



UNIVERSITI KUALA LUMPUR
INSTITUTE OF MEDICAL SCIENCE TECHNOLOGY

FINAL EXAMINATION
MARCH 2025 SEMESTER

COURSE CODE : HRB20903
COURSE TITLE : HUMAN BIOMECHANICS
PROGRAMME NAME : BACHELOR OF OCCUPATIONAL SAFETY & HEALTH (HONOURS)
DATE : 02 JULY 2025
TIME : 9:00AM - 12:00PM
DURATION : 3 HOURS



INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. *Tick if applicable*
9. Refer to the attached Formula/ Appendies. *Tick if applicable*

THERE ARE 19 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 40 marks)

Answer ALL questions.

Please use the answer booklet provided.

1. Which joint in the body has the most range of motion?
 - A. Glenohumeral
 - B. Humeroulnar
 - C. Humeroulnar
 - D. Acromioclavicular

2. The optimal length for maximal muscle tension is when the muscle is _____.
 - A. at its resting length
 - B. completely relaxed
 - C. very short
 - D. slightly stretched

3. The biceps brachii can develop the most force when the _____.
 - A. shoulder is flexed
 - B. forearm is pronated
 - C. forearm is supinated
 - D. forearm is in the neutral position

4. Which of the following is not a rotator cuff muscle?
 - A. Subscapularis
 - B. Teres major
 - C. Infraspinatus
 - D. Supraspinatus

5. Muscle torque differs from muscle force because _____.
- A. force does not consider the duration of the contraction
 - B. torque does not consider the fiber type
 - C. torque does not consider the velocity of contraction
 - D. force does not consider the distance to the axis of rotation
6. Where is the series elastic component of a muscle found?
- A. Muscle spindle
 - B. Tendons
 - C. Muscle membrane
 - D. Ligaments
7. When an opposing torque at a joint is greater than the torque created by a muscle, what type of contraction occurs in that muscle?
- A. Concentric
 - B. Isometric
 - C. Eccentric
 - D. Isotonic
8. Which of the following statements represents the force-velocity relationship for muscle tissue?
- A. Contraction is faster when the load is heavier.
 - B. Contraction is slower when the load is lighter.
 - C. Contraction speed is not affected by load.
 - D. Contraction is slower when the load is heavier.

9. Grip strength can be enhanced by _____.
- A. abducting the fingers
 - B. flexing the wrist
 - C. pronating the forearm
 - D. extending the wrist
10. Which of the following muscles is not an elbow flexor?
- A. Triceps
 - B. Brachialis
 - C. Biceps
 - D. Brachioradialis
11. The muscle that turns the palm downward is the _____.
- A. flexor carpi ulnaris
 - B. supinator
 - C. extensor digitorum
 - D. pronator quadratus
12. Which of the following muscles contributes to arm flexion at the glenohumeral joint?
- A. Teres minor
 - B. Deltoid
 - C. Teres major
 - D. Latissimus dorsi

13. The following are the purposes of the patella, except to _____.
- A. protect the anterior aspect of the knee
 - B. increase the mechanical advantage of the quadriceps
 - C. increase the angle between the patellar tendon and the fibula
 - D. increase the contact area between the patellar tendon and the femur
14. The _____ are the major power producers in cycling.
- A. hamstrings
 - B. quadriceps
 - C. plantar flexor
 - D. gluteus muscles
15. The knee can flex through a greater range of motion when the _____.
- A. thigh is flexed
 - B. foot is pronating
 - C. foot is supinating
 - D. thigh is hyperextended
16. Which of the following causes hip adduction?
- A. Gluteus medius
 - B. Gracilis
 - C. Gluteus maximus
 - D. Gluteus minimus

