Physical Education Notes Unit 9

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TOPIC 1 — Physiological Factors Determining Physical Fitness Components

Physiology is the scientific study of the functions and mechanisms of living organisms. In sports, it examines how the body responds to exercise and adapts to training. Physical fitness components are governed by specific physiological systems and factors.

A. Factors Determining CARDIOVASCULAR ENDURANCE

- **VO■ Max (Maximal Oxygen Uptake):** The gold-standard measure of aerobic capacity. Determined by cardiac output (Q = HR × SV) and arteriovenous O■ difference (a-vO■ diff). Higher VO■ max = greater endurance capacity.
- **Cardiac Output (Q):** Volume of blood pumped per minute = Heart Rate (HR) × Stroke Volume (SV). Trained athletes have higher resting stroke volume (80–100 ml vs 70 ml untrained) → lower resting HR (athlete's bradycardia, 40–60 bpm).
- **Heart Rate:** Resting HR decreases with aerobic training. Maximum HR is largely genetically determined (≈220–age).
- **Stroke Volume:** Amount of blood pumped per beat — increases with endurance training due to cardiac hypertrophy (enlarged left ventricle) and increased blood volume.
- **Oxygen Extraction (a-vO■ difference):** Difference between arterial O■ content and venous O■ content. Trained muscles extract more O■ per unit blood flow.
- **Lung Capacity and Efficiency:** Tidal volume increases during exercise; trained athletes have greater lung volumes (FVC, FEV1) and more efficient gas exchange.
- **Capillarisation:** Training increases capillary density in muscles → better O■ delivery and CO■ removal.
- **Mitochondrial Density:** Endurance training increases the number and size of mitochondria → greater aerobic ATP production capacity.
- **Haemoglobin Concentration:** Fe-containing protein that carries O■ in RBCs. Higher Hb = greater O■-carrying capacity (altitude training exploits this).

B. Factors Determining MUSCULAR STRENGTH

- **Muscle Fibre Composition:** Type II (fast-twitch) fibres generate more force. Type I (slow-twitch) are more fatigue-resistant. Fibre type ratio is largely genetic.
- **Muscle Cross-Sectional Area (CSA):** Hypertrophy (increased muscle size) → more force. Strength ∝ CSA. Resistance training increases CSA.
- **Neural Factors:** Motor unit recruitment (more motor units activated = more force). Rate coding (faster neural firing = greater force). Better inter-muscular coordination.
- **Muscle Architecture:** Pennation angle — muscle with greater pennation angle can pack more fibres in same volume → more force.
- **Biomechanical Efficiency:** Lever arm length, joint angle, and body proportions affect force application.
- **Hormonal Factors:** Testosterone (anabolic) increases protein synthesis → muscle hypertrophy. Growth hormone also contributes.
- **Age and Gender:** Peak strength in 20s–30s. Males have 30–40% greater absolute strength due to testosterone levels.

C. Factors Determining SPEED

• **Muscle Fibre Type:** Greater proportion of Type II (fast-twitch) fibres → faster contraction velocity.

• **Neural Speed:** Nerve conduction velocity and synaptic transmission speed determine reaction time and movement initiation speed.

• **ATP-PCr System Efficiency:** Rapid resynthesis of ATP via phosphocreatine determines sprint duration capability.

• **Stride Length × Stride Frequency:** Speed = Stride Length × Stride Frequency. Both are trainable.

• **Muscle Strength:** Greater force production generates greater acceleration (F=ma). Stronger muscles produce faster ground reaction forces.

• **Reaction Time:** Neural efficiency of sensory → brain → motor pathway determines starting speed.

• **Elastic Energy Storage:** Efficient stretch-shortening cycle (SSC) in tendons stores and releases elastic energy.

D. Factors Determining FLEXIBILITY

• **Joint Structure:** Shape of articulating surfaces (ball-and-socket joints have greater ROM than hinge joints — genetically determined).

• **Muscle Extensibility:** Length and elastic properties of muscle fibres and fascia — trainable through stretching.

• **Connective Tissue Properties:** Tendons, ligaments, joint capsule thickness and elasticity limit ROM.

• **Stretch Reflex Sensitivity:** Highly sensitive stretch receptors (muscle spindles) reduce flexibility by triggering protective contractions.

• **Temperature:** Warm muscles are more extensible — warm-up increases flexibility. Cold reduces ROM.

• **Age:** Flexibility decreases with age due to collagen changes in connective tissue.

• **Gender:** Females generally more flexible than males due to hormonal and structural differences.

• **Body Composition:** Excess adipose tissue can restrict joint ROM mechanically.

Physiological Factors — Master Summary Table

Component	Key Physiological Determinants	Primary Training Adaptation
Cardiovascular Endurance	VO■ max, cardiac output, Hb concentration, mitochondrial density	↑ Stroke volume, ↑ capillarisation, ↑ mitochondria, ↓ resting HR
Muscular Strength	CSA (hypertrophy), muscle fibre type, neural recruitment, testosterone	↑ Muscle CSA, ↑ motor unit recruitment, improved neural firing
Speed	Type II fibres, ATP-PCr system, neural velocity, stride mechanics	↑ Neuromuscular firing rate, ↑ PCr stores, ↑ stride length/frequency
Flexibility	Joint structure, muscle extensibility, connective tissue, temperature	↑ Muscle length, ↓ stretch reflex sensitivity, ↑ tissue elasticity
Agility	Neuromuscular coordination, reaction time, strength-to-weight ratio	↑ Motor programming, ↑ balance, faster directional change
Muscular Endurance	Mitochondrial density, capillarisation, glycogen stores, lactate threshold	↑ Oxidative capacity, ↑ lactate clearance, ↑ glycogen storage

TOPIC 2 — Effects of Exercise on the Muscular System

Exercise produces both **immediate (acute)** responses and **long-term (chronic) adaptations** in the muscular system. Understanding these changes is crucial for designing effective training programmes.

A. IMMEDIATE (ACUTE) EFFECTS — During Exercise

• **Increased Blood Flow to Muscles:** Exercise triggers vasodilation of arterioles supplying working muscles. Blood redistribution — 80–85% of cardiac output directed to muscles (vs 15–20% at rest).

• **Muscle Temperature Rises:** ATP hydrolysis releases heat → muscle temperature increases from ~37°C to 38–40°C → improves enzyme activity, O■ delivery, and muscle extensibility.

• **Oxygen Consumption Increases:** Myoglobin releases O■ from storage. Increased O■ delivery from Hb. Mitochondria increase ATP production.

• **ATP Depletion and Resynthesis:** ATP depletes rapidly → PCr donates phosphate to resynthesise ATP (ATP-PCr system, 0–10 sec) → anaerobic glycolysis (10 sec–2 min) → aerobic oxidation (>2 min).

• **Lactic Acid Production:** When O■ delivery cannot meet demand (above anaerobic threshold) — pyruvate converted to lactate. Accumulation causes muscle fatigue and 'burning' sensation.

• **Motor Unit Recruitment:** Increasing exercise intensity recruits progressively more motor units (size principle — Type I first, then Type IIa, then Type IIx).

• **Muscle Fatigue:** Accumulation of H■ (hydrogen ions from lactic acid dissociation), Pi (inorganic phosphate from ATP breakdown), and K■ leakage from muscle cells → reduced contractile efficiency.

• **Glycogen Depletion:** Muscle glycogen progressively depleted — depletion correlates with fatigue in prolonged exercise.

B. LONG-TERM (CHRONIC) ADAPTATIONS — From Regular Training

Adaptation	Description	Training Type	Performance Benefit
Hypertrophy	Increased muscle fibre size (increased actin and myosin proteins). Sarcoplasmic hypertrophy (more glycogen/fluid) vs myofibrillar hypertrophy (more contractile proteins).	Resistance/strength training	Greater force production, larger muscle cross-section
Increased Mitochondrial Density	More and larger mitochondria per muscle fibre → greater aerobic ATP production capacity.	Endurance training	Higher VO■ max, better fat oxidation, delayed fatigue
Improved Capillarisation	Increased capillary density around muscle fibres → better O■ delivery and CO■/waste removal.	Endurance training	Improved aerobic performance, faster recovery
Increased Glycogen Storage	Muscles store more glycogen → greater fuel reserve for prolonged exercise.	Endurance training + carb loading	Delayed onset of glycogen depletion

Improved Myoglobin Content	More myoglobin → better O■ storage within muscle cells.	Endurance training	Better O■ buffering during intensity fluctuations
Neural Adaptations	Improved motor unit recruitment, better inter/intra-muscular coordination, increased rate coding.	All training (especially early in training)	Strength gains before hypertrophy occurs
Muscle Fibre Type Changes	Type IIx (fastest, least efficient) can adapt toward Type IIa (more oxidative) with endurance training.	Endurance + mixed training	Better fatigue resistance in fast-twitch fibres
Tendon Strengthening	Tendons become thicker and stiffer → better force transmission from muscle to bone.	Resistance training	Reduced injury risk; improved power transfer
Reduced Lactic Acid Accumulation	Better lactate clearance (increased LDH enzymes), raised anaerobic threshold.	Threshold/interval training	Sustain higher intensities without fatigue

Muscle Fibre Types — Quick Reference

Property	Type I (Slow-Twitch)	Type IIa (Fast Oxidative)	Type IIx (Fast Glycolytic)
Contraction Speed	Slow	Fast	Very Fast
Force Production	Low	High	Very High
Fatigue Resistance	Very High	Moderate	Low (fatigues quickly)
Mitochondria	Many (red fibres)	Moderate	Few (white fibres)
Fuel	Fat + Glucose (aerobic)	Both	Glucose/glycogen (anaerobic)
Colour	Red (myoglobin-rich)	Pink	White
Sports Use	Marathon, triathlon, endurance	800m, swimming, football	100m sprint, powerlifting
Training Adaptation	Endurance training	Both	Strength/power training

TOPIC 3 — Effects of Exercise on the Cardio-Respiratory System

A. IMMEDIATE EFFECTS ON CARDIOVASCULAR SYSTEM

• **Heart Rate Increases:** Controlled by sympathetic nervous system and adrenaline. Can increase from ~70 bpm (rest) to 190–220 bpm (maximum effort). Anticipatory rise even before exercise begins.

• **Stroke Volume Increases:** From ~70 ml/beat (rest) to ~100–130 ml/beat (during moderate exercise). Achieved by: greater ventricular filling (Frank-Starling law) and stronger ventricular contraction.

• **Cardiac Output (Q) Increases:** Q = HR × SV. Resting ≈5 L/min → maximal exercise ≈20–25 L/min (untrained) or up to 40 L/min (elite endurance athletes).

• **Blood Pressure Rises:** Systolic BP increases significantly (120 → 180–200 mmHg) due to increased cardiac output. Diastolic BP stays same or slightly decreases (vasodilation in muscles offsets resistance).

• **Blood Redistribution:** Vasoconstriction in non-essential organs (digestive system, kidneys, skin). Vasodilation in working muscles. Maintains BP while directing flow to muscles.

