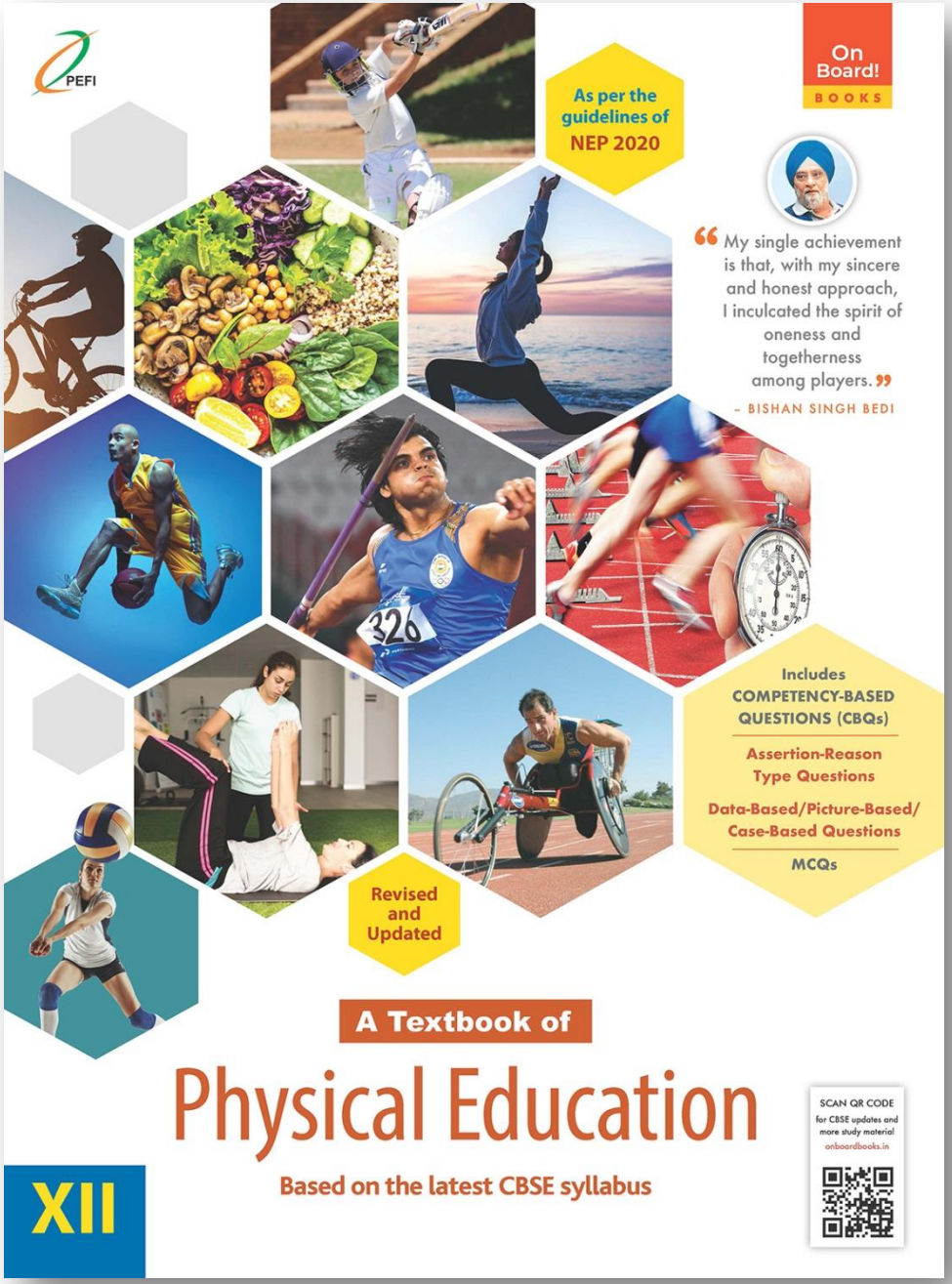
A TEXTBOOK OF PHYSICAL EDUCATION CLASS 12

Chapter 8

BIOMECHANICS AND SPORTS



NEWTON'S LAW OF MOTION AND ITS APPLICATION IN SPORTS

Three Laws of Motion and Their Application

The First Law (Law of Inertia): *A body at rest will continue in its state of rest and a body in motion will remain in its state of uniform motion in the same direction, unless an external force acts on them.*

This law is used in the starting techniques of sports such as rowing, sprinting, hammer throw, etc. and landing in gymnastics

Figure 8.1 Newton's first law is used in sprinting.