17. Which of the following muscles serves to “unlock” the knee from full extension?
- A. Plantaris
 - B. Popliteus
 - C. Gracilis
 - D. Sartorius
18. Lateral pelvic tilt positions the acetabulum in a more favourable position for hip _____.
- A. adduction
 - B. abduction
 - C. flexion
 - D. extension
19. Which of the following is not a hamstring muscle?
- A. Gluteus maximus
 - B. Semitendinosus
 - C. Biceps femoris
 - D. Semimembranosus
20. The two muscles that contribute to lateral flexion in the lumbar region are _____ and _____.
- A. erector spinae; abdominals
 - B. scalenes; quadratus lumborum
 - C. scalenes; abdominals
 - D. psoas major; quadratus lumborum

21. The articulations between adjacent vertebral bodies are _____ joints.
- A. hinge
 - B. gliding
 - C. pivot
 - D. symphysis
22. Attachment to the ribs limits the range of motion in the _____ vertebrae.
- A. cervical
 - B. lumbar
 - C. sacral
 - D. thoracic
23. In the trunk flexion, the posterior fibers of the annulus fibrosus are in _____, while the anterior fibers are in _____.
- A. tension; tension
 - B. tension; compression
 - C. compression; tension
 - D. compression; compression
24. Which spinal motion involves anterior pelvic tilt?
- A. Flexion
 - B. Extension
 - C. Rotation
 - D. Lateral flexion

25. What is the most common type of spinal loading during daily activities?
- A. Tension
 - B. Torsion
 - C. Shear
 - D. Compression
26. Which of the following vertebral regions has the best range of motion?
- A. Sacral
 - B. Lumbar
 - C. Thoracic
 - D. Cervical
27. In a 5K road race, the finish line is also the starting line. What does 5K represent?
- A. Velocity
 - B. Speed
 - C. Distance
 - D. Displacement
28. Which angular direction is conventionally regarded as positive?
- A. Extension
 - B. Clockwise
 - C. Flexion
 - D. Counterclockwise

29. If the knee joint goes through 100° of flexion during the down phase of a squat, what is the total angular distance during 10 complete squats?
- A. 500°
 - B. 0°
 - C. 1000°
 - D. 2000°
30. Range of motion at a joint is a measurement of _____.
- A. linear velocity
 - B. angular velocity
 - C. linear displacement
 - D. angular displacement
31. Which of the following affects the time that a horizontally projected object remains in the air?
- A. Weight
 - B. Mass
 - C. Initial speed
 - D. Projection height
32. The acceleration is _____ when the final velocity is greater than the initial velocity.
- A. negative
 - B. zero
 - C. average
 - D. positive

33. A runner completes 1 full lap around a 400-meter track. What is her displacement?
- A. 400 meters X 2π
 - B. 400 meters
 - C. 200 meters
 - D. 0 meter
34. A 30 kg child sits on the right end of a see saw 1 m from the axis. If a 20 kg child sits on the left end of the see saw 2 m from the axis, the see saw _____.
- A. incline on the left
 - B. decline on the right
 - C. will balance
 - D. decline on the left
35. The perpendicular distance between the line of force and the axis is defined as _____.
- A. fulcrum
 - B. force
 - C. torque
 - D. moment arm
36. The ability to control equilibrium is defined as _____.
- A. stability
 - B. balance
 - C. mobility
 - D. center of mass

37. When knee flexion is increased, what happens to the moment of inertia of the leg about the hip?
- A. increased
 - B. decreased
 - C. remains the same
 - D. not affected by knee flexion
38. A 500 N gymnast performing a giant swing with an angular velocity of 5 rad/sec, exerts 90 Nm of torque on the support bar. How much torque is exerted by the bar on the gymnast's hands?
- A. 90 Nm
 - B. 100 Nm
 - C. 2500 Nm
 - D. 590 Nm
39. The two variables that determine momentum are _____ and _____.
- A. mass; acceleration
 - B. velocity; acceleration
 - C. velocity; mass
 - D. velocity; time
40. A skater gliding on ice will continue to move in the same direction and with the same speed (in the absence of the action of additional forces). This exemplifies _____.
- A. Newton's first law of inertia
 - B. Newton's second law of acceleration
 - C. Newton's law of gravitational force
 - D. Newton's third law of action/reaction

SECTION B (Total: 60 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

Newton's laws of motion are three physical laws that describe the relationship between the motion of an object and the forces acting on it.