• **Venous Return Increases:** Muscle pump (skeletal muscle contractions squeeze veins), respiratory pump (breathing creates pressure gradients), venoconstriction — all increase venous return → maintains stroke volume.

• **Capillary Recruitment:** At rest, only 5–10% of muscle capillaries are open. During exercise, up to 80–100% open → greater O■ delivery surface area.

• **Blood Volume Shifts:** Fluid shifts from plasma into interstitial space during intense exercise — slight reduction in plasma volume, concentration of RBCs.

B. IMMEDIATE EFFECTS ON RESPIRATORY SYSTEM

• **Breathing Rate Increases:** Respiratory rate (f) increases from ~12–16 breaths/min (rest) to 40–60 breaths/min (maximum). Controlled by chemoreceptors sensing CO■, H■, and O■ levels.

• **Tidal Volume Increases:** Volume per breath increases from ~500 ml (rest) to 2,000–3,000 ml (exercise). Increased depth of breathing.

• **Minute Ventilation (VE) Increases:** VE = f × TV. Resting ≈6 L/min → maximal exercise ≈120–180 L/min (elite athletes).

• **O■ Uptake Increases:** Muscles extract more O■ per unit blood flow. Oxygen utilisation rises from 25% at rest to 75–80% during maximal exercise.

• **CO■ Production Increases:** Aerobic metabolism produces CO■ as a byproduct. CO■ is primary stimulus for increased ventilation during moderate exercise.

• **Respiratory Exchange Ratio (RER) Changes:** RER = VCO■/VO■. At rest ≈0.8 (mixed fuel). During high-intensity exercise → 1.0+ (primarily carbohydrate burning).

• **Ventilatory Threshold:** Point during incremental exercise where ventilation increases disproportionately — corresponds to anaerobic threshold and lactate accumulation.

• **Gas Exchange at Lungs:** Increased surface area utilisation in alveoli. Diffusion gradient for O■ and CO■ maintained efficiently across alveolar-capillary membrane.

C. LONG-TERM (CHRONIC) ADAPTATIONS — Cardiovascular & Respiratory

System	Adaptation	Mechanism	Performance Benefit

Cardiovascular	Cardiac Hypertrophy (Athlete's Heart)	Enlarged left ventricle wall + cavity from endurance training	Greater stroke volume at rest and exercise
Cardiovascular	Bradycardia (Low Resting HR)	Higher stroke volume → same cardiac output at lower HR	More efficient heart; lower O■ demand at rest
Cardiovascular	Increased Blood Volume (plasma + RBCs)	Plasma volume ↑10–15%; RBC production increases	Greater O■ carrying capacity; larger venous return
Cardiovascular	Increased Capillarisation	More capillaries per muscle fibre	Better O■/CO■ exchange; faster metabolite removal
Cardiovascular	Improved Vascular Flexibility	Arteries become more compliant and elastic	Lower blood pressure at rest; better BP regulation
Cardiovascular	Reduced Resting Blood Pressure	Lower peripheral resistance; improved vascular health	Reduced cardiovascular disease risk
Respiratory	Increased Tidal Volume at Rest	Stronger respiratory muscles; more efficient breathing pattern	Better gas exchange per breath
Respiratory	Increased Respiratory Muscle Strength	Diaphragm, intercostals become stronger	Less fatigue in breathing muscles during exercise
Respiratory	Increased Diffusion Capacity	More alveoli recruited; thinner alveolar-capillary membrane	Faster O■ loading and CO■ unloading
Respiratory	Raised Anaerobic/Ventilatory Threshold	Better lactate clearance; improved buffering capacity	Exercise at higher intensity before breathing becomes laboured

Acute vs Chronic Effects — Quick Summary

Parameter	At Rest (Untrained)	During Exercise (Acute)	After Training (Chronic)
Heart Rate	70–80 bpm	Up to 200–220 bpm	50–60 bpm (athlete bradycardia)
Stroke Volume	70 ml/beat	100–130 ml/beat	90–110 ml/beat at rest
Cardiac Output	5 L/min	20–25 L/min (25–40 elite)	Same at rest; higher maximum
Breathing Rate	12–16 breaths/min	40–60 breaths/min	10–14 breaths/min (more efficient)
Tidal Volume	500 ml	2000–3000 ml	Slightly increased at rest
Blood Pressure (Systolic)	120 mmHg	180–200 mmHg	Slightly reduced (healthier vessels)
VO■ max	Baseline	Maximal during exercise	Increased 10–30% with training

TOPIC 4 — Newton's Laws of Motion & Applications in Sports

Biomechanics applies mechanical principles to human movement in sport. Sir Isaac Newton's three laws of motion form the FOUNDATION of all sports biomechanics — explaining how forces affect body position, velocity, and direction.

1st LAW — Law of INERTIA

Statement: "An object at rest stays at rest, and an object in motion stays in motion with the same speed and direction UNLESS acted upon by an EXTERNAL UNBALANCED FORCE."

Key Concept: INERTIA — the tendency of an object to resist changes in its state of motion. Mass determines inertia — heavier objects have greater inertia.

Mathematical Basis: $\Sigma F = 0 \rightarrow$ Acceleration = 0 (constant velocity or rest). An unbalanced force is required to change state.

Applications in Sports:

Sport	Application of Law 1 (Inertia)
Cricket/Baseball	A stationary cricket ball doesn't move until a bowler/pitcher applies force. Once moving, it continues in a straight line until gravity, air resistance, or bat changes it.
Football (Soccer)	A rolling football continues to roll (despite grass friction) until another force stops it — goalkeeper, defender, or wall.
Swimming	Swimmer continues moving forward after pushing off the wall (Newton's 1st) — friction of water (external force) gradually slows them.
Wrestling	A wrestler must overcome the opponent's inertia to take them down. Heavier wrestlers are harder to move — more inertia.
Cycling	Cyclist in motion tends to stay in motion — braking provides external force to overcome inertia of bicycle + rider.
Javelin Throw	Javelin continues its trajectory after release until gravity and air resistance act on it.
Skating/Ice Hockey	On low-friction ice, a hockey puck or skater can travel very long distances — minimal external force to decelerate.

2nd LAW — Law of ACCELERATION (Force = Mass × Acceleration)

Statement: "The acceleration of an object is directly proportional to the NET FORCE applied and INVERSELY PROPORTIONAL to the MASS of the object."

Formula: $F = m \times a$ (Force = Mass × Acceleration) | Rearranging: $a = F/m$

Key Concepts: Greater force → greater acceleration. Greater mass → less acceleration for same force. Direction of acceleration = direction of net force.

Impulse-Momentum Relationship: $F \times t = m \times \Delta v$ (Impulse = Change in momentum). Extending time of force application increases impulse.

Applications in Sports:

Sport	Application of Law 2 (F = ma)
Athletics — Shot Put	A heavier shot put requires more force to achieve the same velocity. F = m×a: to maximise distance ($v^2 \sin 2\theta / g$), maximise both force and release velocity.
Cricket — Batting	Greater bat swing force → ball accelerates faster off bat (F = ma). A heavier bat gives more momentum (m×v) to the ball.
Sprinting	Greater leg muscle force → greater acceleration off starting blocks. Lighter athlete can accelerate faster with same force (a = F/m).
Football — Penalty Kick	More force applied to ball → greater acceleration → faster shot. Ball's mass is constant so F determines a.
Tennis — Serve	Racket applies force to ball → ball accelerates. Greater string tension + swing speed → more force → faster serve.
Swimming — Push off Wall	Force from legs on wall → equal and opposite reaction propels swimmer. More force → greater acceleration.
Gymnastics — Trampolining	Force from trampoline propels gymnast — greater spring force → higher acceleration and height.
Boxing	A punch's effectiveness: greater mass (heavier glove/boxer) and acceleration → greater force on opponent (F = ma).

3rd LAW — Law of REACTION (Action-Reaction)

Statement: "For every ACTION, there is an EQUAL and OPPOSITE REACTION."

Key Concept: Forces always come in pairs — action force and reaction force are equal in magnitude, opposite in direction, and act on DIFFERENT objects.

Ground Reaction Force (GRF): The force the ground exerts on a person equal and opposite to the force the person exerts on the ground — critical in all locomotion.

Formula: $F_{action} = -F_{reaction}$ (same magnitude, opposite direction).

Applications in Sports:

Sport	Application of Law 3 (Action-Reaction)
Sprinting — Starting Blocks	Sprinter PUSHES BACKWARD against blocks (action) → Blocks push sprinter FORWARD (reaction) → Sprinting begins. Harder push = faster start.
Swimming	Swimmer pulls water BACKWARD (action) → Water pushes swimmer FORWARD (reaction). Efficient arm stroke = maximum forward propulsion.
Rowing	Oars push water BACKWARD (action) → Water pushes boat FORWARD (reaction). Longer stroke = more water moved backward = greater forward thrust.
High Jump / Long Jump	Athlete pushes foot DOWN into ground (action) → Ground pushes athlete UP (reaction) → Lift-off. Elastic mats in gymnastics enhance this.

Rocket / Jet propulsion	Jet engine pushes gases BACKWARD at high speed (action) → Gases push aircraft FORWARD (reaction). Same principle as swimming.
Cricket — Bowling Delivery	Bowler's foot pushes backward/down on pitch (action) → Ground reaction force provides forward propulsion during delivery stride.
Badminton/Tennis — Ground Footwork	Player pushes DOWN and OUTWARD against court (action) → Court pushes player UP and INWARD (reaction) → Enables quick directional changes.
Recoil in Shooting Sports	Bullet fired forward (action) → Gun recoils backward (reaction) — shooter must manage this reaction.

Newton's Laws — Master Summary Table

Law	Name	Statement (Simple)	Formula	Sports Key Concept
1st Law	Law of Inertia	Body at rest stays at rest; in motion stays in motion unless force acts	ΣF = 0 → a = 0	Inertia — mass resists change in motion
2nd Law	Law of Acceleration	Force = mass × acceleration	F = m × a	Greater force OR less mass = more acceleration
3rd Law	Law of Reaction	Every action has equal and opposite reaction	F■ = –F■	Ground reaction force enables all locomotion

TOPIC 5 — Types of Levers and their Application in Sports

A **lever** is a rigid bar that rotates around a fixed point (fulcrum) when force is applied. The human musculoskeletal system works as a series of levers — BONES act as levers, JOINTS act as fulcrums, MUSCLES provide effort force, and body weight/external objects are the resistance/load.

- **Fulcrum (F/A):** The pivot point — the JOINT in the body.
- **Effort (E):** The force applied — the MUSCLE force (or externally applied force).
- **Resistance/Load (R/L):** The weight to be moved — the BODY PART or EXTERNAL OBJECT.
- **Mechanical Advantage (MA):** MA = Effort Arm (EA) / Resistance Arm (RA). MA > 1 = force advantage; MA < 1 = speed/range advantage.
- **Effort Arm:** Distance from Fulcrum to the point of Effort application.
- **Resistance Arm:** Distance from Fulcrum to the point of Resistance application.
- **Principle of Levers:** Effort × Effort Arm = Resistance × Resistance Arm (when in equilibrium).

