Devil Physics
Baddest Class on Campus
AP Physics

LSN 3-5: PROJECTILE MOTION
LSN 3-6: SOLVING PROJECTILE MOTION PROBLEMS

Two-Dimensional Projectile Motion

Useful Applications of Projectile Motion

VĬDÉÒS INTRŌDŰĆTÎÖNĀLĘ

Big Idea(s):

- Big Idea 3: The interactions of an object with other objects can be described by forces.
- Big Idea 4: Interactions between systems can result in changes in those systems.

Enduring Understanding(s):

- All forces share certain common characteristics when considered by observers in inertial reference frames.
- The acceleration of the center of mass of a system is related to the net force exerted on the system, where

$$\vec{a} = \frac{\vec{F}}{m}$$

Essential Knowledge(s):

- An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.
  - Displacement, velocity, and acceleration are all vector quantities.
  - Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.
  - A choice of reference frame determines the direction and the magnitude of each of these quantities.

Essential Knowledge(s):

- Forces are described by vectors.
  - Forces are detected by their influence on the motion of an object.
  - Forces have magnitude and direction.
- The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

Essential Knowledge(s):

- The acceleration is equal to the rate of change of velocity with time, and velocity is equal to the rate of change of position with time.
  - The acceleration of the center of mass of a system is directly proportional to the net force exerted on it by all objects interacting with the system and inversely proportional to the mass of the system.
  - Force and acceleration are both vectors, with acceleration in the same direction as the net force.

Learning Objective(s):

- The student is able to express the motion of an object using narrative, mathematical, and graphical representations.
- The student is able to design an experimental investigation of the motion of an object.

Learning Objective(s):

- The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations.
- The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.

Learning Objective(s):

- The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.

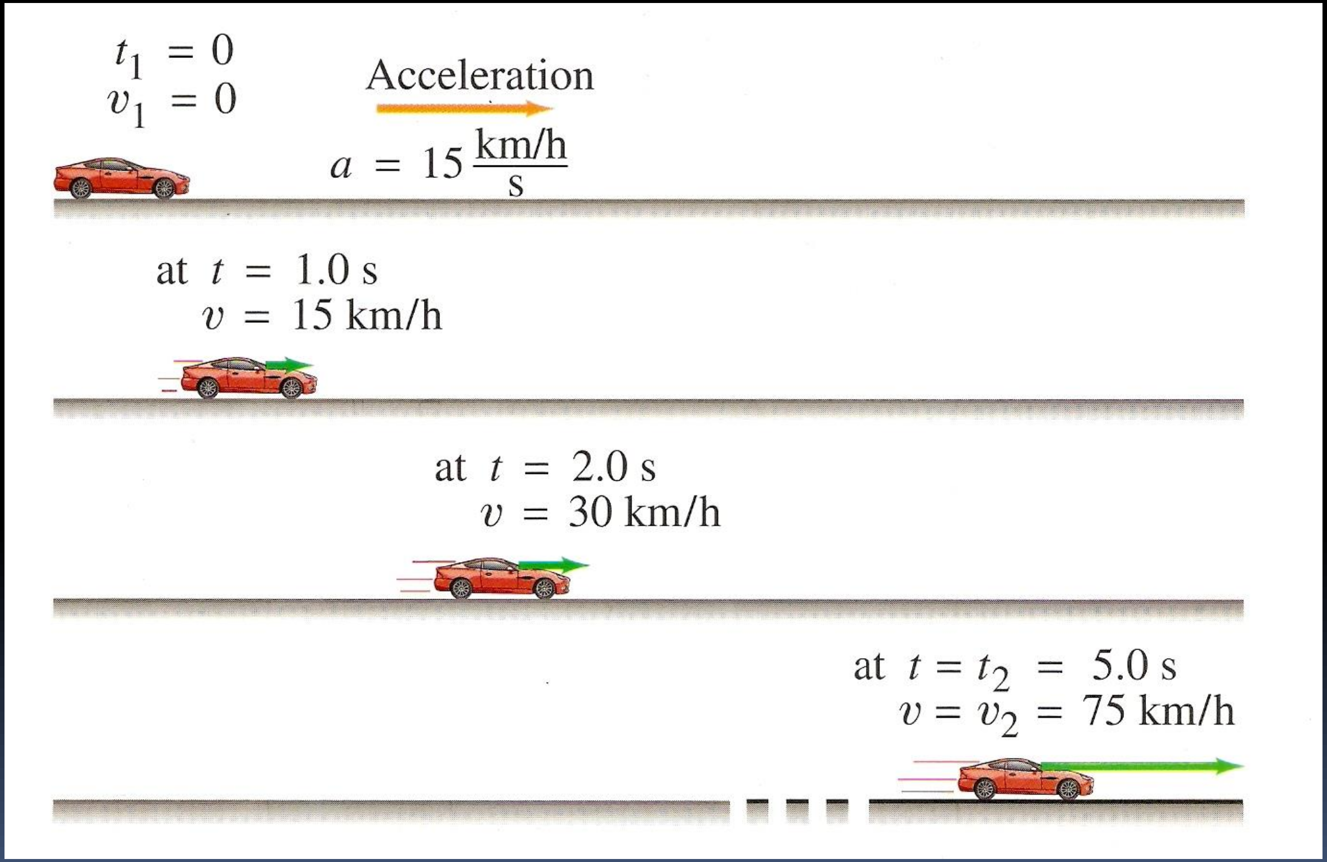
Learning Objective(s):

