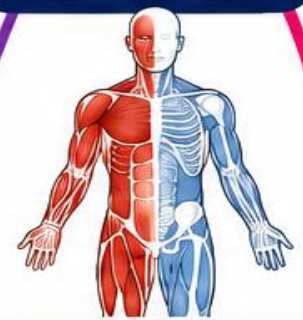
A-Level PE
KNOWLEDGE ORGANISERS
Unit 1
Physiology

A-LEVEL PE PHYSIOLOGY

1.1.a



1. JOINTS, MOVEMENTS AND MUSCLES



SHOULDER

- **Movements:** flexion, extension, abduction, adduction, horizontal flexion/extension, medial and lateral rotation, circumduction
- **Muscles:** deltoid, latissimus dorsi, pectoralis major, trapezius, teres minor



ELBOW

- **Movements:** flexion, extension
- **Muscles:** biceps brachii, triceps brachii



WRIST

- **Movements:** flexion, extension
- **Muscles:** wrist flexors, wrist extensors



HIP

- **Movements:** flexion, extension, abduction, adduction, medial and lateral rotation
- **Muscles:** iliopsoas, gluteus maximus, medius and minimus, adductor longus, brevis and magnus



KNEE

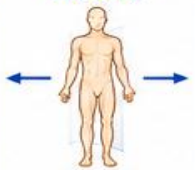
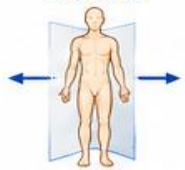
- **Movements:** flexion, extension
- **Muscles:**
  - **Quadriceps group:** rectus femoris, vastus lateralis, vastus intermedius
  - Hamstring group: semi-membranosus, semi-tendinosus
  - vastus lateralis longus and vastus medialis



ANKLE

- **Movements:** dorsi flexion, plantar flexion
- **Muscles:** tibialis anterior, soleus, gastrocnemius

PLANES OF MOVEMENT

FRONTAL	TRANSVERSE	SAGITTAL
		
Divides the body into front and back	Divides the body into upper and lower	Divides the body into left and right

2. FUNCTIONAL ROLES OF MUSCLES AND TYPES OF CONTRACTION

ROLES OF MUSCLES

- **AGONIST**
  The prime mover that produces the movement.



- **ANTAGONIST**
  The muscle that opposes the movement.



- **FIXATOR**
  Stabilises the origin of the agonist so movement can occur.



TYPES OF CONTRACTION

- **ISOTONIC**
  Muscle changes length and produces movement.



- **CONCENTRIC**
  Muscle shortens to produce movement.



- **ECCENTRIC**
  Muscle lengthens under tension.



- **ISOMETRIC**
  Muscle contracts but does not change length.



4. SKELETAL MUSCLE CONTRACTION

- **Structure and role of motor units in skeletal muscle contraction**



- **Nervous stimulation of the motor unit:**

MOTOR NEURON
Carries impulses from the CNS to the muscle.

ACTION POTENTIAL
Electrical impulse travels along the motor neuron.

NEUROTRANSMITTER
Released at the neuromuscular junction to stimulate the muscle fibre.

'ALL OR NONE' LAW
A motor unit either contracts fully or not at all.

5. MUSCLE CONTRACTION DURING EXERCISE OF DIFFERING INTENSITIES AND DURING RECOVERY

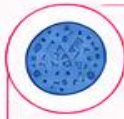
- **Muscle fibre types:**



SLOW OXIDATIVE
High mitochondria, fatigue resistant, low force, uses aerobic metabolism.



FAST OXIDATIVE GLYCOLYTIC
Moderate mitochondria, faster, uses aerobic and glycolytic pathways.



FAST GLYCOLYTIC
Low mitochondria, produces high force quickly, fatigues rapidly, uses anaerobic glycolysis.

- **Recruitment of different fibre types during exercise of differing intensities and during recovery.**



High intensity
All fibre types recruited (fast glycolytic first)

Moderate intensity
Slow oxidative + fast oxidative glycolytic

Low intensity / recovery
Predominantly slow oxidative

DURING RECOVERY:
Intensity decreases → fewer fast fibres recruited → recovery and repair occur.

