Unit 2 Lever Systems, Planes and Axes

Learning objective: Develop your knowledge and understanding of lever systems, axes and planes of movement in the body and the use of each in different sporting movements

Knowledge Checklist

	Revised	Understood	What you need to do
Be able to label and draw the different components of a lever system			
Be able to identify and describe first-, second- and third-class lever systems			
Be able to identify types of levers in the body during sporting movements and link them to different sporting movements			
Be able to name and describe the planes and axes of movement			
Be able to identify the planes and axes of movement used in specific sporting movements			
Be able to perform a movement analysis			

Key Terms

1. **Fulcrum** – the point at which a lever is balanced, or the point at which a lever rotates
2. **Effort** – the force applied to a lever system
3. **Resistance/load** – the opposing resistance to the effort
4. **Resistance arm** – the distance between the fulcrum and the resistance
5. **Effort arm** – the distance between the fulcrum and the effort
6. **Mechanical advantage** – the advantageous features of a particular lever, based on the type of lever system
7. **Frontal plane** – plane that divides the body into front and rear
8. **Transverse plane** – plane that divides the body into upper and lower
9. **Sagittal plane** – plane that divides the body into right and left
10. **Axis** – a theoretical straight line that the body rotates about
11. **Longitudinal axis** – axis that travels from head to toe
12. **Sagittal axis** – axis that travels through the body from rear to front
13. **Transverse axis** – axis that travels through the body from left to right

First-, Second- and Third-class Lever Systems

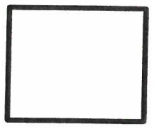
In human bodies, levers are used to create movement around a joint. They are made up of three components:

- **fulcrum**
- **effort**
- **resistance**

The fulcrum is the point at which a lever is balanced, or where rotation occurs around. The effort is the point and direction a force is applied to the lever system. The resistance/load is the force acting against the effort. These three components are usually represented in the following ways:

Fulcrum

Effort
(the direction of the arrow can change)



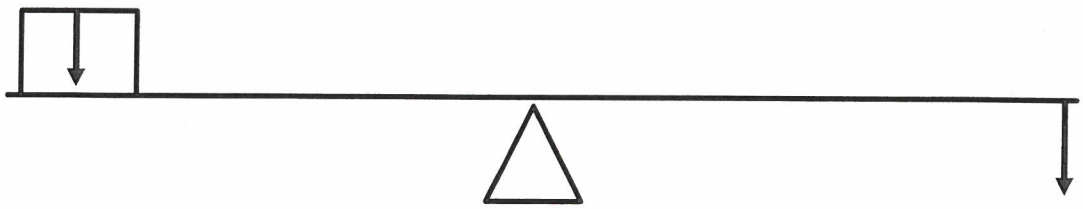
Resistance/Load
(the direction of resistance depends on the type of lever system, but it always works against the effort)

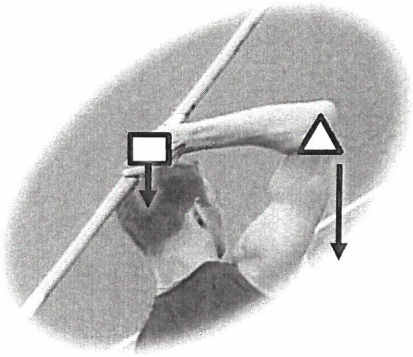
REVISION TIP!

Remembering the order of the components of lever systems is as easy as '**123... FLE**'. This tells you what the middle component will be for each lever system (first-class lever system = fulcrum, second-class = load, and third-class = effort).

