Chapter 10

Linear Kinematics of Human Movement

Basic Biomechanics, 6th edition
By Susan J. Hall, Ph.D.

Linear Kinematic Quantities

How do we define kinematics?

- the pattern or sequencing of movement with respect to time
- the appearance of a motion
- Visually observable aspects of technique or form

Linear Kinematic Quantities

Movement kinematics is also referred to as form or technique.

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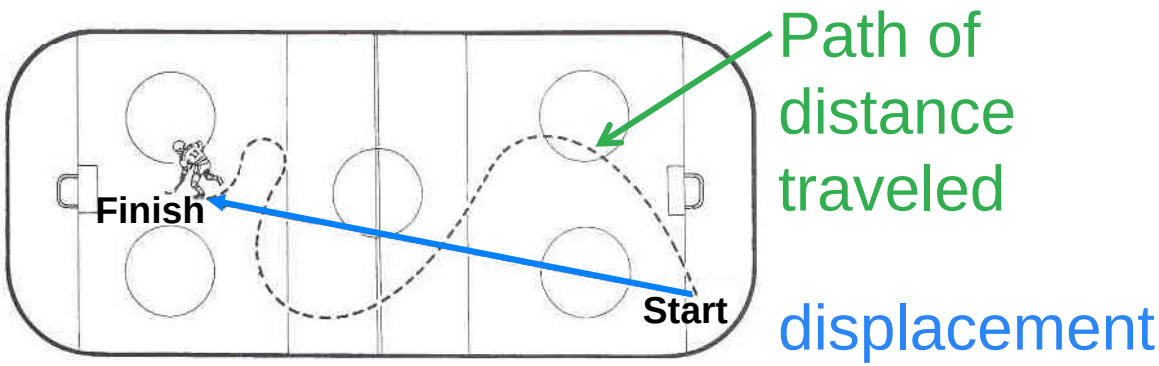
Linear Kinematic Quantities

What is linear displacement?

- change in location
- the directed distance from initial to final location
- the vector equivalent of linear distance
- measured in units of cm, m, km

Linear Kinematic Quantities



The distance a skater travels may be measured from the track left on the ice. The skater's displacement is measured in a straight line from start to finish.

Linear Kinematic Quantities

What is linear speed?

- distance covered over the time taken
- $\text{speed} = \frac{\text{distance}}{\text{time}}$
- a scalar quantity
- measured in units of $\frac{m}{s}$

Linear Kinematic Quantities

Running speed is the product of stride length and stride frequency.

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Linear Kinematic Quantities

What is linear velocity?

- the rate of change in location
- velocity = $\frac{\text{displacement}}{\text{time}}$ $v = \frac{d}{t}$
- the vector equivalent of linear speed
- measured in units of $\frac{m}{s}$

Linear Kinematic Quantities

What is acceleration?