- The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system.

Chapter 2 – One Dimensional Motion

WHERE WE'VE BEEN

Horizontal Motion



Kinematic Equations for Horizontal Motion

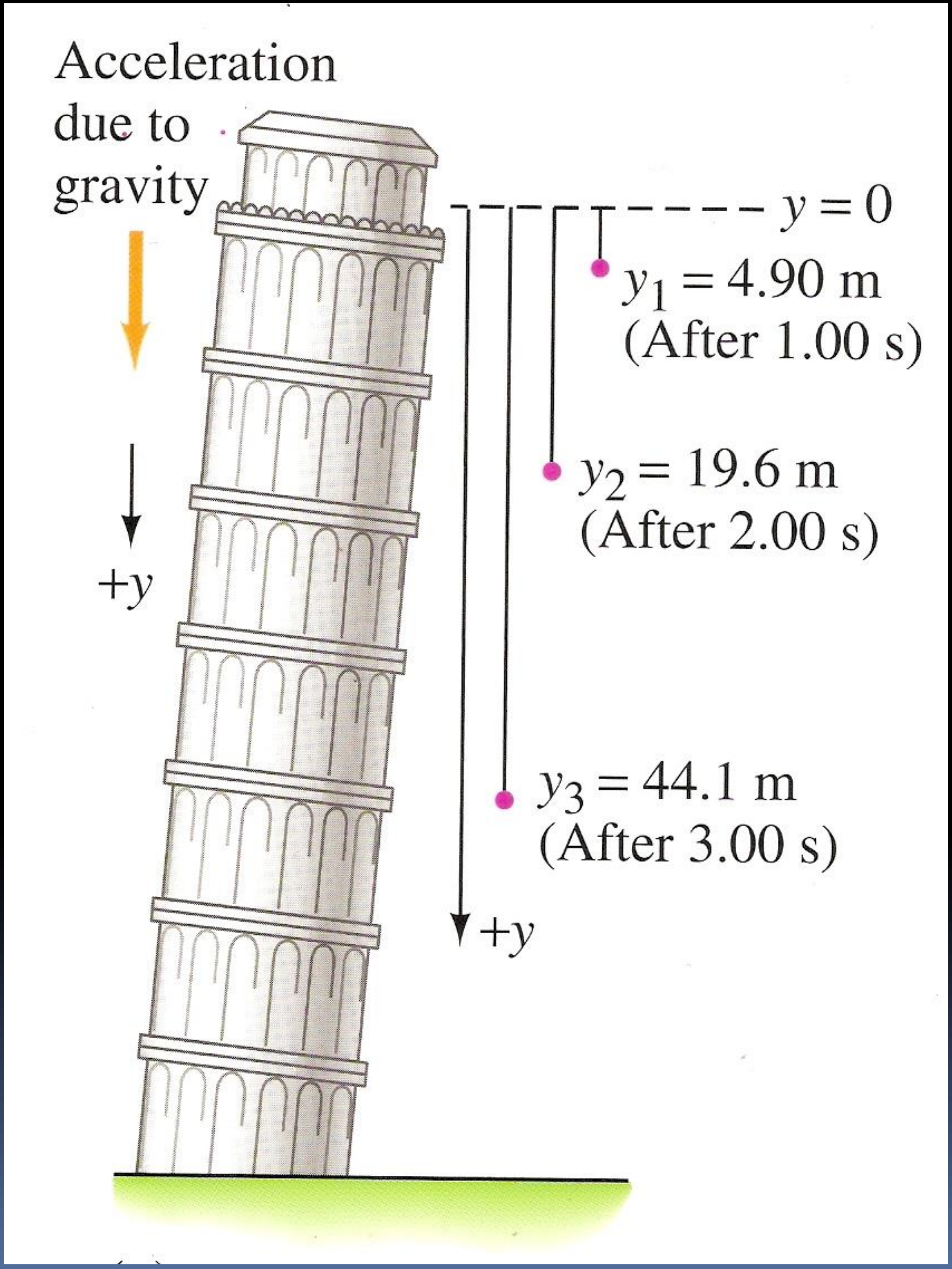
$$v = v_0 + at \qquad [a = \text{constant}] \qquad \text{2-11a}$$

