[ESS14]

UNIVERSITY OF BOLTON

SCHOOL OF SPORT & BIOMEDICAL SCIENCES

BENG (HONS) BIOMEDICAL ENGINEERING

SEMESTER 1 EXAMINATIONS 2019/2020

INTRODUCTION TO BIOMECHANICS

MODULE NO. BME4003

Date: Monday 13th January 2020 **Time: 2:00pm – 4:00pm**

INSTRUCTIONS TO CANDIDATES:

Answer ALL questions on this paper.

This Paper contains both multiple choice and short-answer questions:

For multiple choice questions, select one answer per question unless otherwise directed and write it down in the answer book provided.

For the short-answer questions write down your answer using concise scientific language and diagrams where applicable. Use the marks offered for each question as a guide for time allocation to complete your answers.

A formulae sheet has been provided.

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1. The two main branches of biomechanics are known as:

   a) Velocity: the rate of change of position; Acceleration: the rate of change of velocity.
   b) Kinetics: the study forces that cause motion; Kinematics: the study of quantities of motion
   c) Kinetics: the study quantities of motion; Kinematics: the study of forces that cause motion
   d) Strength: the study of how strong an athlete is; Power: the study of how fast an athlete is

(1 mark)

2. What are the main aims of analysis of human movement through biomechanics?

   a) Assessing how the body extracts and utilises macronutrients
   b) Reducing injury, improving rehabilitation and improving performance
   c) Monitoring the motivation of the athlete to perform
   d) Increasing injury, preventing rehabilitation and reducing performance

(1 mark)

3. List **three** ways to improve static or dynamic stability.

(3 marks)

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4. Which of the following statements best describes postural control in balance.

   a) A complex skill based on the interaction of multiple, dynamic sensorimotor processes.
   b) A summation of static reflexes.
   c) No slouching when standing.
   d) Not falling over when stood on one leg.

(1 mark)

5. General motion in biomechanics is defined as:

   a) Motion of a body along a linear or curvilinear path
   b) Motion around an axis of rotation
   c) Motion along a linear path
   d) Motion around an axis of rotation that brings about motion on a linear or curvilinear path

(1 mark)

6. What is the **Weight** of a 103.3 kg person?

(1 mark)

7. What is the average velocity of a persons' centre of gravity (CoG) during walking, when it is raised 0.54 seconds, with a vertical displacement of 0.06 metres?

a) 0.11 $m \bullet s^{-2}$
b) 9.00 $m \bullet s^{-2}$
c) 0.11 $m \bullet s^{-1}$
d) 9.00 $m \bullet s^{-1}$

(1 mark)

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8. The differences between scalar and vector quantities are best described as:

a) Scalar and Vector quantities both only have a magnitude
b) Scalar quantities have a magnitude, direction and point of application; Vector quantities have a magnitude only
c) Scalar quantities have magnitude only; Vector quantities have a magnitude, direction and point of application
d) Scalar and Vector quantities both have a magnitude, direction and point of application

(1 mark)

9. Calculate the **Stride Length** of a person with a cadence of 2.2 strides per second, when they are walking at 5.2 $km \bullet h^{-1}$?

   a) 2.36 m
   b) 0.42 m
   c) 2.36 $m \bullet s^{-1}$
   d) 11.44 m

(1 mark)

10. A projectile is thrown with an average acceleration of 15.3 $m \bullet s^{-2}$, during the first 0.6 seconds of its' flight. What would be the projectiles resultant velocity at this time point?

   a) 25.5 $m \bullet s^{-1}$
   b) 9.18 $m \bullet s^{-1}$
   c) 9.81 $m \bullet s^{-1}$
   d) 0.039 $m \bullet s^{-1}$

(1 mark)

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11. What is **Newton's Second (2nd) law of motion**? Give a brief description and an applied example of when this law is in action.

