

UNIT-8

BIOMECHANICS AND SPORTS



TOPICS:

1. Newton's Law of Motion & its application in sports
2. Types of Levers and their application in Sports.
3. Equilibrium – Dynamic & Static and Centre of Gravity and its application in sports
4. Friction & Sports
5. Projectile in Sports

Specific learning objectives:

- To understand Newton's Laws of Motion and their Application in Sports.
- To enable the students to understand the lever and its application in sports.
- To enable the students to understand the concept of Equilibrium and its application in sports.
- To understand Friction in Sports.
- To understand the concept of Projectile in sports.

Learning Outcomes with specific Competencies:

- Understand Newton's Law of Motion and its application in sports
- Recognize the concept of Equilibrium and its application in sports.
- Know about the Centre of Gravity and will be able to apply it in sports
- Define Friction and application in sports.
- Understand the concept of Projectile in sports.

MIND MAP

Weightage: 10 M

It focuses on the application of the scientific principles of mechanical physics to understand the movements and actions of human bodies, and their different parts.

1. Kinetics
2. Kinematics

Importance of Biomechanics

1. Optimizing Performance
Technique Analysis and Refinement:
Power Generation
Energy Conservation
2. Injury Prevention:
Identifying Risk Factors
Correcting Movement Dysfunctions
Understanding Overuse Injuries
Neuromuscular Training
3. Rehabilitation:
Monitoring Recovery
Addressing Compensations

4. Equipment Design and Innovation
Enhanced Performance and Safety
Adaptive Equipment
5. Coaching and Training
Evidence-Based Coaching
Individualized Training Programs
Motivation and Trust

Newton's Law of Motion

1. First Law : Law of Inertia
2. Second Law : Law of acceleration
3. Third Law : Law of reaction

Lever

1. First-Class Lever (FLE: Fulcrum in the Middle)
2. Second-Class Lever (FLE: Load in the Middle)
3. Third-Class Lever (FLE: Effort in the Middle)

Equilibrium -
Dynamic & Static
Centre of Gravity

Friction & Sports
Static
Dynamic
Rolling, Fluid

Projectile in Sports

I. Introduction to Biomechanics

Definition: Biomechanics is the study of forces and their effects on living systems, particularly human movement. It combines principles of physics and engineering to analyze and understand how the human body moves in various activities, especially sports.

It seeks to understand *how* biological systems, from individual cells to entire organisms, move and function by analyzing the forces and their effects on these systems.

The term "biomechanics" itself is a combination of two Greek words:

- "Bio," meaning life.

- **"Mechanics,"** the branch of physics concerned with the behaviour of physical bodies when subjected to forces or displacements, and the subsequent effects of these forces on their environment.

Importance of Biomechanics in Sports:

1. Optimizing Performance:

Technique Analysis and Refinement: Biomechanics allows for a detailed analysis of an athlete's movements, identifying inefficient patterns, wasted energy, and areas for improvement. By understanding the forces, angles, and timing involved, coaches can refine technique to maximize power, speed, accuracy, and efficiency.

“For example, analyzing a pitcher's throwing motion can pinpoint inefficiencies that prevent them from throwing faster or with greater accuracy. Similarly, in sports such as long jump and triple jump, biomechanical analysis can identify optimal take-off angles, body positions, and arm movements to achieve greater distances.”

Power Generation: Biomechanics helps understand how muscles generate force and how to optimize body mechanics for maximum power output in movements like jumping, throwing, or striking.

Energy Conservation: By identifying and correcting inefficient movements, biomechanics can help athletes conserve energy, allowing them to perform at a high level for longer periods.

2. Injury Prevention:

Identifying Risk Factors: Biomechanical assessments can pinpoint movement patterns that predispose athletes to injuries. For instance, analyzing landing mechanics in basketball players can identify inadequate techniques that increase the risk of knee injuries (e.g., ACL tears).

Correcting Movement Dysfunctions: Once risk factors are identified, targeted training interventions can be designed to correct biomechanical deficits and improve movement quality, thereby reducing injury incidence.

Understanding Overuse Injuries: Many overuse injuries are linked to repetitive stress and improper mechanics. Biomechanics helps understand these factors and develop strategies like modifying training techniques or improving equipment to prevent them.

Neuromuscular Training: Biomechanics informs neuromuscular training protocols that focus on improving balance, coordination, strength, and power, which are crucial for injury prevention.

3. Rehabilitation:

Monitoring Recovery: Biomechanics helps in monitoring the recovery process after an injury, allowing therapists to track changes in movement patterns and ensure a safe and effective return to sport.

Addressing Compensations: After an injury, athletes may develop compensatory movement patterns. Biomechanics helps identify and correct these to prevent further issues.

4. Equipment Design and Innovation:

Enhanced Performance and Safety: Biomechanics is crucial in the design and development of athletic footwear, apparel, and protective equipment.

For example, biomechanical analysis of running shoes can help develop products that enhance running economy, absorb impact better, or provide optimal stability.

Adaptive Equipment: It also plays a role in the development of prosthetics and adaptive equipment for athletes with disabilities.

5. Coaching and Training:

Evidence-Based Coaching: Biomechanics provides coaches with objective, data-driven insights into an athlete's movement, moving beyond intuition to provide more precise and effective instruction.

Individualized Training Programs: By understanding an athlete's unique biomechanics, coaches can design individualized training programs that cater to their specific needs and optimize their development.

Motivation and Trust: Visual feedback and quantitative data from biomechanical assessments can help athletes understand where they stand, what they need to work on, and build trust in the coaching process.

Kinetics and Kinematics

Biomechanics, the study of forces and their effects on living systems, is broadly divided into two main areas **Kinetics and Kinematics**. While both deal with motion, they focus on different aspects.

