Physical Education Notes Unit 7

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INTRODUCTION — Physical Fitness & Its Components

Physical Fitness is the ability of an individual to perform daily tasks with vigour and alertness, without undue fatigue, and with ample energy to enjoy leisure activities. It has two categories: **Health-Related Fitness** and **Skill-Related Fitness**.

Category	Components	Description
Health-Related Fitness	Cardiovascular Endurance, Muscular Strength, Muscular Endurance, Flexibility, Body Composition	Foundation for disease prevention and general health — needed by everyone
Skill-Related Fitness (Performance-Related)	Speed, Agility, Power, Balance, Coordination, Reaction Time	Required for sports performance — differentiates athletes from non-athletes

The Four Key Components Covered in This Unit:

Component	Definition	Energy System	Primary Training Goal
Strength	Maximum force a muscle can produce in a single contraction	ATP-PCr (Phosphagen) system	Hypertrophy, neural recruitment, power
Endurance	Ability to sustain prolonged physical activity without fatigue	Aerobic system (oxidative phosphorylation)	Cardiovascular efficiency, VO2 max
Speed	Ability to move body or body parts rapidly in minimum time	ATP-PCr + Anaerobic glycolysis	Neural firing rate, stride length/frequency
Flexibility	Range of motion available at a joint or series of joints	Not energy-system dependent	Muscle extensibility, joint mobility

TOPIC 1 — STRENGTH: Types of Muscular Contraction & Training Methods

Strength is the maximum amount of force that a muscle or muscle group can exert against resistance in a single maximum effort. Three major types of muscle contractions form the basis of strength training: **Isometric, Isotonic, and Isokinetic.**

Types of Strength:

Type of Strength	Definition	Example in Sport
Maximum Strength	Greatest force possible in a single all-out effort	Powerlifting, Shot put, Sumo
Explosive/Power Strength	Strength × Velocity — force produced quickly	Long jump, Javelin throw, Karate kick
Strength Endurance	Ability to exert sub-maximal force repeatedly over time	Rowing, Cycling, Swimming, Wrestling
Relative Strength	Strength relative to body weight	Gymnastics, Rock climbing, Judo

A. ISOMETRIC EXERCISES (Static Contraction)

Definition: 'Iso' = same, 'metric' = length. Muscle contracts but produces NO MOVEMENT — muscle length stays constant while tension increases.

Mechanism: Muscle generates tension against an immovable resistance. No joint movement occurs. Neural recruitment increases without visible shortening or lengthening of muscle fibres.

Protocol: Contract target muscle maximally against fixed resistance for 6–10 seconds. Rest 20–30 seconds. Repeat 5–10 times. Perform at different joint angles for full range benefit.

Types: Yielding Isometric (holding against gravity — e.g., wall sit) | Overcoming Isometric (pushing against immovable object — e.g., pushing against a wall).

✓ **Advantages:** No special equipment needed; develops strength at specific joint angle; excellent for rehabilitation (injury recovery — no joint movement required); quick to perform.

✓ **Advantages:** Useful when movement is restricted (post-injury, cast); helps in breaking strength plateaus.

✗ **Limitations:** Strength gains are ANGLE-SPECIFIC — training at 90° doesn't fully transfer to 45° or 120°.

✗ **Limitations:** Can cause temporary blood pressure spike — avoid with hypertension or cardiovascular issues.

✗ **Limitations:** Does not improve coordination, speed, or functional movement patterns.

✗ **Limitations:** Boring/monotonous — poor long-term adherence.

Examples: Wall sit (quadriceps), Plank (core), Pushing against a wall (chest/triceps), Glute bridge hold, Towel bicep curl hold, Wrestler's bridge hold.

Sports Application: Rehabilitation post-surgery, gymnastics holds (Iron Cross, Planche), martial arts stances, shooting sports (gun arm stability).

B. ISOTONIC EXERCISES (Dynamic Contraction)

Definition: 'Iso' = same, 'tonic' = tension. Muscle contracts while changing length, producing MOVEMENT through a joint's range of motion. Tension remains relatively constant (in theory).

Two Types of Isotonic Contraction:

• **Concentric:** Muscle shortens while contracting (positive work) — e.g., lifting phase of bicep curl. Actin and myosin filaments slide toward each other.

• **Eccentric:** Muscle lengthens while contracting against resistance (negative work) — e.g., lowering phase of bicep curl. Muscle acts as a brake. Eccentric causes more DOMS (muscle soreness) but builds more strength.

Protocol: Standard resistance training sets/reps. E.g., 3 sets × 8–12 reps at 60–80% 1RM (one repetition maximum) for hypertrophy; 3–5 sets × 1–5 reps at 85–95% 1RM for max strength.

Equipment: Free weights (barbells, dumbbells), resistance machines, resistance bands, bodyweight.

✓ **Advantages:** Most versatile and widely used — improves strength through full range of motion.

✓ **Advantages:** Builds muscle mass (hypertrophy), improves coordination and functional movement patterns.

✓ **Advantages:** Trains both concentric AND eccentric phases — more complete development.

✓ **Advantages:** Progressive overload easily applied — simply add weight.

✓ **Advantages:** Applicable to all fitness levels — from beginner to elite athlete.

✗ **Limitations:** Resistance is fixed — joint is mechanically at a disadvantage at certain angles (e.g., mid-range of curl is harder than end-range).

✗ **Limitations:** DOMS (Delayed Onset Muscle Soreness) especially from eccentric phase — limits next-day performance.

✗ **Limitations:** Injury risk if form is poor or weight too heavy — requires supervision for beginners.

Examples: Squats, bench press, deadlift, bicep curls, pull-ups, push-ups, lunges, dumbbell rows.

Sports Application: ALL sports — universal method; strength training for virtually every athletic discipline.

C. ISOKINETIC EXERCISES (Constant Velocity Contraction)

Definition: 'Iso' = same, 'kinetic' = movement. Muscle contracts at a CONSTANT, CONTROLLED SPEED through the full range of motion, while resistance varies to match the force applied.

Mechanism: Specialised isokinetic dynamometers (machines) control the speed of movement. When the athlete pushes harder, the machine provides MORE resistance; when push is lighter, resistance decreases. MAXIMAL muscle tension at every point in the range of motion.

Principle: Unlike isotonic (fixed weight), isokinetic allows maximum effort at EVERY joint angle — the machine accommodates the force curve. This is called 'accommodating resistance'.

Protocol: Performed on specialised machines (Cybex, Biodex, KinCom). Speed set at desired velocity (e.g., 60°/sec for strength, 180–300°/sec for endurance). 3–5 sets × 10–15 reps.

Common Equipment: Cybex dynamometer, Biodex Multi-Joint System — found in sports science labs and rehabilitation centres.

✓ **Advantages:** Maximum resistance at EVERY point in range of motion — most efficient strength stimulus.

✓ **Advantages:** SAFE — machine cannot move faster than set speed; zero chance of dropping weights.

✓ **Advantages:** Excellent for REHABILITATION — precise, controlled, measurable.

✓ **Advantages:** Accurate measurement — force-velocity curves quantify strength deficits between limbs.

✓ **Advantages:** Can train at specific sport-relevant velocities.

✗ **Limitations:** EXPENSIVE equipment — limited to sports science labs and high-end clinics.

✗ **Limitations:** Not functional — movements are isolated and don't replicate sport movements.

✗ **Limitations:** Not widely accessible to general athletes or smaller institutions.

✗ **Limitations:** Cannot train free movement patterns (multi-planar sport actions).

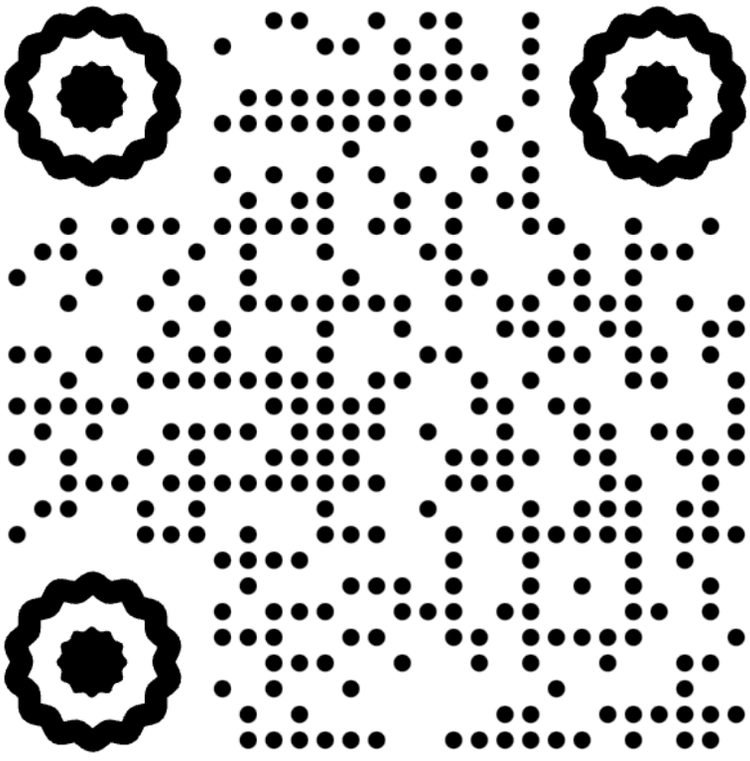
Examples: Knee extension/flexion on dynamometer (hamstring:quadriceps ratio testing), shoulder rotation testing, elbow flexion/extension.

Sports Application: ACL rehabilitation, elite athlete testing, return-to-sport assessment, swimming shoulder evaluation.

Isometric vs Isotonic vs Isokinetic — Master Comparison

Feature	Isometric	Isotonic	Isokinetic
Muscle Length	No change (static)	Changes (shortens/lengthens)	Changes
Joint Movement	None	Full range	Full range at constant speed
Resistance Type	Fixed immovable	Fixed weight	Accommodating (variable)
Speed	Zero	Variable	Constant (controlled)
Equipment	None required	Weights, bands, machines	Specialised dynamometers only

Cost	Free	Moderate	Very expensive
Best For	Rehab, specific angle strength	General strength & muscle building	Rehab, sports science testing
Limitation	Angle-specific gain	Mechanical disadvantage mid-range	Expensive, non-functional
Examples	Plank, wall push, wrestler bridge	Squat, press, curl, pull-up	Cybex knee extension



TOPIC 2 — ENDURANCE: Training Methods

Endurance is the ability to sustain prolonged physical activity. **Cardiovascular Endurance** (aerobic endurance) depends on the efficiency of heart, lungs, and blood vessels to supply oxygen to working muscles. Key measure: **VO■ max** (maximal oxygen uptake — mL/kg/min).