Three Laws of Motion and Their Application

The Second Law (Law of Acceleration): *A change in acceleration of a body is directly proportional to the force acting on it and inversely proportional to the mass of the body.*

This is shown by the formula:

$$F = m\,a$$

An example can be taken of batting in cricket. When a ball is hit, the change in speed depends on the force (*F*) with which it has been hit.

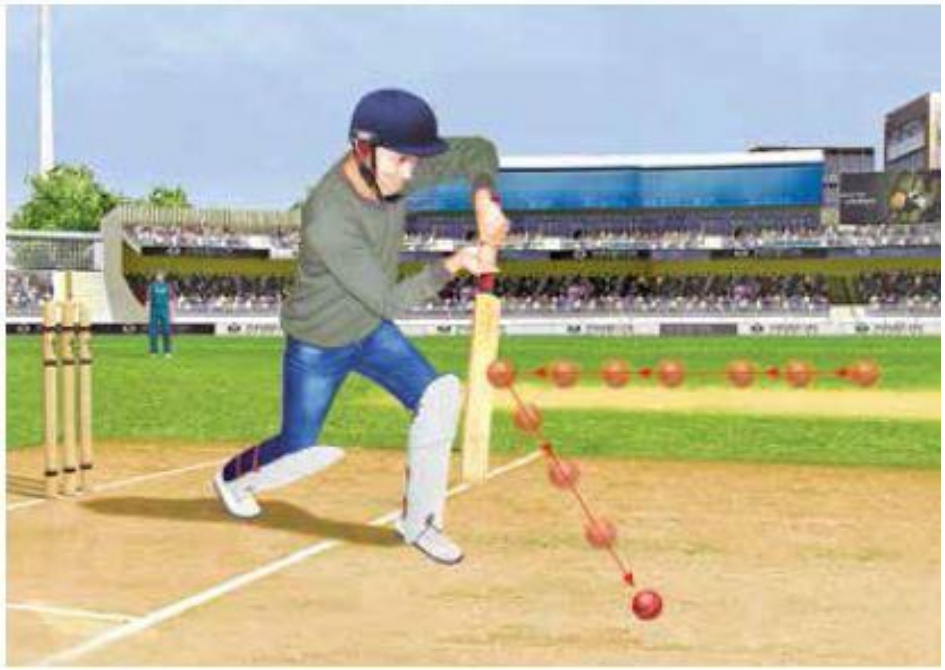


Figure 8.2 Application of Newton's second law of motion in cricket.

Three Laws of Motion and Their Application

The Third Law (Law of Reaction or Law of Counterforce): *For every action, there is always an equal and opposite reaction.*

This law is pivotal in understanding the biomechanics involved in sports like swimming, shooting, high jump, basketball, etc. In swimming, for example, the swimmer will be propelled at greater speed when she/he pushes the water with more force. Hard ground is more suitable for high jumps in comparison to sand because a hard surface reacts with greater force.

Figure 8.3 Application of Newton's third law of motion in swimming.

EQUILIBRIUM – DYNAMIC AND STATIC AND CENTRE OF GRAVITY AND ITS APPLICATION IN SPORTS

Meaning of Equilibrium

A body is said to be in equilibrium when all the forces acting on it are counterbalanced by equal and opposite forces and their sum becomes equal to zero.

Centre of Gravity and Types of Equilibrium

A body's COG is the point at which its weight is evenly distributed and all sides of the body are in balance. It is an imaginary, still an important, point where the entire mass of the body can be located.

Centre of Gravity

- helps the players to move.
- stops the moving object.
- helps the players to accelerate.
- helps the players in throwing objects.
- helps the players to lift the object.
- helps the players to pull the object.

Based on the position of COG, equilibrium is divided into:

1. Static Equilibrium: 2. Dynamic Equilibrium:

Principles of Stability

The degree of stability is influenced by the following factors.

1. Area of Base of Support
2. Vertical Distance of the COG from the Centre of the Base of Support
3. Location of the COG
4. Horizontal Distance of the COG from the Direction of Movement
5. Weight of the Body
6. Friction

Large base of support when both feet are apart.

Equilibrium

It is a state when the resultant of all the forces acting on a body becomes zero.

Based on the degree of stability, equilibrium is divided into three types:

1. Stable Equilibrium: When the body tries to come back to its original position after being moved. The base of support widens and COG is closer to this base of support.
2. Unstable Equilibrium: When the body never returns to its initial position and shifts to a new equilibrium position. The base of support is narrow and the height of COG is more.
3. Neutral Equilibrium: Sometimes, when a body is disturbed, it moves slightly, acquiring a new position where the base of support, the vertical distance of COG and positioning of COG do not change.