Kinetics:

Kinetics is the branch of biomechanics that studies the forces that cause or tend to cause changes in motion. It focuses on the "why" of motion.

“Study of forces that cause or result from motion.”

Key elements:

Ground reaction forces
Joint moments and torques
Muscle forces
External loads

Kinematics is the branch of biomechanics that describes motion without considering the forces that cause that motion. It focuses on the "geometry of motion" or "how" an object moves in terms of its position, velocity, and acceleration.

“Study of motion without regard to the forces that cause it”

Key elements:

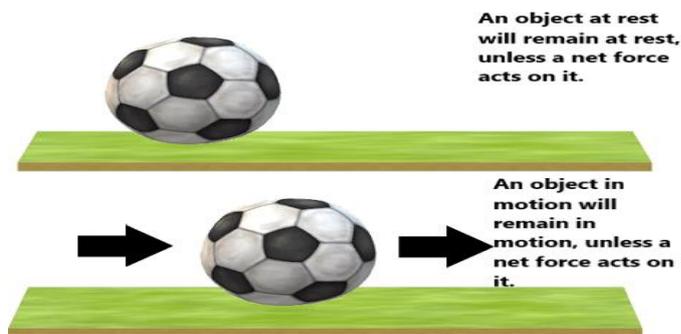
Displacement
Velocity
Acceleration
Joint angles

7.1. Newton's Laws of Motion and Their Application in Sports

Sir Isaac Newton's three laws of motion are fundamental to understanding movement in sports.

7.1.1 Law of Inertia (First Law):

Statement: A body at rest will remain at rest, and a body in motion will remain in motion at the same speed and in the same direction unless acted upon by an external force.



Application in Sports:

1. Soccer/Football:

A stationary ball: A soccer ball sitting on the field will not move until a player kicks it (an unbalanced force). This is inertia of rest.



A kicked ball: Once a ball is kicked, it will continue to roll or fly in a straight line at a relatively constant speed until friction, air resistance, or another player/object applies a force to stop or change its direction. This is inertia of motion.



2. Basketball:

Shooting a free throw: The basketball stays in your hands (inertia of rest) until you apply a force to shoot it. Once released, it continues on its trajectory towards the hoop (inertia of motion) until gravity pulls it down or it hits the rim/backboard.

Changing direction rapidly (crossover dribble): A player dribbling down the court has forward inertia. To change direction quickly (e.g., a crossover dribble), they need to apply a strong force with their feet against the ground to overcome their forward inertia and propel themselves in a new direction.

3. Track and Field:

Sprinting: A sprinter at the starting blocks will remain at rest until they apply force to the ground to start moving.

Shot Put/Discus/Javelin: The athlete builds up momentum in the throwing implement. Once released, the implement continues its flight path due to inertia until gravity and air resistance bring it to the ground.

Long Jump/Triple Jump: After the take-off, the jumper's body continues its horizontal motion due to inertia, allowing them to cover a significant distance.

7.1.2. Law of Acceleration (Second Law):

The acceleration of an object is directly proportional to the net force applied to it and inversely proportional to its mass

$$F=ma$$



Application in Sports:

1. Sprinting (Track and Field):

Applying Force to Accelerate: A sprinter's primary goal at the start of a race is to accelerate as quickly as possible. To do this, they apply a large force against the starting blocks and the ground. The greater the force they can exert for their body mass, the greater their acceleration.

2. Throwing Events (Shot Put, Discus, Javelin, Baseball Pitching):

Maximizing Force for Acceleration: In throwing sports, athletes aim to impart the maximum possible acceleration to the implement (shot, discus, javelin, ball). Since the mass of the implement is constant, the only way to increase its acceleration (and thus its final velocity) is to apply a greater force over a longer distance (the wind-up and release phase).

3. Kicking a Ball (Soccer, Football, Rugby):

Force and Ball Speed: When a player kicks a soccer ball, the force applied by their foot directly determines the ball's acceleration. A harder kick (more force) will result in greater acceleration, sending the ball faster and potentially further.

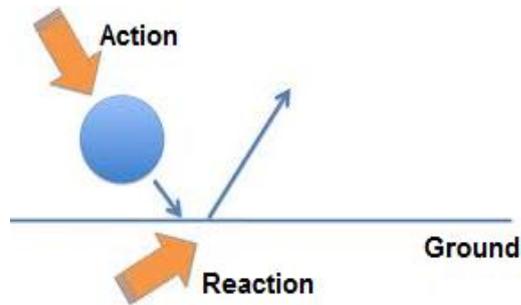
4. Weightlifting:

Lifting and Accelerating: When a weightlifter lifts a barbell, they must apply a force greater than the force of gravity acting on the barbell to cause it to accelerate upwards.

In summary, Newton's Second Law provides a quantitative framework for understanding how athletes generate and apply force to achieve desired changes in motion, whether it's accelerating their own bodies, throwing an object, or hitting a ball. Coaches and sports scientists use this law to analyze performance, identify areas for improvement, and design more effective training programs.

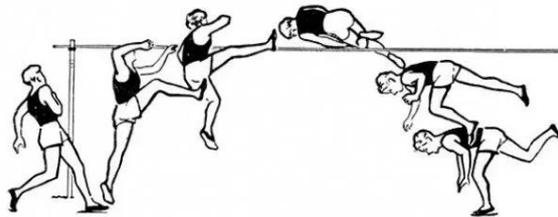
7.1.3. Law of Reaction (Third Law):

“For every action, there is an equal and opposite reaction.”