- (a) Explain the three Newton's Laws.

(6 marks)

- (b) As shown in the Figure below, the crate weighs 350 N. The coefficient of static friction between the crate and the floor is 0.3, and the coefficient of kinetic friction between the crate and the floor is 0.2. If $\theta = 45^\circ$ and $P = 100$ N,
Refer Below - Figure1 : Crate .

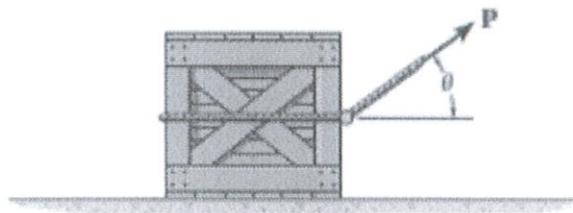


Figure 1: Crate

- i. calculate the force that must be exerted to get the crate in motion.

(6 marks)

- ii. calculate the force required to keep the crate in motion.

(4 marks)

- (c) A 2 kg block sitting on a horizontal surface is subjected to a horizontal force of 7.5 Newton. If the resulting acceleration of the block is 3 m/s^2 , calculate the magnitude of the friction force opposing the motion of the block.

(4 marks)

Question 2

Understanding equilibrium is crucial in biomechanics for optimising body alignment and movement patterns.

- (a) Define static equilibrium, dynamic equilibrium and mechanical advantage.

(6 marks)

- (b) The Figure below shows the force F generated by the biceps brachii of the forearm with a magnitude of 40 N at an angle of 60° with the forearm. Calculate the force component along the forearm, F_s and the force component perpendicular to the forearm, F_T .

Refer Below - Figure2 : Forearm. .

(6 marks)

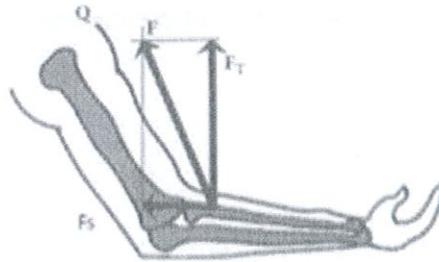


Figure 2: Forearm.

- (c) Referring to the Figure below, the load, L of the wheelbarrow is 70 kg, with perpendicular distances of the load vector L and the effort vector E from the fulcrum are 30 and 120 cm respectively,

Refer Below - Figure3 : Wheelbarrow. .

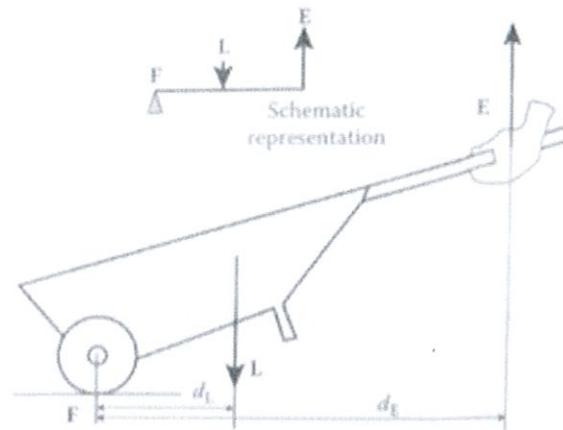


Figure 3: Wheelbarrow

- i. calculate the lifting force, E, required by the operator to lift the wheelbarrow. (4 marks)
- ii. calculate the mechanical advantage of the system. (3 marks)
- iii. suggest the class of lever system in the Figure above. (1 marks)

Question 3

Balance and stability are crucial for everyday activities such as walking, standing, and performing tasks that require an upright posture.

- (a) Define stability and balance. Describe the factors that increase the body's ability to maintain equilibrium.

(6 marks)

- (b) As shown in the Figure below, a worker leans over and picks up a 90 N box at 0.7 meter from the axis of rotation in her spine. Neglecting the effect of body weight, calculate the added force that is required by the low back muscles with an average moment arm of 6 cm to stabilise the box in the position shown.

