National Exams May 2013

**04-Bio-A4 - Biomechanics**

3 hours duration

<u>Notes</u>

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, with approved calculator allowed.

3. Five (5) 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 shows an elderly subject of mass 60 kg exiting from a bath tub 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 <u>sagittal</u> plane. Ignore inertial effects. **(5 marks)**

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

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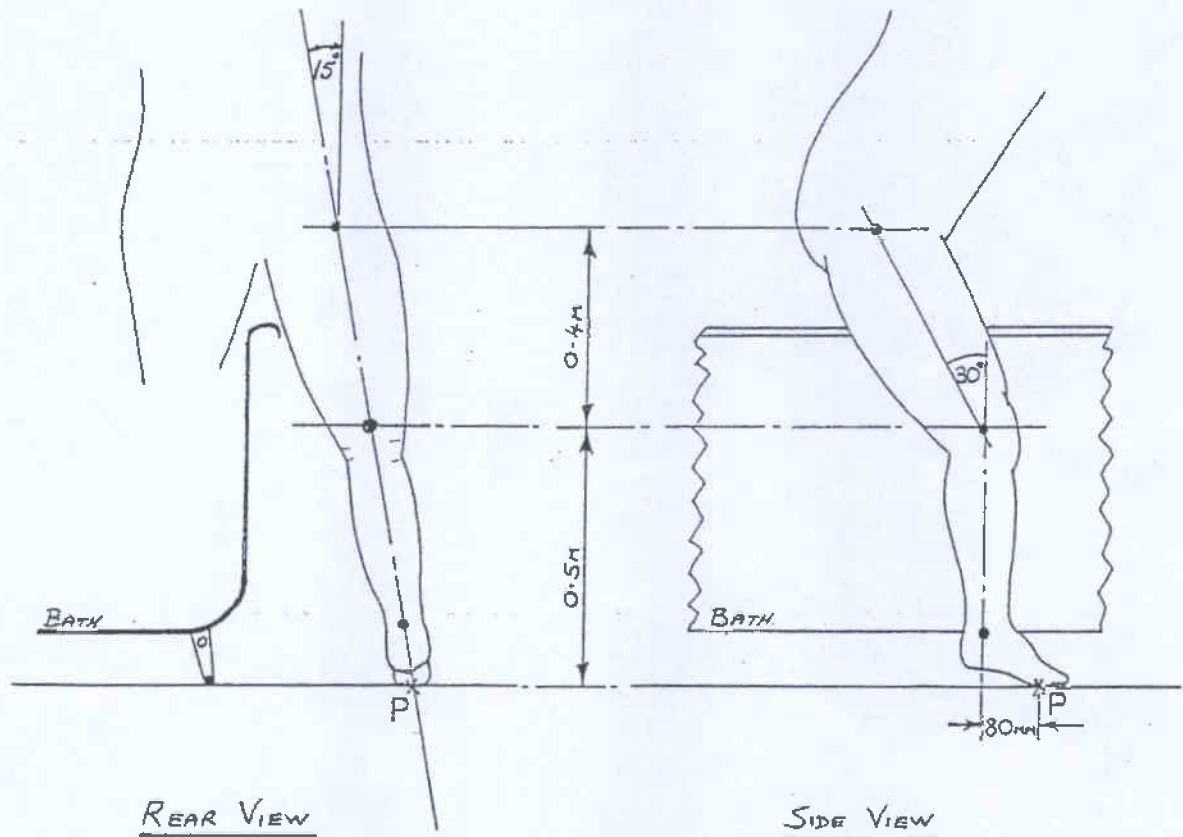


**Figure 1**

**(15 marks)** 2. Figure 2 below shows a link segment model of a person doing a <u>one-armed</u> handstand on their right hand.

