Chapter 3: Kinematics in Two Dimensions; Vectors

Giancoli Text Sections

3-1 Vectors and Scalars
3-2 Addition of Vectors—Graphical Methods
3-3 Subtraction of Vectors, and Multiplication of a Vector by a Scalar
3-4 Adding Vectors by Components
3-5 Projectile Motion
3-6 Solving Problems Involving Projectile Motion

Summary

This chapter moves the concepts of position, displacement, velocity, and acceleration into the two-dimensional world. In two dimensions, direction can no longer be indicated simply by positive and negative signs. Vectors and vector manipulations, important for the remainder of the course, are introduced. Projectile motion, or motion of an object under the influence of gravity only, is treated thoroughly.

Major Concepts

By the end of the chapter you should understand each of the following and be able to demonstrate their understanding in problem applications as well as in conceptual situations.

- Scalars (magnitude only)
- Vectors (magnitude and direction)
  - Components
  - Addition and subtraction
- Vector position, displacement, velocity, and acceleration
- Motion in two dimensions
  - Components of velocity and acceleration
  - Equations of motion for constant acceleration and constant velocity
- Projectile Motion
  - Acceleration due to gravity: g
  - Independence of horizontal and vertical motions
  - Air resistance
  - Basic equations
    - General case
    - Special case: takeoff and landing at same height

Formulas

FOR TRIANGLES:

sin θ = opposite side / hypotenuse

cos θ = adjacent side / hypotenuse

tan θ = opposite side / adjacent side

FOR PROJECTILE MOTION:

Solve in 2 parts... horizontal and vertical

Horizontal part: $v = \Delta x / t$

Vertical part:

$g = (v_f - v_0)/ t$	(use when you don't know or need how high it went)
$\Delta x = v_0 t + 1/2\ g\ t^2$	(use when you don't have or need the final velocity)
$\Delta x = (v_f^2 - v_0^2) / 2g$	(use when you don't have or need time)

SPECIAL CASE:
Use this formula to calculate the range* when the takes off and lands at the same height:

$R = (v_0^2 \sin 2\theta)/ g$
where "R" is the range and v_0 is the initial velocity at angle θ
* the "range" R is simply the object's horizontal displacement.

Projectile Motion Problem Solving Tips

1) Find the vertical and horizontal components of velocity using trig... then keep them separate.
2) Always use the horizontal velocity component when using $v = \Delta x / t$ to solve for the horizontal movement. Remember, the horizontal velocity never changes throughout the problem.
3) Always use the vertical velocity component when calculating the vertical movement. Use any of your acceleration formulas shown above for the vertical analysis. IMPORTANT: The vertical velocity you calculated in step 1 represents the initial vertical velocity. Remember that gravity will slow the object's vertical motion when moving upward and speed up the vertical velocity as it falls.
4) Always look at the horizontal motion as separate and independent from the vertical motion even though they occur simultaneously.