First-class Levers

First-class levers have the fulcrum placed between the effort and resistance. This is represented as follows:





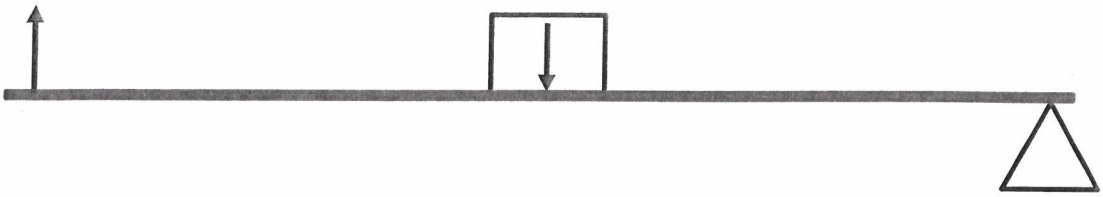
Take this javelin thrower who is about to extend his elbow. The resistance is his hand and the weight of the javelin. The fulcrum point is his elbow and the effort is his triceps contracting, pulling downwards.

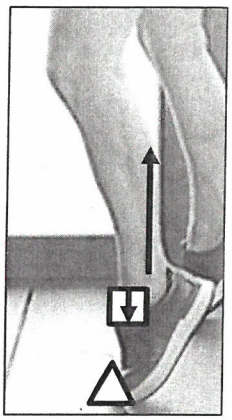
REVISION TIP!

In this example, the resistance acts in the same direction as the effort. Think of this lever as a see-saw. Even though the resistance is acting in the same direction as the effort, the location of the fulcrum means that it creates an opposing force to the effort.

Second-class Levers

Second-class lever systems have the fulcrum at a far end of the lever, then the resistance next closest to it and finally, the effort at the opposite end of the lever:





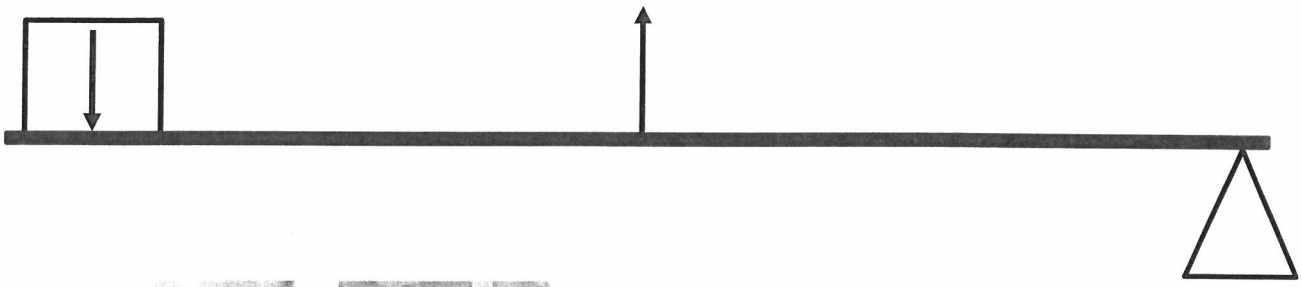
REVISION TIP!

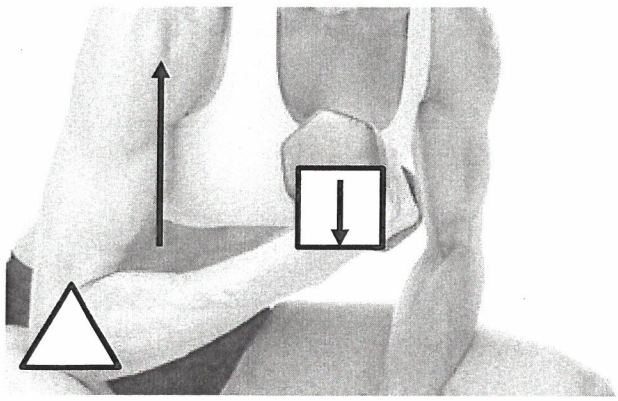
In this example, the resistance acts in the opposite direction to the effort. Think of this lever as a wheelbarrow.

When someone performs dorsiflexion, they are using a second-class lever system. The fulcrum is located at the toes, with the resistance being the mass of the leg and foot pulling downwards. The effort comes from the gastrocnemius, pulling the ankle upwards to go onto tiptoes.