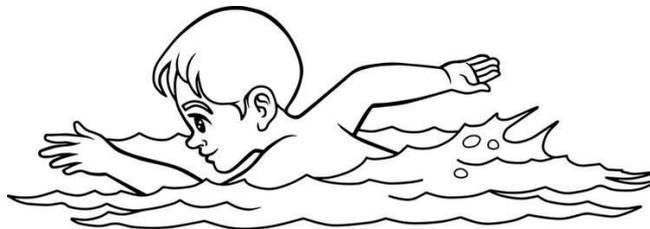


Application in Sports:

Jumping: When a high jumper pushes down on the ground (action), the ground pushes back with an equal and opposite force (reaction), propelling the jumper upwards.



Swimming: A swimmer pushes water backward with their hands and feet (action), and the water pushes the swimmer forward (reaction).



Running: As a runner's foot pushes back against the track (action), the track pushes forward on the foot (reaction), allowing the runner to move forward.



Shooting: When a gun is fired, the bullet moves forward (action), and the gun recoils backward (reaction).

7.2 Levers

I. Introduction to Levers

A lever is a rigid bar that rotates around a fixed point called a fulcrum. In the human body, bones act as rigid bars, joints act as fulcrums, and muscles provide the effort (force) to move a load (resistance).



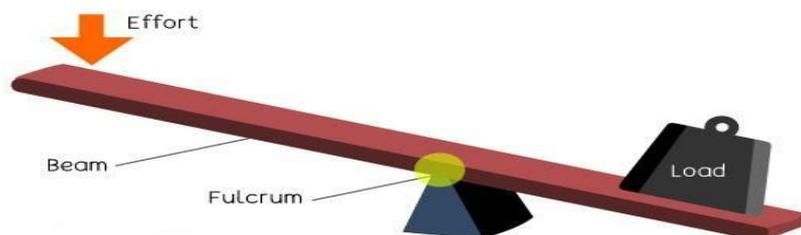
Components of a Lever System:

Fulcrum (F): The fixed point around which the lever rotates. In the human body, this is typically a joint.

Load (L) / Resistance (R): The weight or resistance that needs to be moved. This can be a body part, an external object (e.g., a dumbbell, a ball), or the tension from an opposing muscle.

Effort (E) / Force (F): The muscular force applied to move the load. This is generated by muscle contraction at its insertion point on the bone.

Lever Arm: The rigid bar itself (the bone).



Purpose of Levers in the Body:

- To magnify force (mechanical advantage).
- To increase the speed of movement.
- To increase the range of motion.
- To change the direction of force.

7.2.1 Classes of Levers

Levers are classified based on the relative positions of the fulcrum (F), load (L), and effort (E). A useful mnemonic is "F-L-E" for 1-2-3, indicating the middle component of each class.

1. First-Class Lever (FLE: Fulcrum in the Middle)

The fulcrum (F) is located between the effort (E) and the load (L).

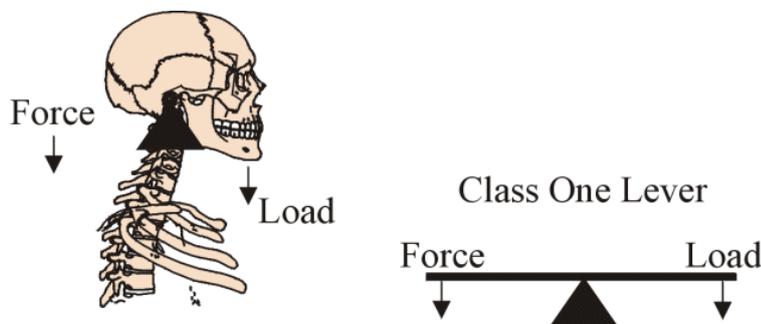
Mechanical Advantage: Can be either high or low, or even balanced, depending on the relative lengths of the effort arm and the load arm.

If the effort arm (distance from fulcrum to effort) is longer than the load arm (distance from fulcrum to load), it has mechanical advantage (less effort for more load).

If the effort arm is shorter than the load arm, it favours speed and range of motion over force.

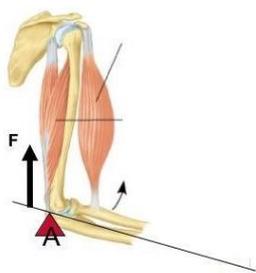
Application in the Human Body & Sports:

Nodding the head: The fulcrum is the atlanto-occipital joint (where the skull meets the spine), the load is the weight of the head, and the effort is provided by the posterior neck muscles (e.g., splenius capitis) to lift the head, or anterior neck muscles to lower it. This is a classic example.



Triceps extension (e.g., pushing off in a push-up): The fulcrum is the elbow joint, the effort is the triceps muscle, and the load is the weight of the forearm, hand, and any external resistance (e.g., body weight in a push-up).

Elbow extension



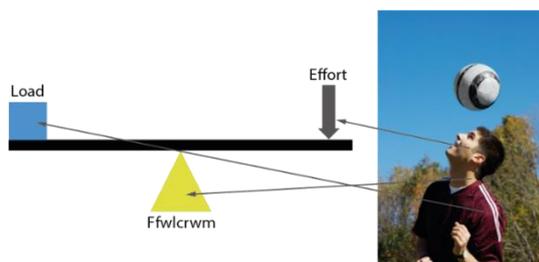
Examples in sports:

Heading a football (neck action).

