Chapter 10
Linear Kinematics of Human Movement

Linear Kinematic Quantities
How do we define kinematics?
• the form, pattern, or sequencing of movement with respect to time
• the appearance of a motion

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

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 velocity?
• the rate of change in location
  \[ \text{velocity} = \frac{\text{displacement}}{\text{time}} = \frac{d}{t} \]
• the vector equivalent of linear speed
• measured in units of \( \text{m/s} \)

The velocity of a swimmer in a river is the vector sum of the velocities of swimmer and current.
Linear Kinematic Quantities

What is acceleration?
• the rate of change in linear velocity
  \[ \text{change in velocity} \]
• acceleration = \[ \frac{v_f - v_i}{t} \] m/s
• measured in units of s

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

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)

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.

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.

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.

Factors Influencing Projectile Trajectory

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

- projection speed - the magnitude of projection velocity

Factors Influencing Projectile Trajectory

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

<table>
<thead>
<tr>
<th>Projection Speed (m/s)</th>
<th>Projection Angle (degrees)</th>
<th>Range (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>3.49</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>6.55</td>
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<td>10</td>
<td>30</td>
<td>8.83</td>
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<td>70</td>
<td>6.55</td>
</tr>
<tr>
<td>10</td>
<td>80</td>
<td>3.49</td>
</tr>
</tbody>
</table>

Factors Influencing Projectile Trajectory

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

- relative projection height - the difference between projection height and landing height
Factors Influencing Projectile Trajectory

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factors of Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight time</td>
<td>Initial vertical velocity, Relative projection height</td>
</tr>
<tr>
<td>Horizontal displacement</td>
<td>Horizontal velocity, Initial vertical velocity</td>
</tr>
<tr>
<td>Vertical displacement</td>
<td>Relative projection height, Initial vertical velocity, Relative projection height</td>
</tr>
<tr>
<td>Trajectory</td>
<td>Initial speed, Projection angle, Relative projection height</td>
</tr>
</tbody>
</table>

Analyzing Projectile Motion

The Equations of Constant Acceleration

1. \( v_2 = v_1 + at \)  
2. \( d = v_1 t + \frac{1}{2} at^2 \)  
3. \( v_2^2 = v_1^2 + 2ad \)

These equations may be used to relate linear kinematic quantities whenever acceleration (a) is a constant, unchanging value.