Third-class Levers

Third-class lever systems have the fulcrum at a far end of the lever, then the effort next closest to it and, finally, the load at the opposite end of the lever:





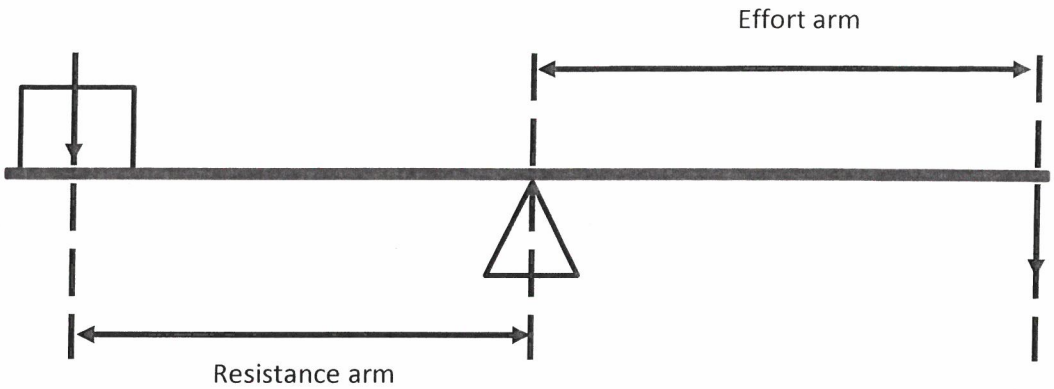
When someone performs a bicep curl, flexing the elbow, they are using a third-class lever system. The fulcrum is at the elbow joint. The resistance is located at the hand/weight and the effort originates at the biceps, lifting the lower arm.

Mechanical Advantages

In levers, different systems have different **mechanical advantages**. The mechanical advantages help an element of movement within that particular lever system. Mechanical advantage can be calculated by dividing the **effort arm** length by the **resistance arm** length.

- Resistance arm – the distance between the fulcrum and the resistance/load
- Effort arm – the distance between the fulcrum and the effort

For example, in a first-class lever system:



REVISION TIP!

The resistance arm length and the effort arm length change, depending on the location of the fulcrum, resistance and effort.

Mechanical advantage = effort arm ÷ resistance arm

Lever System	Mechanical Advantages
First-class	• Movements can be balanced • Wider range of movement than second-class lever
Second-class	• Can move a large load with a small effort • Can only move the large load over a small range of movement
Third-class	• Movement can be completed quickly over a large range of motion

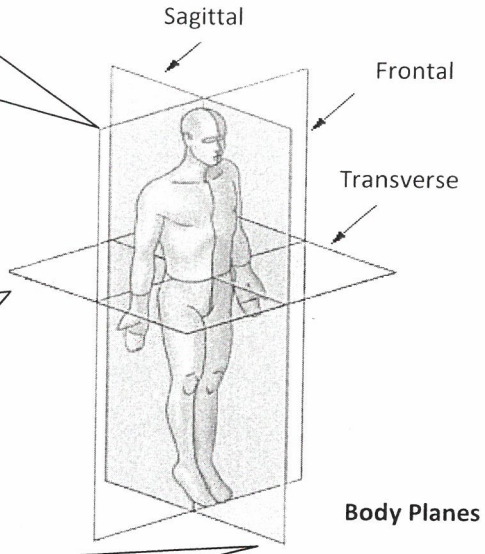
Planes and Axes of Movement

Whenever a movement is being completed by a body, it is acting in one of three **planes**: frontal, transverse or sagittal.

Frontal
The frontal plane divides the body into front and back, which means any **sideways motion** in line with this plane occurs in this plane. Elevation, depression, adduction and abduction are the common movements which take place in this plane, e.g. cartwheel.

Transverse
The transverse plane divides the body into upper and lower parts, which means any **rotational motion** occurs in this plane. Horiztonal extension, horizontal flexion, rotation, pronation and supination are common movements which take place in this plane (e.g. golf drive).

