[ENG 42]

UNIVERSITY OF BOLTON
SCHOOL OF ENGINEERING
BIOMEDICAL ENGINEERING
SEMESTER 2 EXAMINATIONS 2021/22
INTERMEDIATE BIOMECHANICS
MODULE NO. BME5004

Date: Thursday 19th May 2022 **Time: 10:00 – 12:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions on this paper; TWO questions in section A and FOUR questions in section B.

Section A: Answer ONE question

Section B: Answer TWO questions

Write your answers in the answer book provided, NOT on the question paper. You must clearly label each answer with the corresponding section letter, question number and part letter.

Electronic calculators may be used provided that data and programme storage memory is clear prior to the examination.

School of Engineering
Biomedical Engineering
Semester 2 Examinations 2021/22
Intermediate Biomechanics
Module No. BME5004

<u>Section A:</u> Experimental

Answer <u>ONE</u> question from this section.

1. a) You are working with a client who is a wheelchair user and wants to find the most appropriate posture/ position to tolerate fatigue in the upper limbs for prolonged bouts of physical exertion. **Outline** a case study style investigation utilising <u>Electromyography (EMG)</u> in assessment of muscle activation characteristics (e.g., amplitude and frequency) which will provide biomechanical evidence to support your report and recommendations. **(20 marks)**

b) Discuss the anticipated results from the case study outlined above and provide a balanced overview of how the results would influence your recommendations, i.e., offering both primary and alternative recommendations, which will depend on the actual direction of the data should this case study investigation be completed.

(10 marks)

c) Discuss the limitations of <u>EMG</u> as a mode of neuromuscular and biomechanical observation. **(10 marks)**

2. a) You are working with a client who is a wheelchair user and wants to find the most appropriate posture/ position to tolerate fatigue in the upper limbs for prolonged bouts of physical exertion. **Outline** a case study style investigation utilising <u>2-dimensional video analysis</u> in assessment of linear and angular kinematics (e.g., joint displacement, velocities, accelerations) which will provide biomechanical evidence to support your report and recommendations.

(20 marks)

b) Discuss the anticipated results from the case study outlined above and provide a balanced overview of how the results would influence your recommendations, i.e., offering both primary and alternative recommendations, which will depend on the actual direction of the data should this case study investigation be completed.

(10 marks)

c) Discuss the limitations of <u>2-dimensional video analysis</u> as a mode of biomechanical observation.

(10 marks)

PLEASE TURN THE PAGE…

School of Engineering
Biomedical Engineering
Semester 2 Examinations 2021/22
Intermediate Biomechanics
Module No. BME5004

<u>Section B:</u> Theoretical

Answer <u>TWO</u> questions from this section.

3. a) Calculate the **linear tangential velocity** of a robotic arm the instant before releasing a projectile, which reaches peak angular velocity of 18.2 rad·s^{-1} and a radius of rotation of 1.57 m. The projectile is release from the very end of the robotic arm.

(3 marks)

b) Following a reduction in the mass of the robotic arm - after changing the material used in design - the angular velocity of the arm can now reach 26.2 rad·s^{-1} whilst the radius of rotation has remained the same.

i) Calculate the **linear tangential velocity** of the re-designed robotic arm the instant before releasing the projectile at the new angular velocity.

ii) What is the **change** in linear tangential velocity from the original robotic arm to the newer design?

iii) Explain an alternative way that the robotic arm could have been designed to specifically increase the linear tangential velocity.

(12 marks)

c) A human participant is aiming to compete against the newer robotic arm from part b

i) If the length of their radius of rotation (fingers to centre of the chest) is limited to 1.17 m, what **angular velocity** would they need to match the linear tangential velocity higher of the newer robotic arm?

ii) at the angular velocity from part c) i) what would be the **tangential acceleration** and **radial acceleration** the instant before releasing the projectile of that phase of the movement took 0.13 s?

(15 marks)

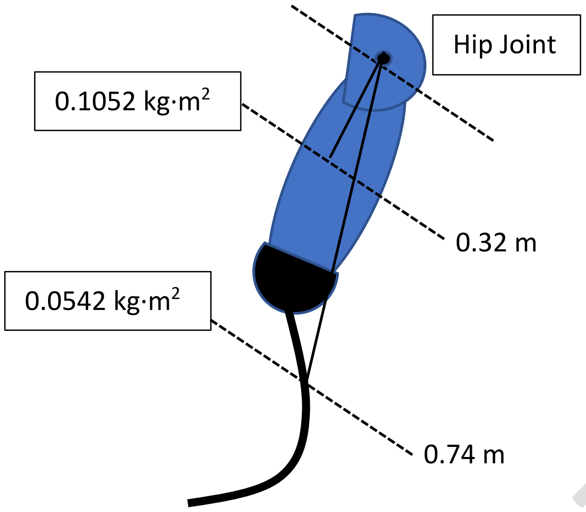
Formulae: $V_t = r\,\omega$

$a_t = r\,\alpha$

$a_r = V_t^2 / r$

PLEASE TURN THE PAGE…

4. a) Using the Parallel Axis Theorem calculate the instantaneous **moment of inertia** of the leg in the recovery (swing phase) about the hip joint axis of a sprinter who has a prosthesis (see figure 1).



