

2024/2025

INDIVIDUAL EXAM

IN

THP 203- BASIC BIOMECHANICS

Information

- Start of exam: Friday May 16. 2025 at 10 a.m
- End of exam: Friday May 16. 2025 at 1 p.m. in WISEflow
- Exam results will be available within three weeks from the exam date: 10th of June 2025
- Aids: Calculator from the list of approved calculators and Formula sheets (distributed in the exam room)

Give your answer in English or Norwegian

Section 1 – Physics (70 points)

Question 1

An athlete completes a vertical jump on a force platform. The impulse during the jump is 211.1 Ns. The athlete jumps with a resultant take off velocity of $2.3 \text{ m}\cdot\text{s}^{-1}$.

- a) What is the mass of the athlete in kilograms?
(4 points)
- b) What is the weight of the athlete in Newtons?
(2 points)

Question 2

A gymnast with a mass of 62 kg is 1.8 metres above the ground during a competition.

- a) How much potential energy does the athlete have?
(4 points)
- b) Two handball players with mass and velocities as detailed in Table 1 below collide on the court. What is the total velocity after the collision?
(6 points)

Table 1: Mass and velocity of the two athletes before they collided

	Athlete 1	Athlete 2
Mass (kg)	68	81
Velocity ($\text{m}\cdot\text{s}^{-1}$)	- 4.1	3.9

Question 3

A ball is kicked with a vertical velocity of $5.1 \text{ m}\cdot\text{s}^{-1}$ and horizontal velocity of $8.8 \text{ m}\cdot\text{s}^{-1}$.

- a) What was the angle between the ball and the ground at the instant it was kicked?
(4 points)
- b) The ball lands back on the ground at the same height as it was kicked from. How far was the ball kicked?
(8 points)

Question 4

A diver is 12.1 metres over the water when they reach their maximum height.

- a) How long (how much time) did it take to reach the water from 12.1 metres?
(6 points)

On the way down, the diver rotates with an angular velocity of $4.01 \text{ rad}\cdot\text{s}^{-1}$ and an angular momentum of $15.0 \text{ kg}\cdot\text{m}^2\cdot\text{s}^{-1}$. Just before landing, the diver changes their body position so that the moment of inertia increases by $0.6 \text{ kg}\cdot\text{m}^2$.

- b) What is the angular velocity of the diver in this new body position?
(6 points)

Question 5

A slalom skier with a mass of 71 kg is skiing downhill on a slope with an incline of 18 degrees relative to the horizontal. What is the friction force acting on the skier if the coefficient of friction between the ground and the skis is 0.08?

(6 points)

Question 6

An athlete is holding a dumbbell (weight) with a mass of 13kg in a static position, as shown in Figure 1 below.

The muscular force (blue arrow, B) acts at an angle of 79 degrees relative to the horizontal, upwards and to the left, at a perpendicular distance of 0.03 m distal from the elbow flexion axis. The external force from the dumbbell acts downwards at a perpendicular distance of 0.33 metres from the elbow flexion axis. The mass of the forearm is 1.6 kg and the mass centre is 0.18 metres from the elbow flexion axis.

- a) What magnitude is the muscular force required to hold this position?
(10 points)
- b) What magnitude are the reaction forces acting at the elbow joint, and in which direction are they acting?
(8 points)