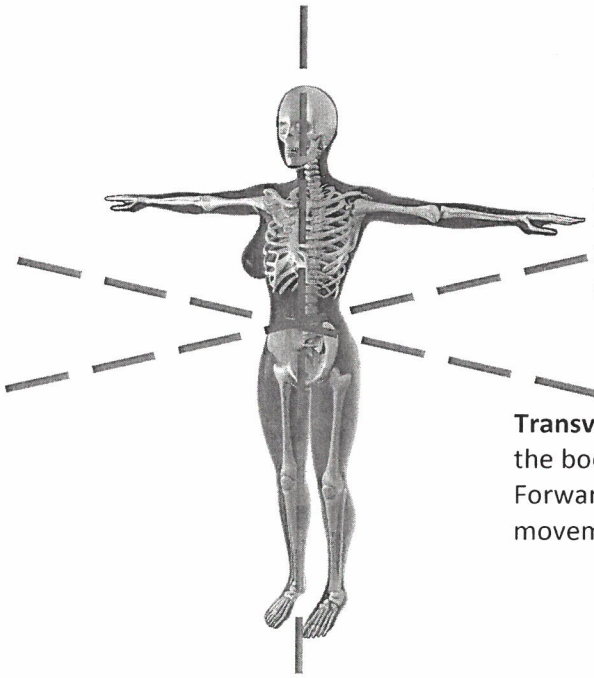
Sagittal
The sagittal plane divides the body into a right side and a left side, with **forwards or backwards motion** in line with this plane occuring in the sagittal plane. Plantar flexion, dorsiflexion, extension and flexion are the movements that take place in this plane (e.g. somersault).



Body Planes

Movements also occur around one of three axes. These are called the **axes of rotation**. There are three axes of rotation: longitudinal, sagittal and transverse.

Longitudinal axis – travels through the head down to the feet. Rotational movements occur around this axis.



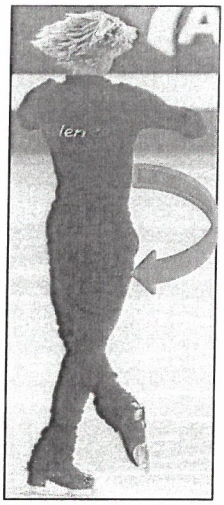
Frontal axis – passes through the body from the rear to the front. Side-to-side movements occur around this axis.

Transverse axis –passes through the body from right to left. Forwards and backwards movements occur around this axis.

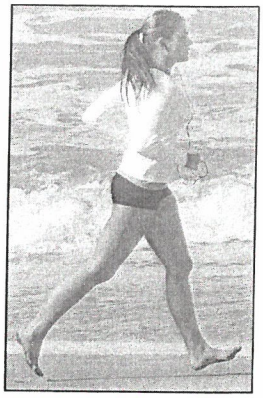
Linking Planes of Movement to Axes of Movement

When a movement is completed by the body, it is acting in both a plane of movement and an axis of movement at the same time. Consider the following examples:

A cartwheel is a side-to-side motion so it is acting in the frontal plane. Rotation is occurring so that the girl can rotate her whole body from left to right. Therefore, the cartwheel is performed around the frontal axis.

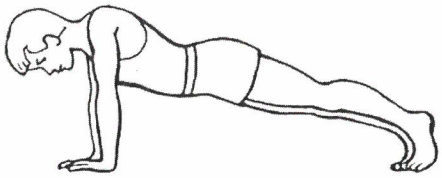


When this ice skater is spinning on the spot, he is moving in the transverse plane and around the longitudinal axis.



Running is a forwards motion, so it occurs in the sagittal plane. Running occurs around the transverse axis.

In Chapter 1, you revised the types of movement that can occur at specific joints and the muscles that cause the movements. You should now be able to analyse sporting examples and the types of movement occurring at joints, the planes and axes the movement occurs in, and the type of contraction taking place.