(5 marks)

12. A persons Centre of Gravity (CoG) has a vertical velocity of -3.23 $m \bullet s^{-1}$ immediately prior to initial contact (IC) during walking. In the instance immediately following IC, CoG vertical velocity was -1.92 $m \bullet s^{-1}$. What was the average **acceleration** of the persons CoG if the change in velocity was achieved in 0.09s?

a) -14.56 $m \bullet s^{-1}$
b) -0.12 $m \bullet s^{-2}$
c) -14.56 $m \bullet s^{-2}$
d) -0.12 $m \bullet s^{-1}$

(1 mark)

13. What three components of ankle movement are generated in Supination?

(3 marks)

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14. What is the force required to horizontally accelerate a 78.9 kg person 3.65 $m \bullet s^{-2}$, on a porters trolley?

    a) 287.99 N
    b) 28.79 N
    c) 21.62 N
    d) 0.05 N

(1 mark)

15. According to **Newton's third (3rd) law** of motion:

    a) For every action by one body on a second there is an equal and opposite reaction by the second body on the first

    b) A body will remain in a state of rest or constant motion in a straight line until acted on by an force

    c) A force applied to a body causes an acceleration of that body which has a magnitude proportional to the force, and takes place in the direction in which the force acts.

    d) All bodies are attracted to one another with a force which is proportional to the product of their masses, and inversely proportional to the square of the distance between them.

(1 mark)

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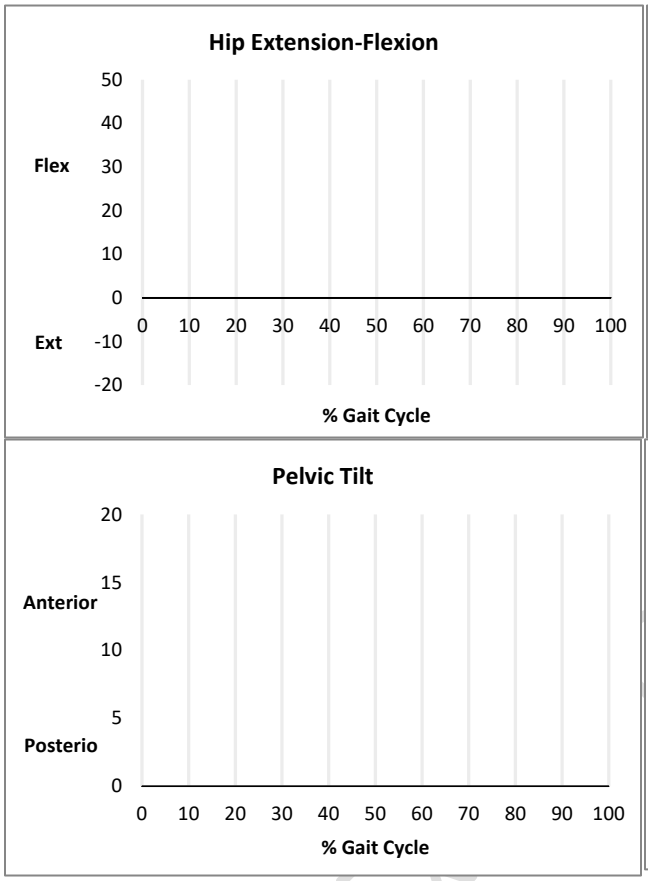
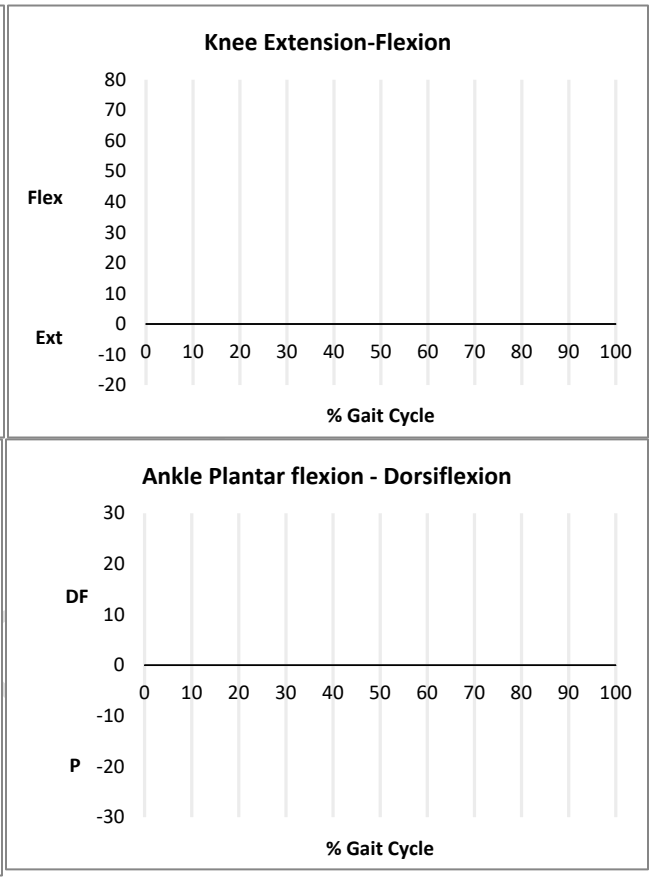
16. On the blank figures below, complete the range of motion (ROM) traces for each of the joints in the sagittal plane, based on 'NORMAL' walking gait.