Sprinter's mass = 78 kg

Segmental Mass ratios:

Thigh = 0.103 (10.3%)

Prosthesis = 0.058 (5.8%)

Formula: $I = I_{CG} + md^2$

Figure 1. Sprinter's leg in the recovery (swing phase), scenario 1

(12 marks)

b) Following a redesign of the prosthesis socket shown in figure 2, you have been able to add a joint that allows simulated flexion without a change in prosthesis mass. Calculate the instantaneous **moment of inertia** in this new position.

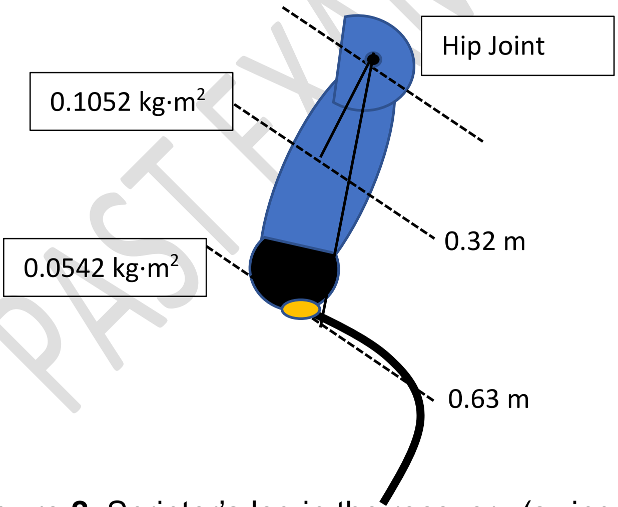


Figure 2. Sprinter's leg in the recovery (swing phase), scenario 2 – new socket joint

(12 marks)

c) Quantify the proportional change with the new socket design and explain the benefit for the sprinter. **(6 marks)**

PLEASE TURN THE PAGE…

5. a) What is the **angular momentum** of a 62 kg gymnast in an almost straight position rotating about her medio-lateral axis in a backflip at an angular velocity of 4.9 rad·s^{-1} given her radius of gyration is 0.78 m?

Formulae:

$I = mk^2$ $\qquad$ $H = I\,\omega$

(6 marks)

b) As shown in figure 3, a diver changes from a tuck position to an almost straight body position to enter the water during a dive. Considering the conservation of angular momentum, calculate the **angular velocity** of the diver just before entering the water given the information below.

Mass 82 kg

k (tuck) = 0.42 m

k (straight) = 0.86 m

ω (tuck) = 5.3 rad·s^{-1}

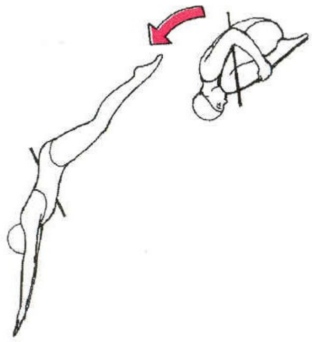


Figure 3. Diver changing from tuck to straight position to enter the water.

(12 marks)

c) Explain the principle of conservation of angular momentum and outline another applied example of this principle in some form of human movement.

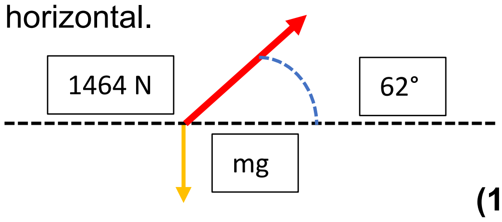
(12 marks)

6. a) Calculate the **resultant acceleration** of a propulsive step for a person of 96 kg applying a thrust of 1464 N at 62° to the horizontal.

Formulae:

$FV = F \cdot \sin\theta - mg$

$FH = F \cdot \cos\theta$ $\qquad$ $F = m \cdot a$



(12 marks)

b) If the same person applies at thrust of 1634 N at 54° to the horizontal on the next step, what is the difference between the two steps in **resultant acceleration**?

(12 marks)

c) Sketch a force-time graph and plot the theoretical force-time curves that you would expect to see for one foot contact in i) walking; ii) rear-foot strike running; iii) forefoot sprinting trials. **(6 marks)**

END OF QUESTIONS