Effects on Biomechanical Movement in Sports and Physical Activities

Distance and Displacement

Distance and displacement measure how far a body or an object has travelled.

Distance is how far a person or an object has travelled between the start and end positions. It is the length of the path taken as the person or object moves from one position to another. It is measured in metres (m).

Displacement is the change in overall position of a person or an object. It is the length of the straight line between the start and end positions after movement. It is measured in metres (m). For example, a person who runs 400 m around a running track has a displacement of 0 m as his start and end positions are the same.

Speed and Velocity

Speed and velocity measure how fast a body or an object moves.

Speed is the rate of change of distance without considering direction. It is measured in metres per second (m/s or ms^{-1}).

$$\text{Speed } (ms^{-1}) = \frac{\text{Distance (m)}}{\text{Time taken (s)}}$$

Velocity is how fast a body travels in a certain direction, which is the rate of change of displacement. Velocity is a more precise representation of motion as it measures how fast a body is moving and in what direction. It is measured in metres per second (m/s or ms^{-1}).

$$\text{Velocity } (ms^{-1}) = \frac{\text{Displacement (m)}}{\text{Time taken (s)}}$$

Acceleration and Deceleration

Acceleration and deceleration measure the rate of change of velocity. Acceleration occurs when rate of change of velocity increases and deceleration occurs when rate of change of velocity decreases. Both are measured in metres per second (m/s^2 or ms^{-2}).

$$\text{Acceleration } (ms^{-2}) = \frac{\text{Change in velocity } (ms^{-1})}{\text{Time taken (s)}}$$

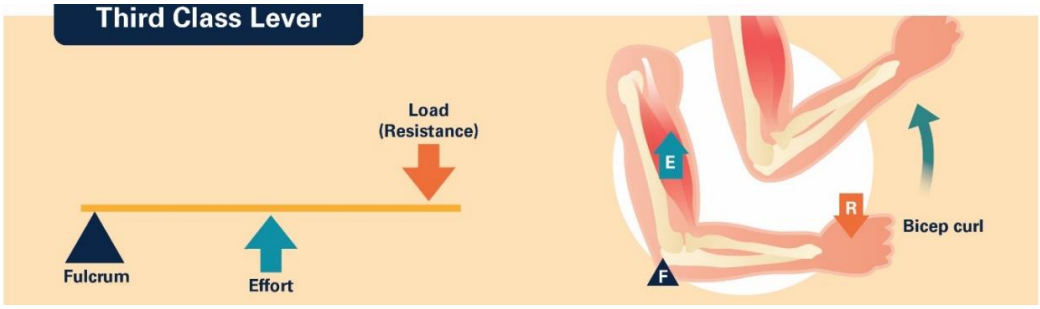
$$= \frac{\text{Final velocity } (ms^{-1}) - \text{Initial velocity } (ms^{-1})}{\text{Time taken (s)}}$$

Third Class Lever

a. Effort (force) is located between the load (resistance) and the fulcrum.

b. Common in human bodies.

c. An example is the bicep curl: the fulcrum is the elbow joint; the load (resistance) is the forearm, wrist and hand; and effort (force) is applied through the bicep muscles when the elbow is flexed.



*Refer to **Annex B** for infographic on 'Different Classes of Levers in the Human Body'*

Summation of Forces

Summation of forces refers to the sum of all forces generated by each body part. It also requires all relevant body parts to move in sequence (from the largest muscles to the smallest) for maximum force to be generated.

Generally, movement skills (e.g., smashing, kicking, throwing) involve the motion of more than one segment of the body. In order to generate maximum force when executing the movement skill, it is important to make use of as many relevant body segments as possible, in a sequential manner.

For example, a badminton player performing a smash transfers his weight from the rear leg to the front leg while sequentially turning the torso, extending the shoulder followed by the arm and flexing the wrist upon contact with the shuttle.

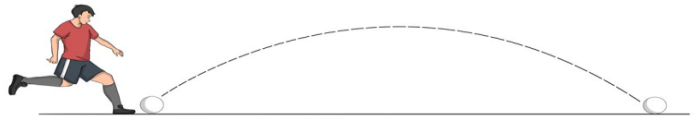
Projectile Motion

Projectile motion refers to the motion of a projected object (e.g., a shot put, a javelin, a human body during pole-vaulting) acted on by forces of gravity and air resistance.