(8 marks)

17. Outline a procedure for collecting **semi-quantitative** technique data of **walking gait**. Consider the protocol you would use and the equipment you would require to collect the data and how you may then analyse it.
Any of the following terms to be used in the correct context:

(10 marks)

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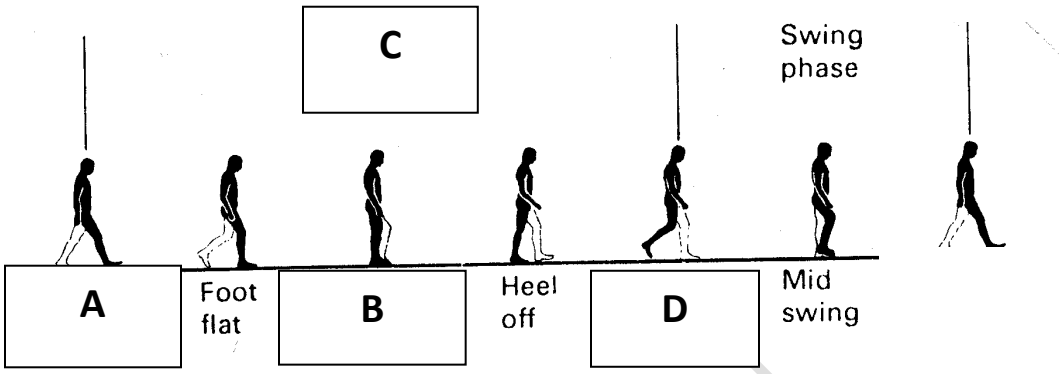
18. List the missing *phases* and *stages* of the gait cycle from the boxes on the diagram below.



(4 marks)

19. Which <u>one</u> of the following statements is **true**?

a) Impulse is a product of force and time; Momentum is a product of mass and velocity
b) Momentum is a product of force and time; Impulse is a product of mass and velocity
c) Momentum is a product of force and velocity; Impulse is a product of mass and time
d) Impulse and Momentum cannot be calculated in kinetics

(1 mark)

20. If an elderly person falls with a velocity of 6.2 $m \cdot s^{-1}$ immediately prior to collision with the floor, assuming a constant mass of 54.32 kg, what is the momentum of the fall victim at the instance of impact?

(2 marks)

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21. If the elderly person (as above in Q.20) manages to place a foot out in front and prevent a fall, what is the average force applied if the person brought themselves to a halt in 0.8s seconds? Assuming mass remained constant (54.32 kg) and velocity before they planted a foot was 5.1 $m \bullet s^{-1}$.

(3 marks)

22. I am bored in my office, so I begin to throw balled-up pieces of paper into the bin on the opposite side of the room. I score ten out of ten immediately because I know I need to release the ball with a horizontal velocity of 7.6 $m \bullet s^{-1}$ and a vertical velocity of 4.3 $m \bullet s^{-1}$ (and I'm awesome at this game). Calculate the paper balls' resultant release velocity and angle of projection.

(5 marks)

23. Sketch a graph to indicate the **vertical force vs. time** relationship you would expect for a **countermovement jump** (include axis labels and units)

(3 marks)

24. Calculate a person's jump height, when their mass is 75kg, and they have a take-off velocity of 2.34 $m \bullet s^{-1}$?

(2 marks)

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25. Sketch a graph to indicate the **vertical force vs. time** relationship you would expect for a **'Heel Strike'** runner (include axis labels and units).

(3 marks)

26. List three ways of improving aerodynamics for a cyclist.

(3 marks)

27. List three important considerations to optimise jumping technique.

(3 marks)

28. Sketch a graph to highlight the relationship between **friction force** and **applied horizontal force** considering static and dynamic friction.