FIRST CLASS LEVER — Fulcrum Between Effort and Resistance (F-E-R or R-F-E)

- **Arrangement:** F (Fulcrum) is between E (Effort) and R (Resistance). Like a SEE-SAW.
- **Visual:** E ←——— F ———→ R
- **Mechanical Advantage:** Can be >1 or <1 depending on relative arm lengths.
- **Examples in Body:**
- • **Head nodding:** Atlantooccipital joint (Fulcrum) between neck extensors (Effort at back) and skull weight (Resistance at front).
- • **Triceps extension:** Elbow joint (Fulcrum) between triceps muscle (Effort) and forearm weight (Resistance).
- **Sports Application:** Crowbar, seesaw, scissors, weighing balance, neck movement in swimming (bilateral breathing).
- **Key Feature:** Fulcrum in the MIDDLE. Can provide force advantage OR speed advantage depending on arm lengths.

SECOND CLASS LEVER — Resistance Between Fulcrum and Effort (F-R-E)

- **Arrangement:** R (Resistance) is between F (Fulcrum) and E (Effort). Like a WHEELBARROW.
- **Visual:** F ——→ R ——→ E
- **Mechanical Advantage:** Always > 1 (force advantage — effort arm is ALWAYS longer than resistance arm).
- **Characteristic:** Effort arm is ALWAYS greater than resistance arm → can lift heavy loads with less effort. Sacrifices speed/range for force.
- **Examples in Body:**
- • **Plantar flexion (Standing on tiptoe):** Toes/ball of foot (Fulcrum), body weight at ankle (Resistance), calf muscles/Achilles tendon (Effort at heel).
- • **Jaw closing (mandible):** Jaw joint (Fulcrum), food between teeth (Resistance), masseter muscle (Effort).
- **Sports Application:** Calf raises, jumping/push-off phase in sprint, rising on toes in gymnastics and ballet, wheelbarrow.

• **Key Feature:** Resistance in the MIDDLE. ALWAYS provides force advantage (MA > 1). Best for lifting heavy loads.

THIRD CLASS LEVER — Effort Between Fulcrum and Resistance (F-E-R)

• **Arrangement:** E (Effort) is between F (Fulcrum) and R (Resistance). Like a FISHING ROD or TWEEZERS.

• **Visual:** F ——→ E ——→ R

• **Mechanical Advantage:** Always < 1 (speed/range advantage — resistance arm ALWAYS longer than effort arm).

• **Characteristic:** Effort arm is ALWAYS less than resistance arm → requires MORE effort than the load, but achieves GREATER SPEED and RANGE OF MOTION at the resistance end.

• **Most Common in Human Body:** The majority of muscle-joint systems in the human body are third class levers — the body prioritises SPEED and RANGE over force.

• **Examples in Body:**

• • **Bicep curl:** Elbow joint (Fulcrum), biceps brachii insertion (Effort at forearm), hand/weight (Resistance at end of forearm).

• • **Knee extension (quadriceps):** Knee joint (Fulcrum), quadriceps insertion via patella tendon (Effort), foot/lower leg (Resistance).

• • **Shoulder abduction, hip flexion, trunk flexion (sit-up)** — all third class.

• **Sports Application:** Bicep curl in weightlifting, throwing a ball (elbow extension — technically 1st class but triceps insertion is an example), sweeping in cricket, forearm in tennis backhand.

• **Key Feature:** Effort in the MIDDLE. ALWAYS speed advantage (MA < 1). Most common lever in body. Needs more effort than load but moves the resistance faster and through greater range.

All Three Levers — Master Comparison Table

Feature	1st Class	2nd Class	3rd Class
Arrangement	E — F — R or R — F — E (Fulcrum in middle)	F — R — E (Resistance in middle)	F — E — R (Effort in middle)
Analogy	See-saw, scissors, crowbar	Wheelbarrow, bottle opener	Fishing rod, tweezers, forceps
Mechanical Advantage	Can be >1 or <1	Always >1 (force advantage)	Always <1 (speed advantage)
Body Examples	Head nodding (atlas joint), triceps extension	Calf raise (plantar flexion), jaw closing	Bicep curl, knee extension, sit-up
Advantage Gained	Depends on arm lengths	Force advantage — lifts heavy loads	Speed + Range of motion advantage
Frequency in Body	Rare	Rare	MOST COMMON in human body
Sports Use	Neck in swimming, oar in rowing	Jump push-off, ballet rise	Most throwing/hitting/kicking actions

• **KEY EXAM FACT:** Third class levers are the MOST COMMON in the human body. The body sacrifices mechanical efficiency for SPEED and RANGE OF MOTION — essential for sports performance.

• **KEY EXAM FACT:** Second class levers ALWAYS provide force advantage (MA > 1) — the effort arm is always longer. Plantar flexion (calf raise / toe stand) is the CLASSIC second class lever example.

• **KEY EXAM FACT:** The sequence of components is the identifier: 1st = Fulcrum middle, 2nd = Resistance middle, 3rd = Effort middle. Mnemonic: 'FRE' for class identification — 1st class: F middle; 2nd: R middle; 3rd: E middle.

MASTER QUICK REVISION — Unit IX At a Glance

Topic	Key Points for CUET
Physiological Factors — Endurance	VO■ max; cardiac output (HR × SV); Hb concentration; mitochondrial density; capillarisation
Physiological Factors — Strength	Muscle CSA (hypertrophy); Type II fibre proportion; neural recruitment; testosterone
Physiological Factors — Speed	Type II fibres; ATP-PCr system; neural velocity; stride length × stride frequency
Acute Effects — Muscular	↑Blood flow; ↑temperature; lactic acid accumulation; glycogen depletion; motor unit recruitment
Chronic Adaptations — Muscular	Hypertrophy; ↑mitochondria; ↑capillarisation; ↑glycogen storage; tendon strengthening
Muscle Fibre Types	Type I = slow/fatigue-resistant/aerobic (red); Type IIx = fast/fatigable/anaerobic (white); Type IIa = intermediate
Acute Effects — CV System	↑HR (to 200+ bpm); ↑Stroke Volume; ↑Cardiac Output (5→20-25 L/min); blood redistribution
Acute Effects — Respiratory	↑Breathing rate (12→60 breaths/min); ↑Tidal Volume; ↑Minute Ventilation; ↑O■ extraction
Chronic Adaptations — CV & Resp	Cardiac hypertrophy; athlete bradycardia; ↑blood volume; improved diffusion; raised anaerobic threshold
Newton's 1st Law	Law of Inertia — body stays at rest/motion unless net force acts. Sports: ball rolling, wrestling inertia
Newton's 2nd Law	F = ma — Force = Mass × Acceleration. Sports: sprinting, throwing, shot put
Newton's 3rd Law	Action-Reaction — every action has equal opposite reaction. Sports: swimming, sprinting blocks, rowing
1st Class Lever	Fulcrum in MIDDLE (like seesaw). Body: head nodding, triceps extension. MA can be <1 or >1
2nd Class Lever	Resistance in MIDDLE (like wheelbarrow). Body: calf raise (plantar flexion). MA ALWAYS >1 (force advantage)
3rd Class Lever	Effort in MIDDLE (like tweezers). Body: bicep curl, knee extension. MA ALWAYS <1. MOST COMMON in body (speed advantage)

SECTION I — TRICKY MCQs (Q.1–Q.10)

Both options may seem correct — choose the MOST scientifically accurate answer.

Q.1. [TRICKY] The bicep curl exercise in weightlifting is an example of which class of lever?

(a) First class — because the elbow joint is in the middle

(b) Third class — because the biceps muscle insertion (effort) is between the fulcrum (elbow joint) and the resistance (hand/weight)

(c) Second class — because the resistance is between the fulcrum and effort

(d) No lever principle applies since muscle pulls rather than pushes

Q.2. [TRICKY] A swimmer pushes water BACKWARD with their arms. According to Newton's Laws, what propels them FORWARD?

(a) Newton's 1st Law — swimmer's inertia carries them forward after the push

(b) Newton's 2nd Law — F = ma accelerates the swimmer's body mass

(c) Newton's 3rd Law — water pushes back on swimmer with EQUAL and OPPOSITE reaction force

(d) Newton's 2nd Law — the water decelerates (a is negative) which releases energy to swimmer

Q.3. [TRICKY] Plantar flexion (standing on tiptoe) is ALWAYS cited as a second class lever. Which feature PROVES it is 2nd class?

(a) The muscle effort comes from the Achilles tendon — which attaches above the ankle joint

(b) The body weight (Resistance at ankle) is BETWEEN the Fulcrum (ball of foot/toes) and Effort (calf muscles at heel)

(c) Both the effort and fulcrum are on the same side of the resistance

(d) The mechanical advantage is less than 1 in all second class levers

Q.4. [TRICKY] An athlete weighing 60 kg and another weighing 80 kg apply the same leg force (800 N) off starting blocks. According to Newton's 2nd Law, which athlete accelerates FASTER?

(a) The 80 kg athlete — more mass means more momentum

(b) The 60 kg athlete — less mass means greater acceleration for same force (a = F/m)

(c) Both accelerate equally — same force applied

(d) The heavier athlete because their inertia generates more force

Q.5. [TRICKY] Athlete's Heart (Cardiac Hypertrophy) from endurance training causes bradycardia. The CORRECT physiological reason is:

(a) The heart beats slower because it is damaged from overuse

(b) Because the enlarged ventricle pumps MORE blood per beat (higher stroke volume), the SAME cardiac output can be maintained at a LOWER heart rate

(c) The nervous system permanently reduces the heart rate set-point in all athletes

(d) Endurance training thickens the heart wall, reducing its elasticity and forcing a slower rhythm

Q.6. [TRICKY] The MOST common class of lever in the human body is Third Class. The PRIMARY reason the body evolved this design is:

(a) Third class levers provide the maximum force with minimum effort

(b) Third class levers provide SPEED and RANGE OF MOTION advantages at the expense of force — most human activities prioritise movement speed over force

(c) Third class levers are the safest for joints under high mechanical load

(d) Third class levers reduce the need for large muscle cross-sections

Q.7. [TRICKY] During maximal exercise, cardiac output can reach 40 L/min in elite athletes (vs ~25 L/min in untrained). The PRIMARY difference is due to:

(a) Elite athletes have a much higher maximum heart rate (240+ bpm)

(b) Elite athletes have significantly greater maximum STROKE VOLUME due to cardiac hypertrophy and greater blood volume

(c) Elite athletes have more red blood cells which pump blood harder

(d) Elite athletes have lower peripheral resistance which reduces the heart's workload

Q.8. [TRICKY] A cricket ball rolling on a field gradually slows down. This is best explained by:

(a) Newton's 1st Law — the ball is in motion and should stay in motion, but friction provides an external force that decelerates it

(b) Newton's 2nd Law alone — F = ma shows the ball is accelerating

(c) Newton's 3rd Law — the ground reacts against the ball's motion

(d) The ball has insufficient inertia to maintain motion

Q.9. [TRICKY] LACTIC ACID accumulation during intense exercise causes muscle fatigue. The MOST accurate modern explanation is:

(a) Lactic acid directly burns muscle fibres, causing the pain

(b) The dissociation of lactic acid produces HYDROGEN IONS (H■) which lower intracellular pH, impairing enzyme function and calcium sensitivity of contractile proteins

(c) Lactic acid removes calcium from muscle cells, preventing contraction

(d) Lactic acid is toxic and immediately destroys the muscle's ATP supply

Q.10. [TRICKY] The HEAD NODDING movement (saying 'yes') is a first class lever. Identify the correct arrangement:

(a) Atlanto-occipital joint (F) in the middle; neck extensor muscles (E) at the back; skull weight (R) at the front

(b) Skull weight (F); neck muscles (E); atlantooccipital joint (R)

(c) Neck extensors (F); skull (E); atlantooccipital (R)

(d) Skull (R) at front; atlantooccipital joint (F) at middle; neck flexors (E) at back

SECTION II — STANDARD MCQs (Q.11–Q.40)

Q.11. VO■ max is measured in units of:

(a) Litres per hour (L/hr)
(b) mL/kg/min (millilitres per kilogram per minute)
(c) Beats per minute (bpm)
(d) mmHg (millimetres of mercury)

Q.12. Which type of muscle fibre is described as 'red' due to high myoglobin content?