Upwards Phase

Movement at elbow: extension

Agonist: triceps

Type of contraction: concentric

Plane of movement: sagittal

Axis of movement: transverse

Downwards Phase

Movement at elbow: flexion

Agonist: triceps

Type of contraction: eccentric

Plane of movement: sagittal

Axis of movement: transverse

Drive Phase

Movement at ankle: plantar flexion
Agonist and contraction: gastrocnemius, concentric

Movement at hip: extension
Agonist and contraction: gluteals, concentric

Movement at knee: extension
Agonist and contraction: quadriceps, concentric

Plane of movement: sagittal

Axis of movement: transverse

Recovery Phase

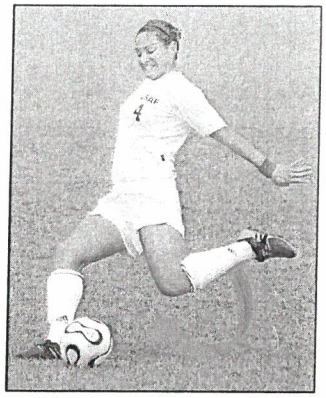
Movement at ankle: dorsiflexion
Agonist and contraction: tibialis anterior, concentric

Movement at hip: flexion
Agonist and contraction: hip flexors, concentric

Movement at knee: flexion
Agonist and contraction: hamstrings, concentric

Plane of movement: sagittal

Axis of movement: transverse



Execution Phase When Kicking (Left Leg)

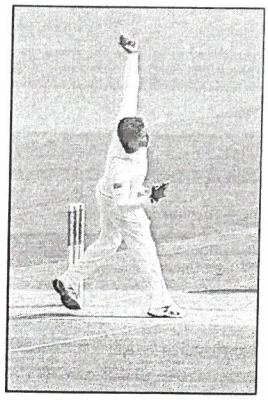
Movement at ankle: plantar flexion
Agonist and contraction: gastrocnemius, isometric

Movement at hip: flexion
Agonist and contraction: hip flexors, concentric

Movement at knee: extension
Agonist and contraction: quadriceps, concentric

Plane of movement: sagittal

Axis of movement: transverse



Cricket Bowl

Movements at shoulder: rotation and extension
Agonists: rotator cuff muscles and deltoids

Plane of movement: transverse

Axis of movement: longitudinal

Squat – Downwards Phase

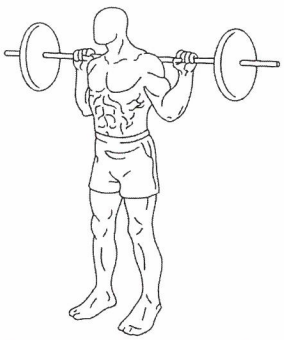
Movement at ankle: dorsiflexion
Agonist and contraction: gastrocnemius, eccentric

Movement at hip: flexion
Agonist and contraction: gluteals, eccentric

Movement at knee: flexion
Agonist and contraction: quadriceps, eccentric

Plane of movement: sagittal

Axis of movement: transverse



Squat – Upwards Phase

Movement at ankle: plantar flexion
Agonist and contraction: gastrocnemius, concentric