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \qquad [a = \text{constant}] \qquad \text{2-11b}$$

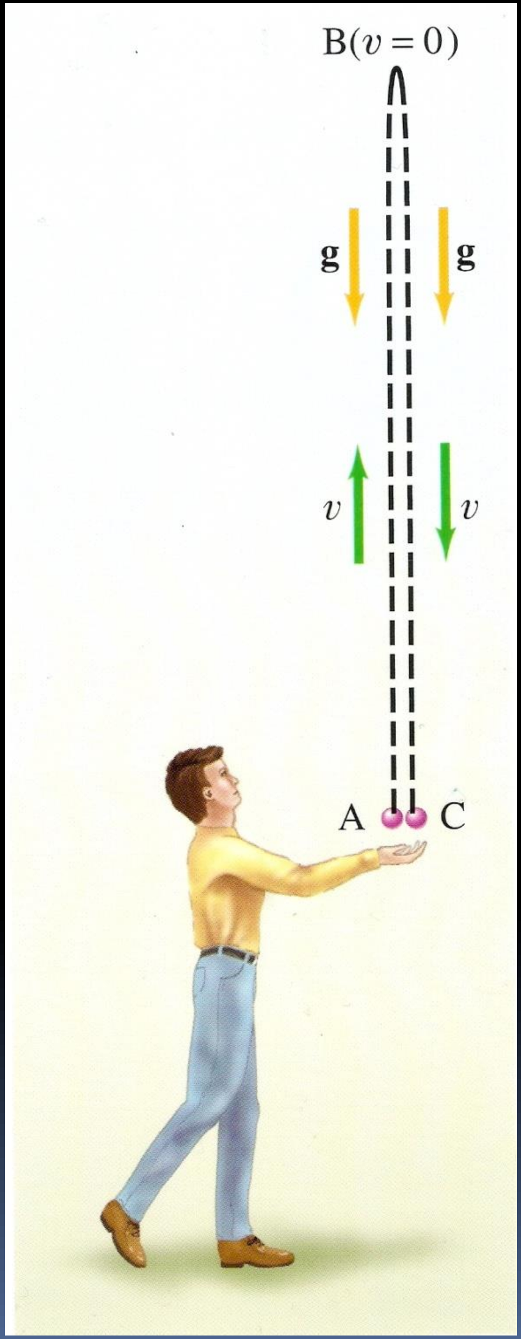
$$v^2 = v_0^2 + 2a(x - x_0) \qquad [a = \text{constant}] \qquad \text{2-11c}$$

$$\overline{v} = \frac{v + v_0}{2}. \qquad [a = \text{constant}] \qquad \text{2-11d}$$

