



## “Role of Physics in Sports”

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### Abstract

Sports, ground reaction forces, and aerodynamic drag.

Across diverse disciplines—including sprinting, cycling, badminton, and throwing events—athletes operate within the framework of Newton’s laws of motion, work–energy relationships, conservation of linear and angular momentum, projectile motion, frictional interactions, and fluid dynamics. Sprint performance, for instance, depends on optimal force application against the ground, stride mechanics, and minimization of resistive forces. Similarly, in shot put and javelin throw, performance outcomes are determined by release velocity, projection angle, height of release, and rotational dynamics.

The systematic application of these principles is studied through biomechanics, which integrates kinematic and kinetic analyses using motion capture systems, force platforms, and computational modelling. By linking theoretical physics with physiological performance is fundamentally governed by principles of classical and applied physics. Athletic movements involve complex interactions of force generation, motion, energy transfer, momentum conservation, and mechanical efficiency. Contemporary sports science employs physical laws to quantitatively analyze performance variables such as velocity, acceleration, impulse, torque, angular momentum and mechanical parameters, biomechanics enables evidence-based technique refinement, injury prevention, and performance optimization. Thus, physics provides the analytical and quantitative foundation for scientific advancement in modern sports.

**Keywords:** Biomechanics, Kinematics, Kinetics, Momentum, Aerodynamics, Sports Performance.

### Introduction: -

Sports involve not only physical skills but are also based on scientific principles, including physics. Concepts such as force, momentum, energy, and fluid dynamics often form the foundation for understanding movements in various sports. For example, analyzing the trajectory of a soccer ball or the force applied in long jump techniques cannot be separated from Newton's laws.

Sports and physical activities involve various movements and forces that can be explained through the principles of physics. Physics plays a crucial role in understanding how athletes move, how equipment functions, and how performance can be improved. Concepts such as force, motion, energy, momentum, and gravity help explain many actions in sports, from the trajectory of a ball to the speed of a runner.

Physics also contributes to the design of sports equipment and facilities. Modern equipment such as lightweight running shoes, aerodynamic bicycles, and high-performance swimsuits is developed using physical principles to reduce air resistance, increase speed, and enhance comfort. In addition, stadium design, playing surfaces, and safety gear are optimized using physics to improve both performance and athlete safety.

Overall, physics provides the scientific foundation for analyzing and improving sports performance. By applying physical laws, athletes, coaches, and Physical Education Teachers can better understand movement, reduce the risk of injuries, and develop advanced equipment that enhances competitive performance.

### Speed and velocity of Physics

Speed and velocity are used to describe how fast something is going. Speed is the rate of change in distance and is a scalar quantity.

### Speed ( $\text{ms}^{-1}$ ) = Distance (m) / Time (s) Walking and Running: -

When you walk or run, physics is at play through the frictional force that helps you maintain balance and avoid slipping. The friction between your shoes and the ground provides the grip needed for stability and control as you move. The surface you walk on, along with the weight you exert, determines how easily you can walk or run. For example, walking on a carpet is easier because the rough texture of the carpet creates more friction, offering better grip



However, walking on ice is much more challenging because the smoothness of the surface reduces friction, making it easy to slip.

Running is one of the simplest yet most powerful examples of force in action. When a sprinter pushes off the starting blocks, they apply a force against the ground by using sports physics.

According to Newton's Third Law of Motion, for every action, there is an equal and opposite reaction.

### Newton's first law of motion: -

**“A body continues in a state of rest or uniform velocity unless acted upon by an external force.”**

This is also known as the ‘law of inertia’ and means that something will either stay still or stay moving unless a force acts on it. For example, a golf ball will remain still unless a force, applied by the golf club, makes it move. Or that same golf ball will continue to move at a constant velocity unless a force acts on it to slow it down (e.g. wind resistance) or change its direction (e.g. gravity)



### Newton's second law of motion: -

**“When a force acts on an object, the rate of change of momentum experienced by the object is proportional to the size of the force and takes place in the direction in which the force acts.”**

This means that when the golf ball, from the example above, is struck by the golf club the rate of change of momentum (or velocity) of the ball is proportional to the size of the force acting on it by the club. A useful way of writing Newton's second law of motion, particularly when doing calculations, is Force = mass x acceleration (or  $F=ma$ ).

### Newton's third law of motion: -

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

‘For every force that is exerted by one body on another, there is an equal and opposite force exerted by the second body on the first.’ This is sometimes referred to as the law of reaction.

For example, when a Tennis player hits a ball, the racket exerts a force on the ball and the ball exerts an equal and opposite force on the racket. The racket exerts what is known as the action force and the ball exerts the reaction force which is felt by the player in the increased resistance at the time the racket strikes the ball. If the same ball, then hits the floor, it exerts a force on the floor and the floor exerts an equal and opposite force on the ball



### . Acceleration - The Essential Skill for Success in All Ball Sports

Speed is a crucial factor in the success of athletes across various sports. In ball sports, where split-second decisions and quick movements can make all the difference, **speed acceleration** stands out as a key component of speed development.

### A) Football/Basketball

In these fast-paced sports, being able to accelerate rapidly is a game-changer. Players need to get to the ball first to gain possession, escape from defenders, or quickly close in on an opponent with the ball. The ability to make quick bursts of speed (especially within 5-10 meters), can often determine the outcome of a match, making acceleration a crucial skill for success.