Fulcrum: The neck joint (atlanto-occipital joint)

Effort: The muscles in the back of the neck (e.g., erector spinae)

Load: The weight of the head and the football

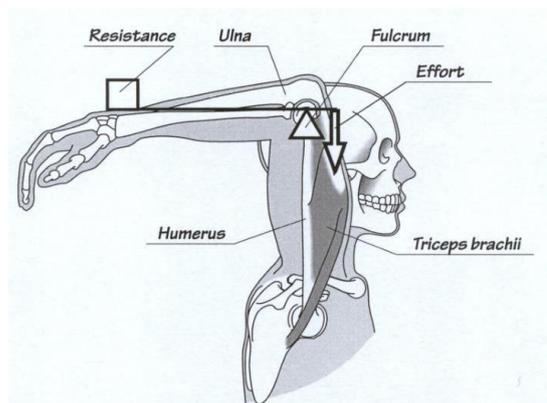


Extension phase of a punch or a tennis serve (triceps at the elbow).

Fulcrum: The elbow joint

Effort: The triceps muscle (pulling on the olecranon process of the ulna)

Load: The forearm, hand, and any object being held (e.g., a rugby ball, tennis racket)

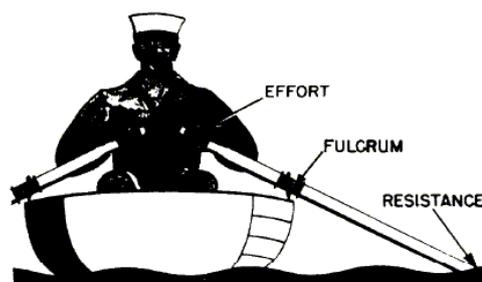


Rowing:

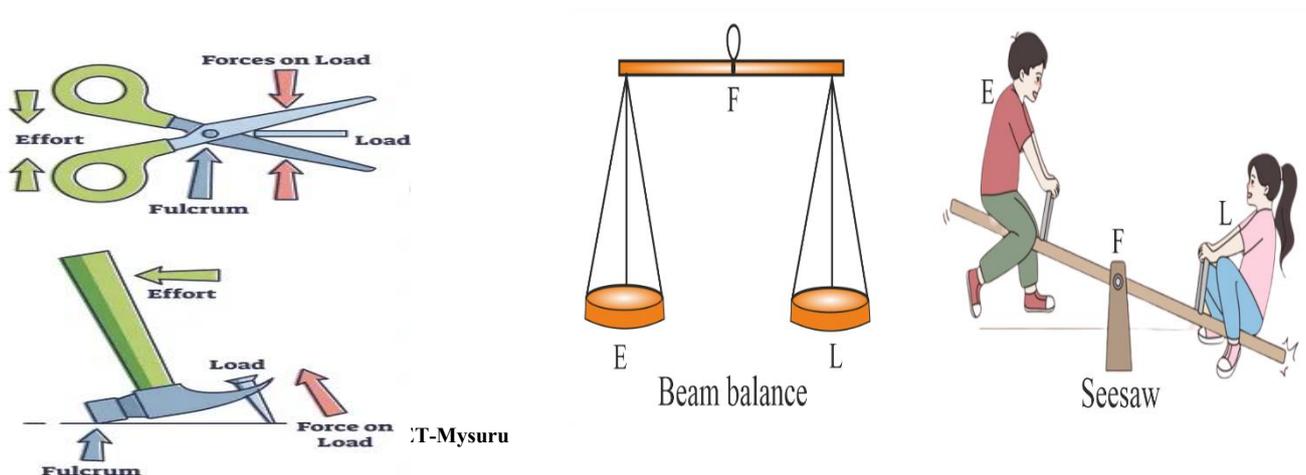
Fulcrum: The oarlocks (where the oar pivots on the boat)

Effort: The rower's hands pulling on the oar handle

Load: The water resisting the oar blade



Analogy: A seesaw, crowbar, or a pair of scissors.



7.2.2 Second-Class Lever (FLE: Load in the Middle)

The load (L) is located between the fulcrum (F) and the effort (E).

Mechanical Advantage: Always provides a mechanical advantage because the effort arm (distance from fulcrum to effort) is always longer than the load arm (distance from fulcrum to load). This means a small effort can move a large load, but over a shorter range of motion and with less speed.

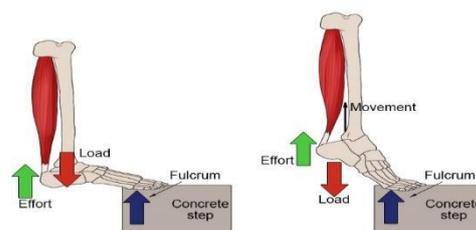
Application in the Human Body & Sports:

Plantar flexion (standing on tip of toes): The fulcrum is the ball of the foot (metatarsophalangeal joints), the load is the body's weight passing through the ankle, and the effort is provided by the calf muscles (gastrocnemius and soleus) pulling on the heel.



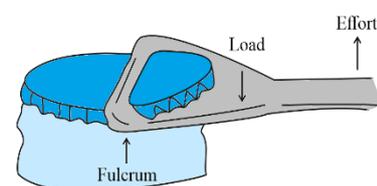
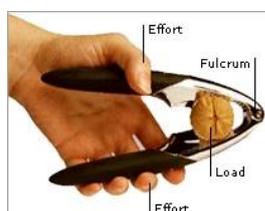
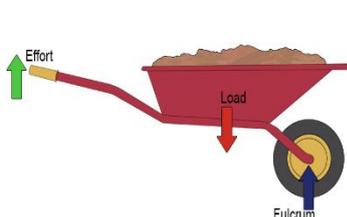
Examples in sports:

Taking off for a jump: The powerful push-off from the ankles utilizes a second-class lever.



Wheelbarrowing in gymnastics/partner activities: The feet act as the fulcrum, body weight is the load, and the hands provide effort.

Analogy: A wheelbarrow, nutcracker, or a bottle opener.



