Generating movement in the body

B1 · SL and HL

Why does a muscle need more force than the weight in the hand?

Follow movement from anatomy to force transmission

B1 covers anatomical descriptions, connective tissues and joints, muscular function and levers.

AHL: anthropometry and sliding filaments.

All numerical data and simplified diagrams are invented teaching models. Name the joint, movement phase and model assumptions.

Separate axial support from appendicular movement

Division / reference	Identify structures and meaning
Axial	Skull, vertebral column, ribs and sternum support/protect central structures
Appendicular	Shoulder/pelvic girdles and limbs link moving segments
Reference	Upright, palms forwards; left/right are the person's own sides

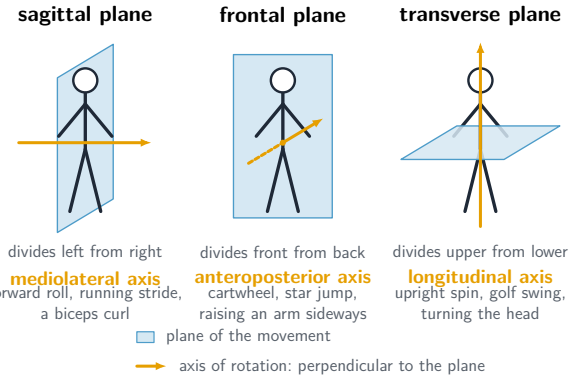
Locate the bones before describing the movement

1. **Upper limb.** Scapula/clavicle at shoulder; humerus in upper arm; radius/ulna in forearm; carpals/metacarpals/phalanges in hand.
2. **Lower limb.** Pelvic girdle; femur, patella, tibia/fibula; tarsals/metatarsals/phalanges in foot.
3. **Check.** Radius is lateral to ulna in anatomical position; tibia is medial to fibula. Position terms retain their anatomical reference.

Give a reference structure when naming a position

Pair / term	Meaning and example
Superior / inferior	Towards head / feet; compare named structures
Anterior / posterior	Towards front / back in anatomical reference
Medial / lateral	Nearer / farther from midline; intermediate = between
Proximal / distal	Nearer / farther from limb attachment; elbow distal to shoulder, proximal to wrist

Match a rotation plane to its perpendicular axis



A **plane** is a surface; its perpendicular rotation **axis** is a line.

Name the plane, then the perpendicular axis

1. **Forward roll.** Mainly sagittal **plane**, about a mediolateral **axis** (side to side).
2. **Cartwheel.** Mainly frontal plane, about an anteroposterior axis (front to back).
3. **Upright spin.** Transverse plane, about a longitudinal axis (head to foot). Real actions can combine planes.

A side view does not reveal every component of a throw

Choose the camera geometry to match the question

Identify the joint and phase, calibrate distance and know frame rate. Keep the camera fixed and approximately perpendicular to the main movement plane.

Use visible landmarks consistently; perspective and hidden landmarks introduce uncertainty.

A two-dimensional recording can hide out-of-plane movement. It does not establish injury causation.

Distinguish bending, moving sideways and moving across the chest

Movement pair	**Definition and sporting phase**
Flexion / extension	Usually decrease / increase joint angle; bend / straighten elbow
Abduction / adduction	Move away from / towards midline; raise / lower arm sideways
Horizontal flexion / extension	Move raised arm across chest / reverse; mainly transverse **plane**

Do not confuse circumduction with axial rotation

Movement pair	Anatomical description
Rotation / circumduction	Turn about segment's long **axis** / distal end traces a cone through combined movements
Pronation / supination	Forearm turns palm backwards / forwards from anatomical reference
Dorsiflexion / plantarflexion	Foot towards shin / pointing away; distinguish from whole-leg motion

Describe the foot, shoulder girdle and thumb accurately

Movement pair	Reference and action
Inversion / eversion	Sole turns towards / away from midline
Protraction / retraction	Shoulder girdle moves forwards / backwards around chest
Elevation / depression	Structure moves up / down, as in shrugging
Opposition / reposition	Thumb towards fingertips / return

Different connective tissues solve different mechanical problems

Tissue	**Structure/function connection**
Bone / tendon	Rigid support/lever; tendon transmits muscle tension to bone
Ligament	Usually connects bone to bone; limits excessive motion
Cartilage / fascia	Smooth load-bearing joint covering; surrounding/connective tissue links structures

