When you have worked through this chapter, you will have developed a knowledge and understanding of:

- first, second and third class levers and their use in physical activity
- mechanical advantage and disadvantage of the body’s lever systems and the impact this has on sporting performance
- planes and axes of movement applied to sporting actions.
Levers are seen in everyday life as well as in sport and exercise. A lever system is a rigid bar that moves around a fixed fulcrum with two forces applied to it. Levers can change the size or direction of the effort used to make a task more manageable.

All levers consist of three key elements:

1 Fulcrum: a fixed pivot point.
2 Effort: the source of the energy that will do the work.
3 Load: the weight/resistance to be moved.

**Activity**

The picture shows how a lever can be useful.

a) Explain how this lever works and what advantage a person gains using a lever in this situation.

b) Can you identify the fulcrum, effort and load in the picture?

**First, second and third class levers**

There are three classes of lever: first class levers, second class levers and third class levers. The positioning of the fulcrum, load and effort in relation to each other will determine what class the lever is.

In the human body, the musculo-skeletal system creates levers around every joint. These allow us to move. The joint acts as the fulcrum, effort comes from contracting muscles and the load is the body part being moved, plus any additional objects held or resistance met. The body contains all classes of lever, but third class levers are most common.
### Class of lever | Lever drawing | Well-known example for you to remember easily | Best example in the human body
--- | --- | --- | ---
**First class lever** | ![First class lever diagram](image1.png) | ![Fulcrum, Load, Effort](image2.png) | ![Fulcrum, Load, Effort](image3.png)
**Second class lever** | ![Second class lever diagram](image4.png) | ![Fulcrum, Load, Effort](image5.png) | ![Fulcrum, Load, Effort](image6.png)
**Third class lever** | ![Third class lever diagram](image7.png) | ![Fulcrum, Load, Effort](image8.png) | ![Fulcrum, Load, Effort](image9.png)

### Exam tip
It is important to think about where a muscle attaches to the bone when labelling the effort. This is especially key at the elbow. The biceps attach between the fulcrum (the elbow joint) and the load, meaning a biceps curl uses a third class lever. The triceps attach behind the fulcrum, meaning that a triceps extension uses a first class lever.

### Activities
1. Using a ruler, a rubber and a pencil, make a first class, second class and third class lever. You will need to act as the effort.
2. Experiment with the examples of levers in the human body given, to increase your understanding. Nod your head backwards and forwards imagining the pivot point in the middle (first class lever); move up and down on your tip toes pivoting on the ball of your foot (second class lever); and perform the upward phase of a biceps curl, recognising that your biceps muscle is pulling on your forearm (third class lever).
There are two main benefits of lever systems:

1. Large loads can be moved with a relatively small amount of effort.
2. The distance a load can be moved, or the speed with which it can be moved, can be increased without an increase in effort.

To work out the benefit of a particular lever, you need to look at the length of two arms. The distance from the load to the fulcrum is known as the **load arm**, while the distance from the effort to the fulcrum is known as the **effort arm**.

### Activity

4. Draw a simple diagram of each of the three lever classes and label the effort arm and load arm. Here is an example of a first class lever to show you how this is done.

#### Mechanical advantage and disadvantage

**Mechanical advantage**

When a lever's effort arm is longer than its load arm it is said to have **mechanical advantage**. Levers with mechanical advantage can move large loads with a relatively small amount of effort. They have a high load force to effort ratio. Second class levers always have mechanical advantage.

If we consider a long jumper taking off, we see how the second class lever, where the foot contacts the ground, has a high mechanical advantage because the effort arm is longer than the load arm. The result of this, for the long jumper, is that the force produced by the muscles, which is relatively small, is able to drive the full weight of the athlete off the ground.

**Key terms**

- **Load arm**: The distance from the load to the fulcrum.
- **Effort arm**: The distance from the effort to the fulcrum.

**Key term**

- **Mechanical advantage**: Second class levers allow a large load to be moved with a relatively small amount of muscular effort.
Mechanical disadvantage
When a lever’s load arm is longer than its effort arm, it is said to be at a mechanical disadvantage. It has a low load force to effort ratio. Third class levers always have mechanical disadvantage.

Despite operating at mechanical disadvantage, third class levers are able to increase the distance covered and, therefore, the speed at the end of a lever arm. They can produce a larger range of movement with relatively low effort.

The hip joint is a third class lever. It cannot produce the same load force to effort ratio as a second class lever. However, this doesn’t mean that it is not good at what it does. Third class levers can take a small movement near the fulcrum and make a large movement where the load is. This provides a relatively large range of movement, which results in relatively high speed being produced.