A-LEVEL PE PHYSIOLOGY 1.1.b
CARDIOVASCULAR & RESPIRATORY SYSTEMS

1. CARDIOVASCULAR SYSTEM AT REST

KEY RELATIONSHIPS

- **Heart Rate (HR)**
  - number of heart beats per minute (bpm)
- **Stroke Volume (SV)**
  - amount of blood pumped from left ventricle per beat (ml)
- **Cardiac Output (Q)**
  - total amount of blood pumped by the heart per minute (L/min)

CALCULATION

Cardiac Output
= Heart Rate × Stroke Volume

$Q = HR \times SV$

Example:
HR = 70 bpm
SV = 70 ml
Q = 4900 ml/min (4.9 L/min)

2. CARDIAC CYCLE

DIASTOLE

- Heart relaxes
- Chambers fill with blood
- Atria and ventricles receive blood

SYSTOLE

- Heart contracts
- Ventricles pump blood out
- Blood leaves through arteries

CONDUCTION SYSTEM OF THE HEART
(Controls the cardiac cycle)

SA Node (natural pacemaker)
- Creates electrical impulse

→ **AV Node**
- Delays impulse
- Allows ventricles time to fill

→ **Bundle of His**

→ **Purkinje Fibres**
- Cause ventricular
- contraction

3. CARDIOVASCULAR SYSTEM DURING EXERCISE & RECOVERY

EFFECTS OF EXERCISE INTENSITY

Heart Rate (HR)	↑ increases as intensity increases ↓ gradually returns to resting level in recovery
Stroke Volume (SV)	↑ increases during exercise • plateaus at higher intensities
Cardiac Output (Q)	↑ increases as exercise intensity increases $Q = HR \times SV$

4. REDISTRIBUTION OF CARDIAC OUTPUT

Vascular Shunt Mechanism
Blood is redirected depending on body demands

During Exercise:

↑ more blood to:
- working muscles
- heart
- skin

↓ less blood to:
- digestive system
- kidneys

Vasomotor Centre
(located in medulla oblongata)
Controls:
- vasoconstriction
- vasodilation

Arterioles
- control blood flow into tissues
- vasodilation → ↑ blood flow
- vasoconstriction → ↓ blood flow

Pre-capillary Sphincters
- open and close capillaries
- control blood supply to muscles

5. VENOUS RETURN DURING EXERCISE & RECOVERY

Mechanisms Increasing Venous Return

Muscle Pump
- contracting muscles squeeze veins
- pushes blood back to the heart

Respiratory Pump
- breathing movements change pressure
- helps move blood towards the heart

Venoconstriction
- veins narrow
- more blood returns to the heart

★ KEY EXAM LINKS ★

CARDIOVASCULAR	RESPIRATORY
HR × SV = CARDIAC OUTPUT	BF × TV = MINUTE VENTILATION

EXERCISE INTENSITY INCREASES:

↑ Heart rate	↑ Breathing frequency
↑ Stroke volume	↑ Tidal volume
↑ Cardiac output	↑ Minute ventilation

RECOVERY: All values gradually return towards resting levels.

1. RESPIRATORY SYSTEM AT REST

KEY RELATIONSHIPS

- **Breathing Frequency (BF)**
  - number of breaths per minute
- **Tidal Volume (TV)**
  - amount of air in or out per breath
- **Minute Ventilation (VE)**
  - total air moved in one minute

CALCULATION

Minute Ventilation
= Breathing Frequency × Tidal Volume

$VE = BF \times TV$

MECHANICS OF BREATHING AT REST

INSPIRATION (BREATHING IN)

↓ Diaphragm contracts
- flattens
- increases thoracic volume

↓ External intercostals contract
- lift ribs upwards and outwards

↓ Pressure in lungs
→ Air moves into alveoli

EXPIRATION (BREATHING OUT)

- Relaxation of breathing muscles
- Thoracic volume decreases

→ Air moves out

AT THE ALVEOLI

Gas Exchange
O_2: alveoli → blood
CO_2: blood → alveoli
(Due to pressure gradients)

AT THE MUSCLES

Gas Exchange
O_2: blood → muscles
CO_2: muscles → blood

2. RESPIRATORY SYSTEM DURING EXERCISE & RECOVERY

EFFECTS OF EXERCISE INTENSITY

Breathing Frequency (BF)
↑ increases as intensity increases

Tidal Volume (TV)
↑ increases during exercise

Minute Ventilation (VE)
↑ increases
VE = BF × TV
↓ gradually decreases back to resting values in recovery