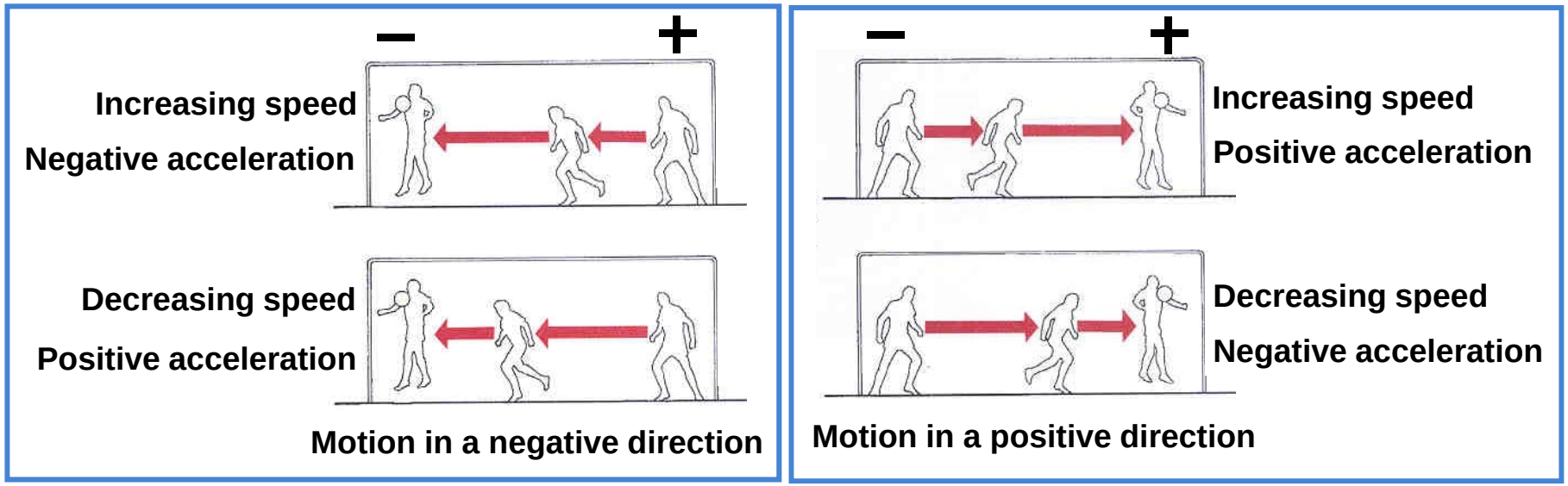
- the rate of change in linear velocity

- acceleration = $\frac{\text{change in velocity}}{\text{time}}$

- $a = \frac{v_2 - v_1}{t}$

- measured in units of $\frac{m}{s}$

Linear Kinematic Quantities



Acceleration may be positive, negative, or equal to zero, based on the direction of motion and the direction of the change in velocity.

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Linear Kinematic Quantities

Sliding into base involves negative acceleration of the base runner.

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Kinematics of Projectile Motion

What is a projectile?

(a body in free fall that is subject only to the forces of gravity and air resistance)

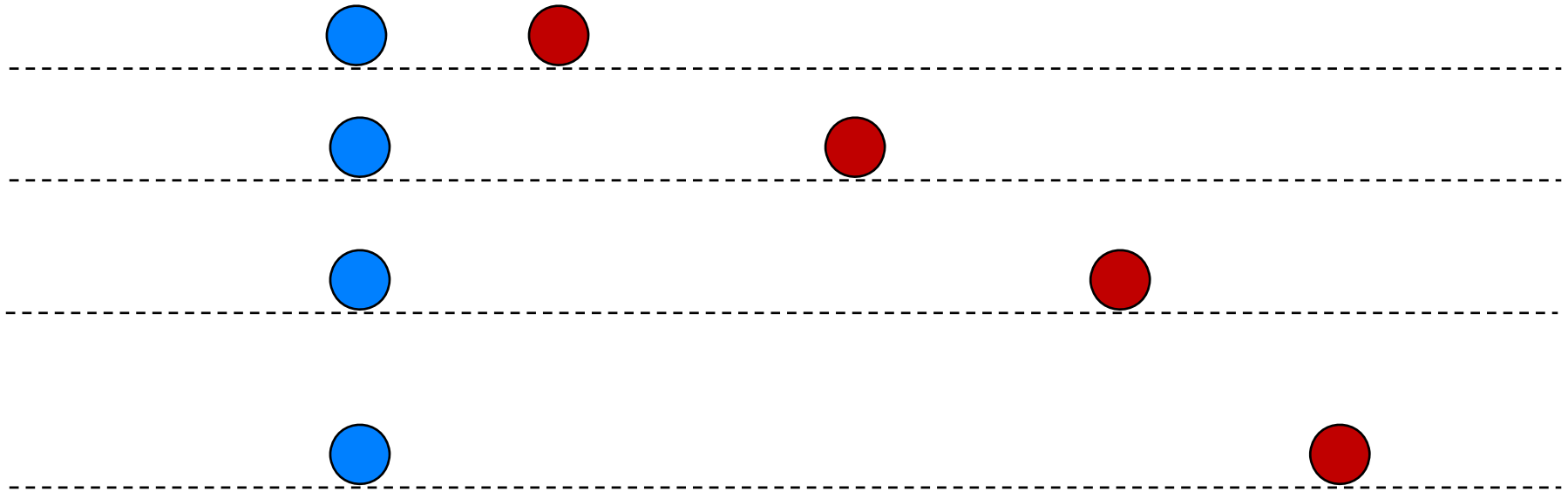
Kinematics of Projectile Motion

Why do we analyze the horizontal and vertical components of projectile motion separately?

(the vertical component is influenced by gravity and the horizontal component is not)

Kinematics of Projectile Motion

Two balls - one dropped and one projected horizontally from the same height:



Both land at the same time since gravity affects their vertical velocities equally.