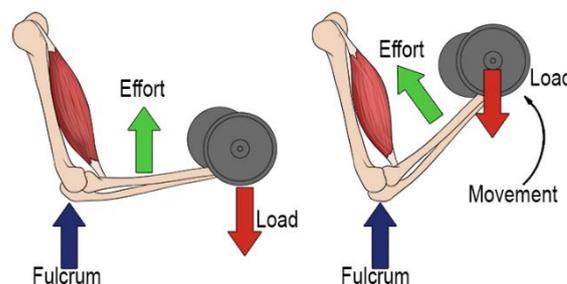
7.2.3. Third-Class Lever (FLE: Effort in the Middle)

The effort (E) is located between the fulcrum (F) and the load (L).

Mechanical Advantage: Always operates at a mechanical disadvantage because the effort arm (distance from fulcrum to effort) is always shorter than the load arm (distance from fulcrum to load). This means a large effort is required to move a relatively smaller load, but it allows for a greater range of motion and speed at the load end. This is the most common type of lever in the human body.

Application in the Human Body & Sports:

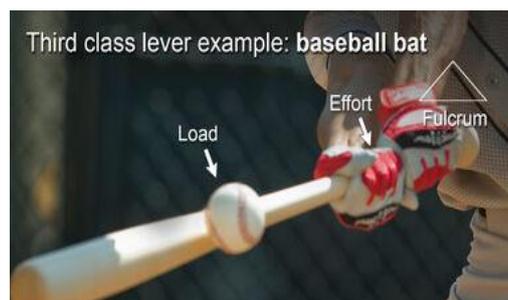
Bicep curl (flexing the elbow): The fulcrum is the elbow joint, the effort is the biceps muscle (inserting close to the elbow), and the load is the weight of the forearm, hand, and any dumbbell.



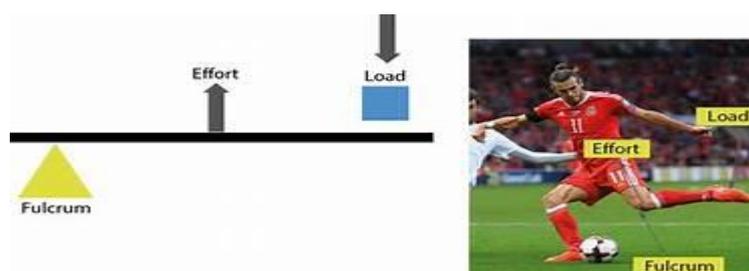
Knee flexion (e.g., hamstring curl): The fulcrum is the knee joint, the effort is the hamstring muscles, and the load is the lower leg and foot.

Examples in sports:

Throwing events (e.g., javelin, baseball pitch): The arm acts as a third-class lever, allowing for a large range of motion and high speed at the hand, despite requiring significant muscular effort.



Kicking a football: The leg (especially the lower leg) acts as a third-class lever during the swing phase, generating high speed at the foot.



Analogy: A fishing rod, shovel, or a pair of tweezers.

7.3.1 Equilibrium

Equilibrium refers to a state where the sum of all forces and torques acting on a body is zero, so the body remains at rest or moves with constant velocity.

Equilibrium refers to a state of balance where all forces and torques acting on an athlete's body are balanced, allowing for stability and control.

This concept is absolutely critical for performance, injury prevention, and the execution of skilled movements across virtually every sport.

Types of Equilibrium in Sports:

There are two primary types of equilibrium relevant to sports:

Static Equilibrium:

Definition: This is a state of balance when an athlete's body is at rest or in a stationary position. The net force and net torque acting on the body are both zero.

Purpose: To maintain a stable posture, to prepare for an action, or to hold a position. It's about resisting any tendency to move or fall.

Examples in Sports:

- A gymnast holding a handstand or a balanced pose on a beam before beginning their routine.
- A shot-putter holding the shot at their neck just before initiating the throw.
- An archer aiming before releasing an arrow.
- A weightlifter holding a barbell overhead after a successful lift.
- A goalkeeper in a ready stance before a shot.

Dynamic Equilibrium:

Definition: This is a state of balance when an athlete's body is in motion, but moving with a constant velocity (meaning no acceleration). While forces are acting, they are balanced, preventing a change in speed or direction.

Purpose: To maintain control and stability while performing movements, changing direction, or accelerating/decelerating. It requires continuous adjustments.

Application in Sports:

- A sprinter running at a constant speed on a straight track (before accelerating or decelerating).
- A cyclist riding in a straight line at a steady pace.
- A gymnast performing a routine on a balance beam where he is constantly adjusting his body to stay on.
- A soccer player dribbling the ball while moving across the field.
- A skier gliding down a gentle slope at a consistent speed.
- A figure skater performing a continuous spin.

Importance and Role of Equilibrium in Athletic Performance:

A. Execution of Skills: Many complex movements require precise balance.

For example, a basketball player needs dynamic equilibrium to drive to the basket and shoot, and a tennis player needs it to hit a powerful forehand while moving.

B. Injury Prevention: Poor balance significantly increases the risk of falls, sprains (especially ankle sprains), and other musculoskeletal injuries. Balance training is a common component of injury prevention programs.

C. Efficiency of Movement: When an athlete is in good equilibrium, their movements are more efficient, requiring less energy to maintain stability and allowing more energy to be directed towards the intended action (e.g., throwing, jumping, hitting).

D. Power and Force Generation: A stable base allows for greater force production. Think of a baseball pitcher needing to brace their body to transfer power from their legs to their arm.

E. Agility and Change of Direction: The ability to quickly shift weight and re-establish balance is crucial for changing direction rapidly, a key component of many invasion sports.