MECHANICS OF BREATHING DURING EXERCISE

INSPIRATION MUSCLES

Primary:
- Diaphragm
- External intercostals

Additional:
- Sternocleidomastoid
- Pectoralis minor

EXPIRATION MUSCLES

Additional muscles used during high intensity exercise:
- Internal intercostals
- Rectus abdominis

REGULATION OF BREATHING

Neural Control
- Brain controls breathing rate
- Responds quickly to exercise demands

Chemical Control
Chemoreceptors detect:
↑ CO_2 ↓ O_2 ↑ H^+ (↓ pH)

Response:
↑ breathing rate and depth

GAS EXCHANGE DURING EXERCISE

AT THE ALVEOLI

Exercise causes:
- ↑ blood flow
- ↑ diffusion rate
- ↑ pressure gradient

Result:
- More O_2 enters blood
- More CO_2 removed

AT THE MUSCLES

Exercise causes:
- ↑ O_2 demand

Oxyhaemoglobin Dissociation
- Hb releases more O_2 during exercise

Caused by:
- ↑ temperature
- ↑ CO_2
- ↑ acidity

Result:
→ More O_2 delivered to working muscles

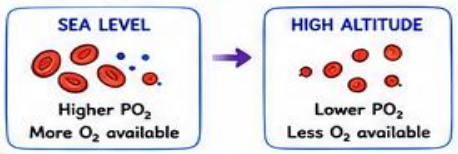
A-LEVEL PE PHYSIOLOGY 1.1.c ENVIRONMENTAL FACTORS & ERGOGENIC AIDS

EXERCISE AT ALTITUDE

1. EFFECT OF ALTITUDE ON THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS

a) Reduced arterial PO_2 (partial pressure of oxygen)

- As altitude increases, barometric pressure falls → less oxygen in each breath → reduced arterial PO_2.
- This leads to impaired muscle O_2 delivery → fatigue and reduced performance.



b) Elevated heart rate and ventilation



- Heart rate increases to maintain cardiac output and O_2 delivery.



- Ventilation increases to take in more O_2 and remove CO_2.

2. ACCLIMATISATION (Above 2400 m)

The body adapts over time to reduce the negative effects of altitude.

Key Adaptations

- ↑ Red blood cell production (↑ haemoglobin)
- ↑ Capillary density
- ↑ Mitochondria in muscles
- ↑ Breathing efficiency
- Improved O_2 delivery and utilisation



Importance of Timing Arrival



- Arrive early enough before competition to allow acclimatisation (1–3 weeks ideal).

If Arrival Too Early



- Adequate time to acclimatise
- Improved adaptations
- Better performance
- Reduced risk of altitude illness

If Arrival Too Late



- Insufficient time to adapt
- Higher risk of altitude illness (e.g. AMS)
- Poor performance

KEY TAKEAWAY



At altitude: ↓ arterial PO_2 → impaired muscle O_2 delivery, but the body adapts over time (acclimatisation).
Proper timing of arrival above 2400 m is essential.

KEY TERMS

PO_2	= Partial pressure of oxygen	Acclimatisation	= Body's adaptation to a new environment
O_2	= Oxygen	Cardiovascular drift	= Progressive rise in heart rate during prolonged exercise in the heat
AMS	= Acute Mountain Sickness		

EXERCISE IN THE HEAT

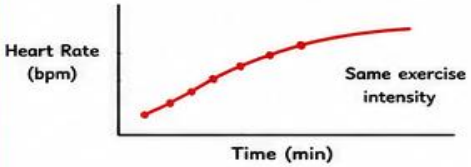
1. EFFECT OF HEAT ON THE CARDIOVASCULAR AND RESPIRATORY SYSTEMS

a) Temperature regulation



- The body must maintain a stable core temperature (~37°C).
- Heat is lost through:
  - ✓ Sweating (evaporation)
  - ✓ Increased skin blood flow (vasodilation)
  - ✓ Convection, radiation and conduction
- Increased skin blood flow → more blood to the skin → less available for working muscles.
- Sweating → loss of water and electrolytes → dehydration risk.

b) Cardiovascular drift



- During prolonged exercise in the heat, heart rate progressively increases.
- Stroke volume decreases due to dehydration and reduced venous return.
- To maintain cardiac output, heart rate must rise → cardiovascular drift.
- Leads to greater fatigue and reduced performance.