(a) Type IIx (fast glycolytic)
(b) Type IIa (fast oxidative)
(c) Type I (slow oxidative)
(d) Type III (transitional)

Q.13. Newton's Formula F = m × a represents his:

(a) First Law of Motion
(b) Second Law of Motion
(c) Third Law of Motion
(d) Law of Gravitation

Q.14. In which class of lever is the RESISTANCE always positioned between the Fulcrum and Effort?

(a) First class lever
(b) Second class lever
(c) Third class lever
(d) All classes equally

Q.15. Cardiac Output is calculated as:

(a) Systolic BP – Diastolic BP
(b) Heart Rate × Stroke Volume
(c) VO■ max × Haemoglobin
(d) Tidal Volume × Breathing Rate

Q.16. A gymnast holding a static balance position on a beam demonstrates which Newton's Law?

(a) Newton's 1st Law — the gymnast is at rest (equilibrium) because net force = zero
(b) Newton's 2nd Law — F = ma shows maximum acceleration
(c) Newton's 3rd Law — action-reaction between feet and beam
(d) Both 1st and 3rd Laws simultaneously

Q.17. Hypertrophy as a long-term muscular adaptation means:

(a) Increase in the NUMBER of muscle fibres (hyperplasia)
(b) Increase in the SIZE of individual muscle fibres due to increased protein content
(c) Decrease in muscle mass due to exercise stress
(d) The splitting of Type II fibres into multiple smaller fibres

Q.18. The Ventilatory Threshold during incremental exercise corresponds to:

(a) The point of maximum heart rate
(b) The point where ventilation increases disproportionately, corresponding to the anaerobic threshold
(c) The moment when breathing rate equals heart rate
(d) The point of exhaustion and total VO■ max

Q.19. Which class of lever provides a FORCE ADVANTAGE (Mechanical Advantage > 1)?

(a) First class only
(b) Second class only

(c) Third class only

(d) Both first and second class

Q.20. The 'Athlete's Heart' refers to which physiological adaptation?

(a) A disease causing enlarged heart from overtraining

(b) Physiological cardiac hypertrophy — enlarged left ventricle with increased stroke volume — from chronic endurance training

(c) Increased resting heart rate from aerobic training

(d) Thickening of coronary arteries from high intensity training

Q.21. Blood redistribution during exercise involves:

(a) Equal blood flow to all organs

(b) Vasoconstriction in muscles and vasodilation in digestive organs

(c) Vasoconstriction in digestive organs/kidneys; vasodilation in working muscles

(d) All blood directed to the heart and lungs only

SECTION II — STANDARD MCQs (Continued)

Q.22. A rowing stroke involves the oar pushing water backward. This is an application of Newton's:

(a) 1st Law
(b) 2nd Law
(c) 3rd Law
(d) Law of Gravitation

Q.23. Myoglobin in muscle fibres serves which primary function?

(a) Producing lactic acid during anaerobic exercise
(b) Storing and transporting O■ within muscle cells
(c) Providing structural support to muscle fibres
(d) Transmitting nerve impulses to the muscle

Q.24. Which of the following is an example of Newton's 1st Law (Inertia) in sport?

(a) A sprinter accelerates faster with lighter running shoes (F = ma)
(b) A swimmer propels forward by pushing water backward
(c) A golf ball continues to travel after being struck until slowed by air resistance and gravity
(d) A gymnast uses the trampoline's bounce to gain height

Q.25. During exercise, the primary stimulus for increased VENTILATION (breathing) during MODERATE intensity is:

(a) Decreased oxygen levels in blood (hypoxia)
(b) Increased CO■ levels (hypercapnia) detected by chemoreceptors
(c) Increased body temperature only
(d) Lactic acid burning the airways

Q.26. The Frank-Starling Law of the Heart explains that:

(a) Heart rate increases proportionally with exercise intensity
(b) The heart contracts MORE FORCEFULLY when filled with MORE BLOOD (greater ventricular stretch = greater contraction force)
(c) Maximum cardiac output is limited by lung capacity
(d) The heart adapts to altitude by producing more haemoglobin

Q.27. In shot put, a heavier shot (7.26 kg for men vs 4 kg for women/junior) requires:

(a) Less force to throw the same distance (Newton's 1st Law)
(b) MORE force to achieve the same acceleration/distance — Newton's 2nd Law (F = ma; same a, more m = more F needed)
(c) No different force — weight doesn't affect throw distance
(d) Less acceleration — Newton's 3rd Law applies differently to heavier objects

Q.28. Which adaptation explains why trained athletes have a LOWER RESTING HEART RATE than untrained individuals?

(a) Athletes have fewer sinoatrial node cells, reducing electrical signals
(b) Increased stroke volume from cardiac hypertrophy allows the same cardiac output at lower HR
(c) Athletes' blood is thicker, requiring fewer beats to circulate it
(d) Athletic training permanently damages the heart rhythm

Q.29. The Respiratory Exchange Ratio (RER) of 0.7 indicates the body is primarily using:

(a) Carbohydrates (glucose) as the primary fuel
(b) Proteins as the primary fuel
(c) Fats (free fatty acids) as the primary fuel

(d) Mixed fuel with equal carb and fat

Q.30. Which of the following BEST describes the role of the ATP-PCr system in sport?

(a) Provides sustained energy for marathon running

(b) Provides rapid, powerful energy for 0–10 seconds of maximal effort — sprinting, jumping, throwing

(c) Converts fat to ATP for long-duration activities

(d) Produces ATP using oxygen from haemoglobin

Q.31. Capillarisation as a long-term adaptation to endurance training means:

(a) The heart develops more capillaries around the sinoatrial node

(b) Increased density of capillaries around skeletal muscle fibres — improving O■ delivery and CO■ removal

(c) Capillaries in the lungs become thicker, speeding up gas exchange

(d) New arteries form in the body to bypass existing vessels

SECTION II — STANDARD MCQs (Continued)

Q.32. A sprinter pushes BACKWARD and DOWNWARD against the starting blocks. The reaction force from the blocks propels them FORWARD. This application of Newton's 3rd Law also involves 2nd Law because:

(a) The 3rd Law force creates acceleration ($a = F/m$) of the sprinter's body mass
(b) The blocks provide an equal force and the sprinter's inertia stays constant
(c) Only the 3rd Law is relevant — the 2nd Law never applies to starting blocks
(d) The 2nd Law explains why the sprinter's legs don't break under the reaction force

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Q.33. Minute Ventilation (VE) is calculated as:

(a) Heart Rate × Stroke Volume
(b) Tidal Volume × Breathing Rate
(c) VO■ max × Exercise Intensity
(d) Systolic BP – Diastolic BP

Q.34. The 'Size Principle' of motor unit recruitment states that:

(a) Larger muscles are always recruited before smaller ones
(b) Motor units are recruited in ORDER OF SIZE — smallest (Type I) first, then Type IIa, then Type IIx as force demand increases
(c) All motor units fire simultaneously regardless of exercise intensity
(d) Fast-twitch fibres are always recruited first because they produce more power

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Q.35. Which lever system is analogous to a WHEELBARROW?

(a) First class lever
(b) Second class lever
(c) Third class lever
(d) Fourth class lever

Q.36. Tidal Volume during maximum exercise increases to approximately:

(a) 500–600 ml
(b) 1,000–1,500 ml
(c) 2,000–3,000 ml
(d) 5,000–6,000 ml

Q.37. Which of the following movements uses a FIRST CLASS LEVER in the body?

(a) Bicep curl
(b) Standing on tiptoe (plantar flexion)
(c) Nodding the head 'YES' — atlanto-occipital joint
(d) Kicking a football

Q.38. Lactate Threshold (anaerobic threshold) in trained athletes occurs at a HIGHER percentage of VO■ max than untrained. This means:

(a) Trained athletes fatigue faster at high intensities
(b) Trained athletes can maintain HIGHER exercise intensities before lactate accumulates — working harder aerobically before needing anaerobic glycolysis
(c) Untrained athletes produce less lactic acid than trained athletes
(d) Training eliminates lactic acid production entirely

Q.39. The formula F■ × d■ = F■ × d■ represents the principle of levers where d■ and d■ are:

(a) Muscle length and tendon length
(b) Effort Arm length and Resistance Arm length
(c) Velocity of effort and velocity of resistance

(d) Distance jumped and force applied

Q.40. Exercise increases bone density as a long-term adaptation. This is primarily due to:

(a) Increased calcium intake from sports nutrition programmes

(b) Mechanical loading (stress on bones from exercise) stimulates OSTEOBLASTS (bone-forming cells) to deposit more bone mineral

(c) Hormones from muscles (myokines) that permanently alter calcium absorption

(d) Bones simply grow larger from increased blood flow during exercise

SECTION III — MATCH THE FOLLOWING (Q.41–Q.43)

Match Column A with Column B.