Type	Definition	Duration	Example Sports
Speed Endurance	Maintain high speed for extended period	6–60 seconds	400m, 800m running
Short-Term Aerobic Endurance	Sustain intensity above anaerobic threshold	2–8 minutes	1500m, 3000m
Medium-Term Aerobic Endurance	Sustained aerobic effort	8–30 minutes	5000m, 10000m
Long-Term Aerobic Endurance	Extended aerobic effort — fat as primary fuel	30+ minutes	Marathon, Triathlon, cycling

A. CONTINUOUS TRAINING METHOD (Steady-State / LSD Training)

Definition: Exercise performed at a CONSTANT, MODERATE intensity for a PROLONGED duration without rest intervals. Also called 'Long Slow Distance (LSD) training' or 'Steady-State training'.

Intensity: 60–80% of maximum heart rate (MHR). Stays below anaerobic threshold. Can maintain conversation (conversational pace).

Duration: Typically 20 minutes to 2+ hours per session. Minimum 20 minutes needed for aerobic adaptation.

Heart Rate Formula: MHR = 220 – Age. Target zone = 60–80% MHR. E.g., 20-year-old: MHR = 200; Target = 120–160 bpm.

Energy System: Aerobic (oxidative phosphorylation) — primarily fat and carbohydrates.

Protocol Types: Slow Continuous (60–70% MHR, long duration) | Fast Continuous (70–80% MHR, moderate duration) | Variable Continuous (alternating intensities without stopping — e.g., Fartlek).

✓ **Advantages:** Improves cardiovascular efficiency — increases stroke volume, cardiac output, capillarisation of muscles.

✓ **Advantages:** Increases VO■ max, mitochondrial density, fat oxidation capacity.

✓ **Advantages:** Simple to implement — no complex equipment or timing needed.

✓ **Advantages:** Low injury risk — sub-maximal intensity, controlled environment.

✓ **Advantages:** Ideal for beginners building aerobic base; essential for marathon/endurance athletes.

✓ **Advantages:** Improves psychological tolerance for sustained effort.

✗ **Limitations:** Time-consuming — long sessions needed for adequate stimulus.

✗ **Limitations:** Monotonous — same pace throughout can be boring; poor adherence long-term.

✗ **Limitations:** Does NOT develop anaerobic capacity or speed — inadequate for sprint/power sports.

✗ **Limitations:** Risk of overuse injuries (stress fractures, IT band syndrome) with high weekly volume.

✗ **Limitations:** May lead to muscle catabolism (protein breakdown) if sessions too long without nutrition.

Sports: Marathon, triathlon, long-distance cycling, open-water swimming, cross-country skiing.

Sample Programme: 5km easy jog at 65% MHR, 3 days/week; progress to 10–20km over 12 weeks.

B. INTERVAL TRAINING METHOD (High-Intensity with Planned Rest)

Definition: Alternating periods of HIGH-INTENSITY exercise with planned RECOVERY (rest/low-intensity) periods. The body repeatedly stresses the aerobic and anaerobic systems and recovers.

Key Variables (DIRT): D = Distance/Duration of work interval | I = Intensity of work interval | R = Recovery duration | T = Total repetitions.

Work:Rest Ratio Examples: 1:1 (high aerobic — e.g., 2 min on, 2 min off) | 1:2 (aerobic/anaerobic — e.g., 1 min on, 2 min off) | 1:3 or 1:4 (anaerobic/speed — e.g., 30 sec sprint, 90 sec rest).

Intensity: Work intervals at 80–95% MHR (above anaerobic threshold). Recovery at <50% MHR.

Types: Short Intervals (15–90 sec work — anaerobic) | Long Intervals (2–8 min work — aerobic) | HIIT (High-Intensity Interval Training — popular modern variant).

Modern HIIT Example: 20 sec all-out sprint, 10 sec rest × 8 rounds (Tabata Protocol). Develops both aerobic and anaerobic systems in minimal time.

✓ **Advantages:** Develops BOTH aerobic AND anaerobic systems — most versatile training method.

✓ **Advantages:** Time-efficient — significant physiological adaptation in shorter time than continuous training.

✓ **Advantages:** Increases VO■ max MORE effectively than continuous training at same weekly volume.

✓ **Advantages:** Raises EPOC (Excess Post-Exercise Oxygen Consumption) — elevated calorie burn after session.

✓ **Advantages:** More mentally engaging — varied intensity prevents boredom.

✓ **Advantages:** Can be adapted to any fitness level and any sport.

✗ **Limitations:** Higher injury risk than continuous training — high intensity places more stress on joints and muscles.

✗ **Limitations:** Requires adequate aerobic base before starting (not for absolute beginners).

✗ **Limitations:** Needs precise timing and monitoring — more complex to implement.

✗ **Limitations:** Recovery between sessions critical — overuse/overtraining risk if too frequent.

✗ **Limitations:** Psychologically demanding — high discomfort during work intervals.

Sports: Track and field (400m–5000m), swimming, rowing, football, basketball, cycling — essentially ALL sports.

Sample Protocol (800m runner): 6 × 400m at 90% effort with 90-sec recovery jog between reps.

C. FARTLEK TRAINING METHOD (Speed Play)

Definition: Swedish word meaning '**Speed Play**'. Developed by Swedish coach **Gosta Holmer in 1937**. Continuous training with spontaneous, unstructured variations in speed and intensity — a combination of continuous and interval training.

Mechanism: The athlete runs/cycles/swims continuously but VARIES pace freely based on terrain, mood, or predetermined landmarks. E.g., sprint to next tree, jog to next lamppost, stride to bridge, jog to park — all during a single continuous session.

Nature: UNSTRUCTURED — unlike interval training, there is no fixed work:rest ratio. Intensity changes are at the athlete's discretion. Can be structured (semi-planned) or completely spontaneous.

Typical Session: 20–60 minutes outdoors on varied terrain (hills, trails, track mix). Alternates between easy jog, brisk run, hard effort, sprint bursts — all within ONE continuous session.

Intensity Range: 60–95% MHR across the session — the average is submaximal but peaks are high.

Environment: Best performed outdoors on natural terrain (hills add intensity variation naturally). Cross-country, trail running, forest paths — all ideal Fartlek environments.

✓ **Advantages:** Develops BOTH aerobic base AND anaerobic capacity simultaneously.

✓ **Advantages:** Highly enjoyable and mentally stimulating — 'playful' nature reduces monotony significantly.

✓ **Advantages:** No equipment needed — just an outdoor space with varied terrain.

✓ **Advantages:** Mimics real-game demands (football, basketball) — sport-specific as intensity varies unpredictably.

✓ **Advantages:** Less structured = less mental pressure — athlete controls intensity variations.

✓ **Advantages:** Can be adapted to any running ability — beginners to elites.

✗ **Limitations:** Unstructured nature makes it difficult to ensure adequate training load and progression.

✗ **Limitations:** Harder to monitor and quantify — difficult to ensure specific physiological adaptation.

✗ **Limitations:** Self-motivated athletes may under-work; less disciplined athletes may avoid hard efforts.

✗ **Limitations:** Not ideal for precise race preparation where specific pace control is needed.

Sports: Cross-country running, middle-distance track, football, hockey, basketball — any sport with variable effort demands.

Classic Fartlek: 30-min run: 5 min easy warm-up jog → 20 min mixed (sprint to trees, stride to lamp, jog to corner) → 5 min cool-down.

Endurance Training Methods — Master Comparison

Feature	Continuous	Interval	Fartlek
Intensity	Constant (60–80% MHR)	Variable — high during work (80–95%), low in rest	Variable and spontaneous (60–95%)
Rest Periods	None	Planned, structured rest	No formal rest — pace varies
Structure	Highly structured	Highly structured (DIRT)	Unstructured / semi-structured
Origin/Developer	Traditional	Gerschler & Reindell (Germany)	Gosta Holmer (Sweden, 1937)
Systems Trained	Primarily aerobic	Both aerobic AND anaerobic	Both aerobic AND anaerobic
Monotony	High	Moderate	Low — 'playful'
Best For	Aerobic base, beginners, marathon	All sports, speed endurance, VO■ max	Cross-country, team sports, variety
Injury Risk	Low	Moderate-High	Moderate
Equipment	None	Track/timer needed	None — outdoor terrain

TOPIC 3 — SPEED: Training Methods

Speed is the ability to move the body or body segments from one place to another in the shortest possible time. It is determined by: **Stride Length × Stride Frequency**. Speed training targets the **ATP-PCr (phosphagen) system** and **neuromuscular firing rates**.

Type of Speed	Definition	Example
Acceleration Speed	Ability to increase velocity rapidly from rest or low speed	Sprint start (0–30m), first step in football
Maximum Speed	Highest velocity an athlete can achieve	60–80m phase of 100m sprint
Speed Endurance	Ability to maintain near-maximal speed for extended distance	200m, 400m sprint
Reaction Speed	Speed of response to a stimulus	Sprinter's start reaction to gun, goalkeeper reflex
Movement Speed	Speed of single limb movement	Punch in boxing, kick in karate

A. ACCELERATION RUNS (Building Speed from Rest)

Definition: Training runs that focus on developing the ability to INCREASE SPEED PROGRESSIVELY from a standing or slow start to maximum velocity over a specified distance.

Mechanism: Trains the ATP-PCr system and neuromuscular pathways for explosive first-step quickness, stride frequency increase, and coordination of the acceleration phase.

Protocol: Start from rest or jogging pace. Gradually accelerate over 30–60 metres to maximum speed. Full recovery between repetitions (2–5 minutes) to fully replenish phosphocreatine stores. 4–8 repetitions per session.

Types of Acceleration Runs:

• **Sprint Drills:** A-skips, B-skips, high knees — develop stride mechanics for better acceleration.

• **Flying Sprints:** Approach run of 20m at sub-max, then sprint maximally for 20–40m — isolates the top-speed phase.

• **Resisted Sprints:** Sled pulls, parachute runs — overload the acceleration phase for greater force development.

• **Downhill Sprints:** Slight downhill (2–3%) assists neural firing rate for overspeed training.

Key Principle: FULL RECOVERY between reps is essential — speed work done when fatigued trains bad patterns. Rest until heart rate returns to near-resting.

✓ **Improves:** First-step quickness and explosive starting acceleration.

✓ **Improves:** Stride length and stride frequency during acceleration phase.

✓ **Improves:** Neuromuscular coordination and motor unit recruitment.

✓ **Improves:** ATP-PCr system efficiency — faster phosphocreatine resynthesis.

✓ **Improves:** Sport-specific starting speed (from sprint to football/hockey/badminton movements).

✗ **Limitations:** High injury risk if done without adequate warm-up (hamstring, calf tears).

✗ **Limitations:** Requires full recovery between reps — time-consuming session.

✗ **Limitations:** Not effective if performed in fatigued state — quality over quantity essential.