2. SUMMARY OF EFFECTS IN THE HEAT

Cardiovascular Effects



- ↑ Heart rate
- ↑ Skin blood flow
- ↓ Stroke volume (late in exercise)
- → Cardiovascular drift

Risk of dehydration and heat illness

Respiratory Effects



- ↑ Ventilation
- ↑ Breathing frequency
- ↑ Risk of respiratory alkalosis (from hyperventilation)

Factors that worsen effects of heat



- High temperature
- High humidity
- Sun exposure
- Dehydration

KEY TAKEAWAY



In the heat: the body prioritises cooling → ↑ heart rate and ventilation, cardiovascular drift occurs, and dehydration risk increases.
This can lead to fatigue, reduced performance and heat illness.

ERGOGENIC AIDS (CONT.) NUTRITIONAL AIDS

Amount of Food



- Match energy intake to energy needs
- Avoid under- or over-eating

Composition of Meals



- Balanced diet: carbohydrates, protein, fats, vitamins & minerals

Timing of Meals



- Fuel before exercise
- Refuel & recover afterwards

Hydration



- Maintain fluid balance
- Drink before, during & after exercise

Glycogen / Carbohydrate Loading



- Maximise muscle glycogen stores for endurance performance

Creatine



- Increases ATP resynthesis
- Improves strength, power & repeated high-intensity performance

Caffeine



- Increases alertness
- Reduces perception of effort
- Improves endurance and performance

Bicarbonate



- Buffers lactic acid
- Improves high-intensity exercise lasting 1–7 min

Nitrate



- Improves blood flow & efficiency
- May improve endurance performance

A-LEVEL PE PHYSIOLOGY 1.2.a TRAINING FOR PERFORMANCE

1. AEROBIC TRAINING

1.1 AEROBIC CAPACITY & MAXIMAL OXYGEN UPTAKE (VO_{2max})

VO_{2max} = the maximum amount of oxygen the body can take in, transport and use during intense exercise.

1.2 HOW VO_{2max} IS AFFECTED BY:

- Individual physiological make-up
- Training
- Age
- Gender

1.3 METHODS OF EVALUATING AEROBIC CAPACITY

- Laboratory test of VO_{2max} using direct gas analysis
- NCF multi-stage fitness test
- Queen's College step test
- Cooper 12 minute run

1.4 INTENSITY & DURATION OF TRAINING TO DEVELOP AEROBIC CAPACITY

Continuous Training
Moderate intensity, sustained exercise for a longer duration.

High Intensity Interval Training (HIIT)
Short bursts of high intensity exercise with recovery periods.

1.5 TARGET HEART RATE AS AN INTENSITY GUIDE

Target HR zone:
60–90% of HR_{max}

Used to ensure exercise is at the right intensity to improve fitness.

1.6 PHYSIOLOGICAL ADAPTATIONS FROM AEROBIC TRAINING

Cardiovascular	Respiratory	Muscular	Metabolic
↑ Stroke volume	↑ Tidal volume	↑ Mitochondria	↑ Aerobic enzymes
↓ Resting heart rate	↓ Breathing rate	↑ Capillarisation	↑ Fat utilisation
↑ Cardiac output	↑ Ventilation efficiency	↑ Myoglobin	↑ Glycogen sparing
↑ Capillarisation		↑ Oxidative enzymes	↑ Lactate threshold
↓ Blood pressure			

1.7 ACTIVITIES & SPORTS WHERE AEROBIC CAPACITY IS KEY

Distance Running · Cycling · Swimming · Rowing · Cross Country · Triathlon

2. STRENGTH TRAINING

2.1 TYPES OF STRENGTH

- Strength endurance
- Maximum strength
- Explosive/elastic strength
- Static and dynamic strength

2.2 FACTORS THAT AFFECT STRENGTH

- Fibre type
- Cross sectional area of the muscle

2.3 METHODS OF EVALUATING EACH TYPE OF STRENGTH

- Grip strength dynamometer
- 1 Repetition Maximum (1RM)
- Press up or sit-up test
- Vertical jump test

2.4 TRAINING TO DEVELOP STRENGTH

- Repetitions
- Sets
- Resistance guidelines used to improve each type of strength
- Use of multi-gym
- Weights
- Plyometrics
- Circuit/interval training:
  - Work intensity
  - Work duration
  - Relief interval
  - Number of work/relief intervals