Not every articulation has a fluid-filled cavity

Joint group	Structure and movement
Fibrous	Dense connective tissue; skull sutures have very limited movement
Cartilaginous	Cartilage links elements; pubic symphysis and intervertebral-body joints
Synovial	Fluid-filled cavity, articular cartilage and capsule; movement depends on shape/supports

Match synovial shape to permitted motion

Class	Example and movement
Hinge / pivot	Elbow flexion–extension / proximal radioulnar rotation
Ball-and-socket / condyloid	Shoulder multi-axis / radiocarpal wrist mainly two-axis movement
Saddle / **plane**	Thumb-base motions supporting opposition / intercarpal gliding

Range and stability depend on the task and supporting structures

Compare shoulder and hip without declaring a universal winner

The shoulder supports a large range for reaching and throwing; soft-tissue control is important.

The hip's deeper socket and strong supports suit load bearing and stability. Capsule, ligaments and muscles all contribute.

The knee is a modified hinge with some rotation. Joint categories simplify living movements; more mobility is not automatically better.

All-or-none does not mean one possible whole-muscle force

A motor unit is one neuron and the fibres it supplies

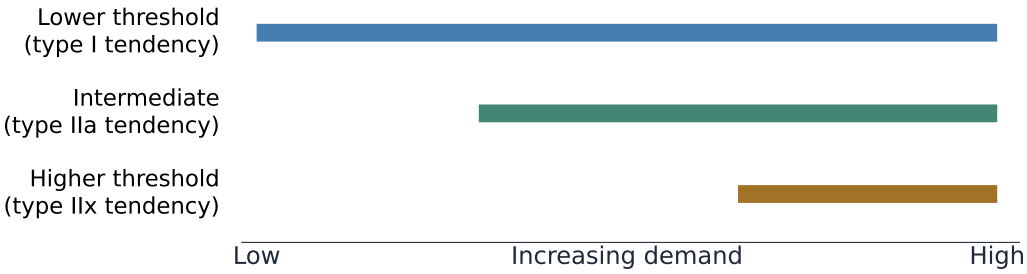
A motor-neuron action potential normally activates all fibres in its unit. All-or-none describes the electrical response to sufficient stimulation.

Whole-muscle force changes with recruitment and firing rate; twitch force also depends on length, fatigue and conditions.

Smaller, lower-threshold units are generally recruited first. More demanding actions add higher-threshold units.

Increasing demand recruits additional units

Additional units join; earlier-recruited units remain active



Required force: illustrative recruitment thresholds

Later recruitment adds units; it does not switch earlier units off.

Compare fibre tendencies rather than inventing exclusive fuels

Fibre type	Relative functional tendency
I	Slow; fatigue resistant; strong oxidative capacity
IIa	Faster; substantial oxidative and glycolytic capacities
IIx	High shortening speed and rapid force potential; fatigues more rapidly in sustained repeated work

Capacity changes can alter the activation needed for the same load

Muscle size and neural activation are related but different

Hypertrophy increases fibre size and can increase force capacity; atrophy reduces it.

Neural adaptations and altered capacity can change recruitment requirements for a fixed external task.

Larger fibres do not automatically mean more motor neurons. All active fibre types require ATP.

Name the active muscle's behaviour during each phase

1. **Raise a dumbbell.** Elbow flexors shorten while active: concentric action.
2. **Hold it still.** Elbow angle and overall active-muscle length remain approximately fixed: isometric action.
3. **Lower under control.** Elbow flexors lengthen while active: eccentric action. Lengthening does not mean the muscle is relaxed.

Constant speed, constant length and constant tension are distinct

Use contraction terminology with its physical meaning

The syllabus uses isotonic concentric/eccentric for dynamic actions; strictly isotonic means constant tension, which ordinary free weights do not guarantee.

Isokinetic action maintains specified angular velocity using suitable resistance; it does not imply constant force.

An isometric hold still consumes ATP despite zero external work on the stationary load.

Agonist and antagonist are roles in a specified action

Reciprocal inhibition supports movement; co-contraction supports control

Elbow flexors are agonists for flexion and extensors are antagonists; roles change for active extension. Synergists assist and stabilizers support other segments.