Movement at hip: extension
Agonist and contraction: gluteals, concentric

Movement at knee: extension
Agonist and contraction: quadriceps, concentric

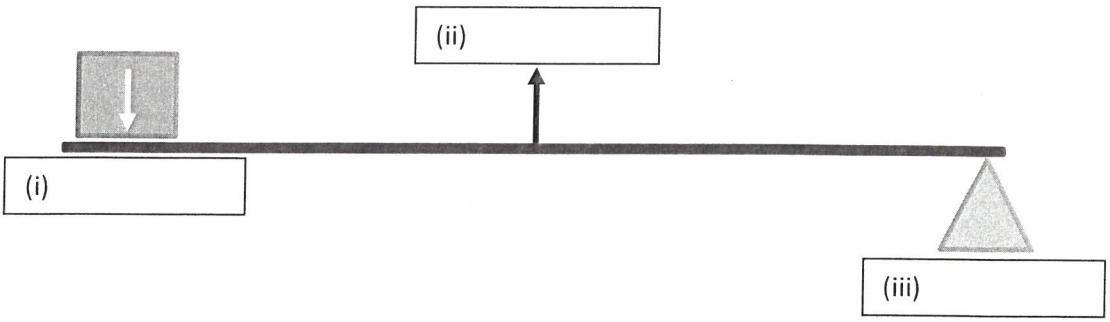
Plane of movement: sagittal

Axis of movement: transverse

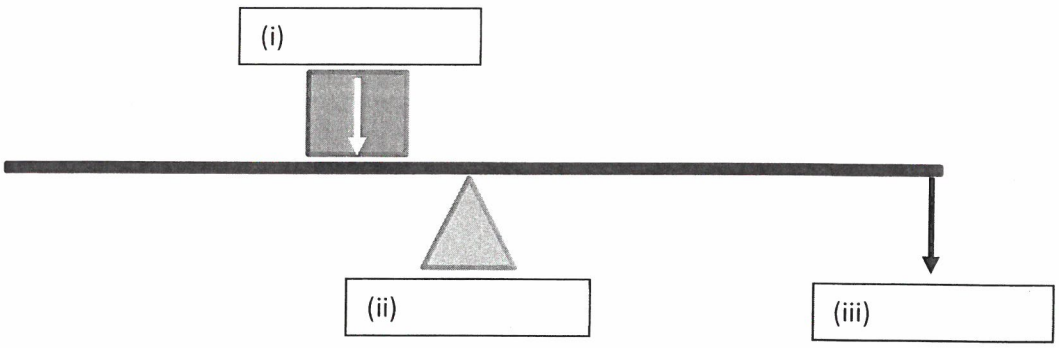
1. Label the following lever systems, identifying the fulcrum, effort and resistance and name the type of lever system. **THIRD-CLASS and FIRST-CLASS**

a)

Type of lever system:



Type of lever system:



b)

2. Draw a second-class lever system occurring at the ankle.

3. Name the mechanical advantage of a second-class lever system.

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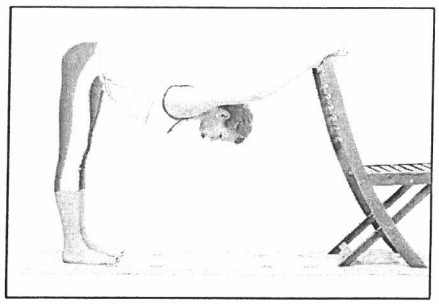
4. a) A ballerina bends forwards and stretches before practice in the position shown.



What plane and axis of movement is the skill being performed in?

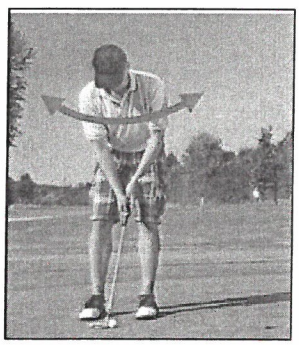
Plane of movement: .....

.....

Axis of movement: .....

.....

b) A golfer is performing a putt.



What plane and axis of movement are the shoulders and arms moving in?

Plane of movement: .....

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Axis of movement: .....

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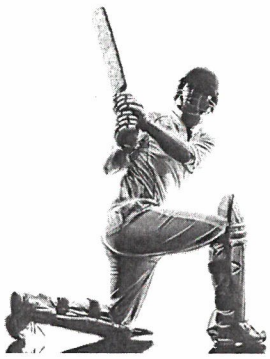
c) A cricket batsman twists his upper body to hit the ball away from the fielders.



What plane and axis of movement is the skill being performed in?

Plane of movement: .....

.....

Axis of movement: .....

.....

1. At the moment of take-off, a high jumper plantar flexes to start their jump.

   Identify the type of lever being used and describe the mechanical advantage of this lever system.

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   (2 marks)

2. It is important to know the mechanical advantage a lever system has, to assess the efficiency of movement.

   How is mechanical advantage calculated?

   .....

   (1 mark)

3. Below is an image of an ice skater skating in a straight line.

   Identify the plane of movement and axis of movement that the ice skater is completing her skill in.

   Plane: .....

   Axis: .....

   (2 marks)