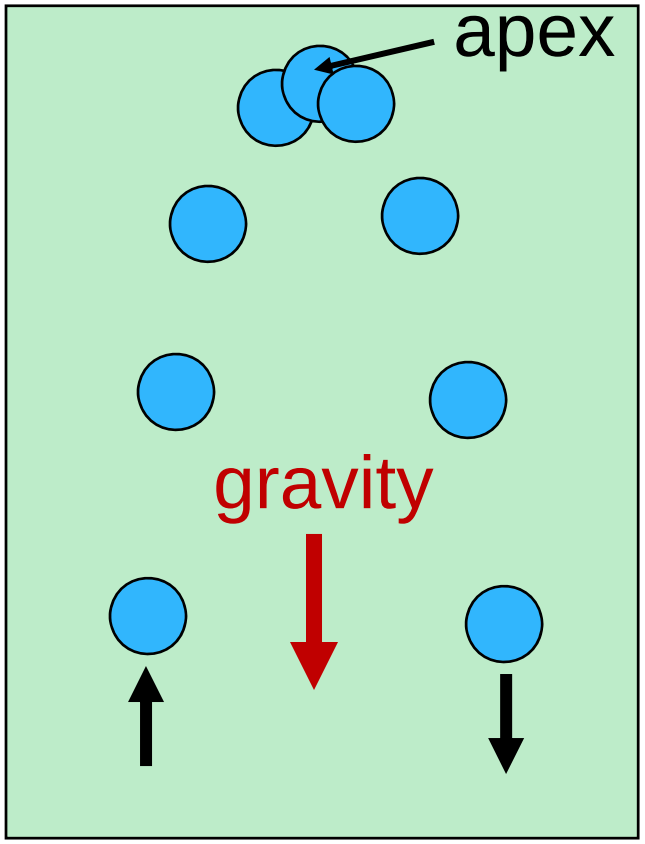
Kinematics of Projectile Motion

What is the effect of gravity?

(The force of gravity produces a constant acceleration of -9.81 m/s^2 on bodies near the surface of the earth.)

Kinematics of Projectile Motion

The pattern of change in the vertical velocity of a projectile is symmetrical about the apex.



Vertical velocity decreases as the ball rises and increases as the ball falls due to the influence of gravitational force.

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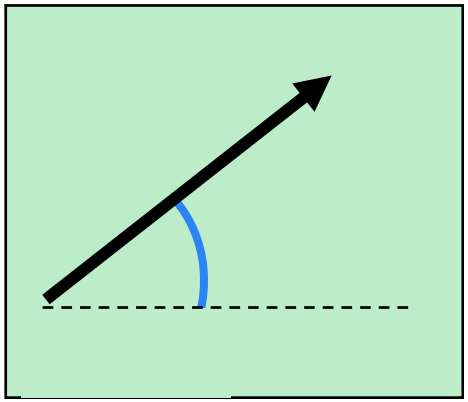
Factors Influencing Projectile Trajectory

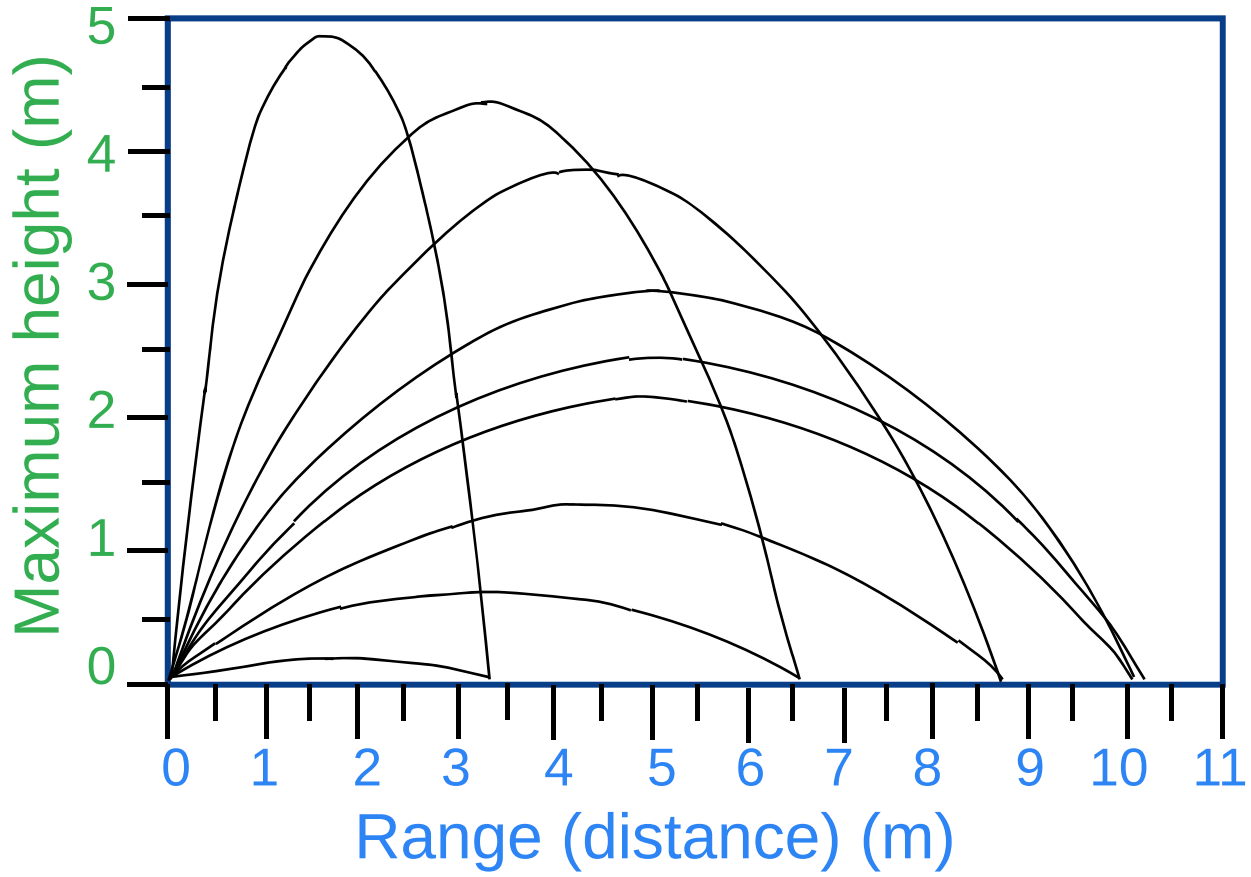
What factors influence the trajectory (flight path) of a projectile?



