

Chapter 8 · Biomechanics and Sports

CBSE Class 12 Physical Education (048) · Unit 8 = 10 marks — the largest unit · Ultimate Revision Sheet

60-SECOND RECALL

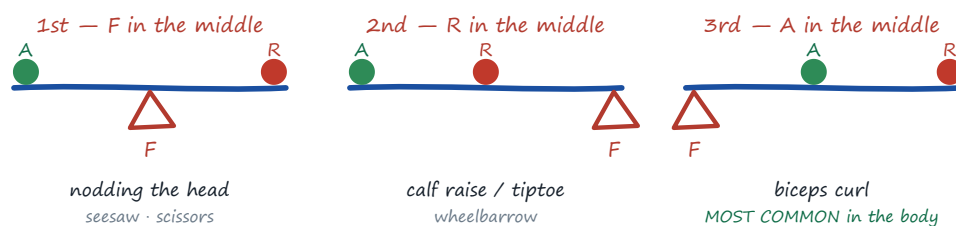
Newton's 3 laws	Inertia · Acceleration ($F = ma$) · Action-Reaction
3 levers	1st: F-A-R (fulcrum middle) · 2nd: A-R-F (resistance middle) · 3rd: A-F-R (effort middle)
Most common in body	THIRD class lever — e.g. biceps curl
Equilibrium	Static = at rest · Dynamic = moving at constant velocity
Stability rules	Lower centre of gravity + wider base + heavier body = more stable
Best projectile angle	45° when release and landing heights are equal

1. Newton's Laws of Motion in Sports

THE THREE LAWS — each needs a sports example

Law	Statement	Sports application
1st — Law of Inertia	A body remains at rest or in uniform motion in a straight line unless acted upon by an external force .	A football lies still until kicked · a hockey ball keeps rolling until friction or a player stops it · a sprinter in blocks stays still until he pushes
2nd — Law of Acceleration	The acceleration of a body is directly proportional to the force applied and inversely proportional to its mass . $F = m \times a$	A harder kick sends the ball further · a shot put (heavier) travels less far than a discus for the same force · a heavier boxer needs more force to move
3rd — Law of Action and Reaction	For every action there is an equal and opposite reaction .	A swimmer pushes water backward and moves forward · a sprinter pushes the blocks and is propelled · a basketball bounces back off the floor · recoil in shooting

2. Levers and Their Application



read the MIDDLE letter — 1st = F 2nd = R 3rd = A

A = effort (the muscle) · F = fulcrum (the joint) · R = resistance (the load)

3rd class gives SPEED and RANGE but a mechanical DISADVANTAGE — muscle works harder than the load.

Three classes, one test: whatever sits between the other two names the class.

THE THREE PARTS Fulcrum (F) — the pivot point (a joint in the body)

Effort / Force (A) — the applied force (muscle contraction)

Resistance / Load (R) — the weight to be moved (body part or implement)

THE THREE CLASSES — identified by WHAT IS IN THE MIDDLE

Class	Order	Middle	Body example
FIRST class	A — F — R	Fulcrum	Neck — nodding the head; the atlanto-occipital joint is the fulcrum. Also: seesaw, scissors.
SECOND class	A — R — F	Resistance	Calf raise — standing on tiptoe; the ball of the foot is the fulcrum, body weight the resistance. Also: wheelbarrow.
THIRD class	F — A — R	Effort	Biceps curl — elbow is the fulcrum, biceps the effort, the weight in the hand the resistance. MOST COMMON in the human body.

Memory hook: read the middle letter — 1st = Fulcrum, 2nd = Resistance, 3rd = Applied force.
Or: FRE 1-2-3.

TRAP The **third class lever** is the most common in the human body because muscles attach close to the joint. It gives a **speed and range advantage** but a **mechanical disadvantage** — the muscle must exert more force than the load it moves.

3. Equilibrium and Centre of Gravity

DEFINITIONS **Equilibrium** is the state in which all the forces acting on a body are **balanced**, so it has no unbalanced acceleration.

Centre of Gravity (CG) is the point at which the **entire weight** of the body is considered to be concentrated. In a standing adult it is roughly at the **navel / upper sacral region**.

Type	Meaning	Sports example
Static equilibrium	The body is at rest ; no motion	A gymnast holding a handstand · a shooter aiming · a wrestler in a stance
Dynamic equilibrium	The body is moving at constant velocity ; forces still balanced	A skater gliding · a cyclist at steady speed · a runner at constant pace

THE FOUR PRINCIPLES OF STABILITY — a guaranteed question

1. **Lower the centre of gravity → MORE stable.** A wrestler crouches; a sprinter bends low in the blocks.
2. **Wider the base of support → MORE stable.** Feet apart in a defensive stance.
3. **The CG must fall WITHIN the base of support.** If the line of gravity falls outside, the body topples.
4. **Greater the body weight → MORE stable.** A heavier sumo wrestler is harder to push over. Also: greater friction between body and surface increases stability.

APPLY IT BOTH WAYS Stability is not always desirable. A **sprinter in starting blocks** deliberately makes himself **unstable** — CG high and forward, near the edge of the base — so that he can accelerate quickly. A **wrestler** wants maximum stability. Mention this contrast and you show application.

4. Friction and Sports

DEFINITION **Friction** is the force that **opposes the relative motion** of two surfaces in contact.

Type	Meaning
Static friction	Acts when the body is at rest and resists the start of motion — the greatest of the three
Sliding friction	Acts when one surface slides over another
Rolling friction	Acts when a body rolls over a surface — the least of the three

Friction is an **ADVANTAGE** when...

- **Spikes and studs** give grip in running and football
- **Gymnasts use chalk** for grip on bars
- **Basketball shoes** grip the court for quick turns
- **Grip on a bat, racquet or javelin**
- **Braking and stopping**

Friction is a **DISADVANTAGE** when...

- **Skating and skiing** — less friction means more speed, so blades are smooth and surfaces waxed
- **Swimming** — smooth suits and caps reduce drag
- **Cycling** — lubricated chains and smooth tyres
- Causes **wear and tear** of equipment and abrasion injuries

5. Projectile in Sports

DEFINITION A **projectile** is any body thrown into the air that then travels under the influence of **gravity and air resistance** alone. Its path is called the **trajectory** and is **parabolic**.

THE FIVE FACTORS AFFECTING PROJECTILE TRAJECTORY

1. **Angle of projection** — 45° gives the maximum horizontal distance **when release and landing heights are equal**. If released from above landing level (shot put, javelin), the optimum angle is **less than 45°** .
 2. **Initial velocity / speed of release** — the **most important** factor; distance increases with the **square** of velocity.
 3. **Height of release** — a greater release height increases distance and lowers the optimum angle.
 4. **Gravity** — pulls the projectile down; constant, and the same for all.
 5. **Air resistance** — opposes motion; affects light objects (shuttlecock, table tennis ball) far more than heavy ones (shot put).
- Also: **spin**, which produces the **Magnus effect** and curves the flight.

Event	Approximate optimum release angle
Long jump	About 20–22°
Shot put	About 38–42° (released above landing height)
Javelin / Discus	About 30–35° (aerodynamic lift matters)
High jump	Steep, about 50–60° — height, not distance, is the aim

6. Question Triggers which law / which lever?

If the question says...	The answer is
"swimmer pushes water back and moves forward"	Third law — action and reaction
"ball stays still until kicked"	First law — inertia
"harder kick makes the ball go further"	Second law — $F = ma$

"sprinter pushes the starting blocks"	Third law
"nodding the head"	First class lever
"standing on tiptoe / calf raise"	Second class lever
"biceps curl, elbow flexion"	Third class lever
"gymnast holds a handstand"	Static equilibrium
"skater glides at constant speed"	Dynamic equilibrium
"wrestler crouches with feet apart"	Lowering CG + widening base → more stability
"spikes on running shoes"	Friction as an advantage
"wax applied to skis"	Reducing friction
"best angle to throw for maximum distance"	45° (equal release and landing height)
"shuttlecock slows quickly in flight"	Air resistance

MOST-ASKED BOARD QUESTIONS

1. **[5M]** Explain Newton's three laws of motion with examples from sports.
2. **[5M]** Explain the types of levers with a diagram and their application in sports.
3. **[5M]** Explain the principles of stability / equilibrium and their application.
4. **[3-5M]** Explain the factors affecting a projectile trajectory.
5. **[3M]** Explain friction and its advantages and disadvantages in sports.
6. **[1M]** Which lever class is most common in the body? → **Third class**

THE HABIT THAT SCORES — This is a **10-mark unit** and every topic in it can be **drawn**. Draw the lever with F, A and R labelled; draw the parabolic trajectory with the angle marked; draw the base of support with the line of gravity. Labelled diagrams carry marks independently of the text.