First class levers: mechanical advantage and disadvantage
In the case of first class levers, the position of the fulcrum is key. If the fulcrum is closer to the load, then relatively low effort will result in larger, more powerful movements at the load end; there will be mechanical advantage. If the fulcrum is closer to the effort, then the lever will operate at mechanical disadvantage but will produce a larger range of movement at the end of the lever and greater speed as a result.

Activity
a) Look at these rowers and discuss the class of lever that the oars create.

b) What is the benefit of this lever system to the rowers’ performance?
Planes and axes can be used when describing movement patterns. A plane is an imaginary line or surface that divides the body into two. Movement occurs in a plane. An axis is an imaginary line around or about which the whole body or part of the body can turn.

Planes and axes are both drawn through a body standing in the anatomical position (upright, with arms by the side of the body and palms facing forwards). All movements are then described from this starting point.

Key terms

**Plane:** An imaginary line dividing the body into two.

**Axis:** An imaginary line around which a body or body part can turn. "Axes" is the plural of axis.

- The **frontal plane** divides the body vertically from front to back. Movement occurs in the frontal plane about the **sagittal axis**. The **sagittal axis** passes horizontally through the body from front to back, allowing abduction and adduction.

- The **transverse plane** divides the body horizontally from front to back. Movement occurs in the transverse plane about the **vertical axis**. The **vertical axis** passes vertically through the body, allowing rotation of the body in an upright position.
By looking at the diagrams and photographs together, we can see that:

- A cartwheel in gymnastics or dance takes place in the frontal plane around the sagittal axis.
- A full twist jump in trampolining takes place in the transverse plane around the vertical axis.
- A somersault in gymnastics or diving (front/back and piked/tucked) takes place in the sagittal plane around the frontal axis.

**Key terms**

- **Frontal plane**: An imaginary line dividing the body vertically from front to back.
- **Sagittal plane**: An imaginary line dividing the body vertically into left and right sides.
- **Transverse plane**: An imaginary line dividing the body horizontally from front to back.
- **Frontal axis**: An imaginary line passing horizontally through the body from left to right, allowing flexion and extension.
- **Sagittal axis**: An imaginary line passing horizontally through the body from front to back, allowing abduction and adduction.
- **Vertical axis**: An imaginary line passing vertically through the body, allowing rotation of the body in an upright position.

**Activity**

6 a) Make a model of a person standing in the anatomical position from Plasticine or Play-Doh. Use a pencil as an axis and two pieces of card as a plane. Push your pencil through your model and attach a piece of card to either side to represent the corresponding plane. If you spin your pencil, the model will rotate around that axis and in line with the plane.

b) Can you think of other sporting actions that take place in the planes and around the axes described on these two pages? They can be whole body movements or movements that involve only part of the body.

c) Use your model to make a video presentation explaining planes and axes, using the examples you came up with for part b.

**Exam tip**

A wheel on a bike spins around a central axle. This is how an axis works. If you had an axis through your belly button, you’d spin like a wheel.

Think of a plane as a thick sheet of glass that you’re trapped tightly inside. Movements that take place in that plane can only occur in the direction that the sheet of glass allows.
Exam-style questions

1 Which one of the following describes a third class lever? (1)
   A The load is to the right of the fulcrum
   B The effort is in the middle of the lever
   C The load is in the middle of the lever
   D The fulcrum is on the left of the lever

2 Which one of the following is an example of a first class lever? (1)
   A A car jack
   B A nutcracker
   C A wheelbarrow
   D A pair of tweezers

3 Which one of the following puts the correct plane and axis together? (1)
   A Sagittal plane with vertical axis
   B Sagittal plane with frontal axis
   C Transverse plane with sagittal axis
   D Frontal plane with frontal axis

4 Which one of the following levers provides mechanical advantage? (1)
   A First class lever where the fulcrum is exactly in the middle
   B First class lever where the fulcrum is nearer the effort
   C Third class lever
   D Second class lever

5 Identify the axis of movement for the cartwheel shown in Figure 1. (1)

6 Figure 2 shows a high jumper during take off.

7 When sprinting, the knee joint of a footballer uses a third class lever system.
Examine the role of the lever in a footballer’s running performance. (3)

8 Using examples, describe how mechanical advantage or disadvantage is determined in a lever system. (4)

9 Evaluate the extent to which second and third class levers impact the performance of a sprinter. (9)

10 Using examples, evaluate how knowledge of different movement planes and axes can assist a gymnast in performing specific movements correctly. (9)