### B) Cricket

In cricket, acceleration is vital for strategic plays. Whether it's sprinting between wickets to score runs or chasing down a ball on the field to prevent it from reaching the boundary, cricket players rely on swift acceleration. This ability not only contributes to individual performance but also impacts the overall dynamics of the game.



### C) Tennis: -

In court sports like tennis, the significance of acceleration is evident in the need to reach the ball and play a shot. Players must accelerate quickly to get to the ball in time to hit winners or just keep the ball in play. This not only enhances their offensive capabilities but also ensures they maintain control of the game. In tennis, where split-second reactions are crucial, acceleration becomes a key factor in staying competitive.

#### Kinematics in Sports (Description of Motion)

Kinematics focuses on the observable, geometric aspects of motion without considering the forces that cause it.

**Sport Applications:** Analyzing the projectile angle of a basketball shot, measuring the velocity of a pitcher's hand, or evaluating joint angles during a runner's gait (e.g., knee flexion/extension)



### Kinetics in Sports (Causes of Motion)

Kinetics studies the internal and external forces acting on the body that produce motion.

**Sport Applications:** Measuring ground reaction forces when landing a jump, evaluating torque on the elbow during pitching, or analyzing muscle forces.

### Fluid dynamics.

Fluid dynamics in sports physics involves optimizing performance by managing air (aerodynamics) or water (hydrodynamics) resistance, utilizing principles like lift, drag, and the Magnus effect to enhance speed and efficiency

### Fluid Dynamics Concepts in Sports

- **Drag Force (Resistance):** Parallel to the fluid flow, this force opposes motion. Key types include form drag (shape) and surface friction. Athletes aim to minimize this by adopting streamlined positions (e.g., cycling, skiing).



- **Lift Force:** Acting perpendicular to the fluid flow, lift allows objects or athletes to stay aloft longer (e.g., ski jumping, discus) or changes trajectory.



- **Boundary Layer & Turbulence:** Dimples on a golf ball or roughness on a javelin induce a turbulent boundary layer, which can reduce the wake area behind the object, lowering overall pressure drag.
- **Magnus Effect:** Spinning balls (like soccer balls or tennis balls) experience a pressure difference between sides, causing them to curve (lift) in flight.
- **Drafting:** Athletes follow closely behind another to enter a lower-pressure zone, significantly reducing air or water resistance.

#### Fluid Dynamics by Application: -

- **Hydrodynamics (Water):** In swimming, athletes focus on reducing skin friction and wave drag. Since water is ~800 times denser than air, stroke technique is heavily geared towards minimizing surface area and maximizing efficiency.
- **Aerodynamics (Air):** Crucial in cycling, speed skating, and bobsled, where streamlining and specialized clothing, helmets, and equipment (like deep-rim wheels) are tested in wind tunnels to reduce drag.

#### Friction: -

Is a force that opposes motion between two surfaces that are in contact. Friction is an important force in every sport and human movement. Friction occurs when two surfaces are in contact. Examples: - cycling and swimming



#### Types of Motion in Sports: -

- **Linear Motion (Translation):** All parts of the body or object move in the same direction at the same time in a straight line or curve. Examples include a skier straight-lining a slope, a swimmer gliding, or a bowling ball moving down a lane.
- **Angular Motion (Rotation):** Movement around a central axis or pivot point. Examples include a gymnast's giant circle on the bar, a diver spinning, or the rotation of joints (e.g., knee hinge).
- **General Motion:** A combination of linear and angular movements, which is most common in sports. For example, a runner's torso moves linearly, while their legs and arms rotate.

#### Energy and power: -

Energy and power in sports are fundamental to performance, with power defined as the ability to exert maximum force quickly and energy as the capacity to perform work via ATP, anaerobic, and aerobic systems. Power enables explosive movements like jumping and sprinting, while energy systems dictate endurance and fatigue management.

#### Energy systems in sports: -

Muscles require Adenosine Triphosphate (ATP) for construction, derived from three primary systems based on duration and intensity systems based on duration and intensity:

- **Phosphagen System (ATP-PCr):** Supplies immediate energy for short, explosive bursts (lasting 0-10 seconds), such as a 100m sprint, shot put, or Olympic lift.

- **Glycolytic System (Anaerobic):** Provides energy for high-intensity, moderate-duration efforts (lasting ~1-2 minutes), typical in middle-distance running or sustained hockey shifts.
- **Aerobic System:** Uses oxygen to sustain long-duration, lower-intensity activity (lasting >2 minutes), crucial for endurance sports like marathons or cycling.

### CONCLUSION: -

These are just some of the things that you need to learn and understand when relating physics to sports. The application of principles of physics not only improves sports performance but also reduce the chance of injuries. The interconnection between physics and sports performance is living proof that the effect of scientific principles on humans has a very profound impact on the level of human achievement. Physics is the academic entity that provides the unavoidable background of everything we do as athletes. Every athlete action has its own set of physics laws. Through the knowledge and practice of these principles, athletes become able to go past the limits of human capabilities, one thing remains abundantly clear that in sports universal realm physics is an ultimate ruler

The application of principles of physics not only improves sports performance but also reduce the chance of injuries.

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