

National Exams December 2013

04-Bio-A4-Biomechanics

3 hours duration

Notes

1. If doubt exists as to the interpretation of any question, the candidate is urged to include a clear statement of any assumptions made in the answer booklet.
2. This is a CLOSED BOOK EXAM.
3. Four (4) questions constitute a complete exam paper.
4. Each question is of equal value.
5. Clarity and organization of the answers are important.

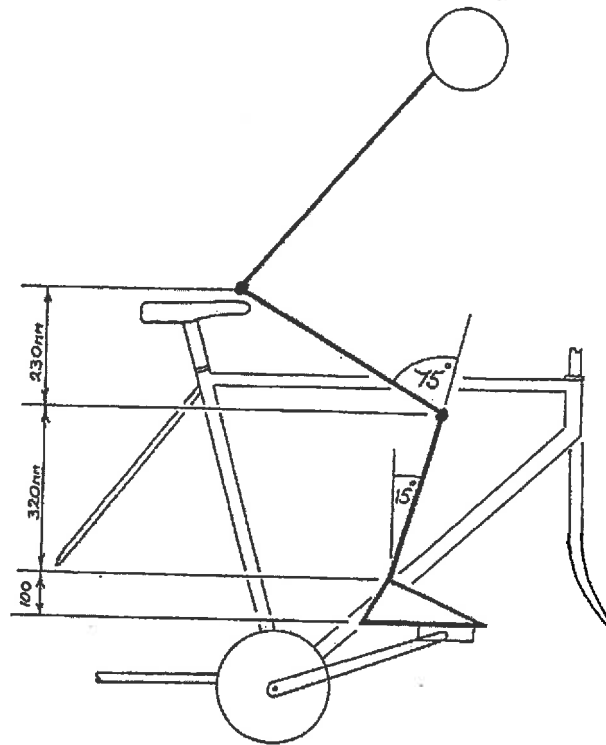
(15 marks)

1. Figure 1 below shows a cyclist pedaling a bicycle. At the instant shown the cyclist is applying a force of 450 N orthogonal to the crank shaft of the pedal. The crank is at 20 degrees above horizontal, the foot is horizontal and the center of pressure on the sole of the foot is 120 mm anterior to the ankle joint center.

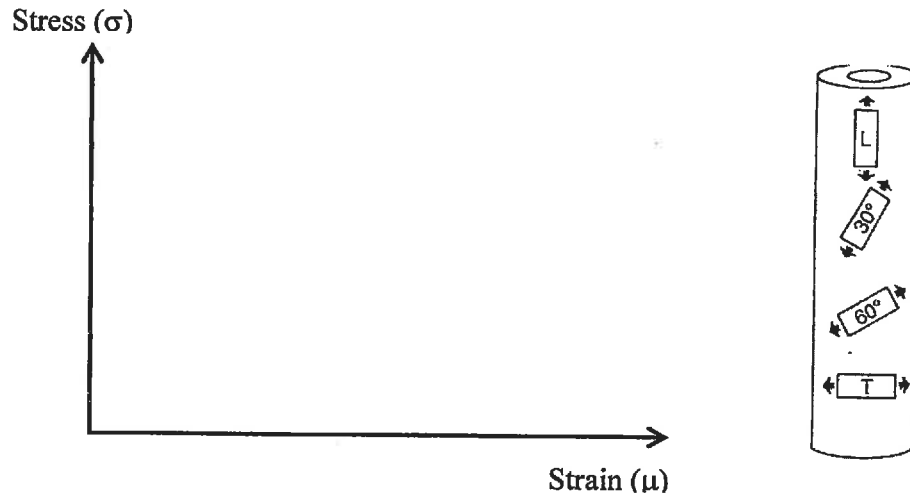
For the limb position and dimensions shown in Figure 1, find the following:

- a) Calculate the moment acting on the ankle joint, (3 marks)
- b) Calculate the moment acting on the knee joint, (4 marks)
- c) Calculate the moment acting on the hip joint, (5 marks)
- d) For each of the three joints, suggest which muscles are active. (3 marks)

Figure 1: Diagram of a cyclist pedaling a bicycle.