F. Confidence: Athletes who feel stable and balanced are more confident in executing challenging movements.

7.3.2 Centre of Gravity (COG):

The **Centre of Gravity (COG)**, also known as the **Centre of Mass (COM)**,

The **Centre of Gravity (COG)** is the imaginary point at which the entire weight of an object. It's the point where the sum of all forces and torques due to gravity acting on the object is effectively zero.

Importance and Role of The Centre of Gravity (COG) in Sports

The Centre of Gravity (COG) is a critical biomechanical concept in sports, influencing nearly every aspect of an athlete's performance, from basic stability to complex, explosive movements. Its importance stems from its direct relationship with balance, stability, and the ability to generate and control force.

1. Fundamental for Balance and Stability:

Maintaining Static Balance: In sports, many actions begin or end in a static, balanced position (e.g., a gymnast holding a pose, a weightlifter standing still with a barbell overhead). For static balance, the line of gravity (an imaginary vertical line passing through the COG) must fall within the athlete's base of support (BOS). A lower COG and a wider Base increase static stability.

Controlling Dynamic Balance: Most sports involve movement, meaning balance must be maintained while the body is in motion (dynamic equilibrium). Athletes constantly adjust their body segments to

keep their COG within their changing Base. This is crucial for running, dribbling, cutting, turning, and performing any moving skill without falling.

Injury Prevention: Poor control of the COG and inadequate balance significantly increase the risk of falls, sprains (especially ankle and knee), and other musculoskeletal injuries. Athletes with better COG control are less likely to be thrown off balance and are better equipped to absorb forces safely.

2. Enhancing Agility and Quickness:

Rapid Change of Direction: Sports like basketball, soccer, and tennis demand constant changes in direction. Athletes need to quickly shift their COG to accelerate, decelerate, and pivot. The ability to efficiently move the COG from one side of the Base to the other allows for quick cuts.

Reacting to Opponents/Situations: A well-controlled COG enables athletes to respond rapidly to changing game situations or opponents' movements, giving them a competitive edge.

3. Technique Optimization:

Sport-Specific Positioning: Every sport has optimal body positions that align the COG for maximal performance. Coaches often use cues related to COG (e.g., "get low," "lean into it," "stay over your feet") to help athletes refine their technique.

Unique Techniques: Some sports involve highly specialized techniques that intentionally manipulate the COG in counterintuitive ways for a performance advantage. The Fosbury Flop in high jump is the classic example, where the athlete's COG actually passes below the bar, allowing them to clear greater heights.

Spin and Rotation: For movements involving rotation (e.g., dives, twists in gymnastics, figure skating spins), understanding the COG is critical. The body rotates around its COG when airborne. Manipulation of limb positions relative to the COG changes the moment of inertia, affecting the speed of rotation.

4. Tactical Advantage:

Offensive Movements: In contact sports, athletes can use their COG to their advantage, for example, by lowering their COG and driving through an opponent to gain ground or make a tackle.

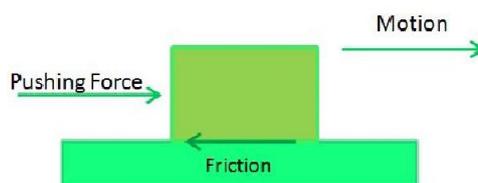
Defensive Stability: Conversely, a strong understanding of COG allows athletes to increase their stability to resist forces from opponents, making them harder to push, pull, or tackle.

7.4 Friction

Friction: A force that opposes the relative motion or tendency of motion between two surfaces in contact.

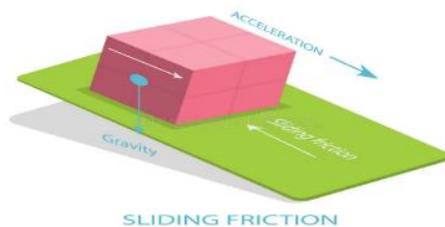
Types of Friction:

Static Friction: The friction that prevents an object from moving when a force is applied. It acts when surfaces are at rest relative to each other.

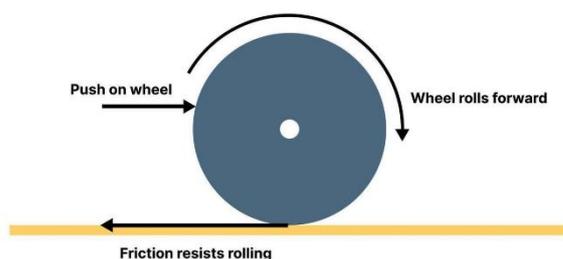


Dynamic (Kinetic) Friction: The friction that opposes the motion of an object once it is already moving.

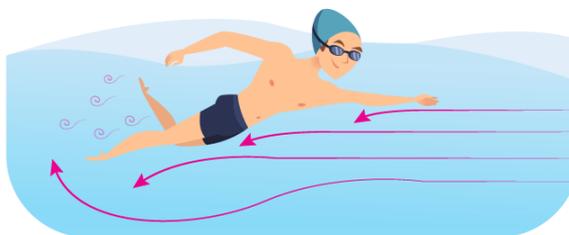
Sliding Friction: When one object slides over another (e.g., a hockey puck sliding on ice).



Rolling Friction: When an object rolls over a surface (e.g., a bowling ball rolling on a lane, a football rolling).



Fluid Friction (Air/Water Resistance): Resistance experienced by objects moving through a fluid (air or water).



Application in Sports:

Beneficial Friction:

Grip: Friction between shoes and the playing surface is essential for running, stopping, and changing direction (e.g., spikes in athletic shoes, rubber soles).

Holding Equipment: Friction between hands and equipment (e.g., chalk in gymnastics, sticky grips on racquets) provides a secure hold.