Refer Below - Figure4 : A worker carries a box. .

(4 marks)



Figure 4: A worker carries a box.

- (c) Referring to the Figure below, the quadriceps tendon attaches to the tibia at a 30° angle, 4 cm from the joint centre at the knee. When an 80 N weight is attached to the ankle 28 cm from the knee joint,

Refer Below - Figure5 : Knee joint .

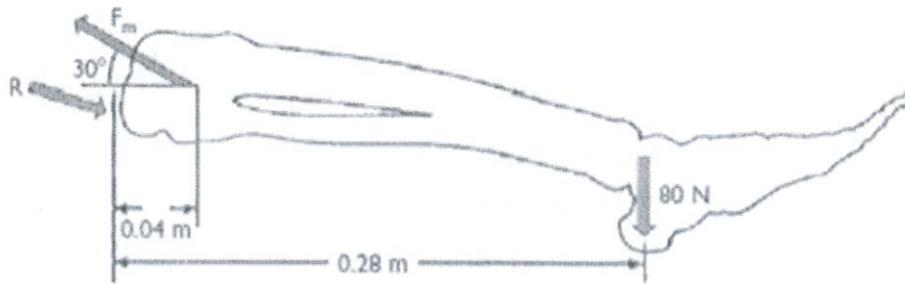


Figure 5: Knee joint

- i. calculate the force required for the quadriceps to maintain the leg in a horizontal position.
(4 marks)
- ii. calculate the magnitude and direction of the reaction force exerted by the femur on the tibia. (Neglect the weight of the leg and the action of other muscles.)
(6 marks)

Question 4

The upper extremity, or upper limb, is made up of several joints that allow for a wide range of movements, including the shoulder, elbow, wrist, and hand joints.

- (a) Rotator cuff muscles include the supraspinatus, infraspinatus, subscapularis and teres minor. Discuss the importance of the rotator cuff muscles as stabilisers of the glenohumeral joint and movers of the humerus.

(5 marks)

- (b) Consider the diagram of the biceps brachii acting on the radius in two joint positions as shown in the Figure below. The angle of pull of the biceps brachii force changes from 15° to 30° . If the muscle force is 1,600 N and the attachment site of the muscle is 0.042 m from the joint axis, calculate the change in joint torque applied by the biceps brachii from 15° to 30° .

Refer Below - Figure6 : Biceps brachii .

(10 marks)

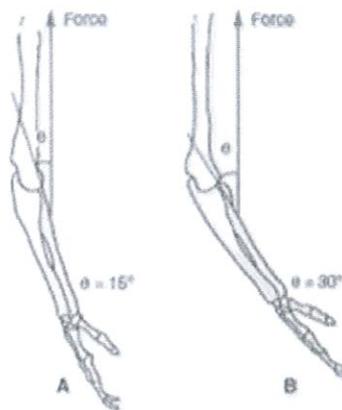


Figure 6: Biceps brachii

- (c) Referring to the Figure below, calculate the tension (F_m) that the triceps must supply to stabilise the arm against an external force (F_e) of 200 N, given $d_m = 2$ cm and $d_e = 25$ cm and the magnitude of the joint reaction force (R)? (Since the forearm is vertical, its weight does not produce torque at the elbow.)

Refer Below - Figure7 : Triceps. .

(5 marks)

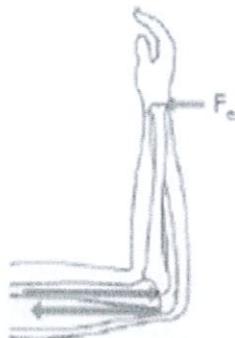


Figure 7: Triceps.