Q.41. MATCH THE FOLLOWING — Newton's Laws and Sports Applications: Column A: 1. Newton's 1st Law 2. Newton's 2nd Law 3. Newton's 3rd Law 4. Newton's 2nd Law (impulse) Column B: P. F = m × a; shot putter's heavier implement needs more force Q. Swimmer pushes water backward — water pushes swimmer forward R. Rolling ball continues until friction acts S. Extending follow-through time in cricket batting increases ball momentum (F × t = m × ∆v)

(a) 1-Q, 2-R, 3-P, 4-S

(b) 1-R, 2-P, 3-Q, 4-S

(c) 1-P, 2-S, 3-R, 4-Q

(d) 1-S, 2-Q, 3-P, 4-R

Q.42. MATCH THE FOLLOWING — Lever Classes and Body Examples: Column A: 1. First Class Lever 2. Second Class Lever 3. Third Class Lever 4. Second Class Lever Column B: P. Bicep curl — elbow joint (F); biceps insertion (E); hand/weight (R) Q. Calf raise — ball of foot (F); body weight at ankle (R); Achilles tendon (E) R. Head nodding — atlanto-occipital joint (F) in middle S. Jaw closing — jaw joint (F); food (R); masseter muscle (E)

(a) 1-P, 2-Q, 3-R, 4-S

(b) 1-Q, 2-R, 3-S, 4-P

(c) 1-R, 2-Q, 3-P, 4-S

(d) 1-S, 2-P, 3-R, 4-Q

Q.43. MATCH THE FOLLOWING — Acute Effects of Exercise: Column A: 1. Heart Rate during max exercise 2. Stroke Volume during exercise 3. Breathing Rate during max exercise 4. Cardiac Output at rest Column B: P. 5 litres per minute Q. 190–220 beats per minute R. 40–60 breaths per minute S. 100–130 ml per beat

(a) 1-S, 2-R, 3-Q, 4-P

(b) 1-P, 2-S, 3-R, 4-Q

(c) 1-Q, 2-P, 3-S, 4-R

(d) 1-Q, 2-S, 3-R, 4-P

SECTION IV — ADDITIONAL MCQs (Q.44–Q.50)

Q.44. Biomechanics is defined as:

(a) The study of biological chemicals in sports performance

(b) The application of mechanical principles to the study of biological/human movement in sport

(c) The psychology of athletic movement patterns

(d) The measurement of body composition in athletes

Q.45. Haemoglobin concentration in blood is important for athletic performance because:

(a) Haemoglobin provides structural support to red blood cells

(b) Haemoglobin CARRIES OXYGEN in red blood cells — higher Hb = greater O■-carrying capacity of blood

(c) Haemoglobin regulates blood pressure by constricting arteries

(d) Haemoglobin is the primary source of energy during endurance exercise

Q.46. The 'Muscle Pump' mechanism during exercise refers to:

(a) The heart pumping blood faster to muscles

(b) Skeletal muscle contractions SQUEEZING VEINS and propelling venous blood back toward the heart — increasing venous return

(c) The pumping of glycogen from liver to muscles during exercise

(d) The mechanism by which muscles store energy for the next contraction

Q.47. A javelin throw involves the athlete's arm applying force. Which Newton's Law directly explains the javelin's flight path after release?

(a) Only Newton's 3rd Law — the arm and javelin react against each other

(b) Newton's 1st Law — the javelin continues in its trajectory until gravity and air resistance act on it; Newton's 2nd Law — gravity and drag provide forces causing acceleration (deceleration and downward arc)

(c) Newton's 2nd Law alone fully explains the flight path

(d) None of Newton's Laws apply to projectile motion

Q.48. An oar in rowing acts as which class of lever?

(a) First class — the water acts as the fulcrum

(b) Second class — the force of water (resistance) is in the middle

(c) Third class — the effort (rower's hands) is in the middle

(d) It does not function as a lever

Q.49. Which physiological adaptation explains improved performance after 4–6 weeks of resistance training even BEFORE significant hypertrophy occurs?

(a) Rapid increase in testosterone levels from the first training session

(b) NEURAL ADAPTATIONS — improved motor unit recruitment, better inter-muscular coordination, and rate coding

(c) Immediate muscle fibre type conversion from Type I to Type IIx

(d) Significant tendon shortening that increases mechanical advantage

Q.50. Which statement BEST summarises the contribution of Newton's Laws to sports biomechanics?

(a) Newton's Laws only apply to projectile sports like javelin and shot put

(b) Newton's Laws collectively explain ALL aspects of force, motion, acceleration, and propulsion in sport — from starting blocks to ball trajectory to lever actions in the body

(c) Newton's Laws are theoretical and have limited practical application in sports coaching

(d) Only Newton's 3rd Law applies to sports — the other two are purely academic

ANSWER KEY — Quick Reference

Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans	Q.	Ans
Q.1	(B)	Q.2	(C)	Q.3	(B)	Q.4	(B)	Q.5	(B)
Q.6	(B)	Q.7	(B)	Q.8	(A)	Q.9	(B)	Q.10	(A)
Q.11	(B)	Q.12	(C)	Q.13	(B)	Q.14	(B)	Q.15	(B)
Q.16	(D)	Q.17	(B)	Q.18	(B)	Q.19	(B)	Q.20	(B)
Q.21	(C)	Q.22	(C)	Q.23	(B)	Q.24	(C)	Q.25	(B)
Q.26	(B)	Q.27	(B)	Q.28	(B)	Q.29	(C)	Q.30	(B)
Q.31	(B)	Q.32	(A)	Q.33	(B)	Q.34	(B)	Q.35	(B)
Q.36	(C)	Q.37	(C)	Q.38	(B)	Q.39	(B)	Q.40	(B)
Q.41	(B)	Q.42	(C)	Q.43	(D)	Q.44	(B)	Q.45	(B)
Q.46	(B)	Q.47	(B)	Q.48	(A)	Q.49	(B)	Q.50	(B)

DETAILED ANSWER EXPLANATIONS

WHY the correct answer is right AND why each wrong option is incorrect.

— TRICKY MCQs —

Q.1 — Correct: (B)

Wrong: (a) First class — because the elbow joint is in the middle

CORRECT: (b) Third class — because the biceps muscle insertion (effort) is between the fulcrum (elbow joint) and the resistance (hand/weight)

Wrong: (c) Second class — because the resistance is between the fulcrum and effort

Wrong: (d) No lever principle applies since muscle pulls rather than pushes

Explanation: BICEP CURL = THIRD CLASS LEVER. Arrangement: Elbow joint (Fulcrum) → Biceps insertion on radial tuberosity (Effort, about 5 cm from elbow) → Hand/dumbbell (Resistance, about 35 cm from elbow). Since EFFORT is between Fulcrum and Resistance → 3rd class. MA = EA/RA = 5/35 = 0.14 (less than 1). The body needs much MORE muscle force than the weight being lifted, BUT achieves great SPEED and ROM at the hand. Option (a) incorrectly identifies it as 1st class. Option (c) is wrong — resistance is NOT between fulcrum and effort here.

Q.2 — Correct: (C)

Wrong: (a) Newton's 1st Law — swimmer's inertia carries them forward after the push

Wrong: (b) Newton's 2nd Law — F = ma accelerates the swimmer's body mass

CORRECT: (c) Newton's 3rd Law — water pushes back on swimmer with EQUAL and OPPOSITE reaction force

Wrong: (d) Newton's 2nd Law — the water decelerates (a is negative) which releases energy to swimmer

Explanation: NEWTON'S 3RD LAW governs swimming propulsion. The swimmer's hand/arm exerts a force on water BACKWARD (action force). By Newton's 3rd Law, water exerts an EQUAL and OPPOSITE force on the swimmer's hand → pushing swimmer FORWARD (reaction force). 2nd Law (F=ma) describes HOW FAST the swimmer accelerates based on this reaction force and their mass, but the CAUSE of forward propulsion is 3rd Law. Option (a) is 1st Law — relevant to maintaining momentum but NOT the propulsion cause.

Q.3 — Correct: (B)

Wrong: (a) The muscle effort comes from the Achilles tendon — which attaches above the ankle joint

CORRECT: (b) The body weight (Resistance at ankle) is BETWEEN the Fulcrum (ball of foot/toes) and Effort (calf muscles at heel)

Wrong: (c) Both the effort and fulcrum are on the same side of the resistance

Wrong: (d) The mechanical advantage is less than 1 in all second class levers

Explanation: PLANTAR FLEXION ARRANGEMENT: Fulcrum = ball of foot/toes (on the ground). Resistance = body weight acts at the ankle. Effort = calf muscles (gastrocnemius/soleus) via Achilles tendon at the heel. Since RESISTANCE (ankle/body weight) is BETWEEN Fulcrum (toes) and Effort (heel) → 2nd class lever. Option (a) is partially true but doesn't prove class. Option (c) is not the defining rule. Option (d) is WRONG — 2nd class levers ALWAYS have MA > 1 (force advantage, not speed advantage).

Q.4 — Correct: (B)

Wrong: (a) The 80 kg athlete — more mass means more momentum

CORRECT: (b) The 60 kg athlete — less mass means greater acceleration for same force (a = F/m)

Wrong: (c) Both accelerate equally — same force applied

Wrong: (d) The heavier athlete because their inertia generates more force

Explanation: Newton's 2nd Law: a = F/m. 60 kg athlete: a = 800/60 = 13.3 m/s^2. 80 kg athlete: a = 800/80 = 10.0 m/s^2. LIGHTER athlete (60 kg) achieves GREATER ACCELERATION with the same force. This is why sprinters tend to have high power-to-weight ratios — not just maximum strength but relative strength matters. Option (a) — momentum (m×v) will eventually differ but initial acceleration favours lighter athlete. Option (c) ignores the mass variable. Option (d) reverses the relationship.

Q.5 — Correct: (B)

Wrong: (a) The heart beats slower because it is damaged from overuse

CORRECT: (b) Because the enlarged ventricle pumps MORE blood per beat (higher stroke volume), the SAME cardiac output can be maintained at a LOWER heart rate

Wrong: (c) The nervous system permanently reduces the heart rate set-point in all athletes

Wrong: (d) Endurance training thickens the heart wall, reducing its elasticity and forcing a slower rhythm

Explanation: ATHLETE'S BRADYCARDIA mechanism: Cardiac output (Q) = HR × Stroke Volume (SV). Endurance training causes CARDIAC HYPERTROPHY — the left ventricle enlarges (eccentric hypertrophy — larger cavity + slightly thicker walls). This allows MORE blood to fill per beat (Frank-Starling law) and MORE blood to be ejected per beat (higher SV). Since Q = HR × SV, if SV increases, HR can DECREASE while maintaining the same resting Q. Option (a) — NOT damage. Option (c) — partially correct (ANS adaptation) but not the primary mechanism. Option (d) — the wall adaptation is beneficial, not stiffening.

Q.6 — Correct: (B)

Wrong: (a) Third class levers provide the maximum force with minimum effort

CORRECT: (b) Third class levers provide SPEED and RANGE OF MOTION advantages at the expense of force — most human activities prioritise movement speed over force

Wrong: (c) Third class levers are the safest for joints under high mechanical load

Wrong: (d) Third class levers reduce the need for large muscle cross-sections

Explanation: Third class levers have MA < 1 — requires MORE muscle force than the load, BUT achieves greater VELOCITY and RANGE OF MOTION at the distal end (hand, foot). The human body evolved to PRIORITISE SPEED and RANGE over pure force because most daily activities and sports require fast, wide-arc movements rather than slow heavy lifts. This is why throwing, kicking, punching — all high-speed sport actions — are third class. Option (a) REVERSES the characteristic — 2nd class provides force advantage. Option (c) — 3rd class actually puts MORE relative stress on muscles. Option (d) is incorrect — more muscle needed, not less.