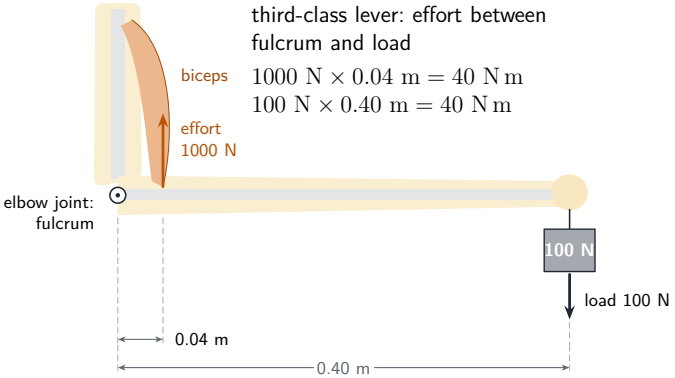
Reciprocal inhibition can reduce antagonist activation during an agonist-driven action.

Antagonists can still co-contract for stability. They are not necessarily completely inactive.

The relative positions identify the lever class

Class	Order and example
First	Effort–fulcrum–load: seesaw; simplified head-extension model
Second	Fulcrum–load–effort: wheelbarrow; simplified heel raise
Third	Fulcrum–effort–load: elbow flexion; forearm moving a held implement

A short muscle moment arm requires a large effort force



Use perpendicular moment arms, not the full length of the bone.

Balance turning effects in a static lever

1. **Load moment.** 100 N $\times$ 0.40 m = 40 newton metres.
2. **Effort and advantage.** 40/0.04 = 1,000 N. Mechanical advantage = 0.04/0.40 = 0.10.
3. **Change one condition.** With effort arm 0.05 m, effort = 800 N. With original 0.04 m arm and extra segment moment 20 $\times$ 0.15 = 3, effort = 1,075 N.

Include segment weight when it is supplied

1. **Practice load.** 120 N $\times$ 0.30 m $=$ 36 newton metres; effort arm 0.045 m gives 800 N.
2. **Add segment weight.** 15 N $\times$ 0.12 m $=$ 1.8 newton metres. Total 37.8; effort $37.8/0.045 = 840$ N.
3. **Model limit.** Mechanical advantage $= 0.15$. Joint reaction also balances forces; acceleration and other loads need a fuller analysis.

Longer implements exchange force demand for movement possibilities

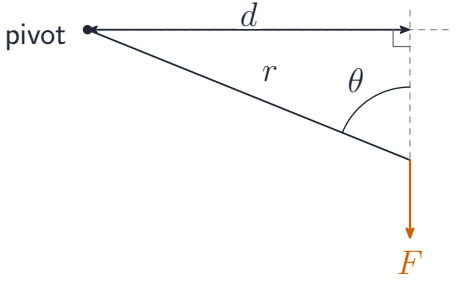
A lever does not provide free energy

A longer radius gives greater endpoint speed at the same angular velocity, but can increase rotational inertia and resisting moments.

Mechanical advantage is effort arm divided by load arm. First-class levers can have advantage above or below one.

Choose equipment for the person and task; a longer racket is not automatically easier to accelerate.

The moment of a force



Moment $= Fd$

Distinguish average net force from peak ground reaction

1. **Same momentum change.** 150 kg metres per second / 0.30 s = 500 N; over 0.60 s = 250 N.
2. **Practice.** 180 / 0.50 = 360 N; 180 / 1.00 = 180 N. A longer interval lowers average net force for this fixed change.
3. **Boundary.** The force-time curve determines peaks. Weight and other forces distinguish net force from ground reaction; do not provoke impacts to collect class data.

State the segment and direction before combining models

Use safe supplied data or consented ordinary low-risk movement

The base of support is the area enclosed by supporting contacts. Its size and centre-of-mass position affect stability, developed further in B2.

Joint angles, muscle action, moments and impulse describe different features of one movement.

A video needs calibration, known frame rate and consistent landmarks. It is not a clinical diagnosis or rehabilitation prescription.

AHL: A product can fit the median and exclude half the sample

1. **Invented records.** Hand lengths 160, 165, 170, 175, 180, 185, 190, 195, 200, 205 mm; median = 182.5 mm.
2. **Fit range.** 175–195 mm includes five of ten records: 50%. Hand breadth, finger reach, gloves and the task also matter.
3. **Design.** A control must accommodate shorter reaches; clearance must accommodate larger dimensions. Adjustability and representative user trials are useful.