Braking: Friction is crucial for braking in cycling or stopping in various sports.

Undesirable Friction:

Air Resistance: Can slow down projectiles or athletes.

Sliding on Ice: Less friction is desired for sports like ice skating or curling to allow for gliding.

Controlling Friction: Athletes and equipment designers manipulate friction to their advantage (e.g., waxing skis to reduce friction, using specialized tires in racing).

7.5 Projectile

Projectile: Any object that is projected into the air and is acted upon only by the forces of gravity and air resistance.

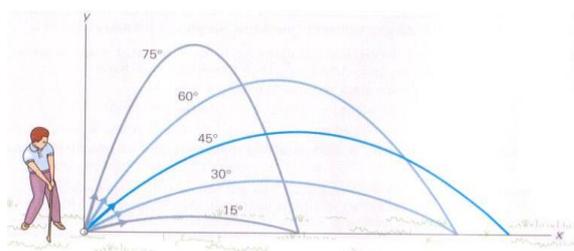
Examples : a shot put, a basketball, a javelin, or even an athlete during a long jump.

Projectile Trajectory: The path followed by a projectile. This path is typically parabolic (curved).

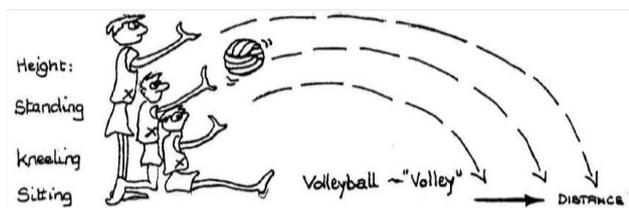
Factors Affecting Projectile Trajectory:

Speed of Release (Initial Velocity): The faster an object is thrown or projected, the farther it will travel (assuming optimal angle and height).

Angle of Release: For maximum horizontal distance, an angle of 45 degrees is generally considered optimal in a vacuum.



Height of Release: The higher the point of release, the greater the distance a projectile can travel, assuming other factors are constant. This is why taller athletes often have an advantage in throwing events.



Gravity: Constant downward force that pulls the projectile towards the earth.

Air Resistance (Drag): A force that opposes the motion of the object through the air. Its effect depends on the object's shape, size, and speed. Aerodynamic shapes reduce air resistance.

1. MULTIPLE CHOICE QUESTIONS (1 MARKS)

1. Biomechanics is the study of:

- A) Anatomy B) Muscles C) Forces and movement in living systems D) Nervous system

Answer: c

2. Which law of motion is also called the "Law of Inertia"?

- A) Second Law B) First Law C) Third Law D) Fourth Law

Answer: b

3. The equation $F = ma$ represents:

- A) Law of Inertia B) Law of Gravity
C) Law of Acceleration D) Law of Friction

Answer: c

4. When a footballer kicks a ball, which Newton's law is applied?

- A) First B) Second C) Third D) Both 1 and 2

Answer: d

5. In which type of lever is the load located between the effort and fulcrum?

- A) First-class B) Second-class
C) Third-class D) Fourth-class

Answer: b

6. Which of the following is an example of a first-class lever in the human body?

- A) Bicep curl B) Standing on toes
C) Nodding the head D) Kicking a ball

Answer: c

7. Dynamic equilibrium occurs when:

- A) The body is at rest B) The body is not moving
C) The body is moving with constant velocity D) The body has no mass

Answer: c

8. Which factor affects projectile motion the most?

- A) Temperature B) Distance C) Air pressure D) Angle of release

Answer: d

9. What is the main purpose of using biomechanics in sports?

- A) Only to prevent injury B) To build muscles
C) To optimize performance and prevent injury D) Only to understand muscles

Answer: c

10. Which type of friction helps a footballer change direction quickly?

- A) Static friction B) Fluid friction
C) Rolling friction D) Kinetic friction

Answer: a

11. Kinetics is related to:

- A) Only movements B) Joint angles
C) Forces causing motion D) Visual learning

Answer: c

12. Centre of Gravity is important because:

- A) It reduces weight B) It improves skin tone
C) It helps in balance and control D) None of the above

Answer: c

13. Which sport best demonstrates the third law of motion?

- A) Golf B) Swimming C) Darts D) Archery

Answer: b

14. In biomechanics, "E" in the lever system stands for:

- A) Energy B) Edge C) Effort D) Equilibrium

Answer: c

15. When a sprinter pushes off starting blocks, which Newton's law is used?

- A) First B) Second C) Third D) Fourth

Answer: b

UNSOLVED QUESTION ANSWER

16. Which type of lever is most common in the human body?

- A) First B) Second C) Third D) Fourth

17. In a bicep curl, which part acts as the fulcrum?

- A) Elbow B) Shoulder C) Wrist D) Finger

18. Which of the following is NOT a type of friction?

- A) Static B) Rolling C) Twisting D) Sliding

19. The trajectory of a projectile is typically:

- A) Straight line B) Vertical C) Parabolic D) Zig-zag

20. Air resistance is an example of:

- A) Static friction B) Fluid friction
C) Rolling friction D) None

2. VERY SHORT ANSWER QUESTIONS (2 Marks, 60–90 words)

1. Define biomechanics and its main focus in sports.

Answer: Biomechanics is the study of forces and their effects on living systems, especially human movement. It helps understand motion, improve performance, and prevent injury in sports.

2. What is Newton's First Law of Motion? Give one sports example.

Answer: It states a body remains at rest or in motion unless acted on by external force. Example: A football stays still until kicked.

3. State Newton's Second Law with a sports-related example.

Answer: The law states $F = ma$ (Force = mass \times acceleration). In sprinting, more force results in faster acceleration.

