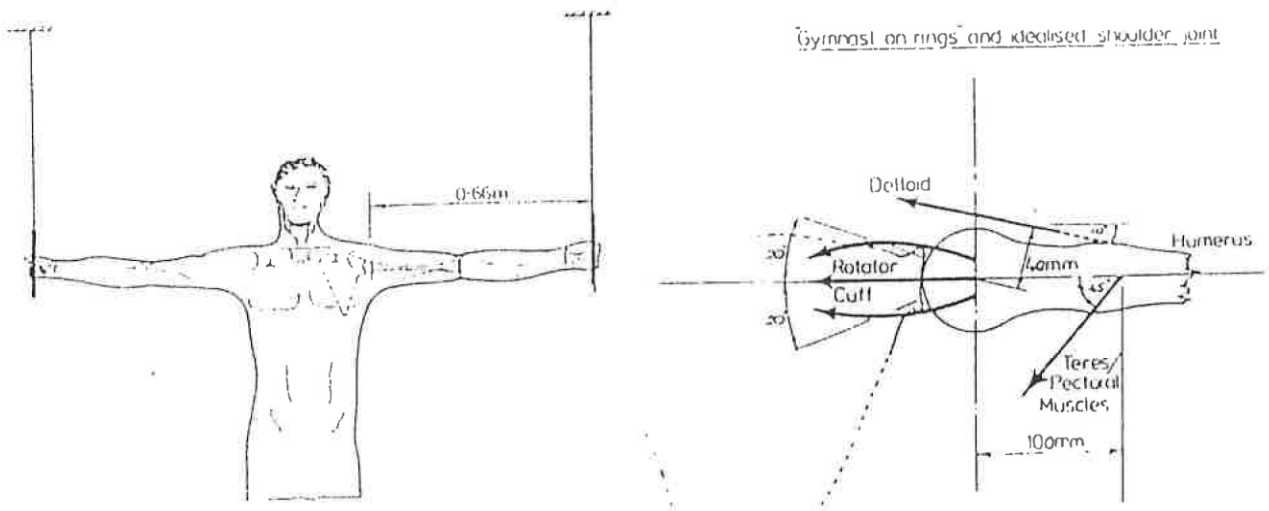


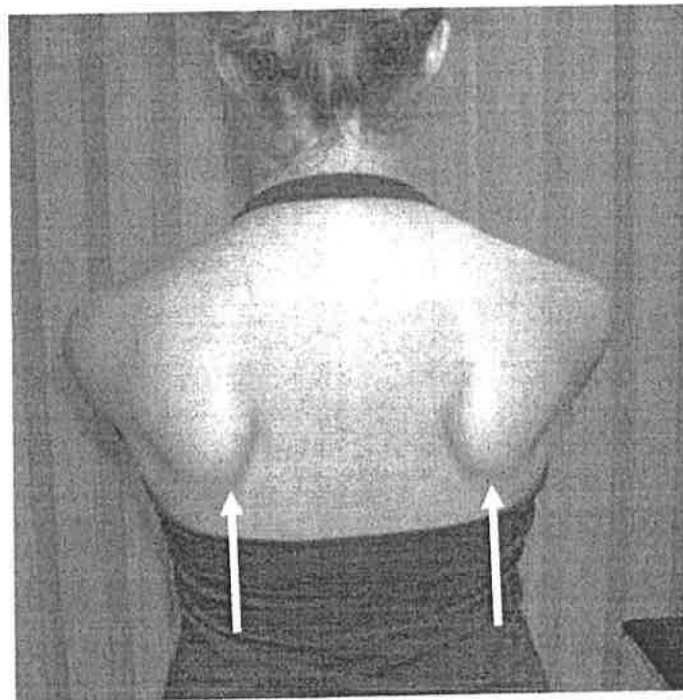
Figure 2: A) Gymnast performing the “iron cross” position on the rings. B) Diagram of the glenohumeral joint of the left shoulder.

3. a) Sketch an example of a stress-strain curve for ligament along its long axis, 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 condition is present at the inferior angles of this young woman's scapulae bilaterally (indicated with white arrows)? **(3 marks)**
- c) What rehabilitation procedure might improve this condition? **(3 marks)**
- d) What musculoskeletal disorder is this patient now at risk for? **(4 marks)**



4. A truck driver is attempting to pull a gear lever toward himself with his right arm and hand (Figure 4). At the instant shown the driver is applying a force of 120 N horizontally to the left and 80 N vertically upwards. The hand also applies a small clockwise moment of 5 Nm to the handle at point H on the diagram. All motion occurs within the plane of the page.

For the limb position and dimensions shown in Figure 1, do the following:

- Draw a free body diagram of the forearm and upper arm showing all relevant forces and moments, (4 marks)
- Calculate the moment at the elbow joint, (4 marks)
- Calculate the moment at the shoulder joint, (5 marks)
- At each of the joints, which muscles are likely to be active? (2 marks)

Figure 4: A truck driver pulling a stiff gear lever with his right arm and hand