2.5 PHYSIOLOGICAL ADAPTATIONS FROM STRENGTH TRAINING

Muscle & Connective Tissues	Neural	Metabolic
↑ Muscle size	↑ Motor unit recruitment	↑ ATP-PC system
↑ Strength	↑ Rate of firing	↑ Anaerobic enzymes
↑ Tendon strength	↑ Coordination	↑ Glycogen stores
↑ Bone density	↑ Intermuscular coordination	

2.6 ACTIVITIES & SPORTS WHERE STRENGTH IS KEY

- Weightlifting
- Rugby
- Gymnastics
- Sprinting
- Throwing events

3. FLEXIBILITY TRAINING

3.1 TYPES OF FLEXIBILITY

- Static flexibility (active and passive)
- Dynamic flexibility

3.2 FACTORS THAT AFFECT FLEXIBILITY

- Type of joint
- Length of surrounding connective tissue
- Age
- Gender

3.3 METHODS OF EVALUATING FLEXIBILITY

- Sit and reach test
- Goniometer

3.4 TRAINING USED TO DEVELOP FLEXIBILITY

- Passive stretching
- Proprioceptive neuromuscular facilitation (PNF)
- Static stretching
- Dynamic stretching
- Ballistic stretching
- Isometric stretching

3.5 PHYSIOLOGICAL ADAPTATIONS FROM FLEXIBILITY TRAINING

Muscle & Connective Tissues

- ↑ Range of movement
- ↑ Elasticity of muscles
- ↑ Flexibility of tendons and ligaments

3.6 ACTIVITIES & SPORTS WHERE FLEXIBILITY IS KEY

Gymnastics · Dance · Martial Arts · Yoga · Swimming

4. PERIODISATION OF TRAINING

4.1 PERIODISATION CYCLES

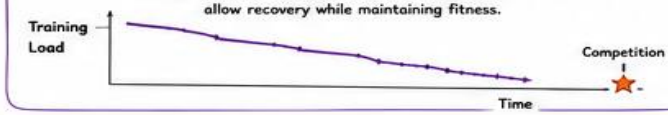
- MACROCYCLE (months to year)
- MESOCYCLE (weeks)
- MICROCYCLE (days to week)

4.2 PHASES OF TRAINING

PREPARATORY	Build fitness, develop skills
COMPETITIVE	Peak performance
TRANSITION	Rest, recovery, active rest

4.3 TAPERING TO OPTIMISE PERFORMANCE

Gradual reduction in training load before competition to allow recovery while maintaining fitness.



4.4 PLAN PERSONAL HEALTH & FITNESS PROGRAMMES

Assess needs → Set goals → Choose training (aerobic, strength, flexibility) → Plan (FITT: Frequency, Intensity, Time, Type) → Monitor → Review

5. IMPACT OF TRAINING ON LIFESTYLE DISEASES

5.1 THE EFFECT OF TRAINING ON LIFESTYLE DISEASES

Cardiovascular System

- Coronary Heart Disease (CHD)
- Stroke
- Atherosclerosis
- Heart Attack

Respiratory System

- Asthma
- Chronic Obstructive Pulmonary Disease (COPD)

Regular training helps to:

- Lower blood pressure
- Improve blood lipid profile
- Improve circulation
- Strengthen the heart
- Reduce risk of CVD

Regular training helps to:

- Improve lung function
- Reduce symptoms
- Improve quality of life
- Increase exercise tolerance

Key Message: Regular training improves health, reduces disease risk and enhances quality of life.

A-LEVEL PE PHYSIOLOGY 1.2.b INJURY & REHABILITATION

1. ACUTE AND CHRONIC INJURIES

1.1 ACUTE INJURIES

Result from a sudden stress to the body.

Hard tissue injuries



- Fractures
- Dislocations
- Stress fractures

Soft tissue injuries



- Sprains
- Strains
- Tears
- Contusions

Concussion



- Injury to the brain caused by a direct or indirect blow to the head

1.2 CHRONIC INJURIES

Result from continuous stress to the body.