Sports: Sprint events (100m, 200m), football, hockey, basketball, badminton, rugby — any sport requiring explosive starts.

Sample Session: 10-min warm-up → 4 × 30m acceleration runs (full rest) → 4 × 60m acceleration runs → cool-down.

B. PACE RUNS (Speed Endurance / Maintained Velocity)

Definition: Running at a PRE-DETERMINED, CONSISTENT PACE that is maintained throughout a specific distance or duration. Also called 'Tempo Runs' when at anaerobic threshold pace, or 'Race-Pace Training'.

Mechanism: Trains the athlete's ability to sustain a specific velocity for the full distance of their race event. Develops speed endurance, lactate tolerance, and pace awareness (kinaesthetic sense of race speed).

Types of Pace Runs:

• **Tempo/Threshold Runs:** Run at anaerobic threshold pace (approximately 80–85% MHR) — 'comfortably hard' — for 20–40 minutes. Improves lactate clearance.

• **Race-Pace Runs:** Run a portion of race distance at actual target race pace — e.g., 400m runner runs 3 × 300m at 400m race pace.

• **Over-Distance Pace Runs:** Run slightly LONGER than race distance at slightly SLOWER than race pace — builds confidence and endurance base.

• **Under-Distance Pace Runs:** Run a SHORTER distance at FASTER than race pace — develops speed reservoir above race pace.

Protocol: 2–4 repetitions of race distance or portion. Rest 3–5 minutes between reps. Performed 1–2 times per week in the specific preparation phase.

Key Benefit: Develops exact race pace 'feel' (proprioceptive awareness of target speed) and psychological confidence at race pace.

✓ **Improves:** Speed endurance — ability to maintain race pace for full distance.

✓ **Improves:** Lactate threshold — body learns to clear lactate more efficiently at race pace.

✓ **Improves:** Pace awareness and race strategy — athlete knows exactly what race pace 'feels like'.

✓ **Improves:** Mental confidence — training at race conditions reduces race anxiety.

✗ **Limitations:** Requires accurate pace knowledge — beginners lack pace awareness.

✗ **Limitations:** Can be monotonous when done repeatedly.

✗ **Limitations:** Less effective for developing raw maximum speed (acceleration runs better for that).

Sports: All track running events (400m–10000m), swimming (lap pace training), cycling (TT race pace), rowing.

Sample Session (800m runner): 3 × 600m at 800m race pace with 4-min rest between reps.

Speed Training Methods — Comparison

Feature	Acceleration Runs	Pace Runs
Primary Goal	Develop explosive starting speed and rate of acceleration	Develop speed endurance and race-specific velocity maintenance
Intensity	Maximal (95–100% effort)	Sub-maximal (80–90% — race pace / threshold)

Distance	Short (20–60m per rep)	Longer (race distance or portion)
Rest	Full rest (2–5 min) — complete recovery	Partial rest (3–5 min)
Energy System	ATP-PCr (Phosphagen system)	Anaerobic glycolysis + Aerobic
Application	100m, 200m sprints; sport first-step speed	400m–10000m; race-specific preparation
Key Benefit	Explosive power, first-step quickness	Race pace tolerance, lactate threshold

TOPIC 4 — FLEXIBILITY: Training Methods

Flexibility is the range of motion (ROM) available at a joint or series of joints. It depends on **muscle extensibility** (muscle length), **joint structure**, **connective tissue** (fascia, tendons, ligaments), and **neural factors** (stretch reflex). Two key neural mechanisms govern flexibility training: **Stretch Reflex** (myotatic reflex) and **Autogenic Inhibition** (inverse myotatic reflex).

Type	Description	Example
Static Active	Hold stretch using antagonist muscle contraction — no external force	Raising leg and holding with hip flexors
Static Passive	External force (partner, gravity, strap) assists stretch — muscles relaxed	Partner-assisted hamstring stretch
Dynamic	Controlled movement through full ROM — momentum controlled	Leg swings, arm circles as warm-up
Ballistic	Bouncing/jerky movements at end-range — uses momentum	Bouncing toe touches, bobbing hamstring stretch
PNF	Partner-assisted — uses contract-relax neuromuscular techniques	Contract hamstring for 6 sec, relax, partner deepens stretch

A. BALLISTIC STRETCHING METHOD

Definition: A dynamic stretching method that uses MOMENTUM and BOUNCING movements to push muscles and joints beyond their normal range of motion. Characterised by rapid, repetitive, bouncing stretches at end-range.

Mechanism: The rapid bouncing movement attempts to lengthen muscles by using the BODY'S MOMENTUM to overcome resistance. Each bounce loads the muscle-tendon unit to its elastic limit.

Stretch Reflex Issue: Ballistic movements TRIGGER the STRETCH REFLEX (myotatic reflex) — the spinal cord detects rapid muscle lengthening and reflexively causes the muscle to CONTRACT to protect itself. This OPPOSES the stretch and increases injury risk.

Protocol: Rhythmic, controlled bouncing movements at end range. 15–30 repetitions per stretch. Best used by experienced athletes who are thoroughly warmed up. NOT recommended for beginners.

Examples: Bouncing toe touches, bobbing forward bends (upper body bobs forward and back), rapid leg swings to maximum height, rhythmic trunk rotations, bobbing groin stretch.

Distinction from Dynamic Stretching: DYNAMIC = controlled, progressive movements through ROM (leg swings without bouncing at end-range). BALLISTIC = bouncing/jerking at END RANGE of motion.

✓ **Advantages:** Useful for sports requiring ballistic movement patterns (gymnastics, martial arts, dance, javelin).

✓ **Advantages:** Can develop dynamic flexibility — ROM during moving actions.

✓ **Advantages:** Sport-specific — mimics explosive movement demands.

✓ **Advantages:** Develops neuromuscular pattern for rapid-stretch movements.

✗ **Limitations:** HIGH INJURY RISK — most dangerous stretching method. Triggers stretch reflex, causing muscle micro-tears and potential strains.

✗ **Limitations:** NOT recommended for beginners, elderly, or those with muscle/joint injuries.

✗ **Limitations:** Less effective at true ROM improvement compared to static or PNF methods.

✗ **Limitations:** Requires thorough warm-up before performing — avoid cold muscles completely.

✗ **Limitations:** Contraindicated for individuals with reduced bone density, osteoporosis, or joint hypermobility.

Sports: Gymnastics, ballet/dance, martial arts (kicks), javelin, discus — movements requiring maximum dynamic ROM.

When to use: After thorough warm-up; as specific preparation for ballistic sport movements; experienced athletes only.

B. PNF — PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION

Definition: Advanced stretching technique that combines passive stretching with muscle contractions to maximally improve flexibility. 'Proprioceptive' = using sensory receptors in muscles/joints; 'Neuromuscular' = involving both nervous and muscular systems.

Origin: Developed by Dr. Herman Kabat and Margaret Knott in the 1940s–50s for neurological rehabilitation. Later adopted extensively in sports and physical therapy.

Key Principle: Exploits the body's natural AUTOGENIC INHIBITION reflex — when a muscle contracts maximally and then relaxes, the Golgi Tendon Organs (GTOs) trigger the INVERSE MYOTATIC REFLEX, causing deeper muscle relaxation and allowing GREATER stretch than passive stretching alone.

Golgi Tendon Organs (GTOs): Sensory receptors in tendons that detect tension. When tension is very high (during maximal isometric contraction), GTOs send inhibitory signals causing the muscle to RELAX. PNF exploits this reflex.

Three Main PNF Techniques:

1. HOLD-RELAX (HR): Most common. Passive stretch → 6–10 sec isometric contraction of the STRETCHED muscle against partner's resistance → Complete RELAX → Partner deepens passive stretch. Repeat 3–4 times. ROM gains through autogenic inhibition.

2. CONTRACT-RELAX (CR): Similar to hold-relax but the contraction phase involves isotonic movement (rotating/shortening) rather than pure isometric hold. The muscle is moved through its range before relaxing.

3. HOLD-RELAX-CONTRACT (AGONIST CONTRACT / AC): Most advanced. After the target muscle relaxes, the ANTAGONIST muscle is actively contracted to pull deeper into the stretch. Uses reciprocal inhibition PLUS autogenic inhibition.

PNF Step-by-Step (Hold-Relax for Hamstrings):

Step 1: Athlete lies on back. Partner passively lifts straight leg to point of gentle tension (initial hamstring stretch). Hold 10 seconds.

Step 2: Athlete CONTRACTS hamstrings maximally against partner's resistance for 6–10 seconds (isometric). Partner holds leg — NO movement occurs.

Step 3: Athlete says 'relax' — completely relaxes hamstrings for 2–3 seconds.

Step 4: Partner GENTLY deepens the stretch (lifts leg higher). Hold new position 20–30 seconds.

Step 5: Repeat sequence 3–4 times. ROM progressively increases each cycle due to GTO activation.

✓ **Advantages:** MOST EFFECTIVE method for increasing ROM — superior to static or ballistic stretching.

✓ **Advantages:** Works on both neural (reflex) and mechanical (tissue extensibility) components.

✓ **Advantages:** Gains are immediate and cumulative — ROM improves session by session.

✓ **Advantages:** Safe when performed correctly — controlled, no sudden movements.

✓ **Advantages:** Therapeutic — widely used in physiotherapy for injury rehabilitation and neurological conditions.

✓ **Advantages:** Develops both flexibility AND strength of target muscles (due to isometric contraction phase).

✗ **Limitations:** Requires a PARTNER (or therapist) — cannot be done alone effectively.

✗ **Limitations:** Time-consuming — proper protocol for one muscle group takes 10–15 minutes.

✗ **Limitations:** Risk of DOMS (muscle soreness) from maximal isometric contraction phase.

✗ **Limitations:** Can cause temporary BLOOD PRESSURE SPIKE during isometric contraction phase.

✗ **Limitations:** Requires technical knowledge — incorrect technique can cause strain/injury.

✗ **Limitations:** Not suitable for complete beginners without trained supervision.

Sports: All sports requiring high flexibility — gymnastics, dance, swimming, athletics, martial arts, yoga practitioners.

Best Use: End-of-training flexibility sessions (not before training — temporary strength loss post-PNF); rehabilitation; off-season flexibility development.