(3 marks)

29. In a lever within the human body that is said to have a **mechanical advantage** which **two** of the following statements are true:

a) The resistive force moment arm is greater than the muscle force moment arm
b) The ankle joint in a calf raise exercise is an example of this lever
c) The muscle force moment arm is greater that the resistive force moment arm
d) This type of lever does not occur within the human body
e) The elbow joint in a bicep curl exercise is an example of this lever

(1 mark)

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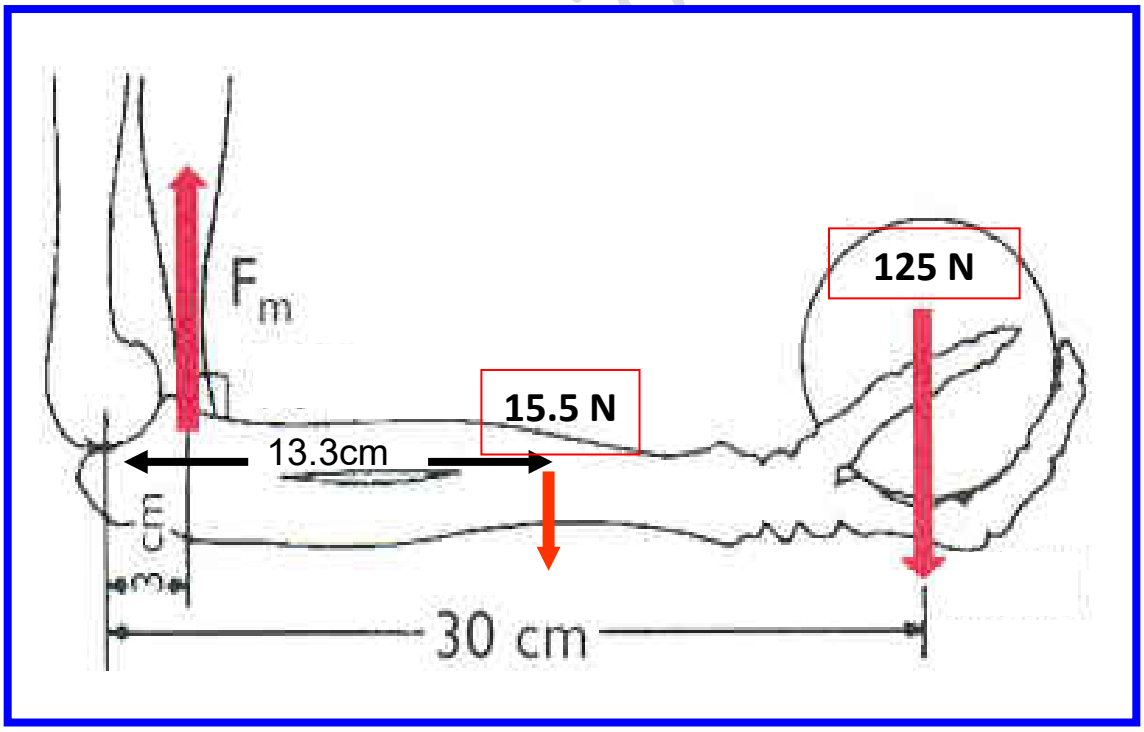
30. The **stair climbing** is a multi-joint activity- which plane of movement would we observe Flexion/Extension at the hip, knee and ankle? What muscle are the **agonists** in the ascent (upward) phase at the hip, knee and ankle joints of the stance leg?

(5 marks)

31. What major muscles are stressed in a vertical **Shoulder Press** movement? And what type of activation are these muscles involved in with the descent or **lowering phase** of the movement?

(5 marks)

32. Calculate the amount of force required in contraction of the Biceps Brachii to maintain a static position/ isometric contraction in the image below. You should consider the resistance from the segments involved, and the external load in your answer.



(5 marks)

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33. Outline a procedure for collecting **force platform data** from an athlete running at 4-5 $m.s^{-1}$. Consider the protocol you would use and the equipment you would require to collect the data.

(10 marks)

END OF QUESTIONS

Formulae
$a^2 + b^2 = c^2$
SOH: Sin = Opposite / Hypotenuse **CAH: Cos = Adjacent / Hypotenuse** **TOA: Tan = Opposite / Hypotenuse**
F= ma
Stride Velocity = Stride Length x Stride Frequency
$v = p_2 – p_1 / t_2 – t_1$
$a = v_2 – v_1 / t_2 – t_1$
m x v
F x t
$F \times t = (m_2 \times v_2) – (m_1 \times v_1)$
$v_2^2 = v_1^2 + 2ad$
$M = F \bullet x$