a) Sketch the diagram of the kinematic chain A-B-C-D-E-F-G and give the number of degrees of freedom for each of the joints that are within the chain (i.e. J1, J2 or J3). Also, label each of the relevant links in the chain (i.e. L1, L2, L3, etc.) **(5 marks)**

b) Calculate the number of degrees of freedom in the <u>entire kinematic chain</u> **(3 marks)**

c) Repeat b) for the case where both hands are on the ground **(4 marks)**

d) Classify the chains in both b) and c) using two of the following four words: serial, branched, open, and closed **(3 marks)**
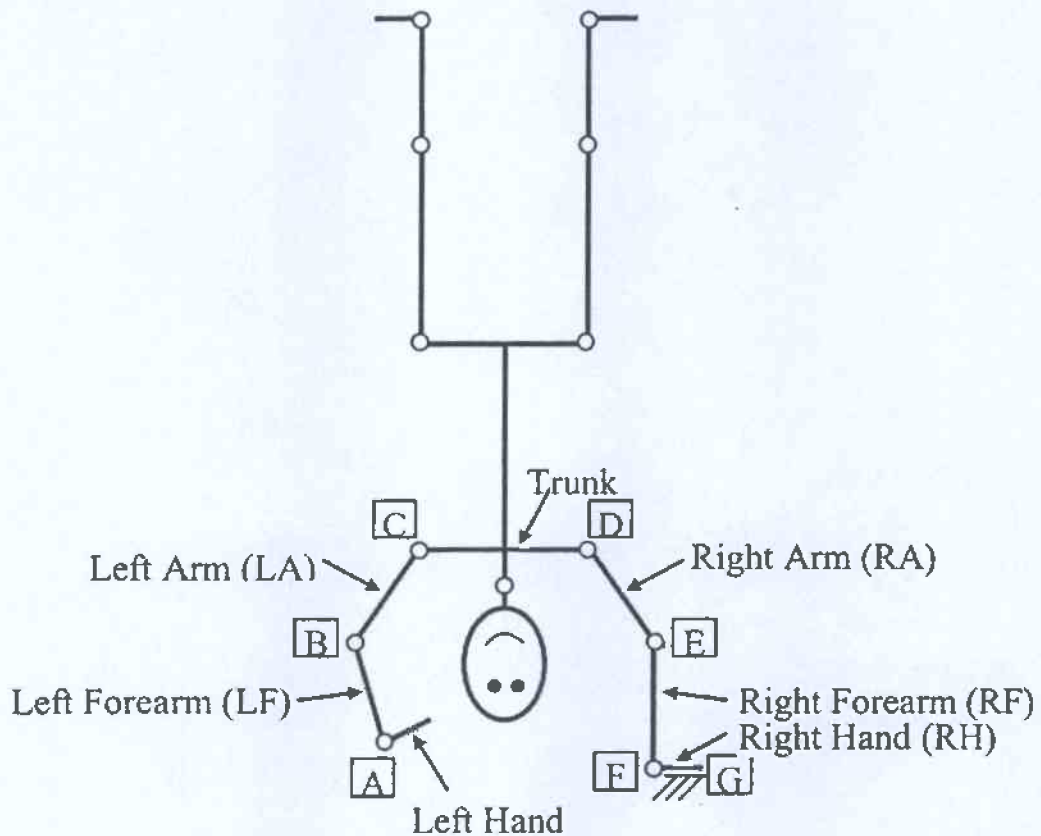


**Figure 2**

(15 marks)  3.  a) Provide short (1-2 sentences) definitions for the following terms (5 marks):
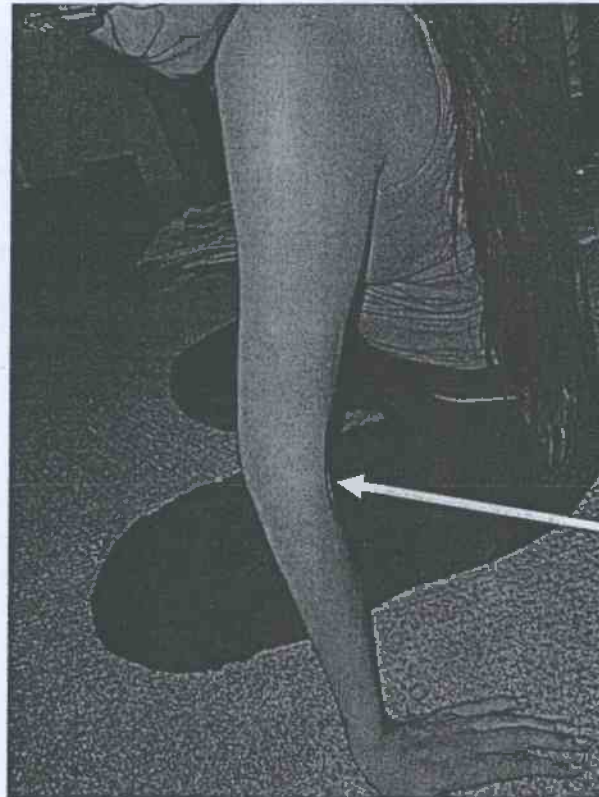
i)      Flexion
ii)     Abduction
iii)    Ulnar deviation
iv)     Internal rotation
v)      Varus angulation