4. Explain Newton's Third Law using a jumping athlete.

Answer: When an athlete pushes the ground downward, the ground reacts with equal upward force, enabling the jump.

5. Define a lever and name its three components.

Answer: A lever is a rigid bar that rotates around a fulcrum. Its three parts are: Fulcrum, Load, and Effort.

6. Give two examples of first-class levers in sports.

Answer: Nodding the head in football and elbow extension during a punch are examples of first-class levers.

7. What is static equilibrium? Give one example from sports.

Answer: Static equilibrium occurs when the body is at rest with balanced forces. Example: A gymnast holding a handstand.

8. Differentiate between static and dynamic equilibrium.

Answer: Static equilibrium is balance at rest; dynamic equilibrium is balance while moving with constant velocity.

9. What is the Centre of Gravity and why is it important in sports?

Answer: It is the point where the body mass is centered. It helps athletes maintain balance and control in movement.

10. Explain one example where low COG benefits performance.

Answer: A wrestler with a low COG resists being toppled easily, enhancing stability and defense.

UNSOLVED QUESTION

11. What is friction? State any two types used in sports.

12. Give two examples where friction is desirable in sports.

13. Define projectile. Give two examples from sports.

14. Name two factors that affect projectile trajectory.

15. What is kinematics and how is it different from kinetics?

3. SHORT ANSWER QUESTIONS (3 Marks, 100–150 words)

1. Describe the three laws of motion with one example for each from sports.

Answer: 1st Law (Inertia): A soccer ball stays still until kicked. 2nd Law ($F=ma$): More force leads to faster sprint starts. 3rd Law (Action-Reaction): A swimmer pushes water back, and moves forward.

2. Explain all three classes of levers with diagrams and sports examples.

Answer: 1st Class: Fulcrum in middle (nodding head). 2nd Class: Load in middle (standing on toes). 3rd Class: Effort in middle (bicep curl). Most levers in the body are 3rd class.

3. Write a note on the importance of equilibrium in sports performance.

Answer: Equilibrium helps the athletes maintain their posture and balance. Static equilibrium helps in still positions like archery, while dynamic equilibrium aids movement control, like dribbling in basketball.

4. How does Centre of Gravity affect performance and injury prevention?

Answer: Lower COG increases balance and reduces risk of falls. Athletes with better COG control perform better and avoid injuries in dynamic movements.

5. Write the difference between static and dynamic friction. Give one example each.

Answer: Static friction prevents motion (e.g., standing start in sprint), while dynamic friction opposes movement (e.g., ice hockey puck).

6. How does biomechanics help in injury prevention?

Answer: Biomechanics identifies poor movement patterns and corrects them through targeted training, reducing injury risk, especially overuse injuries.

UNSOLVED QUESTION

7. What is the role of biomechanics in equipment design?
8. Describe the factors affecting projectile motion in sports.
9. Compare kinematics and kinetics with definitions and examples.

4. CASE STUDY BASED QUESTIONS (4 Marks Each)

Case Study 1: Levers in Sports

Read the case: A footballer is performing a bicep curl during strength training.

- A) Fill in the blank: The _____ joint acts as the fulcrum.
- B) True or False: This is an example of a first-class lever.
- C) Match the component with body part:

Fulcrum → Elbow

Effort → Biceps

- D) Name the class of lever demonstrated here.

Case Study 2: Friction

In a football match, players wear studs.

- A) Fill in the blank: Studs increase _____ friction.
- B) True or False: Fluid friction is most useful in this case.
- C) Match:

Static Friction → Starting movement

Sliding Friction → Hockey puck on ice

Rolling Friction → Bowling ball

- D) Name one sport where low friction is beneficial.

Case Study 3: Projectiles

A Javelin thrower releases the Javelin at 45°.

- A) Fill in the blank: The optimal angle of release is _____ degrees.
- B) True or False: Speed of release does not affect the range.
- C) Match:

Speed of release → Affects distance

Gravity → Pulls object down

Air resistance → Opposes motion

- D) Why does a taller athlete usually have an advantage?

Case Study 4: Centre of Gravity

A basketball player lowers body while defending.

A) Fill in the blank: A _____ COG increases stability.

B) True or False: Narrow base helps maintain balance.

C) Match:

Low COG → High stability

Wide base → Better balance

Line of Gravity inside base → Stable position

D) Why is controlling COG important in invasion sports?

UNSOLVED QUESTION

Case Study 5: Newton's Laws

During sprinting, athletes push hard against the ground.

A) Fill in the blank: According to Newton's Third Law, the ground pushes _____ on the athlete.

B) True or False: Law of Inertia applies during sprint start.

C) Match:

Law of Inertia → Motion without force

Law of Acceleration → $F = ma$

Law of Reaction → Equal and opposite force

D) Which law explains the acceleration during take-off?

Case Study 3: Equilibrium

A gymnast holds a handstand position.

A) Fill in the blank: This is an example of _____ equilibrium.

B) True or False: The gymnast is in motion during handstand.

C) Match:

Static Equilibrium → Handstand

Dynamic Equilibrium → Cycling at constant speed

No Equilibrium → Falling athlete

D) Why is low Centre of Gravity important in such activities?

5. LONG ANSWER QUESTIONS (5 Marks, 150–200 words)

1. Explain with suitable examples, the role of biomechanics in optimizing sports performance.
2. Discuss the applications of Newton's three laws of motion in sports with diagrams.
3. Describe different types of levers in the human body. Give at least two examples of each from sports.
4. Write in detail about the importance of equilibrium and Centre of Gravity in enhancing sports performance.
5. How do friction and projectile motion affect performance in various sports? Explain with examples.