Q.7 — Correct: (B)

Wrong: (a) Elite athletes have a much higher maximum heart rate (240+ bpm)

CORRECT: (b) Elite athletes have significantly greater maximum STROKE VOLUME due to cardiac hypertrophy and greater blood volume

Wrong: (c) Elite athletes have more red blood cells which pump blood harder

Wrong: (d) Elite athletes have lower peripheral resistance which reduces the heart's workload

Explanation: Elite vs untrained cardiac output difference: Both groups have similar MAXIMUM HEART RATES (210–220 bpm — genetically determined by 220-age formula). The DIFFERENCE lies in STROKE VOLUME. Elite endurance athletes develop cardiac hypertrophy (larger left ventricle) + greater total blood volume → SV of 150–200 ml/beat (vs 100–130 ml in untrained). Q = HR × SV: 210 × 190 = ~40 L/min (elite) vs 210 × 120 = 25 L/min (untrained). Option (a) is incorrect — max HR is similar. Options (c) and (d) are contributing factors but not the PRIMARY reason.

Q.8 — Correct: (A)

CORRECT: (a) Newton's 1st Law — the ball is in motion and should stay in motion, but friction provides an external force that decelerates it

Wrong: (b) Newton's 2nd Law alone — F = ma shows the ball is accelerating

Wrong: (c) Newton's 3rd Law — the ground reacts against the ball's motion

Wrong: (d) The ball has insufficient inertia to maintain motion

Explanation: NEWTON'S 1ST LAW explains this perfectly. The rolling ball tends to stay in motion (inertia). However, FRICTION from the grass surface provides an EXTERNAL UNBALANCED FORCE (decelerative) that violates the constant velocity condition — slowing the ball down. Newton's 2nd Law (F=ma) can QUANTIFY the deceleration (a = Friction force / mass), but the EXPLANATION of why the ball slows is 1st Law (an external force — friction — acts to change the state of motion). Option (d) is wrong — mass determines inertia; it doesn't 'run out' of inertia.

Q.9 — Correct: (B)

Wrong: (a) Lactic acid directly burns muscle fibres, causing the pain

CORRECT: (b) The dissociation of lactic acid produces HYDROGEN IONS (H■) which lower intracellular pH, impairing enzyme function and calcium sensitivity of contractile proteins

Wrong: (c) Lactic acid removes calcium from muscle cells, preventing contraction

Wrong: (d) Lactic acid is toxic and immediately destroys the muscle's ATP supply

Explanation: Modern sports physiology understanding: LACTATE itself is not the fatigue-causing molecule. When pyruvate is converted to lactate, it accepts a H■ in the process. The HYDROGEN IONS (from ATP hydrolysis: ATP → ADP + Pi + H■) lower intracellular pH (acidosis). Acidosis: (1) Inhibits phosphofructokinase (PFK) — rate-limiting glycolytic enzyme. (2) Reduces calcium sensitivity of troponin → weaker cross-bridge formation. (3) Inhibits SR calcium release. Lactate is actually EXPORTED as fuel to other muscles/heart (Cori cycle). Option (a) — lactic acid doesn't 'burn' fibres. Options (c) and (d) are incorrect.

Q.10 — Correct: (A)

CORRECT: (a) Atlanto-occipital joint (F) in the middle; neck extensor muscles (E) at the back; skull weight (R) at the front

Wrong: (b) Skull weight (F); neck muscles (E); atlantooccipital joint (R)

Wrong: (c) Neck extensors (F); skull (E); atlantooccipital (R)

Wrong: (d) Skull (R) at front; atlantooccipital joint (F) at middle; neck flexors (E) at back

Explanation: HEAD NODDING — 1st Class Lever. Fulcrum = ATLANTO-OCCIPITAL JOINT (where skull meets C1 vertebra) — in the MIDDLE. Effort = NECK EXTENSOR MUSCLES (at the BACK of neck — e.g., splenius capitis, semispinalis) pull the skull BACKWARD. Resistance = SKULL WEIGHT + FACE (acts in FRONT of the fulcrum, pulling head FORWARD via gravity). Since FULCRUM IS IN THE MIDDLE → 1st class lever. Option (d) describes the same arrangement with different labels but is presented ambiguously. Option (a) is the clearest and most standard textbook description.

— STANDARD MCQs —

Q.11 — Correct: (B)

Wrong: (a) Litres per hour (L/hr)

CORRECT: (b) mL/kg/min (millilitres per kilogram per minute)

Wrong: (c) Beats per minute (bpm)

Wrong: (d) mmHg (millimetres of mercury)

Explanation: VO■ max = maximum oxygen uptake = measured in mL/kg/min (millilitres of O■ per kilogram of body weight per minute). This relative measure allows comparison across athletes of different sizes. Elite male endurance athletes: 70–85 mL/kg/min. Elite female: 60–75 mL/kg/min. Sedentary adults: 30–45 mL/kg/min.

Q.12 — Correct: (C)

Wrong: (a) Type IIx (fast glycolytic)

Wrong: (b) Type IIa (fast oxidative)

CORRECT: (c) Type I (slow oxidative)

Wrong: (d) Type III (transitional)

Explanation: TYPE I (SLOW-TWITCH) fibres are RED because they contain large amounts of MYOGLOBIN (O■-storing protein) and mitochondria. High myoglobin gives the characteristic red colour. Type I fibres are highly fatigue-resistant and aerobic. Type IIx are WHITE (low myoglobin). Type IIa are PINK (intermediate). There is no Type III — it's a common distractor.

Q.13 — Correct: (B)

Wrong: (a) First Law of Motion

CORRECT: (b) Second Law of Motion

Wrong: (c) Third Law of Motion

Wrong: (d) Law of Gravitation

Explanation: $F = m \times a$ is Newton's SECOND LAW of Motion. It states that force equals mass times acceleration — greater force produces greater acceleration, and greater mass requires greater force for the same acceleration. 1st Law describes inertia (no equation but $\Sigma F=0 \rightarrow a=0$). 3rd Law describes action-reaction pairs.

Q.14 — Correct: (B)

Wrong: (a) First class lever

CORRECT: (b) Second class lever

Wrong: (c) Third class lever

Wrong: (d) All classes equally

Explanation: SECOND CLASS LEVER: Fulcrum → Resistance → Effort (F-R-E). Resistance is ALWAYS in the middle. This arrangement means the effort arm is ALWAYS longer than the resistance arm → Mechanical Advantage is ALWAYS greater than 1 → force advantage. Classic example: wheelbarrow (wheel=F, load=R, handles=E).

Q.15 — Correct: (B)

Wrong: (a) Systolic BP – Diastolic BP
CORRECT: (b) Heart Rate × Stroke Volume
Wrong: (c) VO■ max × Haemoglobin
Wrong: (d) Tidal Volume × Breathing Rate

Explanation: CARDIAC OUTPUT (Q) = HEART RATE (HR, beats/min) × STROKE VOLUME (SV, ml/beat). Resting: Q = 70 × 70 = 4,900 ml/min ≈ 5 L/min. Maximal exercise (untrained): Q = 200 × 120 = 24,000 ml = 24 L/min. Tidal Volume × Breathing Rate = Minute Ventilation (VE) — a respiratory measure, not cardiac.

Q.16 — Correct: (D)

Wrong: (a) Newton's 1st Law — the gymnast is at rest (equilibrium) because net force = zero
Wrong: (b) Newton's 2nd Law — F = ma shows maximum acceleration
Wrong: (c) Newton's 3rd Law — action-reaction between feet and beam
CORRECT: (d) Both 1st and 3rd Laws simultaneously

Explanation: A static balance position involves BOTH: 1st Law — the gymnast is at rest because all forces balance (net force = 0 → zero acceleration). 3rd Law — gymnast pushes DOWN on beam (action) → beam pushes gymnast UP (reaction force = normal force), balancing gravity. Both laws are simultaneously applicable and relevant. However, for EXAM purposes — if forced to choose one: 1st Law best explains the equilibrium state.

Q.17 — Correct: (B)

Wrong: (a) Increase in the NUMBER of muscle fibres (hyperplasia)
CORRECT: (b) Increase in the SIZE of individual muscle fibres due to increased protein content
Wrong: (c) Decrease in muscle mass due to exercise stress
Wrong: (d) The splitting of Type II fibres into multiple smaller fibres

Explanation: HYPERTROPHY = increase in MUSCLE FIBRE SIZE (cross-sectional area) due to increased myofibrillar protein content (actin + myosin). NOT increase in number of fibres (that is HYPERPLASIA — debated in humans). Myofibrillar hypertrophy = more contractile proteins (strength/power training). Sarcoplasmic hypertrophy = more fluid/glycogen within fibre (bodybuilding training).

Q.18 — Correct: (B)

Wrong: (a) The point of maximum heart rate
CORRECT: (b) The point where ventilation increases disproportionately, corresponding to the anaerobic threshold
Wrong: (c) The moment when breathing rate equals heart rate
Wrong: (d) The point of exhaustion and total VO■ max

Explanation: VENTILATORY THRESHOLD (VT) = point during increasing exercise intensity where VENTILATION increases disproportionately (non-linear increase). Corresponds to the ANAEROBIC THRESHOLD where lactate accumulates faster than it can be cleared — excess CO■ from bicarbonate buffering of lactic acid stimulates the ventilatory control centres. Trained athletes have a HIGHER VT — can exercise more intensely before this threshold.

Q.19 — Correct: (B)

Wrong: (a) First class only
CORRECT: (b) Second class only
Wrong: (c) Third class only
Wrong: (d) Both first and second class

Explanation: SECOND CLASS LEVER ALWAYS has MA > 1 (force advantage) because the effort arm is ALWAYS longer than the resistance arm. FIRST CLASS can have MA > or < 1 depending on fulcrum position relative to effort and resistance. THIRD CLASS ALWAYS has MA < 1 (speed advantage). So ONLY second class ALWAYS provides force advantage.

Q.20 — Correct: (B)

Wrong: (a) A disease causing enlarged heart from overtraining

CORRECT: (b) Physiological cardiac hypertrophy — enlarged left ventricle with increased stroke volume — from chronic endurance training

Wrong: (c) Increased resting heart rate from aerobic training

Wrong: (d) Thickening of coronary arteries from high intensity training

Explanation: ATHLETE'S HEART = physiological, BENIGN (non-pathological) cardiac adaptation to chronic endurance training: enlarged left ventricle cavity (eccentric hypertrophy) → greater stroke volume → bradycardia (lower resting HR). This is a normal, healthy adaptation — not a disease. Pathological hypertrophy (from disease) has thickened walls but SMALLER cavity. Option (c) reverses the adaptation — endurance training DECREASES resting HR.

Q.21 — Correct: (C)

Wrong: (a) Equal blood flow to all organs

Wrong: (b) Vasoconstriction in muscles and vasodilation in digestive organs

CORRECT: (c) Vasoconstriction in digestive organs/kidneys; vasodilation in working muscles

Wrong: (d) All blood directed to the heart and lungs only

Explanation: BLOOD REDISTRIBUTION during exercise: VASOCONSTRICTION in non-essential organs (digestive system, kidneys, skin) → reduces blood flow there. VASODILATION in WORKING MUSCLES → increases O■ delivery. This is achieved by sympathetic nervous system control and local vasodilators (CO■, H■, lactate, nitric oxide). At maximum exercise: 80–85% of cardiac output directed to muscles (vs 15–20% at rest).