b) What condition does the girl have in the photo below (figure 3, indicated by white arrow)? (3 marks)

c) What muscles might be strengthened to correct this condition? (3 marks)

d)  What musculoskeletal disorders is this girl at risk for? (4 marks)

**Figure 3**

(15 marks)  4.   A villain is kicking the base of a door in order to break it down (Figure 4). At the instant of contact with the door, the toe decelerates with a value of 50 m/s$^2$ (tangential relative to the hip center) and the hip flexors have already relaxed to zero action. The thigh and the lower leg segments are both 44 cm long with centers of mass halfway along that length. The masses of the thigh and lower leg segments are 7.2 kg and 4.3 kg respectively and their radii of gyration are 14 cm and 15 cm respectively.

Assume that the knee joint is flexed to 28 degrees and the ankle joint is in the neutral position and that there is no relative motion or acceleration between the segments of the leg.

a)   Draw the free body diagram of the entire leg (including all linear and angular accelerations) and show all relevant dimensions. **(5 marks)**

b)   Draw the free body diagram of the entire leg showing all the relevant forces and moments. **(5 marks)**

c)   Calculate the contact force between the door and the toe at the instant shown assuming the hip joint to be not moving or accelerating linearly in any direction (i.e. is fixed in space). **(5 marks)**
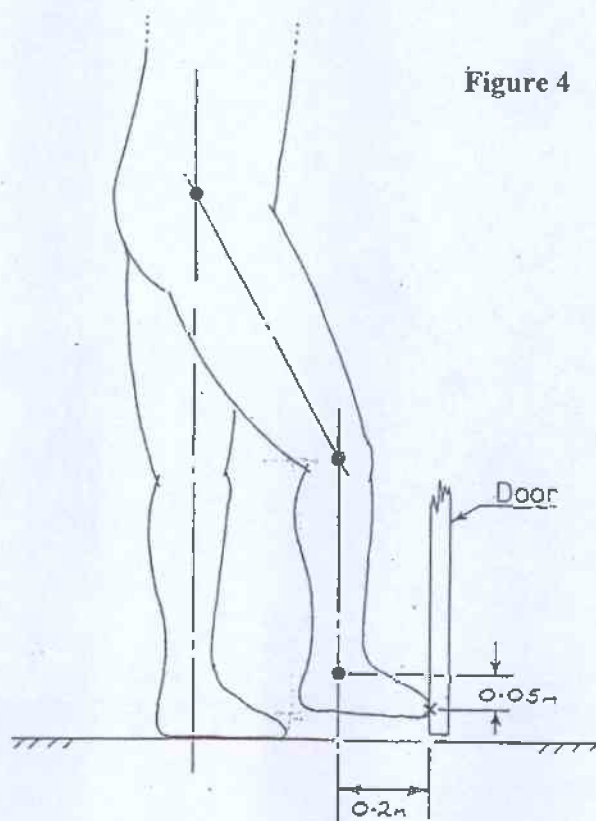


**Figure 4**

**(15 marks)** 5. Consider the x-ray in Figure 5 below. This is a frontal view of the right hip and thigh of a 67 year old female complaining of pain and loss of weight-bearing in the right hip.

    a) What injury has this person sustained (indicated by white arrow)? **(4 marks)**
    b) Suggest a biomechanical mechanism by which this injury occurred **(5 marks)**
    c) What surgical procedure should be used to correct this injury? How long do you expect the healing process to take before return to full function? **(4 marks)**
    d) Give two possible complications during the healing process. **(2 marks)**



Figure 5: X-ray frontal view of the right hip and thigh.

# Marking scheme

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