Soft tissue injuries



- Tendinopathies
- Stress syndrome
- Overuse injuries (e.g. shin splints)

Hard tissue injuries



- Stress fractures
- Overuse conditions (e.g. stress reactions)

2. INJURY PREVENTION

2.1 INTRINSIC RISK FACTORS

Individual variables

- Age
- Gender
- Body composition
- Previous injury history
- Flexibility
- Strength
- Skill level

Training effects

- Poor fitness
- Fatigue
- Overtraining
- Inadequate recovery

2.2 EXTRINSIC RISK FACTORS

Poor technique / training

- Incorrect movement patterns
- Faulty coaching
- Poor progression

Incorrect equipment / clothing

- Poorly fitted footwear
- Faulty or unsuitable equipment
- Inappropriate clothing

Inappropriate intensity, duration or frequency of activity

- Too much, too soon
- Sudden changes in training load
- Inadequate rest

2.3 DEBATE: EFFECTIVE WARM UP AND COOL DOWN

Warm up benefits

- ✓ Increases body temperature
- ✓ Improves blood flow
- ✓ Enhances performance
- ✓ Reduces injury risk

VS.

Cool down benefits

- ✓ Aids recovery
- ✓ Removes waste products
- ✓ Lowers heart rate gradually
- ✓ Improves flexibility

3. RESPONDING TO INJURIES AND MEDICAL CONDITIONS IN A SPORTING CONTEXT

3.1 ASSESSING SPORTING INJURIES USING 'SALTAPS'

S	See	What happened?
A	Ask	What are their symptoms?
L	Look	Observe for swelling, deformity, bruising.
T	Touch	Feel around the injury for heat, tenderness, irregularity.
A	Active	Ask the person to move the injured part.
P	Passive	Move the injured part for them.
S	Strength	Test muscle strength (if appropriate).

3.2 ACUTE MANAGEMENT OF SOFT TISSUE INJURIES USING 'PRICE'

- **P – Protection**: Protect the injury from further harm.
- **R – Rest**: Relative rest – avoid activities that cause pain.
- **I – Ice**: Apply ice for 15–20 minutes every 2–3 hours.
- **C – Compression**: Use bandage or wrap to reduce swelling.
- **E – Elevation**: Elevate the injured part above heart level.

3.3 RECOGNISING CONCUSSION: IRB's 'RECOGNISE AND REMOVE' 6 R's

- **Recognise**: Observe signs and symptoms.
- **Remove**: Remove from play.
- **Refer**: Refer for medical assessment.
- **Rest**: Physical and cognitive rest.
- **Recover**: Recover fully under medical guidance.
- **Return**: Return to play gradually and safely.

When in doubt, sit them out!

4. REHABILITATION OF INJURY

4.1 TREATMENT OF COMMON SPORTING INJURIES

Injuries:

Fractures
- Simple fractures
- Stress fractures

Joint injuries
- Dislocation
- Sprain
- Torn cartilage

Exercise-induced muscle damage
- DOMS
- Muscle strains

4.2 TREATMENTS

- **Stretching**: Improves flexibility and restores movement.
- **Massage**: Reduces muscle tension, promotes circulation.
- **Heat, cold and contrast therapies**: Reduce pain, swelling and inflammation.
- **Anti-inflammatory drugs**: Reduce pain and inflammation.
- **Physiotherapy**: Rehabilitation exercises, modalities, education.
- **Surgery**: Required in severe cases.

4.3 GOALS OF REHABILITATION

- ✓ Restore pain-free movement
- ✓ Restore strength, flexibility and function
- ✓ Prevent re-injury
- ✓ Return to sport safely and at the right time



KEY TAKEAWAY

Understand injuries, prevent them, respond effectively and rehabilitate correctly to return athletes to full performance.

INJURIES
Acute = sudden
Chronic = over time

→ **PREVENTION**
Manage risk factors
Use effective warm up and cool down

→ **RESPOND**
Assess (SALTAPS)
Manage (PRICE)
Recognise concussion (6 R's)

→ **REHABILITATE**
Use appropriate treatments and progress safely

→ **OUTCOME**
Healthy, resilient athlete with reduced injury risk and optimal performance.

A-LEVEL PE PHYSIOLOGY 1.3a & 1.3b BIOMECHANICS & MOTION IN SPORT

1.3a BIOMECHANICS

1. NEWTON'S LAWS OF MOTION

1st Law: Inertia
An object will remain at rest or in uniform motion in a straight line unless acted upon by a resultant force.

2nd Law: Acceleration
The acceleration of an object is directly proportional to the resultant (net) force and inversely proportional to mass.

$$F = ma$$

3rd Law: Reaction
For every action, there is an equal and opposite reaction.