- projection angle - the direction of projection with respect to the horizontal

Factors Influencing Projectile Trajectory

This scaled diagram shows the size and shape of trajectories for an object projected at 10 m/s at different angles.



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Factors Influencing Projectile Trajectory

The Effect of Projection Angle on Range (Relative Projection Height = 0)

Projection Speed (m/s)	Projection Angle (degrees)	Range (m)
10	10	3.49
10	20	6.55
10	30	8.83
10	40	10.04
10	45	10.19
10	50	10.04
10	60	8.83
10	70	6.55
10	80	3.49

Factors Influencing Projectile Trajectory

Projection angle is particularly important in shooting a basketball. A common error among novice players is shooting the ball with too flat a trajectory.

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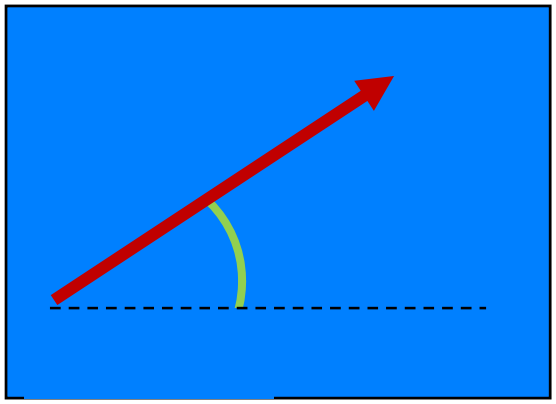

- projection speed - the magnitude of projection velocity

Factors Influencing Projectile Trajectory

The instantaneous velocity of the shot at the moment of release primarily determines the ultimate horizontal displacement of the shot.

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Factors Influencing Projectile Trajectory

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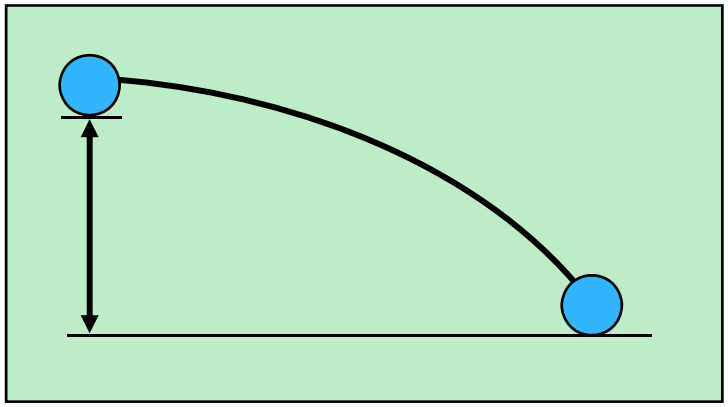

- relative projection height - the difference between projection height and landing height

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Factors Influencing Projectile Trajectory

FACTORS INFLUENCING PROJECTILE MOTION (Neglecting Air Resistance)	
Variable	**Factors of Influence**
Flight time	Initial vertical velocity Relative projection height
Horizontal displacement	Horizontal velocity Relative projection height
Vertical displacement	Initial vertical velocity Relative projection height
Trajectory	Initial speed Projection angle Relative projection height

Factors Influencing Projectile Trajectory

The human body becomes a projectile during the airborne phase of a jump.

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