Vertical Motion – Drop Problem



Vertical Motion with Vertical Velocity



Kinematic Equations

Horizontal

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + 1/2\, a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$$

Vertical

$$v_y = v_{y0} + gt$$

$$y = y_0 + v_{y0} t + 1/2\, g t^2$$

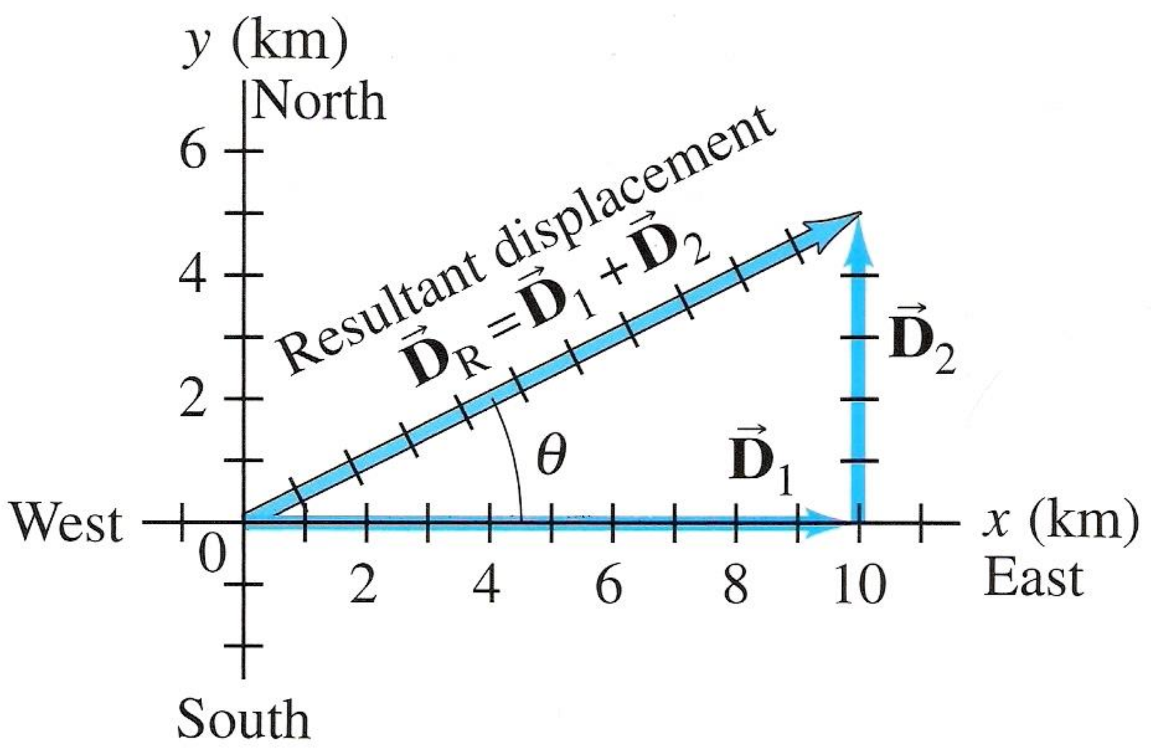
$$v_y^2 = v_{y0}^2 + 2g (y - y_0)$$

Chapter 3 – Vectors

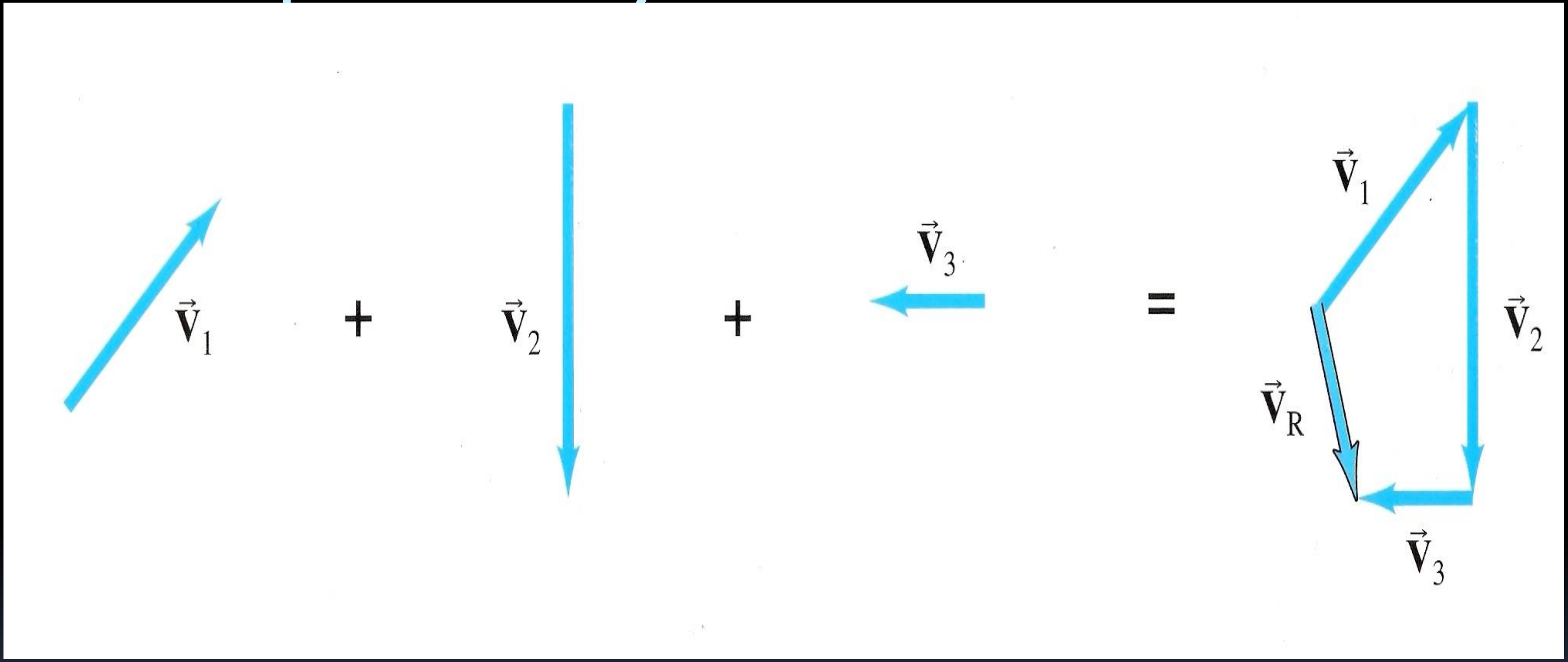
WHERE WE'VE BEEN

Vectors and Scalars