Flexibility Methods — Master Comparison

Feature	Ballistic	PNF (Hold-Relax)
Nature	Dynamic — bouncing/momentum	Active/Passive — muscle contraction + stretch
Mechanism	Momentum overcoming resistance; TRIGGERS stretch reflex	Exploits autogenic inhibition via Golgi Tendon Organs (GTOs)
Effectiveness	Moderate for dynamic ROM	HIGHEST — best ROM gains of all methods
Safety	LOWEST — highest injury risk	Moderate-High — safe when correct technique used
Partner Required	No	Yes — requires trained partner/therapist
For Beginners	NOT recommended	With supervision only
Pain/DOMS Risk	Moderate (micro-tears)	Moderate (from isometric contraction)
Best Timing	Sport warm-up (experienced athletes)	Post-training / off-season
Sports Use	Gymnastics, martial arts, dance	All high-flexibility sports; rehabilitation
Neural Reflex Used	Stretch reflex (myotatic) — works AGAINST it	Autogenic inhibition (inverse myotatic) — EXPLOITS it

MASTER QUICK REVISION — Unit VII At a Glance

Component / Method	Key Points for CUET
Isometric	Static — no joint movement; angle-specific strength gain; no equipment; rehabilitation use; avoid with high BP
Isotonic	Dynamic — concentric (shortens) + eccentric (lengthens); most common; free weights/machines; DOMS from eccentric
Isokinetic	Constant velocity; accommodating resistance; maximum effort throughout ROM; expensive Cybex/Biodex machines; rehabilitation
Continuous Training	Steady-state; 60–80% MHR; no rest; aerobic only; simple; good for beginners/marathon; monotonous
Interval Training	Work + rest alternation; DIRT principle; 80–95% during work; develops aerobic + anaerobic; time-efficient; HIIT variant
Fartlek Training	Swedish: Speed Play; Gosta Holmer 1937; unstructured; continuous with pace variations; outdoors; both systems; fun
Acceleration Runs	Build speed from rest; maximal effort; 20–60m; full rest (2–5 min); ATP-PCr; improves first-step quickness
Pace Runs	Maintained race-pace velocity; speed endurance; tempo/threshold; race-specific preparation; lactate tolerance
Ballistic Stretching	Bouncing at end-range; TRIGGERS stretch reflex; high injury risk; for experienced athletes/gymnastics/martial arts
PNF Stretching	Best ROM gains; EXPLOITS autogenic inhibition via GTOs; Hold-Relax most common; requires partner; 3 types: HR, CR, AC
Key Reflexes	Stretch Reflex (myotatic) = muscle contraction on rapid stretch; Autogenic Inhibition (inverse myotatic) = GTO → muscle relaxation

UNIT VII — PRACTICE MCQ BANK

50 Questions | Hard Level | CUET / Class 12

10 Tricky | 30 Standard | 3 Match the Following | 7 Additional
Complete Answer Key + Detailed Explanations

SECTION I — TRICKY MCQs (Q.1–Q.10)

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

Q.1. [TRICKY] Both Ballistic Stretching and Dynamic Stretching involve MOVEMENT, yet they are fundamentally different. The MOST accurate distinction is:

(a) Dynamic stretching is performed cold; ballistic stretching requires warm muscles

(b) Ballistic stretching uses MOMENTUM and BOUNCING at end-range, triggering the stretch reflex; dynamic stretching uses CONTROLLED movements through ROM without bouncing

(c) Dynamic stretching can only be done with a partner; ballistic stretching is always solo

(d) Ballistic is for upper body only; dynamic is for lower body only

Q.2. [TRICKY] In PNF stretching, the isometric contraction phase works because it activates which sensory receptor to produce AUTOGENIC INHIBITION?

(a) Muscle Spindles — detect rapid lengthening and trigger stretch reflex

(b) Golgi Tendon Organs (GTOs) — detect high tension and send inhibitory signals causing the muscle to relax

(c) Ruffini Endings — detect sustained pressure and signal joint position

(d) Meissner's Corpuscles — detect light touch and reduce muscular tension

Q.3. [TRICKY] An athlete completes an Isokinetic exercise at 60°/second. If they increase effort, the machine responds by:

(a) Moving FASTER to match the increased force

(b) Increasing resistance to match the force while MAINTAINING the same 60°/sec velocity

(c) Stopping movement to prevent joint injury

(d) Decreasing speed to 30°/sec as a safety response

Q.4. [TRICKY] Fartlek Training was developed in Sweden. The PRIMARY advantage it offers over standard Interval Training is:

(a) It develops only the aerobic system, making it more efficient for endurance sports

(b) It is more structured and quantifiable, allowing precise training load monitoring

(c) Its unstructured, playful nature makes it less monotonous while still developing both aerobic and anaerobic systems

(d) It must be done in water, making it joint-friendly compared to land-based interval training

Q.5. [TRICKY] An isometric exercise produces strength gains that are ANGLE-SPECIFIC. This means a strength gain from training at 90° of knee flexion will transfer LEAST to which angle?

(a) 85° of knee flexion

(b) 95° of knee flexion

(c) 180° of knee flexion (full extension)

(d) 88° of knee flexion

Q.6. [TRICKY] In the DIRT principle for Interval Training, what does the letter 'R' stand for and why is it critical?

(a) Repetitions — determines total training volume; more reps = more total work

(b) Recovery — duration and type of rest between intervals; determines which energy system is primarily trained

(c) Rate — speed of each interval; determines whether it is aerobic or anaerobic

(d) Resistance — load applied during each interval; determines strength vs endurance adaptation

Q.7. [TRICKY] Eccentric muscle contraction causes MORE DOMS than concentric. The physiological reason is:

(a) Eccentric contractions use more ATP, depleting energy stores faster

(b) Eccentric contractions cause more mechanical stress and micro-tears in sarcomeres because muscle fibres are forced to lengthen against high tension, causing more Z-line disruption

(c) Eccentric contractions activate more type I (slow-twitch) fibres which fatigue faster

(d) Eccentric contractions increase lactic acid production, causing the burning sensation 24–48 hours later

Q.8. [TRICKY] Acceleration Runs and Pace Runs both train SPEED but are used for completely different purposes. Which athlete pairing is MOST logically matched?

(a) 100m sprinter — primarily uses Pace Runs; Marathon runner — primarily uses Acceleration Runs

(b) 100m sprinter — primarily uses Acceleration Runs; 800m runner — primarily uses Pace Runs

(c) Long jumper — primarily uses Pace Runs; High jumper — primarily uses Acceleration Runs

(d) Both methods are equally used by all athletes regardless of event

Q.9. [TRICKY] The 'Hold-Relax-Contract' (HRC/Agonist Contract) variant of PNF is considered the MOST advanced because it uses:

(a) A heavier weight during the contraction phase compared to Hold-Relax

(b) BOTH autogenic inhibition (from contracting the target muscle) AND reciprocal inhibition (from contracting the antagonist), producing maximum muscle relaxation

(c) Two partners instead of one to achieve deeper stretch

(d) Ballistic movements after the isometric contraction to maximise ROM gains

Q.10. [TRICKY] Continuous Training builds aerobic endurance but does NOT improve anaerobic capacity. The MOST accurate physiological reason is:

(a) Continuous training uses the same muscles as anaerobic training, causing neural confusion

(b) The intensity (60–80% MHR) stays BELOW the anaerobic threshold — lactate production never exceeds clearance, so the anaerobic glycolytic system is never significantly stressed

(c) Continuous training sessions are always too short to stimulate anaerobic adaptation

(d) Anaerobic capacity only improves through weight training, not cardiovascular exercise

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

Q.11. In an Isometric exercise, which of the following occurs?

(a) Muscle shortens while contracting
(b) Muscle lengthens while contracting
(c) Muscle contracts but length stays constant — no joint movement
(d) Muscle relaxes completely while held in position

Q.12. Fartlek is a Swedish word meaning:

(a) Long run
(b) Speed Play
(c) Hill training
(d) Tempo work

Q.13. Which of the following CORRECTLY describes an Eccentric muscle contraction?

(a) Muscle shortens against resistance
(b) Muscle length stays constant
(c) Muscle LENGTHENS while still contracting against resistance
(d) Muscle is completely passive with no tension

Q.14. The DIRT principle of Interval Training stands for:

(a) Distance, Intensity, Rhythm, Time
(b) Duration, Intensity, Recovery, Total repetitions
(c) Drive, Interval, Rest, Training
(d) Distance, Interval, Resistance, Time

Q.15. Isokinetic exercises are performed at a CONSTANT:

(a) Resistance (weight stays the same)
(b) Speed/velocity of movement
(c) Number of repetitions
(d) Rest period between sets

Q.16. Continuous Training is MOST suitable for which athlete?

(a) 100m sprinter
(b) Powerlifter
(c) Marathon runner
(d) Gymnast performing a floor routine

Q.17. The stretch reflex (myotatic reflex) is triggered by which receptor?

(a) Golgi Tendon Organs (GTOs)
(b) Pacinian corpuscles
(c) Muscle Spindles (intrafusal fibres)
(d) Ruffini endings

Q.18. Which endurance training method was developed by Gosta Holmer?

(a) Interval Training
(b) Continuous Training
(c) Fartlek Training
(d) Circuit Training

Q.19. In PNF stretching, autogenic inhibition occurs because:

(a) The muscle spindles detect rapid lengthening
(b) Golgi Tendon Organs detect high muscle tension and inhibit the muscle

(c) The brain consciously decides to relax the muscle
(d) Cold temperature numbs the stretch receptors

Q.20. Which type of exercise contraction is MOST associated with DOMS (Delayed Onset Muscle Soreness)?

(a) Isometric contraction
(b) Concentric isotonic
(c) Isokinetic at high speed
(d) Eccentric isotonic

Q.21. Pace Runs are also called:

(a) Sprint drills
(b) Tempo runs or race-pace training
(c) Resistance sprints
(d) Overspeed training

SECTION II — STANDARD MCQs (Continued)

Q.22. Which of the following is an example of an ISOMETRIC exercise?

(a) Barbell squat
(b) Pull-up
(c) Wall sit held for 30 seconds
(d) Cycling at steady pace

Q.23. The 'work to rest ratio' of 1:4 in interval training is MOST appropriate for developing:

(a) Aerobic endurance — trains cardiovascular system
(b) Lactate threshold — trains clearance
(c) Anaerobic speed and power — allows full ATP-PCr recovery
(d) Flexibility — allows muscles to recover between stretches

Q.24. Maximum Heart Rate (MHR) is estimated using which formula?

(a) MHR = 200 + Age
(b) MHR = 220 – Age
(c) MHR = 180 × Age
(d) MHR = 250 – (Age × 2)

Q.25. Which flexibility method is MOST EFFECTIVE for improving ROM?

(a) Static passive stretching
(b) Ballistic stretching
(c) Dynamic stretching
(d) PNF (Proprioceptive Neuromuscular Facilitation)

Q.26. Which muscle contraction type produces the GREATEST force?

(a) Concentric isotonic
(b) Isometric
(c) Isokinetic at high speed
(d) Eccentric isotonic

Q.27. An athlete performs 6 × 400m runs at 85% MHR with 90-sec rest between reps. This is an example of:

(a) Continuous Training
(b) Fartlek Training
(c) Acceleration Runs
(d) Interval Training

Q.28. PNF stretching is CONTRAINDICATED (should be avoided) in which condition?