- (15 marks) 2. a) In your answer booklet, using axes similar to those below, sketch a stress-strain curve for cortical bone along the long axis of a long bone (i.e. in the direction of specimen L in the diagram below). Clearly indicate the i) elastic region, ii) yield point, iii) plastic region and iv) ultimate strength. (4 marks)



- b) Sketch a stress-strain curve for the same bone as in a), but now in the transverse direction (i.e. in the direction of specimen T). Clearly indicate the i) elastic region, ii) yield point, iii) plastic region and iv) ultimate strength. (4 marks)
- c) What abnormality of walking gait is the person in Figure 2 exhibiting? (3 marks)
- d) Which muscles should be strengthened to correct this? (4 marks)



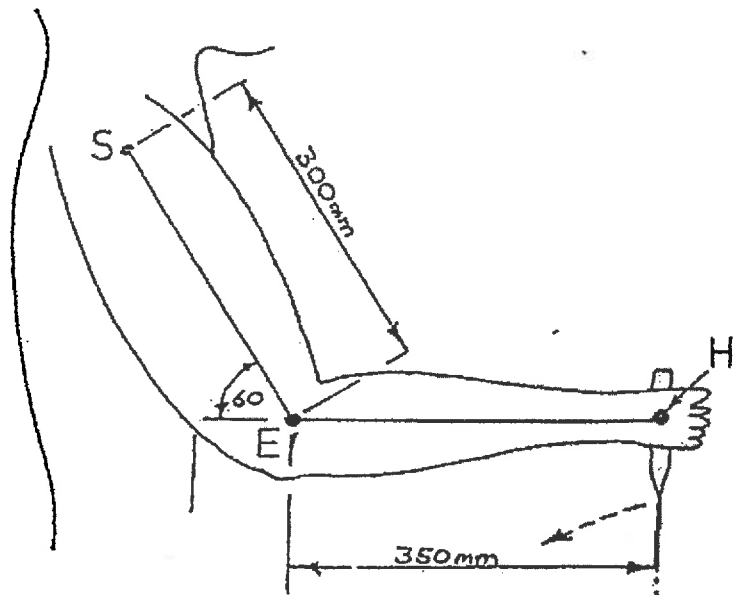
Figure 2:

3. A truck driver is attempting to pull a gear lever toward himself with his right arm and hand (Figure 3). At the instant shown the driver is applying a force of 220 N horizontally to the left and 60 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 3, 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 3: A truck driver pulling a stiff gear lever with his right arm and hand



4. Consider the x-ray in Figure 4 below. This is a view of the forearm of a 25 year old male who has returned to the emergency room following a fracture, complaining of pain and loss of left hand function.

- a) Which bone was originally injured (indicated by white arrow)? (2 marks)
- b) What has happened now to make this person return to the emergency room? (2 marks)
- c) Suggest a biomechanical mechanism by which this injury occurred (5 marks)
- d) What surgical procedure should be used to correct this injury? (4 marks)
- e) Give two possible complications during the healing process. (2 marks)

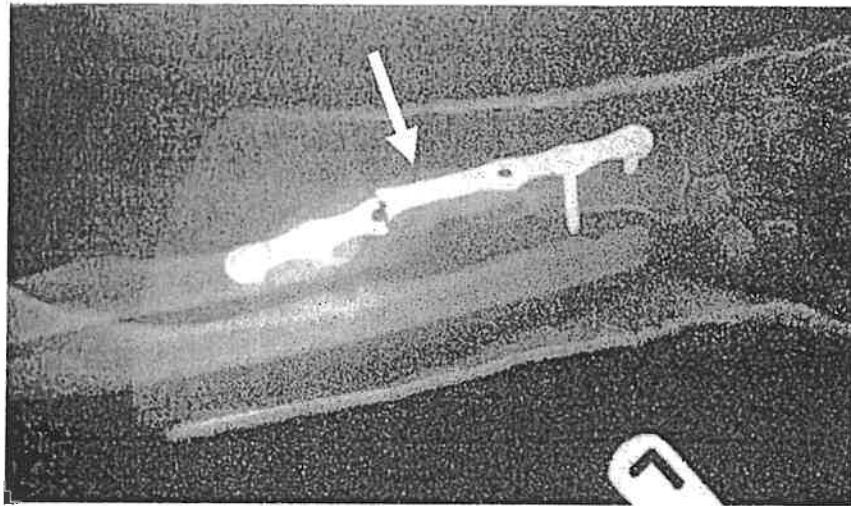


Figure 4: X-ray of the left forearm.

Marking scheme

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