END OF EXAMINATION PAPER

Biomechanical Formulas

(Formulas will be provided for assessments involving calculation based problem solving)

MATHEMATICAL FORMULAS

Pythagorean theorem:

$$a^2 + b^2 = c^2$$

Sine rule:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Cosine rule:

$$a^2 = b^2 + c^2 - 2bc \cos A$$

Trigonometric functions:

$$\sin \theta = \frac{\textit{opposite}}{\textit{hypotenuse}}$$

$$\cos \theta = \frac{\textit{adjacent}}{\textit{hypotenuse}}$$

$$\tan \theta = \frac{\textit{opposite}}{\textit{adjacent}}$$

$$\theta = \sin^{-1} \left(\frac{\textit{opposite}}{\textit{hypotenuse}} \right)$$

$$\theta = \cos^{-1} \left(\frac{\textit{adjacent}}{\textit{hypotenuse}} \right)$$

$$\theta = \tan^{-1} \left(\frac{\textit{opposite}}{\textit{adjacent}} \right)$$

FLUID MECHANICS

Pressure:

$$P = \frac{F}{A}$$

LINEAR KINEMATICS

Average speed:

$$sp = \frac{\Delta d}{\Delta t}$$

Average velocity:

$$v = \frac{\Delta s}{\Delta t}$$

Average acceleration:

$$a = \frac{\Delta v}{\Delta t}$$

$$a = \frac{v - u}{t}$$

UNIFORMLY ACCELERATED MOTION

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

PROJECTILE MOTION

Vertical motion:

$$D_{\text{vert}} = \frac{(U_{\text{vert}})^2}{2g}$$

$$D_{\text{vert}} = \frac{(V \sin \theta)^2}{2g}$$

Horizontal motion:

$$D_{\text{hor}} = U_{\text{hor}} \times t$$

$$D_{\text{hor}} = \frac{V^2 \sin 2\theta}{g}$$

LINEAR KINETICS

Newton's 2nd Law – law of acceleration:

$$F = ma$$

Weight:

$$w = mg$$

Friction:

$$Fr = \mu R$$

$$Fs = \mu_s R$$

Linear momentum:

$$M = mv$$

Impulse:

$$I = Ft$$

$$I = \Delta M$$

$$I = m(v - u)$$

Impulse-momentum relationship:

$$Ft = m(v - u)$$

ANGULAR KINETICS

Torque:

$$T = F \perp d$$

Moment of inertia:

$$I = mr^2$$

$$I = mk^2$$

Angular momentum:

$$H = I\omega$$

WORK, POWER & ENERGY

Work:

$$W = Fd$$

Power:

$$P = \frac{W}{t}$$

$$P = Fv$$

Kinetic Energy:

$$KE = \frac{1}{2}mv^2$$

Gravitational Potential Energy:

$$PE = mgh$$

ANGULAR KINEMATICS

Angular displacement:

$$l = r\theta$$

Average angular velocity:

$$\omega = \frac{\Delta\theta}{\Delta t}$$

Angular velocity & linear velocity:

$$v = r\omega$$

Average angular acceleration:

$$\alpha = \frac{\Delta\omega}{\Delta t}$$

Tangential acceleration:

$$aT = \frac{(v - u)}{t}$$

Radial acceleration:

$$aR = \frac{v^2}{r}$$

Legend of Abbreviations for Equations

a = acceleration

a_R = radial acceleration

a_T = tangential acceleration

d = distance

D_{vert} = vertical distance (height)

D_{hor} = horizontal distance (range)

F = force

F_r = limiting friction

F_s = sliding friction

g = gravity

h = height

H = angular momentum

I = impulse

I = moment of inertia

k = radius of gyration

KE = kinetic energy

l = arc length (linear distance)

m = mass

M = momentum

P = power

PE = gravitational potential energy

r = radius

R = normal reaction force

s = displacement

sp = speed

t = time

u = initial velocity

U_{hor} = initial horizontal velocity

U_{vert} = initial vertical velocity

v = velocity

v = final velocity

w = weight

W = work

α = angular acceleration

ω = angular velocity

μ = coefficient of limiting friction

μ_s = coefficient of sliding friction

θ = theta (angle)

θ = angular displacement

Δ = change in