(a) Reduced flexibility from sedentary lifestyle
(b) Recent acute muscle strain or joint instability
(c) Sports requiring high ROM like gymnastics
(d) Post-workout flexibility sessions

Q.29. Ballistic stretching is MOST appropriate for which athlete group?

(a) Elderly individuals with joint stiffness
(b) Beginners starting a fitness programme
(c) Experienced gymnasts, martial artists, or dancers as sport-specific warm-up
(d) Individuals in post-injury rehabilitation

Q.30. Speed is mathematically expressed as a product of:

(a) Strength × Flexibility
(b) Stride Length × Stride Frequency

(c) Power × Endurance
(d) Acceleration × Time

Q.31. Which of the following is the MAIN advantage of Isokinetic exercise over Isotonic?

(a) Can be done without any equipment
(b) Muscles work maximally at EVERY point in the range of motion due to accommodating resistance
(c) Produces greater DOMS and therefore more hypertrophy
(d) Can develop speed more effectively than any other method

SECTION II — STANDARD MCQs (Continued)

Q.32. Continuous training at 60–80% MHR primarily develops which energy system?

(a) ATP-PCr (Phosphagen system)
(b) Anaerobic glycolysis (lactic acid system)
(c) Aerobic (oxidative phosphorylation)
(d) All three equally

Q.33. A 25-year-old athlete's Maximum Heart Rate is:

(a) 185 bpm
(b) 195 bpm
(c) 200 bpm
(d) 210 bpm

Q.34. The term 'EPOC' in exercise physiology refers to:

(a) Every Person's Oxygen Consumption
(b) Excess Post-Exercise Oxygen Consumption
(c) Effective Performance Output Coefficient
(d) Extended Physical Output Control

Q.35. In the Hold-Relax PNF technique, the initial passive stretch is held for approximately:

(a) 1–2 seconds
(b) 10 seconds before the contraction phase
(c) 60 seconds without any contraction
(d) Only 0.5 seconds as a brief positioning

Q.36. Acceleration Runs should be performed with FULL RECOVERY between repetitions. The primary reason is:

(a) To prevent the athlete from sweating too much
(b) To allow complete ATP-PCr (phosphocreatine) replenishment so each rep can be performed at maximum velocity
(c) To reduce the risk of cardiovascular overload
(d) Full recovery is not needed — shorter rest increases the training effect

Q.37. Which flexibility method does NOT require a partner?

(a) PNF Hold-Relax
(b) PNF Contract-Relax
(c) Ballistic Stretching
(d) Both (a) and (b) require a partner; (c) does not

Q.38. Interval Training's 'HIIT' variant (Tabata Protocol) consists of:

(a) 60 seconds all-out, 60 seconds rest × 10 rounds
(b) 20 seconds all-out, 10 seconds rest × 8 rounds (4 minutes total)
(c) 5 minutes hard, 5 minutes easy × 3 rounds
(d) 45 seconds work, 15 seconds rest × 20 rounds

Q.39. Strength Endurance is MOST required in which sport?

(a) 100m sprint
(b) Powerlifting
(c) Rowing a 2000m race
(d) High jump

Q.40. The 'MHR' in training intensity prescription stands for:

(a) Minimal Heart Rate

(b) Maximal Heartbeat Rhythm
(c) Maximum Heart Rate
(d) Mean Heart Rate

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

Match Column A with Column B — choose correct combination.

Q.41. MATCH THE FOLLOWING — Strength Training Types: Column A: 1. Isometric 2. Concentric Isotonic 3. Eccentric Isotonic 4. Isokinetic Column B: P. Muscle shortens during contraction — positive work Q. Constant velocity; accommodating resistance R. Static; no joint movement; angle-specific S. Muscle lengthens against resistance — causes most DOMS

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

Q.42. MATCH THE FOLLOWING — Endurance Training Methods: Column A: 1. Continuous Training 2. Interval Training 3. Fartlek Training 4. HIIT (Tabata) Column B: P. 20s work, 10s rest × 8 = 4 min; develops both aerobic and anaerobic Q. Steady-state; 60–80% MHR; no rest; primarily aerobic R. Unstructured speed play; Gosta Holmer 1937; outdoor terrain S. Structured work + rest (DIRT); develops both aerobic and anaerobic systems

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

Q.43. MATCH THE FOLLOWING — Flexibility Methods and Key Principles: Column A: 1. Ballistic Stretching 2. PNF Hold-Relax 3. Static Passive 4. Dynamic Stretching Column B: P. Controlled movement through ROM — no bouncing at end-range Q. Contract target muscle → relax → partner deepens stretch; uses autogenic inhibition R. External force holds stretch while muscles are relaxed S. Bouncing at end-range; triggers stretch reflex; highest injury risk

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

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

Q.44. VO■ max is the standard measure of cardiovascular endurance. What does it measure?

(a) Maximum heart rate during exercise
(b) Maximum volume of oxygen the body can consume per minute per kilogram of body weight (mL/kg/min)
(c) Maximum blood volume pumped by the heart per beat
(d) Maximum speed achieved during a treadmill test

Q.45. Which training method most closely mimics the variable intensity demands of a football match?

(a) Continuous Training at steady pace
(b) Pure Isometric training
(c) Fartlek Training with spontaneous intensity variations
(d) Isokinetic dynamometer training

Q.46. Resisted sprints (sled pulls, parachute runs) are a form of which speed training?

(a) Pace Runs
(b) Overspeed Training
(c) Acceleration Runs (Assisted/Resisted variant)
(d) Continuous speed training

Q.47. Static stretching immediately BEFORE a power sport event (e.g., sprinting) may be HARMFUL because:

(a) It raises body temperature too much before competition
(b) It temporarily DECREASES muscle stiffness and reduces elastic energy return — impairing power output for 30–60 minutes post-stretch
(c) It activates the muscle spindles too much, causing excessive muscle contraction during sprinting
(d) Static stretching always improves sprint performance and is always beneficial

Q.48. The term 'DOMS' stands for:

(a) Dynamic Output Muscular Stimulation
(b) Delayed Onset Muscle Soreness
(c) Direct Overload Maximum Strength
(d) Dynamic Oxidative Muscle Strain

Q.49. Which component of fitness is trained by 'Flying Sprints' (run-up then maximal sprint)?

(a) Aerobic endurance
(b) Flexibility
(c) Maximum speed (top-speed phase of sprinting)
(d) Strength endurance

Q.50. Which statement BEST summarises the difference between Isometric and Isokinetic exercises?

(a) Both have no joint movement; only the speed differs
(b) Isometric has no joint movement and no velocity; Isokinetic has joint movement at constant velocity with accommodating resistance
(c) Isometric is for endurance; Isokinetic is for flexibility
(d) Isometric requires expensive equipment; Isokinetic requires no equipment

ANSWER KEY — Quick Reference

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

CORRECT: (b) Ballistic stretching uses MOMENTUM and BOUNCING at end-range, triggering the stretch reflex; dynamic stretching uses CONTROLLED movements through ROM without bouncing

Wrong: (c) Dynamic stretching can only be done with a partner; ballistic stretching is always solo

Wrong: (d) Ballistic is for upper body only; dynamic is for lower body only

Explanation: The critical difference: BALLISTIC = uses MOMENTUM to bounce at the END RANGE of motion — this triggers the STRETCH REFLEX (muscle contracts to protect itself) and creates high injury risk. DYNAMIC = CONTROLLED, smooth movements through the full ROM — no bouncing at end range, momentum is controlled throughout, and the stretch reflex is not triggered. Dynamic is safe for warm-up; ballistic is high-risk. Options (a), (c), (d) describe incorrect distinctions.

Q.2 — Correct: (B)

Wrong: (a) Muscle Spindles — detect rapid lengthening and trigger stretch reflex

CORRECT: (b) Golgi Tendon Organs (GTOs) — detect high tension and send inhibitory signals causing the muscle to relax

Wrong: (c) Ruffini Endings — detect sustained pressure and signal joint position

Wrong: (d) Meissner's Corpuscles — detect light touch and reduce muscular tension

Explanation: In PNF's isometric contraction phase, the muscle creates HIGH TENSION. This tension is detected by GOLGI TENDON ORGANS (GTOs) in the muscle-tendon junction. When tension reaches a threshold, GTOs send inhibitory signals to the alpha motor neurons via Ib afferent fibres — causing the muscle to RELAX (autogenic inhibition). This reflex relaxation allows the muscle to be stretched further than normal. Option (a) describes MUSCLE SPINDLES which trigger the STRETCH REFLEX (opposite effect — contraction). Options (c) and (d) are irrelevant tactile receptors.

Q.3 — Correct: (B)

Wrong: (a) Moving FASTER to match the increased force

CORRECT: (b) Increasing resistance to match the force while MAINTAINING the same 60°/sec velocity

Wrong: (c) Stopping movement to prevent joint injury

Wrong: (d) Decreasing speed to 30°/sec as a safety response

Explanation: This is the DEFINING PRINCIPLE of isokinetic exercise — 'ACCOMMODATING RESISTANCE'. The isokinetic dynamometer is designed to maintain a CONSTANT SPEED regardless of force applied. When force increases, the machine increases resistance to maintain the pre-set velocity. When force decreases, resistance decreases. This means MAXIMUM muscle force is applied throughout the entire range of motion — something no other exercise type achieves. Option (a) describes variable speed machines. Options (c) and (d) are incorrect machine behaviours.

Q.4 — Correct: (C)

Wrong: (a) It develops only the aerobic system, making it more efficient for endurance sports

Wrong: (b) It is more structured and quantifiable, allowing precise training load monitoring

CORRECT: (c) Its unstructured, playful nature makes it less monotonous while still developing both aerobic and anaerobic systems

Wrong: (d) It must be done in water, making it joint-friendly compared to land-based interval training

Explanation: Fartlek's key advantage over interval training: PSYCHOLOGICAL — the SPONTANEOUS, UNSTRUCTURED, 'PLAYFUL' nature (fartlek = speed play) makes it less monotonous than the rigid work:rest structure of interval training. Both develop aerobic AND anaerobic systems. Option (a) is wrong — fartlek develops BOTH systems. Option (b) is REVERSED — interval training is MORE structured; fartlek is LESS structured. Option (d) is completely incorrect — fartlek is an outdoor land-based method.

Q.5 — Correct: (C)

Wrong: (a) 85° of knee flexion

Wrong: (b) 95° of knee flexion

CORRECT: (c) 180° of knee flexion (full extension)

Wrong: (d) 88° of knee flexion

Explanation: Isometric strength gains are most significant at the TRAINED ANGLE and within ±15° of that angle. The further away from the training angle, the less strength transfer occurs. Training at 90° will transfer to 85° and 95° (close angles — options a, b, d) with reasonable transfer. But 180° (full extension) is the FURTHEST from 90° and receives LEAST strength benefit. This is why athletes should train isometrics at multiple joint angles for functional strength.

Q.6 — Correct: (B)

Wrong: (a) Repetitions — determines total training volume; more reps = more total work

CORRECT: (b) Recovery — duration and type of rest between intervals; determines which energy system is primarily trained

Wrong: (c) Rate — speed of each interval; determines whether it is aerobic or anaerobic

Wrong: (d) Resistance — load applied during each interval; determines strength vs endurance adaptation

Explanation: DIRT = Duration, Intensity, Recovery, Total repetitions. 'R' = RECOVERY — the duration and TYPE of rest between work intervals is one of the most important variables because: SHORT REST (30–60 sec) = incomplete ATP-PCr recovery → aerobic system compensates → aerobic adaptation. LONG REST (2–5 min) = full ATP-PCr recovery → anaerobic/speed system can work maximally → speed/power adaptation. So Recovery duration determines WHICH ENERGY SYSTEM is primarily stressed. Option (a) — repetitions is 'T' in DIRT. Option (c) — rate/intensity is 'I'. Option (d) — resistance is not part of DIRT (DIRT applies to running-based interval training).

Q.7 — Correct: (B)

Wrong: (a) Eccentric contractions use more ATP, depleting energy stores faster

CORRECT: (b) Eccentric contractions cause more mechanical stress and micro-tears in sarcomeres because muscle fibres are forced to lengthen against high tension, causing more Z-line disruption

Wrong: (c) Eccentric contractions activate more type I (slow-twitch) fibres which fatigue faster

Wrong: (d) Eccentric contractions increase lactic acid production, causing the burning sensation 24–48 hours later

Explanation: DOMS from eccentric exercise is primarily caused by MECHANICAL MICRO-DAMAGE: during eccentric contraction, fewer motor units are active yet each must bear greater LOAD (because eccentric strength is greater than concentric strength — same force, fewer fibres = greater force per fibre). This causes disruption of SARCOMERE Z-LINES (titin protein stretching, Z-band streaming), triggering inflammation 24–48 hours later (DOMS). Option (a) — eccentric uses LESS ATP than concentric. Option (c) — eccentric activates MORE type II fibres. Option (d) — DOMS is NOT caused by lactic acid (lactate clears within 1–2 hours post-exercise; DOMS appears 24–48 hours later).

Q.8 — Correct: (B)

Wrong: (a) 100m sprinter — primarily uses Pace Runs; Marathon runner — primarily uses Acceleration Runs

CORRECT: (b) 100m sprinter — primarily uses Acceleration Runs; 800m runner — primarily uses Pace Runs

Wrong: (c) Long jumper — primarily uses Pace Runs; High jumper — primarily uses Acceleration Runs

Wrong: (d) Both methods are equally used by all athletes regardless of event

Explanation: ACCELERATION RUNS = develop explosive first-step speed, maximal acceleration from rest — critical for 100m sprinters, long jumpers, team sport athletes where explosive starting speed is the primary demand. PACE RUNS = develop speed endurance, race-pace maintenance, lactate tolerance — critical for 800m, 1500m, 400m athletes who need to maintain a specific velocity for a prolonged time. Option (a) REVERSES the appropriate methods. Options (c) and (d) are incorrect.

Q.9 — Correct: (B)

Wrong: (a) A heavier weight during the contraction phase compared to Hold-Relax

CORRECT: (b) BOTH autogenic inhibition (from contracting the target muscle) AND reciprocal inhibition (from contracting the antagonist), producing maximum muscle relaxation

Wrong: (c) Two partners instead of one to achieve deeper stretch

Wrong: (d) Ballistic movements after the isometric contraction to maximise ROM gains

Explanation: HRC/AC (Agonist Contract) PNF uses TWO neural inhibition mechanisms simultaneously: (1) AUTOGENIC INHIBITION — target muscle contracts → GTO activation → target muscle inhibited/relaxed; (2) RECIPROCAL INHIBITION — antagonist muscle actively contracts → neural inhibition of target muscle via Ia inhibitory interneurons. Using BOTH mechanisms together produces greater muscle relaxation and therefore deeper stretch than Hold-Relax alone. Option (a) — weight is not a variable in PNF. Options (c) and (d) are incorrect descriptions.

Q.10 — Correct: (B)

Wrong: (a) Continuous training uses the same muscles as anaerobic training, causing neural confusion

CORRECT: (b) The intensity (60–80% MHR) stays BELOW the anaerobic threshold — lactate production never exceeds clearance, so the anaerobic glycolytic system is never significantly stressed

Wrong: (c) Continuous training sessions are always too short to stimulate anaerobic adaptation

Wrong: (d) Anaerobic capacity only improves through weight training, not cardiovascular exercise

Explanation: The anaerobic threshold is the exercise intensity above which lactate production EXCEEDS lactate clearance (typically ~80–85% MHR for trained athletes). CONTINUOUS TRAINING at 60–80% MHR stays BELOW this threshold — the aerobic system fully covers energy demands, lactate is continuously cleared, and the ANAEROBIC GLYCOLYTIC pathway is not significantly activated. Without anaerobic system overload, there is no anaerobic adaptation (lactate tolerance, lactate buffer capacity). Interval training and speed work that pushes ABOVE threshold are needed for anaerobic development. Options (a), (c), (d) are physiologically incorrect.

— STANDARD MCQs —

Q.11 — Correct: (C)

Wrong: (a) Muscle shortens while contracting

Wrong: (b) Muscle lengthens while contracting

CORRECT: (c) Muscle contracts but length stays constant — no joint movement

Wrong: (d) Muscle relaxes completely while held in position

Explanation: ISOMETRIC = iso (same) + metric (length). The defining feature is that the muscle produces force/tension but does NOT CHANGE LENGTH and NO JOINT MOVEMENT occurs. The muscle contracts isometrically against an immovable resistance (e.g., pushing against a wall). Option (a) = concentric isotonic; option (b) = eccentric isotonic.

Q.12 — Correct: (B)

Wrong: (a) Long run

CORRECT: (b) Speed Play

Wrong: (c) Hill training

Wrong: (d) Tempo work

Explanation: FARTLEK is a Swedish compound word: 'Fart' = speed + 'lek' = play = SPEED PLAY. Developed by Swedish athletics coach Gosta Holmer in 1937 as an unstructured, playful alternative to rigid interval training.

Q.13 — Correct: (C)

Wrong: (a) Muscle shortens against resistance

Wrong: (b) Muscle length stays constant

CORRECT: (c) Muscle LENGTHENS while still contracting against resistance

Wrong: (d) Muscle is completely passive with no tension

Explanation: ECCENTRIC contraction = muscle generates force WHILE LENGTHENING — it acts as a 'brake' to control movement against gravity or resistance. Example: lowering a barbell during bicep curl (biceps is eccentrically contracting to control the descent). Eccentric produces the most force and most DOMS. Option (a) = concentric; option (b) = isometric.

Q.14 — Correct: (B)

Wrong: (a) Distance, Intensity, Rhythm, Time

CORRECT: (b) Duration, Intensity, Recovery, Total repetitions

Wrong: (c) Drive, Interval, Rest, Training

Wrong: (d) Distance, Interval, Resistance, Time

Explanation: DIRT = Duration (or Distance) of work interval, Intensity of work, Recovery duration/type, Total repetitions. These four variables can be manipulated to design interval training for different physiological adaptations (aerobic, anaerobic, speed, endurance).

Q.15 — Correct: (B)

Wrong: (a) Resistance (weight stays the same)

CORRECT: (b) Speed/velocity of movement

Wrong: (c) Number of repetitions

Wrong: (d) Rest period between sets

Explanation: ISOKINETIC = iso (same) + kinetic (motion). The defining feature is CONSTANT VELOCITY — the isokinetic machine maintains a pre-set speed regardless of force applied. As force increases, resistance increases (accommodating resistance) to keep speed constant. This allows maximal muscle effort at every point in the range of motion.

Q.16 — Correct: (C)

Wrong: (a) 100m sprinter

Wrong: (b) Powerlifter

CORRECT: (c) Marathon runner

Wrong: (d) Gymnast performing a floor routine

Explanation: Continuous training (steady-state aerobic exercise at 60–80% MHR for 20+ minutes without rest) is specifically designed to build AEROBIC ENDURANCE — the primary fitness quality needed by MARATHON runners and other long-duration aerobic athletes. Sprinters need acceleration training; powerlifters need maximal strength; gymnasts need power and flexibility.

Q.17 — Correct: (C)

Wrong: (a) Golgi Tendon Organs (GTOs)

Wrong: (b) Pacinian corpuscles

CORRECT: (c) Muscle Spindles (intrafusal fibres)

Wrong: (d) Ruffini endings

Explanation: MUSCLE SPINDLES (intrafusal fibres) detect rapid LENGTHENING of muscles and trigger the STRETCH REFLEX (myotatic reflex) — the spinal cord sends signals causing the muscle to CONTRACT to resist further lengthening. This protects muscles from over-stretching. Ballistic stretching triggers this reflex. GTOs trigger the OPPOSITE — autogenic inhibition (relaxation). Exploited by PNF.

Q.18 — Correct: (C)

Wrong: (a) Interval Training

Wrong: (b) Continuous Training

CORRECT: (c) Fartlek Training

Wrong: (d) Circuit Training

Explanation: FARTLEK TRAINING was developed by Swedish coach GOSTA HOLMER in 1937. He created it as an alternative to the rigid interval training methods of German coaches Gerschler and Reindell. Fartlek was designed to be more enjoyable and natural by using outdoor terrain variations.

Q.19 — Correct: (B)

Wrong: (a) The muscle spindles detect rapid lengthening

CORRECT: (b) Golgi Tendon Organs detect high muscle tension and inhibit the muscle

Wrong: (c) The brain consciously decides to relax the muscle

Wrong: (d) Cold temperature numbs the stretch receptors

Explanation: AUTOGENIC INHIBITION: During PNF's isometric contraction, GOLGI TENDON ORGANS (GTOs) in the musculotendinous junction detect HIGH TENSION. They send inhibitory signals (via Ib afferent fibres) to the spinal cord, inhibiting the alpha motor neurons of the contracting muscle — causing it to RELAX. This reflex relaxation allows greater ROM. It protects the tendon from rupture under extreme tension.

Q.20 — Correct: (D)

Wrong: (a) Isometric contraction
Wrong: (b) Concentric isotonic
Wrong: (c) Isokinetic at high speed
CORRECT: (d) Eccentric isotonic
Explanation: ECCENTRIC contractions are most strongly associated with DOMS because: fewer motor units are recruited per unit force (higher force per fibre), causing Z-line disruption (sarcomere micro-damage). Examples: lowering weights, downhill running, landing from jumps. DOMS peaks 24–48 hours post-exercise.