2. FORCE

- **Net force** – the resultant of all forces acting on a body.
- **Balanced force** – net force = 0 N (no change in motion).
- **Unbalanced force** – net force ≠ 0 N (change in motion).
- **Weight** – gravitational force acting vertically downwards.
- **Reaction** – force exerted by a surface at 90° to the surface.
- **Friction** – force that opposes motion between surfaces.
- **Air resistance** – force that opposes motion through air.

FACTORS AFFECTING FRICTION
- Surface roughness
- Normal (reaction) force
- Type of surfaces
- Lubrication

MANIPULATION:
- Smooth surfaces
- Lubricants
- Reduce unnecessary normal force

FACTORS AFFECTING AIR RESISTANCE
- Speed
- Frontal cross-sectional area
- Shape (streamlining)
- Surface roughness (clothing)

MANIPULATION:
- Streamline body/equipment
- Reduce frontal area
- Smooth clothing/equipment

FREE BODY DIAGRAMS
Show vertical and horizontal forces acting on a body at an instant in time.

Air resistance, Thrust, Reaction

CALCULATIONS
Use and apply:
- Force (F = ma)
- Momentum (p = mv)
- Acceleration ($a = \frac{\Delta v}{\Delta t}$)
- Weight (W = mg)

CENTRE OF MASS (COM)
The point where the mass of an object is considered to be concentrated.

FACTORS AFFECTING POSITION OF COM
- Body position
- Body shape
- Distribution of mass (limb movement)
- Height and build

COM & STABILITY
Lower centre of mass = greater stability.

Wider base of support = lower COM = most stable.

3. LEVERS

COMPONENTS OF A LEVER SYSTEM
- **Load** – resistance to be overcome
- **Effort** – force applied
- **Fulcrum** – pivot point
- **Effort arm** – distance from fulcrum to effort
- **Load arm** – distance from fulcrum to load

Load, Effort, Load arm, Fulcrum, Effort arm

1ST CLASS LEVER
Fulcrum is between load and effort.

Load, Effort, Fulcrum

2ND CLASS LEVER
Load is between fulcrum and effort.

Fulcrum, Load, Effort

3RD CLASS LEVER
Effort is between fulcrum and load.

Effort, Load, Fulcrum

MECHANICAL ADVANTAGE OF A 2ND CLASS LEVER: MA > 1
(Load arm > Effort arm → Less effort needed to lift a greater load)

4. ANALYSING MOVEMENT THROUGH THE USE OF TECHNOLOGY

4.1 LIMB KINEMATICS
The study of movement of body segments.

Used to:
- Analyse technique
- Measure angles, velocity, acceleration
- Improve efficiency and performance

4.2 FORCE PLATES
Platforms that measure ground reaction forces.

Used to:
- Analyse force production
- Assess jump height, balance and landings
- Reduce injury risk

4.3 WIND TUNNELS
Measure aerodynamic forces on the body or equipment.

Used to:
- Test body position and equipment
- Reduce air resistance
- Optimise performance

TECHNOLOGY IN SPORT = MEASURE → ANALYSE → ADAPT → IMPROVE PERFORMANCE

KEY EQUATIONS
- F = ma
- p = mv
- W = mg

Linear: $v = \frac{s}{t}$ $a = \frac{\Delta v}{\Delta t}$ $v = \frac{\Delta x}{t}$

Angular: $I = \Sigma mr^2$ $\omega = \frac{\Delta \theta}{\Delta t}$ $L = I\omega$

KEY IDEAS
- Forces cause changes in motion.
- Optimise technique, equipment and body position to reduce resistance and improve performance.

1.3b MOTION IN SPORT

1. LINEAR MOTION

1.1 DEFINITION
Movement of an object in a straight line.

1.2 CREATED BY DIRECT FORCE THROUGH THE CENTRE OF MASS
Force applied through the COM → linear motion (no rotation).

1.3 QUANTITIES (DEFINITIONS, CALCULATIONS & UNITS)

QUANTITY	DEFINITION	EQUATION	UNITS
Distance (s)	Total length of path travelled	–	metres (m)
Displacement (Δx)	Straight line distance and direction from start to finish	$\Delta x = x_f - x_i$	metres (m)
Speed (v)	Distance travelled per unit time	$v = s/t$	$m \cdot s^{-1}$
Velocity (v)	Displacement per unit time (includes direction)	$v = \frac{\Delta s}{t/t}$	$m \cdot s^{-1}$
Acceleration (a)	Rate of change of velocity	$a = \frac{\Delta v}{\Delta t}$	$m \cdot s^{-2}$