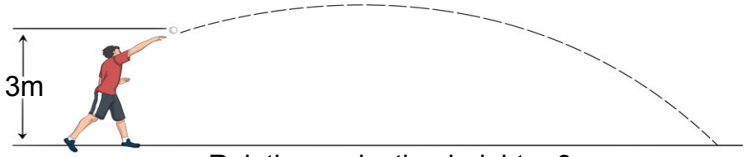
In sports, once the projected object is released or thrown in the air, control of the object is no longer possible. Therefore, it is important to consider the following factors that affect the flight path of the projectile prior to its release:

a. Height at release

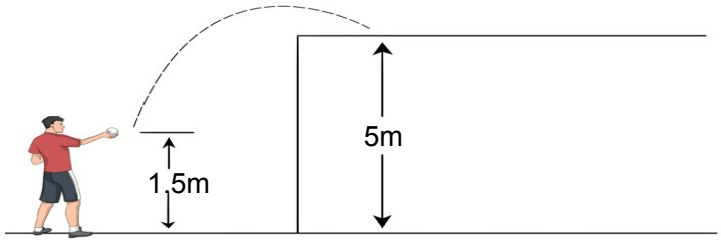
- Relative projection height refers to the difference in the height from which the body is projected and that at which it lands or stops.



Relative projection height = 0

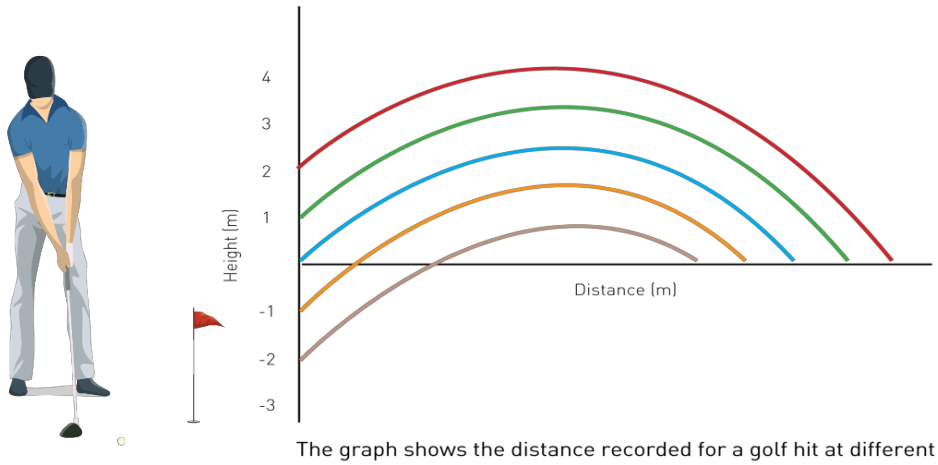


Relative projection height = 3m



Relative projection height = -3.5m

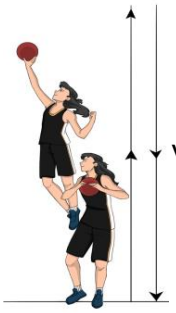
- The difference between the projection height and landing height determines the flight time and horizontal displacement. A greater relative projection height will increase the maximum distance and flight time of the projectile.

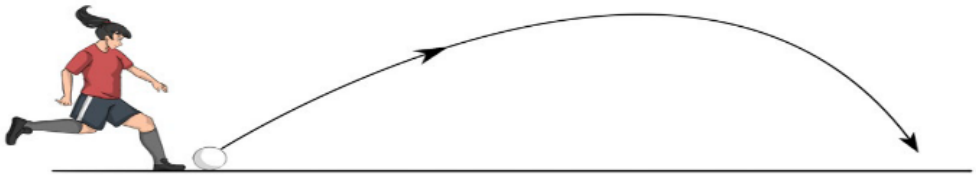


The graph shows the distance recorded for a golf hit at different projection heights. The velocity at release and angle of release are the same for all the projection heights.

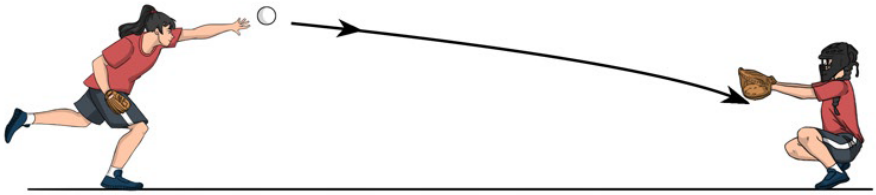
b. Angle of release

- Angle of release refers to the angle at which the projectile is thrown.
- The direction of projection with respect to the horizontal determines the shape of flight.