Q.22 — Correct: (C)

Wrong: (a) 1st Law

Wrong: (b) 2nd Law

CORRECT: (c) 3rd Law

Wrong: (d) Law of Gravitation

Explanation: ROWING = NEWTON'S 3RD LAW. Oar/blade pushes water BACKWARD (action force on water) → water pushes oar/blade FORWARD with equal and opposite force (reaction force) → boat propelled forward. Same principle as swimming, sprinting from blocks, and jet propulsion. The 3rd Law governs all propulsion mechanisms in sport.

Q.23 — Correct: (B)

Wrong: (a) Producing lactic acid during anaerobic exercise

CORRECT: (b) Storing and transporting O■ within muscle cells

Wrong: (c) Providing structural support to muscle fibres

Wrong: (d) Transmitting nerve impulses to the muscle

Explanation: MYOGLOBIN = oxygen-storing protein within muscle cells (similar to haemoglobin in blood). It: (1) Stores O■ within the muscle. (2) Facilitates O■ diffusion from capillaries to mitochondria. (3) Provides an O■ buffer — releases O■ when blood O■ delivery temporarily falls. High myoglobin = red muscle fibres (Type I). Low myoglobin = white fibres (Type IIx).

Q.24 — Correct: (C)

Wrong: (a) A sprinter accelerates faster with lighter running shoes (F = ma)

Wrong: (b) A swimmer propels forward by pushing water backward

CORRECT: (c) A golf ball continues to travel after being struck until slowed by air resistance and gravity

Wrong: (d) A gymnast uses the trampoline's bounce to gain height

Explanation: NEWTON'S 1ST LAW (INERTIA): The golf ball is in motion after being struck. It tends to remain in motion (inertia). Only EXTERNAL FORCES — gravity (pulling down) and air resistance (decelerating it) — change its path and speed. Option (a) = 2nd Law (F=ma with changed mass). Option (b) = 3rd Law (action-reaction). Option (d) = 3rd Law (trampoline reaction) and 2nd Law (acceleration).

Q.25 — Correct: (B)

Wrong: (a) Decreased oxygen levels in blood (hypoxia)

CORRECT: (b) Increased CO■ levels (hypercapnia) detected by chemoreceptors

Wrong: (c) Increased body temperature only

Wrong: (d) Lactic acid burning the airways

Explanation: During MODERATE exercise, the primary ventilation stimulus is INCREASED CO■ from aerobic metabolism. Central chemoreceptors (medullary) detect rise in CO■/H■ → increase respiratory rate and depth. During INTENSE exercise, additional stimuli include: low pH (lactic acid), K■, neural signals from muscle proprioceptors. O■ levels rarely drop significantly during exercise — CO■ rise is the dominant ventilatory driver at moderate intensity.

Q.26 — Correct: (B)

Wrong: (a) Heart rate increases proportionally with exercise intensity

CORRECT: (b) The heart contracts MORE FORCEFULLY when filled with MORE BLOOD (greater ventricular stretch = greater contraction force)

Wrong: (c) Maximum cardiac output is limited by lung capacity

Wrong: (d) The heart adapts to altitude by producing more haemoglobin

Explanation: FRANK-STARLING LAW: The strength of the heart's contraction (and therefore stroke volume) is directly proportional to the END-DIASTOLIC VOLUME — the amount of blood filling the ventricle before contraction. More blood in → muscle fibres more stretched → stronger contraction → more blood ejected per beat. This is one mechanism by which stroke volume increases during exercise (increased venous return). Exercise → more venous return → greater ventricular filling → Frank-Starling → larger stroke volume.

Q.27 — Correct: (B)

Wrong: (a) Less force to throw the same distance (Newton's 1st Law)

CORRECT: (b) MORE force to achieve the same acceleration/distance — Newton's 2nd Law (F = ma; same a, more m = more F needed)

Wrong: (c) No different force — weight doesn't affect throw distance

Wrong: (d) Less acceleration — Newton's 3rd Law applies differently to heavier objects

Explanation: NEWTON'S 2ND LAW directly explains this. $F = m \times a$. If the shot has GREATER MASS (7.26 kg vs 4 kg) and the athlete wants to achieve the same acceleration (and therefore same release velocity and distance), MORE FORCE must be applied. This is why men's shot put records are shorter than if men threw the women's lighter shot — the heavier implement requires more force to accelerate to any given velocity.

Q.28 — Correct: (B)

Wrong: (a) Athletes have fewer sinoatrial node cells, reducing electrical signals

CORRECT: (b) Increased stroke volume from cardiac hypertrophy allows the same cardiac output at lower HR

Wrong: (c) Athletes' blood is thicker, requiring fewer beats to circulate it

Wrong: (d) Athletic training permanently damages the heart rhythm

Explanation: Trained athletes have CARDIAC HYPERTROPHY → increased STROKE VOLUME (more blood per beat). Since $Q = HR \times SV$, the same resting cardiac output (5 L/min) can be achieved at a LOWER HR when SV is higher. E.g., Trained: 50 bpm × 100 ml = 5,000 ml/min. Untrained: 72 bpm × 70 ml = 5,040 ml/min. This is healthy bradycardia — not a defect or damage (option d). Option (a) is incorrect physiology.

Q.29 — Correct: (C)

Wrong: (a) Carbohydrates (glucose) as the primary fuel

Wrong: (b) Proteins as the primary fuel

CORRECT: (c) Fats (free fatty acids) as the primary fuel

Wrong: (d) Mixed fuel with equal carb and fat

Explanation: RER = VCO■ / VO■ (ratio of CO■ produced to O■ consumed). FAT oxidation: C■■H■■■O■ + 80O■ → 57CO■ + 55H■O → RER = 57/80 = 0.7. CARBOHYDRATE oxidation: C■H■■O■ + 6O■ → 6CO■ + 6H■O → RER = 6/6 = 1.0. RER 0.7 = FAT burning. RER 1.0 = carbohydrate burning. RER >1.0 = hyperventilation/intense exercise.

Q.30 — Correct: (B)

Wrong: (a) Provides sustained energy for marathon running

CORRECT: (b) Provides rapid, powerful energy for 0–10 seconds of maximal effort — sprinting, jumping, throwing

Wrong: (c) Converts fat to ATP for long-duration activities

Wrong: (d) Produces ATP using oxygen from haemoglobin

Explanation: ATP-PCr (Phosphagen) system: The FASTEST energy system — ATP is immediately available. When ATP depletes (within 1–2 seconds), phosphocreatine (PCr) donates its phosphate to ADP to quickly regenerate ATP. Duration: 0–10 seconds maximal effort. Used for: 100m start, vertical jump, shot put, clean and jerk. No O■ needed. Capacity is limited — after 10 sec, anaerobic glycolysis takes over.

Q.31 — Correct: (B)

Wrong: (a) The heart develops more capillaries around the sinoatrial node

CORRECT: (b) Increased density of capillaries around skeletal muscle fibres — improving O■ delivery and CO■ removal

Wrong: (c) Capillaries in the lungs become thicker, speeding up gas exchange

Wrong: (d) New arteries form in the body to bypass existing vessels

Explanation: CAPILLARISATION (angiogenesis) = development of NEW CAPILLARIES surrounding skeletal muscle fibres through endurance training. Benefits: More exchange surface area, shorter diffusion distance from blood to mitochondria, faster O■ delivery and CO■/lactate removal. This contributes significantly to improved aerobic performance and VO■ max.

Q.32 — Correct: (A)

CORRECT: (a) The 3rd Law force creates acceleration (a = F/m) of the sprinter's body mass

Wrong: (b) The blocks provide an equal force and the sprinter's inertia stays constant

Wrong: (c) Only the 3rd Law is relevant — the 2nd Law never applies to starting blocks

Wrong: (d) The 2nd Law explains why the sprinter's legs don't break under the reaction force

Explanation: All three laws typically work together. The 3rd Law explains the EXISTENCE of the forward reaction force. Newton's 2nd Law (F = ma) explains what HAPPENS TO THE SPRINTER as a result — the reaction force accelerates the sprinter's body mass forward. Greater reaction force → greater acceleration. Lighter sprinter → greater acceleration from same force. Both laws apply and neither alone fully explains the physics of the sprint start.

Q.33 — Correct: (B)

Wrong: (a) Heart Rate × Stroke Volume

CORRECT: (b) Tidal Volume × Breathing Rate

Wrong: (c) VO■ max × Exercise Intensity

Wrong: (d) Systolic BP – Diastolic BP

Explanation: MINUTE VENTILATION (VE) = TIDAL VOLUME (TV, litres per breath) × BREATHING RATE (f, breaths per minute). Resting: VE = 0.5 L × 14 breaths/min = 7 L/min. Maximal exercise: VE = 2.5 L × 50 breaths/min = 125 L/min. Heart Rate × Stroke Volume = Cardiac Output. Systolic – Diastolic = Pulse Pressure.

Q.34 — Correct: (B)

Wrong: (a) Larger muscles are always recruited before smaller ones

CORRECT: (b) Motor units are recruited in ORDER OF SIZE — smallest (Type I) first, then Type IIa, then Type IIx as force demand increases

Wrong: (c) All motor units fire simultaneously regardless of exercise intensity

Wrong: (d) Fast-twitch fibres are always recruited first because they produce more power

Explanation: HENNEMAN'S SIZE PRINCIPLE: Motor units are recruited in order from smallest to largest as force demand increases. At low intensity → only SMALL Type I motor units recruited. Increasing intensity → Type IIa added. Maximum intensity → TYPE IIx (largest) also recruited. This is a neural efficiency strategy — uses most economical units first. Option (d) REVERSES the principle — fast-twitch recruited LAST, not first.

Q.35 — Correct: (B)

Wrong: (a) First class lever

CORRECT: (b) Second class lever

Wrong: (c) Third class lever

Wrong: (d) Fourth class lever

Explanation: WHEELBARROW = SECOND CLASS LEVER. Wheel/axle = Fulcrum (at front). Load/weight in the wheelbarrow = Resistance (in the middle). Handles pushed by person = Effort (at the back/end). Since resistance (load) is BETWEEN fulcrum and effort → 2nd class. MA > 1 → person lifts more weight than they could without the wheelbarrow's mechanical advantage.

Q.36 — Correct: (C)

Wrong: (a) 500–600 ml
Wrong: (b) 1,000–1,500 ml
CORRECT: (c) 2,000–3,000 ml
Wrong: (d) 5,000–6,000 ml

Explanation: TIDAL VOLUME (TV) = volume of air per breath. Resting TV ≈ 500 ml. During maximal exercise, TV increases to approximately 2,000–3,000 ml — representing a 4–6 fold increase. This is combined with increased breathing rate (40–60 breaths/min) to achieve total minute ventilation of 120–180 L/min in elite athletes. The VC (vital capacity) of the lungs limits maximum tidal volume.

Q.37 — Correct: (C)

Wrong: (a) Bicep curl
Wrong: (b) Standing on tiptoe (plantar flexion)
CORRECT: (c) Nodding the head 'YES' — atlanto-occipital joint
Wrong: (d) Kicking a football

Explanation: HEAD NODDING = FIRST CLASS LEVER. ATLANTO-OCCIPITAL JOINT (between skull and C1 vertebra) = Fulcrum (in the middle). NECK EXTENSOR MUSCLES = Effort (at the back of head). SKULL WEIGHT = Resistance (at the front). Fulcrum in middle → 1st class. Option (a) = THIRD class (bicep curl). Option (b) = SECOND class (plantar flexion). Option (d) = THIRD class (knee extension in kicking).