1.4 PLOT & INTERPRET GRAPHS OF LINEAR MOTION

DISTANCE / TIME

Distance (m), Time (s)

Gradient = speed

SPEED / TIME

Speed ($m \cdot s^{-1}$), Time (s)

Area under graph = distance

VELOCITY / TIME

Velocity ($m \cdot s^{-1}$), Time (s)

Area under graph = displacement

2. ANGULAR MOTION

2.1 DEFINITION
Movement of an object about an axis of rotation.

2.2 CREATED BY ECCENTRIC FORCE ABOUT AN AXIS
Force applied away from the axis → rotation about an axis.

2.3 AXES OF ROTATION
Longitudinal (vertical), Frontal (antero-posterior), Transverse (lateral)

2.4 QUANTITIES (DEFINITIONS, CALCULATIONS & UNITS)

QUANTITY	DEFINITION	EQUATION	UNITS
Moment of inertia (I)	Resistance of a body to change in angular velocity	$I = \Sigma mr^2$	$kg \cdot m^2$
Angular velocity (ω)	Rate of change of angular displacement	$\omega = \frac{\Delta \theta}{\Delta t}$	$rad \cdot s^{-1}$
Angular momentum (L)	Product of moment of inertia and angular velocity	$L = I\omega$	$kg \cdot m^2 \cdot s^{-1}$

2.5 FACTORS AFFECTING MOMENT OF INERTIA
- Mass of the body (or body part) – greater mass → greater I
- Distribution of mass from the axis of rotation – mass further from axis → greater I

Lower I (faster rotation), Higher I (slower rotation)

2.8 INTERPRET GRAPHS OF ANGULAR MOTION

ANGULAR VELOCITY (ω) / TIME, Time (s)

2.6 RELATIONSHIP BETWEEN I AND ω
For a given amount of angular momentum (L):

$L = I\omega$

If I ↓ → ω ↑ If I ↑ → ω ↓

2.7 CONSERVATION OF ANGULAR MOMENTUM (ANGULAR ANALOGUE OF NEWTON'S 1ST LAW)
In the absence of external torque, angular momentum remains constant: $L_{initial} = L_{final}$

During flight: as I ↓ → ω ↑ (e.g. diver tucking in).

3. FLUID MECHANICS

FACTORS AFFECTING AIR RESISTANCE (DRAG)
- Velocity – ↑ velocity → ↑ drag
- Frontal cross-sectional area – ↑ area → ↑ drag
- Streamlining and shape – streamlined → ↓ drag
- Surface characteristics – smooth → ↓ drag (rough → ↑ drag)

4. PROJECTILE MOTION

4.1 FACTORS AFFECTING HORIZONTAL DISTANCE
- Height of release ↑
- Speed of release ↑
- Angle of release (optimum ≈ 45°)

4.2 FORCES ACTING ON PROJECTILE IN FLIGHT
- Weight (W) – acts vertically downwards
- Air resistance (D) – acts opposite to direction of motion

W, D

4.3 RESOLUTION OF FORCES (PARALLELOGRAM OF FORCES)

V, V, R, O

4.4 PATTERNS OF FLIGHT PATHS
- Parabolic (symmetrical) – shot put
- Non-parabolic (asymmetric) – badminton shuttle

4.5 LIFT THROUGH BERNOULLI'S PRINCIPLE
Angle of attack creates an upwards lift force.

- Discus
- Javelin
- Ski jumper

4.6 DOWNWARDS LIFT (DOWNFORCE)
Design equipment to create a downwards lift force.

- F1 racing cars
- Track cycling

4.7 SPIN IN SPORT – MAGNUS FORCE
- Spin creates deviations to expected flight paths.
- Importing spin through an eccentric force
- Types of spin:
  - Top spin, side spin, back spin (tennis, table tennis)
  - Side spin (football)
  - Hook and slice (golf)

APPLY → ANALYSE → OPTIMISE PERFORMANCE

Understand principles → Analyse movement → Use technology & measure → Make informed adjustments → Improve performance