Q.21 — Correct: (B)

Wrong: (a) Sprint drills
CORRECT: (b) Tempo runs or race-pace training
Wrong: (c) Resistance sprints
Wrong: (d) Overspeed training
Explanation: Pace Runs = TEMPO RUNS or RACE-PACE TRAINING. They involve running at a pre-determined, consistent pace matching the target race pace or anaerobic threshold. 'Tempo run' specifically refers to training at threshold pace (comfortably hard — 80–85% MHR). Both develop speed endurance and lactate tolerance.

Q.22 — Correct: (C)

Wrong: (a) Barbell squat
Wrong: (b) Pull-up
CORRECT: (c) Wall sit held for 30 seconds
Wrong: (d) Cycling at steady pace
Explanation: WALL SIT held statically = classic isometric exercise. The quadriceps contract to maintain the position but no joint movement occurs — the muscle generates tension at a constant length. Barbell squat and pull-up are isotonic (concentric + eccentric movement). Cycling is continuous aerobic training.

Q.23 — Correct: (C)

Wrong: (a) Aerobic endurance — trains cardiovascular system
Wrong: (b) Lactate threshold — trains clearance
CORRECT: (c) Anaerobic speed and power — allows full ATP-PCr recovery
Wrong: (d) Flexibility — allows muscles to recover between stretches
Explanation: 1:4 ratio (e.g., 15 sec sprint, 60 sec rest) allows NEAR-COMPLETE RECOVERY of the ATP-PCr (phosphagen) system between reps. With full rest, the athlete can repeat maximal speed/power efforts. This trains the ANAEROBIC SPEED and POWER systems. 1:1 or 1:2 ratios with incomplete rest target aerobic and lactate systems. Flexibility has nothing to do with work:rest ratio.

Q.24 — Correct: (B)

Wrong: (a) MHR = 200 + Age
CORRECT: (b) MHR = 220 – Age
Wrong: (c) MHR = 180 × Age
Wrong: (d) MHR = 250 – (Age × 2)
Explanation: The most widely used formula: MHR = 220 – AGE (Fox & Haskell, 1970). Example: 20-year-old MHR = 220 – 20 = 200 bpm. 60–80% of this = 120–160 bpm (continuous training zone). 80–95% = 160–190 bpm (interval training zone). Note: This is an ESTIMATE with ±10–12 bpm variation.

Q.25 — Correct: (D)

Wrong: (a) Static passive stretching
Wrong: (b) Ballistic stretching
Wrong: (c) Dynamic stretching
CORRECT: (d) PNF (Proprioceptive Neuromuscular Facilitation)
Explanation: PNF is consistently shown in research to be the MOST EFFECTIVE method for improving ROM — superior to static, dynamic, and ballistic stretching. It achieves this by using BOTH neural mechanisms (autogenic inhibition + reciprocal inhibition in advanced variants) and mechanical tissue elongation. However, it requires a trained partner and more time.

Q.26 — Correct: (D)

Wrong: (a) Concentric isotonic
Wrong: (b) Isometric
Wrong: (c) Isokinetic at high speed
CORRECT: (d) Eccentric isotonic
Explanation: Force production ranking: ECCENTRIC > ISOMETRIC > CONCENTRIC. Eccentric contractions produce 15–30% MORE force than concentric contractions of the same muscle. This is because during lengthening, passive elastic elements (titin, connective tissue) contribute additional force beyond active cross-bridge cycling. This is why 'negatives' in weight training build strength rapidly.

Q.27 — Correct: (D)

Wrong: (a) Continuous Training
Wrong: (b) Fartlek Training
Wrong: (c) Acceleration Runs
CORRECT: (d) Interval Training
Explanation: INTERVAL TRAINING = defined work periods (6 × 400m) at high intensity (85% MHR) with structured rest periods (90 sec) between reps. This matches the DIRT principle precisely. Continuous training has no rest periods. Fartlek is unstructured with no defined rest. Acceleration runs are shorter maximal sprints, not 400m runs.

Q.28 — Correct: (B)

Wrong: (a) Reduced flexibility from sedentary lifestyle
CORRECT: (b) Recent acute muscle strain or joint instability
Wrong: (c) Sports requiring high ROM like gymnastics
Wrong: (d) Post-workout flexibility sessions
Explanation: PNF involves MAXIMAL ISOMETRIC CONTRACTION of the target muscle — this places very high tension on an already injured muscle or unstable joint, risking further damage (muscle tear, ligament sprain, joint capsule damage). Avoid PNF with: acute muscle strains, joint instability, recent surgery, acute inflammation. Static passive stretching is safer in these situations.

Q.29 — Correct: (C)

Wrong: (a) Elderly individuals with joint stiffness
Wrong: (b) Beginners starting a fitness programme
CORRECT: (c) Experienced gymnasts, martial artists, or dancers as sport-specific warm-up
Wrong: (d) Individuals in post-injury rehabilitation
Explanation: Ballistic stretching is ONLY appropriate for EXPERIENCED athletes in sports that REQUIRE ballistic movements — gymnastics (dynamic splits, cartwheels), martial arts (head-height kicks), dance (grand battements). It mimics the rapid force demands of these sports. It is CONTRAINDICATED for beginners, elderly, and rehabilitation patients due to high injury risk from stretch reflex triggering.

Q.30 — Correct: (B)

Wrong: (a) Strength × Flexibility
CORRECT: (b) Stride Length × Stride Frequency
Wrong: (c) Power × Endurance
Wrong: (d) Acceleration × Time
Explanation: SPEED = STRIDE LENGTH × STRIDE FREQUENCY (step rate). To run faster, an athlete must either take LONGER strides (stride length) or take strides MORE QUICKLY (stride frequency/cadence), or both. Training focuses on improving both components through sprint drills, plyometrics (length) and high-cadence drills (frequency).

Q.31 — Correct: (B)

Wrong: (a) Can be done without any equipment
CORRECT: (b) Muscles work maximally at EVERY point in the range of motion due to accommodating resistance
Wrong: (c) Produces greater DOMS and therefore more hypertrophy
Wrong: (d) Can develop speed more effectively than any other method

Explanation: The primary advantage of isokinetic: ACCOMMODATING RESISTANCE ensures maximum muscle force at every joint angle throughout the ROM. In ISOTONIC (free weights), mechanical disadvantage means the muscle is NOT at maximum tension throughout — it's easiest at some angles and hardest at others (weakest link principle). Isokinetic eliminates this limitation. Options (a), (c), (d) are incorrect.

Q.32 — Correct: (C)

Wrong: (a) ATP-PCr (Phosphagen system)
Wrong: (b) Anaerobic glycolysis (lactic acid system)
CORRECT: (c) Aerobic (oxidative phosphorylation)
Wrong: (d) All three equally
Explanation: At 60–80% MHR, exercise intensity is BELOW the anaerobic threshold. The body primarily uses the AEROBIC (oxidative) system — oxygen is available, mitochondria produce ATP via Krebs cycle and electron transport chain. Fat and glycogen are the primary fuels. The anaerobic systems (ATP-PCr and glycolysis) are minimally involved at this intensity.

Q.33 — Correct: (B)

Wrong: (a) 185 bpm
CORRECT: (b) 195 bpm
Wrong: (c) 200 bpm
Wrong: (d) 210 bpm
Explanation: MHR = 220 – Age = 220 – 25 = 195 bpm. For continuous training: 60–80% × 195 = 117–156 bpm. For interval training: 80–90% × 195 = 156–175 bpm. For anaerobic/sprint intervals: >90% × 195 = >175 bpm.

Q.34 — Correct: (B)

Wrong: (a) Every Person's Oxygen Consumption
CORRECT: (b) Excess Post-Exercise Oxygen Consumption
Wrong: (c) Effective Performance Output Coefficient
Wrong: (d) Extended Physical Output Control
Explanation: EPOC (Excess Post-Exercise Oxygen Consumption) = elevated oxygen consumption after exercise ends, as the body restores metabolic state (replenishes ATP-PCr, clears lactate, reduces body temperature, restores hormones). Interval training produces HIGHER EPOC than continuous training — meaning more calories burned after the session ends ('afterburn effect').

Q.35 — Correct: (B)

Wrong: (a) 1–2 seconds
CORRECT: (b) 10 seconds before the contraction phase
Wrong: (c) 60 seconds without any contraction
Wrong: (d) Only 0.5 seconds as a brief positioning
Explanation: Hold-Relax PNF sequence: Initial passive stretch to gentle tension → HOLD 10 seconds to allow muscle to accommodate → isometric contraction 6–10 sec → relax 2–3 sec → partner deepens stretch for 20–30 sec → repeat 3–4 cycles. The initial 10-second hold allows the tissue to adapt before the contraction phase.

Q.36 — Correct: (B)

Wrong: (a) To prevent the athlete from sweating too much
CORRECT: (b) To allow complete ATP-PCr (phosphocreatine) replenishment so each rep can be performed at maximum velocity
Wrong: (c) To reduce the risk of cardiovascular overload
Wrong: (d) Full recovery is not needed — shorter rest increases the training effect
Explanation: Acceleration runs are maximal-intensity (95–100% effort) sprints that rely on the ATP-PCr (phosphagen) system. PCr takes 3–5 MINUTES for near-complete resynthesis. If rest is insufficient, PCr is not fully restored → the glycolytic system compensates → speed decreases → the athlete is NOT training the acceleration system optimally. QUALITY speed work requires FULL RECOVERY.

Q.37 — Correct: (C)

Wrong: (a) PNF Hold-Relax
Wrong: (b) PNF Contract-Relax
CORRECT: (c) Ballistic Stretching
Wrong: (d) Both (a) and (b) require a partner; (c) does not
Explanation: BALLISTIC STRETCHING can be performed completely independently — no partner needed. The athlete uses their own momentum for the bouncing movements. PNF Hold-Relax and Contract-Relax classically require a TRAINED PARTNER or physiotherapist to apply resistance during the contraction phase and deepen the stretch during the relax phase. Self-PNF with straps is possible but less effective.

Q.38 — Correct: (B)

Wrong: (a) 60 seconds all-out, 60 seconds rest × 10 rounds
CORRECT: (b) 20 seconds all-out, 10 seconds rest × 8 rounds (4 minutes total)
Wrong: (c) 5 minutes hard, 5 minutes easy × 3 rounds
Wrong: (d) 45 seconds work, 15 seconds rest × 20 rounds
Explanation: TABATA PROTOCOL (developed by Dr. Izumi Tabata, 1996): 20 SECONDS all-out maximum effort, 10 SECONDS rest, repeated 8 ROUNDS = 4 minutes total. Research showed Tabata protocol improved BOTH VO■ max (aerobic) AND anaerobic capacity — highly time-efficient. This is a specific, trademarked form of HIIT with a 2:1 work-to-rest ratio.

