# LECTURE 09: Projectile motion

Select LEARNING OBJECTIVES:

i. Understand the strict definition of projectile motion.
ii. Demonstrate the ability to describe the motion of an object in both 1-D and 2-D scenarios through the use of kinematic equations with constant acceleration.
iii. Understand the vector nature of the kinematic equations. Specifically how x and y components are decoupled under the constraint of no air resistance.
iv. Demonstrate the ability to quantitatively solve algebraic expressions, including quadratic equations.
v. Begin the development of problem solving strategies, which includes but is not limited to translating problems into different representations, determining knowns/unknowns, and identifying the relevant physics.
vi. Demonstrate the ability to construct kinematic equations with the knowns and unknowns which are specific to a problem

TEXTBOOK CHAPTERS:

- Giancoli (Physics Principles with Applications 7th) :: 3-5 ; 3-6 ; 3-7
- Knight (College Physics : A strategic approach 3rd) :: 3.6 ; 3.7
- BoxSand :: Kinematics ( Projectile Motion )

Projectile motion is a special case of 1-D and 2-D motion (1-D is often referred to as free fall), where the object of interest is only influenced by gravity (i.e. no horizontal acceleration, and only the acceleration is due to gravity in the vertical direction). There is nothing new to point out here other than that definition of projectile motion. Otherwise these problems are still analyzed with kinematic equations and all the other assumptions about air resistance, point particle approximation, etc… are the same.

PRACTICE: A cart is rolling on a horizontal table when a ball is launched from the cart, vertically as seen with respect to the cart. Where does the ball land with respect to the cart?

1. In front of the cart.
2. Behind the cart.
3. On the cart.

PRACTICE: (a) Draw a motion diagram for a ball rolling across a table at a constant velocity.

(b) Draw a motion diagram for a ball dropped from rest. Let the initial position of this ball be the initial position of the ball from part (a).

(c) Use your knowledge of how the horizontal and vertical components of motion are treated to draw a motion diagram of a ball launched horizontally from a table with the same initial velocity as the ball from part (a). Use the initial position of the ball from part (a) and (b) as your initial position for this motion diagram.

PRACTICE: Ball A with mass m is dropped at rest from a height h above the ground. At the same instant ball B with mass 2m is launched horizontally with a speed of 20 m/s from the same height that ball A was dropped. Which ball hits the floor first?

1. A
2. B
3. Both hit at the same time.

PRACTICE: A baseball is hit 1.0 m above the ground, at an angle of 30° above the horizontal.

1. If it's speed after being hit is 40 m/s, how far will the baseball travel before hitting the ground?

1. Draw graphs of the vertical acceleration and horizontal acceleration vs time.

1. Draw graphs of the vertical velocity and horizontal velocity vs time.

1. Draw graphs of the vertical position and horizontal position vs time.

## Conceptual questions for discussion

1) Discuss the statement, acceleration due to gravity is -9.8 $m/s^2$.
2) By ignoring air resistance, there is no real world application of projectile motion. Comment on this statement. Provide examples that support your thoughts.
3) Discuss the following statement: A baseball undergoes projectile motion after it is thrown through the air at some angle above the horizontal. At the top of the trajectory, the velocity of the baseball is zero.