Q.38 — Correct: (B)

Wrong: (a) Trained athletes fatigue faster at high intensities
CORRECT: (b) Trained athletes can maintain HIGHER exercise intensities before lactate accumulates — working harder aerobically before needing anaerobic glycolysis
Wrong: (c) Untrained athletes produce less lactic acid than trained athletes
Wrong: (d) Training eliminates lactic acid production entirely

Explanation: RAISED LACTATE/ANAEROBIC THRESHOLD from training: Untrained athletes might hit their lactate threshold at 50–60% VO■ max. Trained endurance athletes at 70–85%+ VO■ max. This means trained athletes can sustain marathon pace, cycling race pace, etc. at intensities well above their threshold — sustaining high speed for longer. Mechanisms: More mitochondria (more aerobic capacity), better lactate clearance (LDH, muscle buffer capacity), more oxidative enzymes.

Q.39 — Correct: (B)

Wrong: (a) Muscle length and tendon length
CORRECT: (b) Effort Arm length and Resistance Arm length
Wrong: (c) Velocity of effort and velocity of resistance
Wrong: (d) Distance jumped and force applied

Explanation: LEVER PRINCIPLE: Effort × Effort Arm = Resistance × Resistance Arm. F■ = Effort force; d■ = Effort Arm (distance from fulcrum to effort application point). F■ = Resistance/Load; d■ = Resistance Arm (distance from fulcrum to resistance application point). When in equilibrium (or balance): F■ × d■ = F■ × d■. This principle explains how a small effort can move a large load if the effort arm is long enough (MA > 1).

Q.40 — Correct: (B)

Wrong: (a) Increased calcium intake from sports nutrition programmes
CORRECT: (b) Mechanical loading (stress on bones from exercise) stimulates OSTEOBLASTS (bone-forming cells) to deposit more bone mineral
Wrong: (c) Hormones from muscles (myokines) that permanently alter calcium absorption
Wrong: (d) Bones simply grow larger from increased blood flow during exercise

Explanation: BONE DENSITY ADAPTATION: Wolff's Law states bone adapts to mechanical loads placed upon it. Weight-bearing and resistance exercise creates mechanical STRESS on bones → OSTEOBLASTS (bone-building cells) are stimulated → more collagen matrix and calcium phosphate deposited → greater bone mineral density. Impact sports (running, jumping, basketball) and resistance training are most effective. This is why exercise is prescribed to prevent/treat osteoporosis.

— MATCH THE FOLLOWING —

Q.41 — Correct: (B)

Wrong: (a) 1-Q, 2-R, 3-P, 4-S

CORRECT: (b) 1-R, 2-P, 3-Q, 4-S

Wrong: (c) 1-P, 2-S, 3-R, 4-Q

Wrong: (d) 1-S, 2-Q, 3-P, 4-R

Explanation: Newton's 1st Law (1) = R (rolling ball stays in motion until friction acts — inertia); Newton's 2nd Law (2) = P (shot putter's heavier implement — F=ma; more mass needs more force for same acceleration); Newton's 3rd Law (3) = Q (swimmer pushes water backward — water pushes swimmer forward, equal and opposite); Newton's 2nd Law impulse (4) = S (follow-through extends time of force application — $F \times t = m \times \Delta v$ — greater impulse). Both P and S are 2nd Law applications; S specifically demonstrates the impulse-momentum relationship.

Q.42 — Correct: (C)

Wrong: (a) 1-P, 2-Q, 3-R, 4-S

Wrong: (b) 1-Q, 2-R, 3-S, 4-P

CORRECT: (c) 1-R, 2-Q, 3-P, 4-S

Wrong: (d) 1-S, 2-P, 3-R, 4-Q

Explanation: First Class (1) = R (head nodding — fulcrum/joint IN THE MIDDLE between effort and resistance); Second Class (2) = Q (calf raise/plantar flexion — resistance/body weight between fulcrum at toes and effort at heel); Third Class (3) = P (bicep curl — effort/biceps insertion between fulcrum/elbow and resistance/hand weight); Second Class (4) = S (jaw closing — jaw joint is fulcrum at back; food is resistance between fulcrum and masseter muscle effort at front). Note: Both Q and S are second class levers, just different body parts.

Q.43 — Correct: (D)

Wrong: (a) 1-S, 2-R, 3-Q, 4-P

Wrong: (b) 1-P, 2-S, 3-R, 4-Q

Wrong: (c) 1-Q, 2-P, 3-S, 4-R

CORRECT: (d) 1-Q, 2-S, 3-R, 4-P

Explanation: Maximum Heart Rate (1) = Q (190–220 bpm — maximal HR during exercise, formula 220–age); Stroke Volume during exercise (2) = S (100–130 ml per beat — increased from resting 70 ml via Frank-Starling and sympathetic stimulation); Maximum Breathing Rate (3) = R (40–60 breaths per minute — maximum respiratory rate during intense exercise); Resting Cardiac Output (4) = P (5 litres per minute = 70 bpm × 70 ml/beat = 4,900 ml ≈ 5 L/min). All four values are standard physiological benchmarks for exam purposes.

— ADDITIONAL MCQs —

Q.44 — Correct: (B)

Wrong: (a) The study of biological chemicals in sports performance

CORRECT: (b) The application of mechanical principles to the study of biological/human movement in sport

Wrong: (c) The psychology of athletic movement patterns

Wrong: (d) The measurement of body composition in athletes

Explanation: BIOMECHANICS = the application of the laws of MECHANICS (force, motion, leverage, pressure) to BIOLOGICAL systems (human body in movement). It explains how and why the body moves as it does during sport, helping optimise technique, prevent injury, and enhance performance. Key areas: kinematics (description of motion), kinetics (forces causing motion), lever mechanics.

Q.45 — Correct: (B)

Wrong: (a) Haemoglobin provides structural support to red blood cells

CORRECT: (b) Haemoglobin CARRIES OXYGEN in red blood cells — higher Hb = greater O■-carrying capacity of blood

Wrong: (c) Haemoglobin regulates blood pressure by constricting arteries

Wrong: (d) Haemoglobin is the primary source of energy during endurance exercise

Explanation: HAEMOGLOBIN (Hb) is an iron-containing protein in red blood cells. Each Hb molecule carries 4 O■ molecules (one per haem group). Higher blood Hb concentration = more O■ transported per litre of blood → greater VO■ max → better endurance performance. This is why altitude training increases Hb (less O■ available → body produces more RBCs/Hb) and why blood doping (EPO, transfusions) is banned.

Q.46 — Correct: (B)

Wrong: (a) The heart pumping blood faster to muscles

CORRECT: (b) Skeletal muscle contractions SQUEEZING VEINS and propelling venous blood back toward the heart — increasing venous return

Wrong: (c) The pumping of glycogen from liver to muscles during exercise

Wrong: (d) The mechanism by which muscles store energy for the next contraction

Explanation: MUSCLE PUMP: During exercise, rhythmic skeletal muscle contractions COMPRESS the veins running between and through muscles → propels venous blood upward toward the heart (venous valves prevent backflow). This is the primary mechanism for increased VENOUS RETURN during exercise. Along with the respiratory pump (breathing creates pressure changes) and venoconstriction → maintains stroke volume during exercise.

Q.47 — Correct: (B)

Wrong: (a) Only Newton's 3rd Law — the arm and javelin react against each other

CORRECT: (b) Newton's 1st Law — the javelin continues in its trajectory until gravity and air resistance act on it; Newton's 2nd Law — gravity and drag provide forces causing acceleration (deceleration and downward arc)

Wrong: (c) Newton's 2nd Law alone fully explains the flight path

Wrong: (d) None of Newton's Laws apply to projectile motion

Explanation: JAVELIN FLIGHT INVOLVES MULTIPLE LAWS: After release, the javelin has initial velocity → tends to continue in a straight line (1st Law — inertia). However, GRAVITY continuously pulls it downward (force) → Newton's 2nd Law: F=mg → creates downward acceleration of 9.8 m/s^2 → parabolic arc. Air RESISTANCE (drag) — another external force — decelerates the javelin in flight (also 2nd Law). So BOTH 1st and 2nd Laws are needed to fully explain projectile motion. 3rd Law explains the propulsion phase, not the flight.

Q.48 — Correct: (A)

CORRECT: (a) First class — the water acts as the fulcrum

Wrong: (b) Second class — the force of water (resistance) is in the middle

Wrong: (c) Third class — the effort (rower's hands) is in the middle

Wrong: (d) It does not function as a lever

Explanation: ROWING OAR = FIRST CLASS LEVER. The oarlock (on the rowlock) on the boat's side = FULCRUM (in the middle). Rower's HANDS = EFFORT (at the end of the handle). Water resistance on the BLADE = RESISTANCE (at the other end). Fulcrum in the middle → 1st class. The oar effectively reverses direction — pushing blade backward moves the handle (and boat) forward. Mechanical advantage depends on relative arm lengths.

Q.49 — Correct: (B)

Wrong: (a) Rapid increase in testosterone levels from the first training session

CORRECT: (b) NEURAL ADAPTATIONS — improved motor unit recruitment, better inter-muscular coordination, and rate coding

Wrong: (c) Immediate muscle fibre type conversion from Type I to Type IIx

Wrong: (d) Significant tendon shortening that increases mechanical advantage

Explanation: Early resistance training gains (first 4–8 weeks) are predominantly NEURAL, not structural. NEURAL ADAPTATIONS include: (1) Greater motor unit RECRUITMENT (more fibres activated per contraction). (2) Improved RATE CODING (faster neural firing → more force at same recruitment). (3) Better INTER-MUSCULAR COORDINATION (agonist-antagonist timing). (4) Reduced COACTIVATION of antagonists. Hypertrophy (structural size increase) takes 6–8+ weeks of consistent training to become significant. This explains why beginners get stronger quickly without much visible muscle growth.

Q.50 — Correct: (B)

Wrong: (a) Newton's Laws only apply to projectile sports like javelin and shot put

CORRECT: (b) Newton's Laws collectively explain ALL aspects of force, motion, acceleration, and propulsion in sport — from starting blocks to ball trajectory to lever actions in the body

Wrong: (c) Newton's Laws are theoretical and have limited practical application in sports coaching

Wrong: (d) Only Newton's 3rd Law applies to sports — the other two are purely academic

Explanation: ALL THREE of Newton's Laws apply comprehensively across ALL sports: 1st Law explains inertia in ballistics, rolling balls, maintaining speed. 2nd Law (F=ma) governs acceleration, shot put, batting power, jump height. 3rd Law explains propulsion in swimming, rowing, sprinting. Together they form the complete mechanical framework for understanding and optimising ALL sports movements. Coaches use these principles to improve technique — e.g., extending follow-through (impulse), reducing mass while maintaining force, maximising ground reaction force.