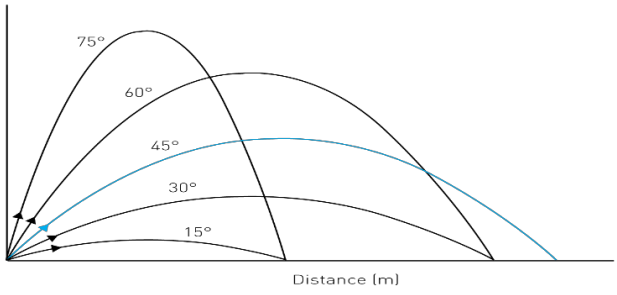


Oblique trajectory



Horizontal trajectory

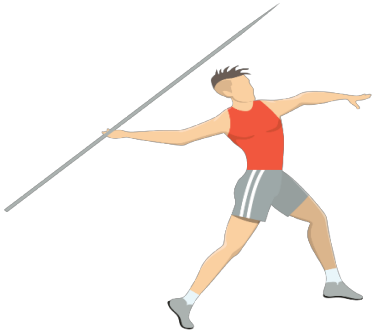
- A higher projection angle will result in a higher maximum height achieved by the projectile. When the relative projection height is zero, for the projectile to achieve a greater maximum distance, the projection angle should be close to 45 degrees.

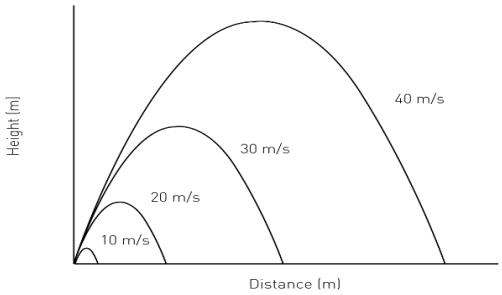


The graph shows the distance recorded for a football kick at different projection angles. The velocity at release is constant for all the projection angles while the relative projection height is zero.

c. Velocity at release

- The speed of projection determines the length of trajectory (range).
- A higher velocity at release will increase the maximum distance and flight time of the projectile.





The graph shows the distance recorded for a javelin throw at different projection speeds. The angle of release and height at release are constant for all the projection speeds.

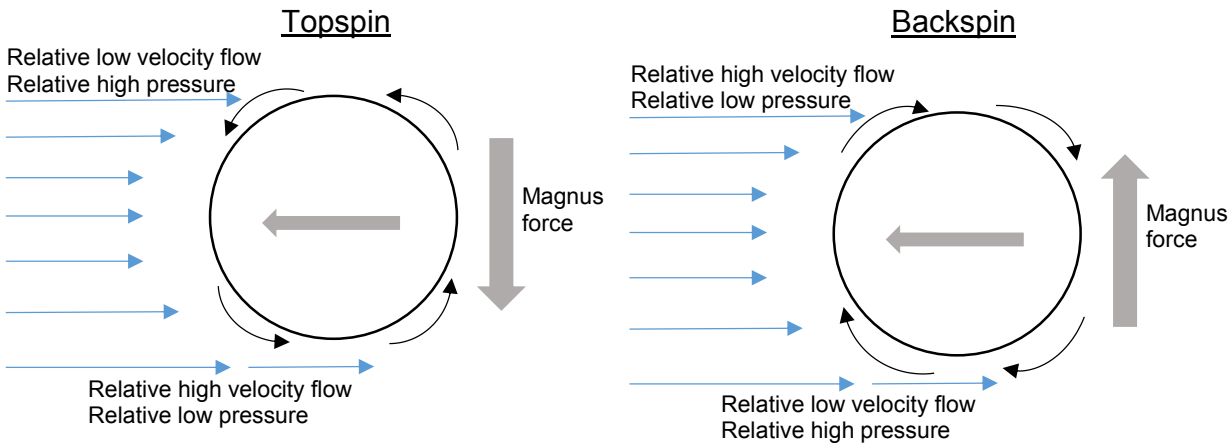
*Refer to **Annex C** for infographic on 'Projectile Motion'*

Magnus Effect

For round projectile objects such as balls, it is also possible to influence the flight path by spinning the object. The lift force created by the spin results in the Magnus effect.

When a spinning ball moves through the air, it creates a difference in pressure between the top and bottom of the ball. The interaction between the air layer on the side of the ball that is rotating in the same direction as the surrounding air, but against the direction that the ball is moving in, causes an area of low pressure to form. The other side of the ball, where the air layer is moving against the direction of the surrounding air, slows the air down and thus creates an area of high pressure.

The difference in pressure creates what is called the Magnus force, a lift force directed from the high-pressure zone to the low-pressure zone. The Magnus force affects the flight path of the spinning ball as it travels through the air, causing the moving ball to deviate gradually along the direction of the spin (i.e., towards the low-pressure zone). This deviation is known as the Magnus effect.



The Magnus effect is employed in the following types of spin: