

2025/2026

INDIVIDUAL EXAM

IN

THP 203- BASIC BIOMECHANICS

Information

- Start of exam: Friday May 29. 2026 at 10 a.m
- End of exam: Friday May 29. 2026 at 1 p.m. in WISEflow
- Exam results will be available within three weeks from the exam date: 19th of June 2026
- 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 holds an 8.0 kg dumbbell horizontally out to the side of their body, with an extended elbow. The dumbbell is 0.45 m from the axis of shoulder rotation. The mass of the upper arm and forearm apply a weight of 19.0 N and 13.2 N, respectively. The centre of mass of the upper arm and forearm are 0.16 m and 0.31 m respectively from the axis of shoulder rotation. The deltoid muscle, D, applies a force at an angle of 24 degrees relative to the upper arm, as shown in Figure 1 below. This muscular force, D, acts 0.13 m distally from the shoulder joint.

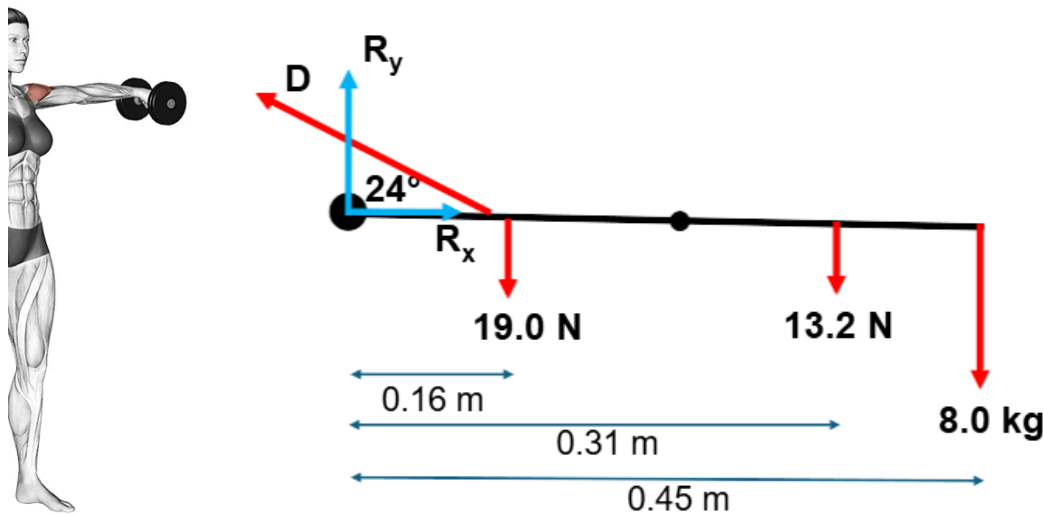


Figure 1. Muscular force (red arrow going upwards to the left, at an angle of 24 degrees to the horizontal) and locations of the centre of masses (upper arm, forearm and barbell) that are applied to the arm whilst holding a dumbbell of mass 8.0kg in a static position. The upper arm and forearm have a weight of 19.0 N and 13.2 N respectively. The perpendicular distance from the shoulder axis to the muscular force is 0.13 m, to the upper arm centre of mass is 0.16 m; to the forearm centre of mass is 0.31 m; and to the dumbbell centre of mass is 0.45 m.

a) Calculate the magnitude of the deltoid muscle force, D.

(13 points)

b) Calculate the reaction forces acting at the shoulder joint and state in which direction they are acting.

(8 points)

Question 2

A long jumper with a mass of 68 kg runs towards the take-off board. They complete the final three metres of the run in 0.75 seconds.

- a) How much kinetic energy does the athlete have on average during these final three metres of the run?

(4 points)

Question 3

An American football player with a mass of 94 kg runs with a velocity of -5.0 m.s^{-1} and collides with an opponent who is running with a velocity of 5.8 m.s^{-1} . After the collision, the two players have a combined total velocity of 0 m.s^{-1} .

- a) What is the mass of the opponent player?

(6 points)

- b) What is the opponent's weight in Newtons?

(2 point)

Question 4

A tennis player serves the ball. At the instant of contact between the racket and the ball, the arm is fully extended. The rotation of the arm about the shoulder joint has a velocity of $2830.41 \text{ deg.s}^{-1}$.

- a) What is the angular velocity of the arm rotation in radians per second?

(3 points)

- b) The length between the shoulder joint and the point of contact with the ball is 85 cm. What is the linear velocity of the ball when it travels away from the tennis racket?

(3 points)

Question 5

An athlete with mass 73 kg jumps from the ground with a vertical velocity of 3.41 m.s^{-1} .

a) How high did they jump?

(6 points)

b) What was their potential energy at the highest point of the jump?

(3 points)

c) What was the impulse applied to the ground in to order to achieve this take-off velocity?

(4 points)

Question 6

An athlete lifts a 50kg barbell 0.45 metres vertically upwards by applying a constant force of 620 N in 0.2 seconds.

a) What is the work done by gravity during the lift?

(2 points)

b) How much power is applied by the athlete?

(4 points)

Question 7

A downhill skier with a mass of 55 kg is skiing down a slope that has an incline of 13 degrees relative to the horizontal. A drag resistance of 35 N is acting to decelerate the skier. The coefficient of friction between the skis and the snow is 0.08.

a) What is the resultant force acting on the skier?

(12 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 stiffness and elastic energy calculated from the curve?
(3 points)
3. Define the safety factor for connective tissue. How is it related to tissue injury?
(2 points)

Bone Mechanics

4. List and briefly describe five types of mechanical loading that apply to bones.
(2 points)
5. Name and explain five of the eight factors that influence the mechanical properties of bone tissue.
(3 points)
6. Using the example of the gluteus medius attached to the greater trochanter, explain how strong, active muscles can reduce the risk of bone fractures.
(2 points)

Muscle and Tendon Mechanics

7. Describe how to measure the stiffness of the patellar tendon using ultrasound and a dynamometer. Your answer should include the calculation method.

(3 points)

8. Explain how electromyographic (EMG) activity and torque measurements can be used to estimate quadriceps force, accounting for co-activation of hamstrings.

(2 points)

Section 3 – Applied biomechanics (10 points)

1. Why are running and jumping movements commonly divided into phases? Give examples. (2 points)
2. Explain the difference between walking and running using biomechanical principles. (2 points)
3. What is a ground reaction force and why is it important in gait analysis? (2 points)
4. Describe the role of the ankle plantarflexors during late stance in walking and running. (1 points)
5. Why is the inverted pendulum model considered appropriate for walking but not running? (2 points)
6. What structures in the human body contribute to spring-like behavior during running? (1 points)