Q.39 — Correct: (C)

Wrong: (a) 100m sprint
Wrong: (b) Powerlifting
CORRECT: (c) Rowing a 2000m race
Wrong: (d) High jump
Explanation: STRENGTH ENDURANCE = ability to exert force repeatedly over a prolonged period. A 2000m ROWING race lasts ~6 minutes and requires rowers to generate powerful strokes (strength) consistently for the full duration (endurance). 100m sprint = maximum speed; Powerlifting = maximum strength; High jump = explosive power (single maximal effort).

Q.40 — Correct: (C)

Wrong: (a) Minimal Heart Rate
Wrong: (b) Maximal Heartbeat Rhythm
CORRECT: (c) Maximum Heart Rate
Wrong: (d) Mean Heart Rate
Explanation: MHR = MAXIMUM HEART RATE — the highest heart rate an individual can achieve during maximal exercise. Estimated by 220 – Age. Used to set intensity zones for aerobic training (60–80% MHR for continuous training; 80–95% for interval training).

— MATCH THE FOLLOWING —

Q.41 — Correct: (C)

Wrong: (a) 1-P, 2-Q, 3-R, 4-S
Wrong: (b) 1-S, 2-R, 3-P, 4-Q
CORRECT: (c) 1-R, 2-P, 3-S, 4-Q
Wrong: (d) 1-Q, 2-S, 3-R, 4-P
Explanation: Isometric (1) = R (static, no joint movement, angle-specific strength gain — e.g., plank, wall push); Concentric Isotonic (2) = P (muscle shortens — positive work — lifting phase, e.g., curling barbell up); Eccentric Isotonic (3) = S (muscle lengthens against resistance — causes most DOMS — lowering phase); Isokinetic (4) = Q (constant velocity, accommodating resistance via dynamometer). The concentric/eccentric distinction and isokinetic definition are critical exam differentiators.

Q.42 — Correct: (D)

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

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

Explanation: Continuous Training (1) = Q (steady-state, 60–80% MHR, no rest, primarily aerobic); Interval Training (2) = S (structured work + rest, DIRT principle, develops both systems); Fartlek Training (3) = R (unstructured speed play, Gosta Holmer 1937, outdoor natural terrain); HIIT/Tabata (4) = P (20s work, 10s rest, 8 rounds = 4 minutes, Tabata Protocol). Option (b) gives Continuous Training as Interval characteristics — reversed trap.

Q.43 — Correct: (C)

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

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

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

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

Explanation: Ballistic Stretching (1) = S (bouncing at end-range, triggers stretch reflex, highest injury risk); PNF Hold-Relax (2) = Q (contract target muscle → relax → partner deepens; exploits autogenic inhibition via GTOs); Static Passive (3) = R (external force — partner, gravity, strap — holds stretch while muscles relax); Dynamic Stretching (4) = P (controlled movement through ROM without bouncing at end-range — safe warm-up). The ballistic vs dynamic distinction and PNF mechanism are the most tested concepts in this topic.

— ADDITIONAL MCQs —

Q.44 — Correct: (B)

Wrong: (a) Maximum heart rate during exercise

CORRECT: (b) Maximum volume of oxygen the body can consume per minute per kilogram of body weight (mL/kg/min)

Wrong: (c) Maximum blood volume pumped by the heart per beat

Wrong: (d) Maximum speed achieved during a treadmill test

Explanation: VO■ MAX = maximum oxygen uptake = the maximum VOLUME of O■ consumed per MINUTE per KG of body weight (mL/kg/min). It is the gold standard measure of aerobic fitness and cardiovascular endurance. Elite marathon runners: 70–85 mL/kg/min. Sedentary adults: 30–45 mL/kg/min. Continuous training increases VO■ max through improved cardiac output, oxygen extraction, and mitochondrial density.

Q.45 — Correct: (C)

Wrong: (a) Continuous Training at steady pace

Wrong: (b) Pure Isometric training

CORRECT: (c) Fartlek Training with spontaneous intensity variations

Wrong: (d) Isokinetic dynamometer training

Explanation: FARTLEK most closely mimics football's demands: a football match involves periods of walking, jogging, striding, and sprinting — all at varying intensities throughout 90 minutes with no formal rest. This is exactly what fartlek replicates — spontaneous intensity variations during a continuous session. Continuous training is too steady; isometric and isokinetic don't replicate sport-specific movement.

Q.46 — Correct: (C)

Wrong: (a) Pace Runs

Wrong: (b) Overspeed Training

CORRECT: (c) Acceleration Runs (Assisted/Resisted variant)

Wrong: (d) Continuous speed training

Explanation: RESISTED SPRINTS (sled pulls, parachute runs, uphill sprints) are a variant of ACCELERATION RUNS that OVERLOAD the acceleration phase — the athlete must generate more horizontal force against the added resistance. This improves force production per stride during acceleration. OVERSPEED training (downhill sprints, assisted sprints) is the OPPOSITE — supra-maximal speed assistance.

Q.47 — Correct: (B)

Wrong: (a) It raises body temperature too much before competition

CORRECT: (b) It temporarily DECREASES muscle stiffness and reduces elastic energy return — impairing power output for 30–60 minutes post-stretch

Wrong: (c) It activates the muscle spindles too much, causing excessive muscle contraction during sprinting

Wrong: (d) Static stretching always improves sprint performance and is always beneficial

Explanation: Research shows that prolonged static stretching (>30–60 seconds) immediately before power/speed activities can temporarily REDUCE MUSCLE STIFFNESS and REDUCE POWER OUTPUT by 5–8% for 30–60 minutes. The elastic energy storage capacity of the muscle-tendon unit is reduced (less 'spring'). This is why modern warm-up protocols favour DYNAMIC STRETCHING before speed/power sports and reserve static/PNF for post-exercise or separate flexibility sessions.

Q.48 — Correct: (B)

Wrong: (a) Dynamic Output Muscular Stimulation

CORRECT: (b) Delayed Onset Muscle Soreness

Wrong: (c) Direct Overload Maximum Strength

Wrong: (d) Dynamic Oxidative Muscle Strain

Explanation: DOMS = DELAYED ONSET MUSCLE SORENESS — the muscular pain and stiffness that peaks 24–48 hours after unaccustomed exercise, especially exercise with a significant ECCENTRIC component. Caused by sarcomere micro-damage, inflammation, and sensitisation of nociceptors. NOT caused by lactic acid (which clears within 1–2 hours post-exercise).

Q.49 — Correct: (C)

Wrong: (a) Aerobic endurance

Wrong: (b) Flexibility

CORRECT: (c) Maximum speed (top-speed phase of sprinting)

Wrong: (d) Strength endurance

Explanation: FLYING SPRINTS = sub-maximal run-up of 20–30m to reach near-maximum speed, then maintain MAXIMUM VELOCITY for 20–40m. The run-up eliminates the acceleration phase so the athlete can focus on developing and maintaining TOP/MAXIMUM SPEED. This is the primary method for training the maximum velocity phase (60–80m in a 100m sprint) — the fastest point of running.

Q.50 — Correct: (B)

Wrong: (a) Both have no joint movement; only the speed differs

CORRECT: (b) Isometric has no joint movement and no velocity; Isokinetic has joint movement at constant velocity with accommodating resistance

Wrong: (c) Isometric is for endurance; Isokinetic is for flexibility

Wrong: (d) Isometric requires expensive equipment; Isokinetic requires no equipment

Explanation: The complete summary: ISOMETRIC = static (no joint movement, zero velocity, fixed resistance — muscle generates tension without changing length, no equipment needed). ISOKINETIC = dynamic (joint moves at constant velocity, accommodating variable resistance from machine, maximum effort throughout ROM, requires expensive dynamometer). Both develop strength but by fundamentally different mechanisms. Options (a), (c), (d) reverse or incorrectly state key features.

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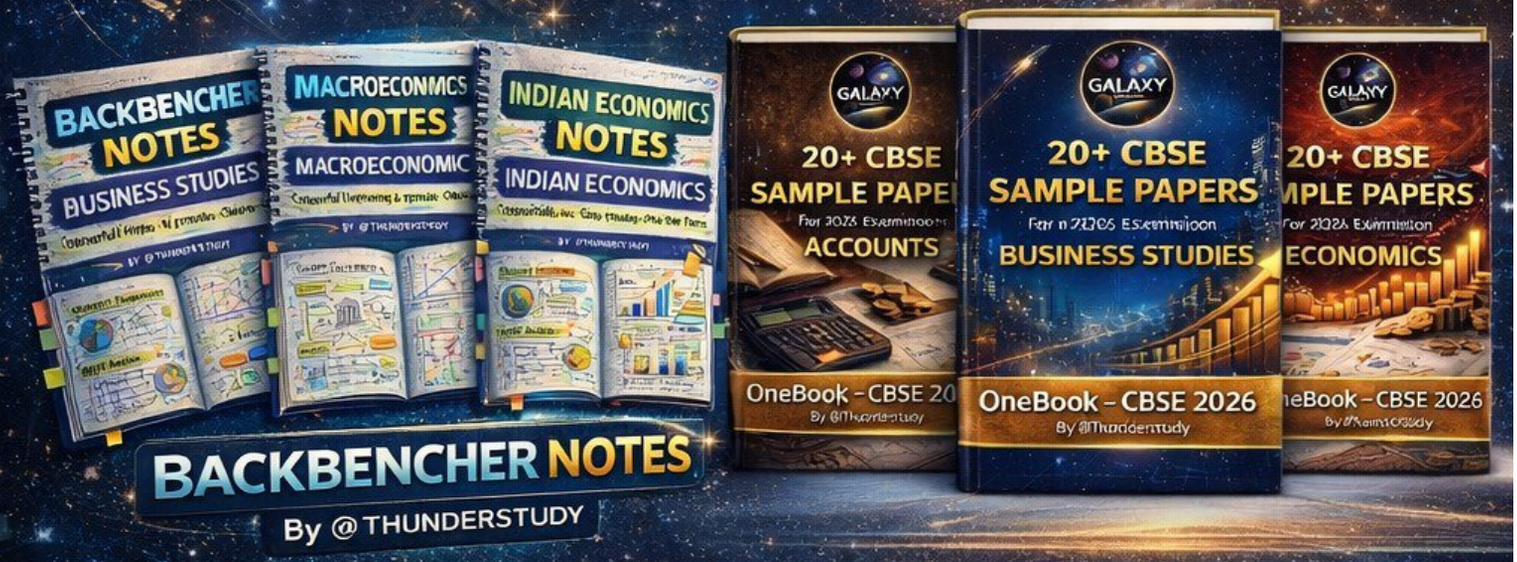

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