# Kinematics Reference Guide

## The Three Equations of Motion

### First Equation of Motion

**$v = u + at$**

Where:

- v = final velocity (m/s)
- u = initial velocity (m/s)
- a = acceleration ($m/s^2$)
- t = time (s)

This equation relates velocity, acceleration, and time.

### Second Equation of Motion

**$s = ut + \frac{1}{2}at^2$**

Where:

- s = displacement (m)
- u = initial velocity (m/s)
- t = time (s)
- a = acceleration ($m/s^2$)

This equation gives displacement in terms of initial velocity, time, and acceleration.

### Third Equation of Motion

**$v^2 = u^2 + 2as$**

Where:

- v = final velocity (m/s)
- u = initial velocity (m/s)
- a = acceleration ($m/s^2$)
- s = displacement (m)

This equation relates velocities, acceleration, and displacement (time-independent).

## Key Concepts

### Displacement vs Distance

- **Displacement**: Vector quantity (direction matters)
- **Distance**: Scalar quantity (magnitude only)

### Velocity vs Speed

- **Velocity**: Vector (includes direction)
- **Speed**: Scalar (magnitude of velocity)

### Acceleration

Rate of change of velocity with time. Can be positive (speeding up) or negative (slowing down).

## Problem-Solving Steps

1. **Identify given values**
2. **Determine what to find**
3. **Choose appropriate equation**
4. **Substitute values**
5. **Solve and check units**

## Common Problem Types

### Type 1: Finding Final Velocity

Given: u, a, t

Use: $v = u + at$

### Type 2: Finding Displacement

Given: u, a, t

Use: $s = ut + \frac{1}{2}at^2$

### Type 3: Time-Independent Problems

Given: u, v, a

Use: $v^2 = u^2 + 2as$

## Sign Conventions

- **Positive direction**: Usually upward or rightward
- **Negative direction**: Usually downward or leftward
- **Gravity**: $g = -9.8$ m/s² (when upward is positive)

## Example Problem

A car accelerates from rest at 2 m/s² for 5 seconds.

**Given:**

- $u = 0$ m/s (from rest)
- $a = 2$ m/s²
- $t = 5$ s

**Find final velocity:** $v = u + at = 0 + (2)(5) = 10$ m/s

**Find displacement:** $s = ut + \frac{1}{2}at^2 = 0(5) + \frac{1}{2}(2)(5)^2 = 25$ m

## Quick Reference Table

| Given Variables | Use Equation | To Find |
|---|---|---|
| u, a, t | $v = u + at$ | v |
| u, a, t | $s = ut + \frac{1}{2}at^2$ | s |
| u, v, a | $v^2 = u^2 + 2as$ | s |
| u, v, t | $s = (u + v)t/2$ | s |

## Units

- Displacement/Distance: meters (m)
- Velocity/Speed: meters per second (m/s)
- Acceleration: meters per second squared ($m/s^2$)
- Time: seconds (s)

## Tips for Success

- Always define your coordinate system
- Check if acceleration is constant
- Pay attention to signs (positive/negative)
- Verify units in final answer
- Sketch the motion when possible