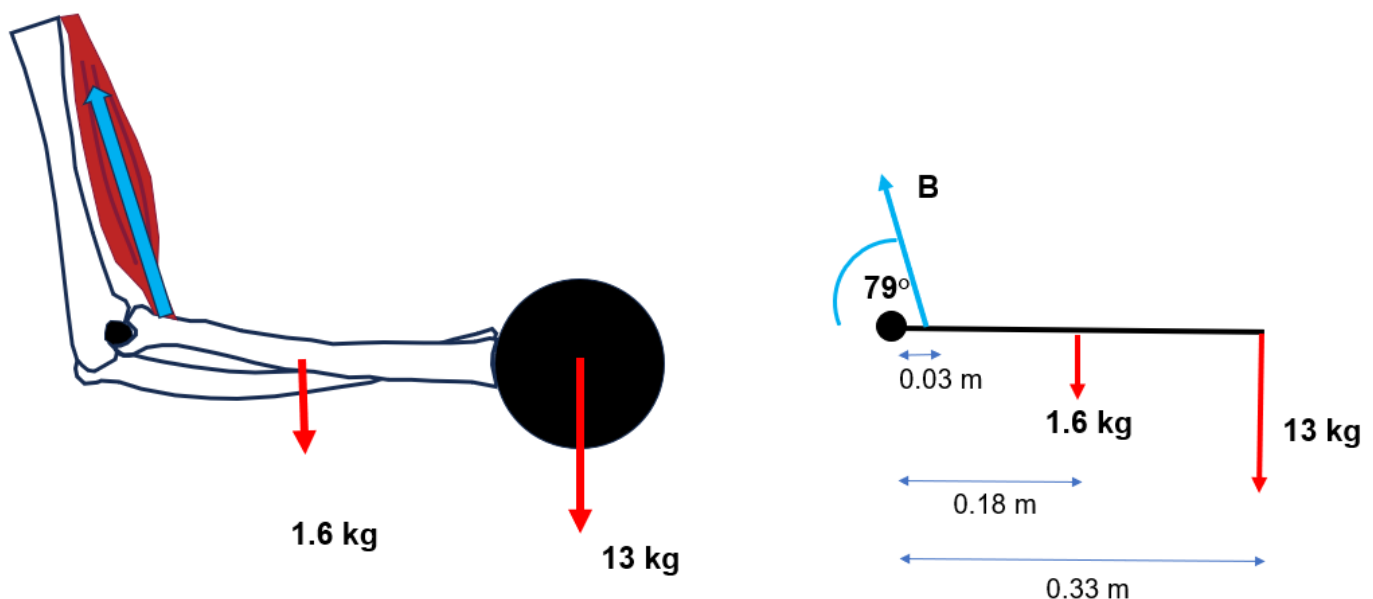


Figure 1. Muscular force (blue arrow going upwards to the left, at an angle of 79 degrees to the horizontal) and locations of the centre of masses (forearm and barbell) that are applied to the forearm whilst holding a dumbbell of mass 13kg in a static position. The perpendicular distance from the elbow flexion axis to the muscular force is 0.03m, to the forearm centre of mass is 0.18m and to the dumbbell centre of mass is 0.33 m.

Question 7

An athlete of mass 74 kg completes a long jump with a horizontal take-off velocity of $7.94 \text{ m}\cdot\text{s}^{-1}$ at an angle of 26 degrees to the horizontal.

a) What is the vertical take-off velocity?

(2 points)

b) What was the kinetic energy of the athlete in the vertical direction at take-off?

(4 points)

Section 2 – Muscle and connective tissue mechanics (20 points)

General Questions

1. Define stiffness and Young's modulus. Explain why Young's modulus is necessary for comparing different tissues.

(3 points)

2. Describe the stress-strain curve for a viscoelastic material. How are Young's modulus and elastic energy calculated from the curve?

(3 points)

Bone Mechanics

3. List and briefly describe five types of loading that apply to bones.

(3 points)

4. Briefly explain the factors that influence bone fractures.

(3 points)

Muscle and Tendon

5. Define skeletal muscle work, and power in relation to force.

(2 points)

6. Describe how to measure the stiffness of the patellar tendon using ultrasound and a dynamometer.

(3 points)

7. Explain how electromyographic (EMG) activity can be used to measure force from antagonist muscles.

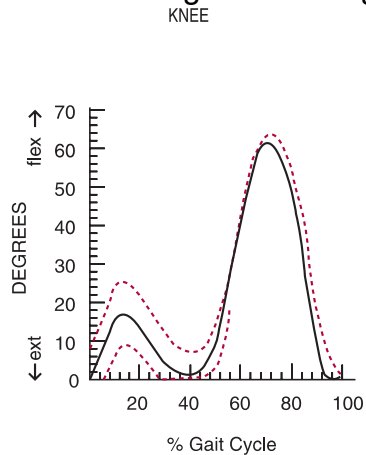
(3 points)

Section 3 – Applied biomechanics (10 points)

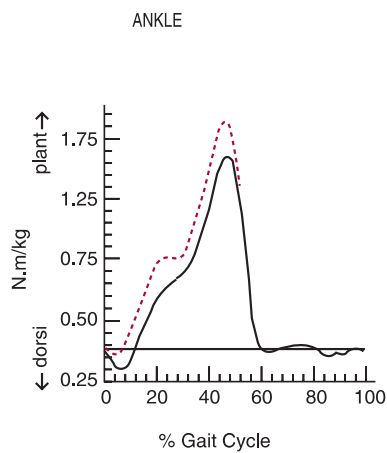
1. Technique analysis

- a) Why are different locomotive patterns or specific sport techniques divided into different phases?
(2 points)

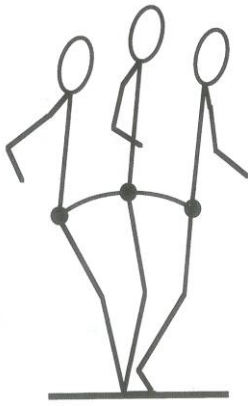
2. Walking and running



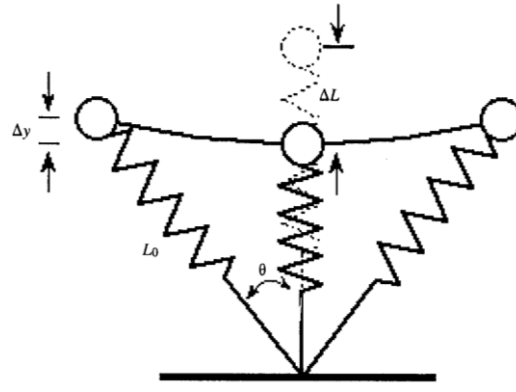
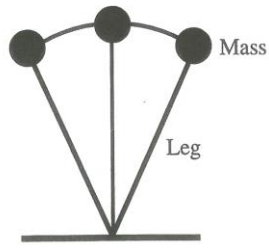
- a) The figure above shows the position of the knee joint during a full gait cycle (100%). What joint movements and in what position is the knee joint from 0 to about 40% of the gait cycle?
(2 points)



- b) The figure above shows the internal joint moment over the ankle joint during a full gait cycle (100%). What is the internal joint moment from 0 to about 10% and from 10 to about 60% of the gait cycle?
(2 points)



Inverted pendulum



Mass-spring model

- c) The figure above shows both the inverted pendulum and mass-spring model. Explain the differences between these models and how and why they are applied to walking and running.

(4 points)