AHL: Match the database and measurement procedure to the users

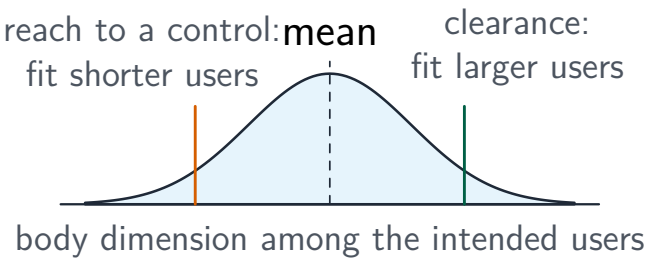
Anthropometry measures segments and proportions

Define landmarks, posture and instruments; repeated and between-observer readings help evaluate reliability.

Adult elite-athlete dimensions need not represent schoolchildren or wheelchair athletes. A mean does not cover every relevant combination of dimensions.

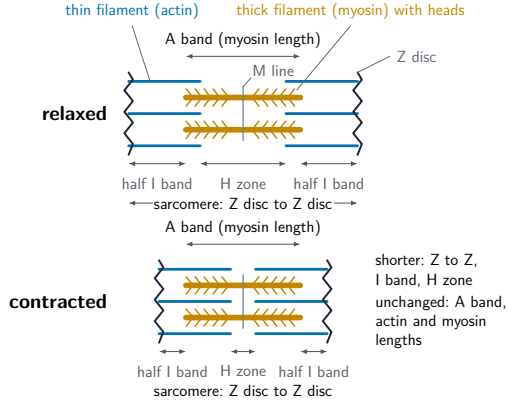
Practice: 150, 160, 170, 180, 190, 200, 210, 220 mm has median 185 mm; 170–200 mm includes four of eight, again 50%.

Design for the range of users



Clearance: design for the largest

AHL: Overlap increases without shortening either filament



Z discs approach while the thick-filament span stays constant.

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AHL: Separate regulation, force generation and detachment

1. **Regulation.** Excitation releases calcium from sarcoplasmic reticulum; calcium binds troponin, moving tropomyosin away from actin's binding sites.
2. **Cycle.** Energized myosin binds actin and power strokes slide the thin filaments. ATP binding permits detachment; hydrolysis re-energizes the head.
3. **Restoration.** ATP-powered calcium uptake reduces activation. Without ATP, heads do not simply detach and relax.

AHL: Test the sliding model against structural measurements

1. **Invented comparison.** Sarcomere 2.4 $\rightarrow$ 2.0 micrometres: shortening about 16.7%; thick span remains 1.6.
2. **Practice.** 2.5 $\rightarrow$ 2.0 gives 20% shortening. Z-disc separation falls, overlap increases, I bands and H zone narrow.
3. **Invariant and limit.** A band and filament lengths remain unchanged. A static image cannot show every molecular event.

Attempt the handout questions before checking the worked answers

Name structures, trace mechanisms and calculate with units

Describe anatomical positions and movements; connect joint tissues and shapes to movement and stability.

Explain graded recruitment and contraction types; calculate lever moments and effort, and distinguish impulse from a peak force.

AHL: evaluate anthropometric fit and explain sarcomere structure, regulatory proteins and ATP.

Check the quantitative conclusions and their assumptions

1. **Lever.** Load moment 36 newton metres; effort 800 N; advantage 0.15. With segment weight, total moment 37.8 and effort 840 N.
2. **Impulse.** Average net forces 360 and 180 N; neither alone gives peak ground reaction.
3. **Interpretation.** Use perpendicular moment arms, distinguish net from individual forces and state which loads the model omits.

Check yourself

Define the reference, phase and model before explaining

Plane and axis are perpendicular; position terms need reference structures. Tendons transmit muscle force; ligaments usually link bones.

Active lengthening is eccentric; a fixed hold still consumes ATP. Recruitment grades force despite all-or-none electrical responses.

AHL: median fit does not establish population fit. Filaments slide without shortening; calcium regulates access and ATP supports cycling, detachment and restoration.