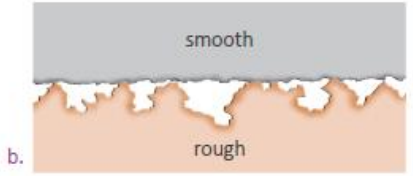
Application in Sports Biomechanics

Equilibrium, stability and COG form the bases of many scientific studies of sports mechanics and developments and upgrade of techniques. Understanding these concepts is advantageous for gymnasts, runners, footballers, weightlifters and a host of various other sportspersons, as they give an idea of how to hold positions and stay balanced while performing; how to increase their speed and minimise physical effort, etc.

FRICTION AND SPORTS

What is Friction?

Friction is defined as a force that develops on the surface of contact of two bodies and which opposes their relative motion.

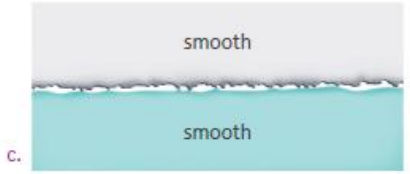


Types of Friction

Static Friction and Dynamic Friction

Types of dynamic friction:

1. Sliding Friction: 2. Rolling Friction: 3. Rolling Friction



Factors Affecting Friction

1. Friction can be reduced by applying a lubricant like oil, grease and wax between two surfaces.
2. Polishing a surface reduces its unevenness and makes it smooth, thus reducing the friction. For example, cricket players rub and shine the ball to increase its swing.
3. Rolling an object encounters less friction compared to pushing an object. Example is seen in roller skates.
4. Streamlining the shape of the objects reduces friction. For example, javelin, boats and ships are made with a sharp point to reduce friction.
5. Friction can be increased by making the surfaces rough or by making both the surfaces highly smooth.
6. Friction increases when the force between two objects is increased.

Advantages of Friction in Sports

1.In athletics, the shoes (spikes) are designed in a way that they increase friction, which helps players in increasing speed. Short distance runners have shoes with spikes in front only while long distance runners used a specially

2. A strong grip on rackets in badminton helps to deliver a perfect shot and prevents the racket from slipping.

3. In basketball, friction between the shoes and the court helps players maintain control on their movement. For this reason, players often wipe their shoes.

4. In cricket, players wear shoes with spikes which helps them in running around without the fear of slipping or falling. See more on page153.

Disadvantages of Friction in Sports

1.During cycling race, the tyres in contact with ground can get heated up due to friction. These might burst and can lead to severe accidents.

2. In weightlifting and gymnastics, skin of the palm of the athletes may get damaged due to friction and they may even slip while in action. So, they are advised to use powder on their palms and wear special shoes.See more on page 154.

Coefficient of Friction

Coefficient of friction (COF) is a ratio of the frictional force resisting the motion of two surfaces in contact to the normal force pressing the two surfaces together. It is symbolized by the Greek letter mu (μ).

PROJECTILE IN SPORTS

Meaning of Projectile

A projectile may be defined as any object that once projected, continues in motion by its own inertia and is influenced only by the downward force of gravity.

Factors Affecting Projectile Motion

Some of the factors affecting projectile motion are:

1. Angle of Projection:
2. Projection Height Relevant to the Landing Surface:
3. Initial Velocity:
4. Gravity:
5. Air Resistance, etc.

SUMMARY

1. Sir Isaac Newton was an English physicist and mathematician and a genius with few equals. He put forward three laws of motion in 1686. These laws are known as Newton's laws of motion.

2. A body at rest will continue in its state of rest and a body in motion will remain in its state of uniform motion in the same direction, unless an external force acts on them. This is the first law of motion or law of inertia.

3. A change in acceleration of a body is directly proportional to the force acting on it and inversely proportional to the mass of the body. This is the second law of motion or law of acceleration.**4.** Abduction is a movement in the frontal plane that takes the body part away from the midline or towards an imaginary centre line.

4. For every action, there is always an equal and opposite reaction. This is the third law of motion or law of reaction or law of counterforce.

5. A body is said to be in equilibrium when all the forces acting on it are counter balanced by equal and opposite forces and their sum becomes zero.

SUMMARY

6. A body's centre of gravity is the point at which its weight is evenly distributed and all sides of the body are in balance.

7. Friction is defined as a force that develops on the surface of contact of two bodies and which opposes their relative motion.

8. Friction plays a large role in the field of games and sports. Without the help of friction, one won’t be able to give a better performance.

9. Friction can be reduced by polishing the surface, by using lubricants, by streamlining the shape of the objects and by using ball bearing.

10. A projectile may be defined as any object that once projected, continues in motion by its own inertia and is influenced only by the downward force by gravity.