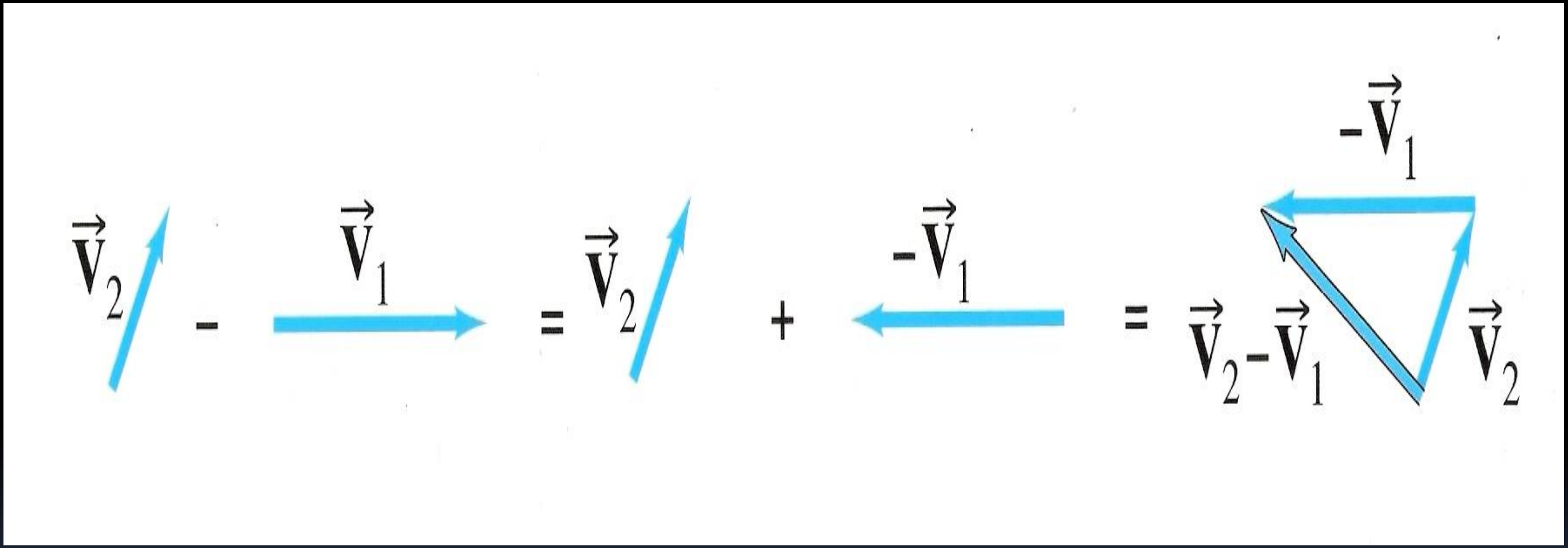
Figure 3-3 A person walks 10.0 km east and then 5.0 km north



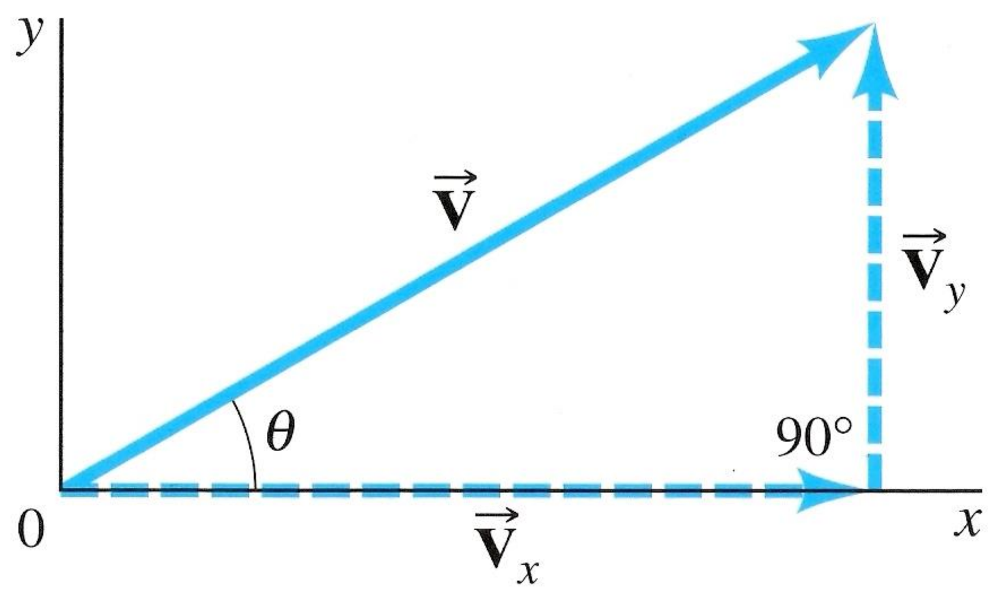
Vector Addition - Graphically



Vector Subtraction - Graphically



Breaking Vectors Down Into Components



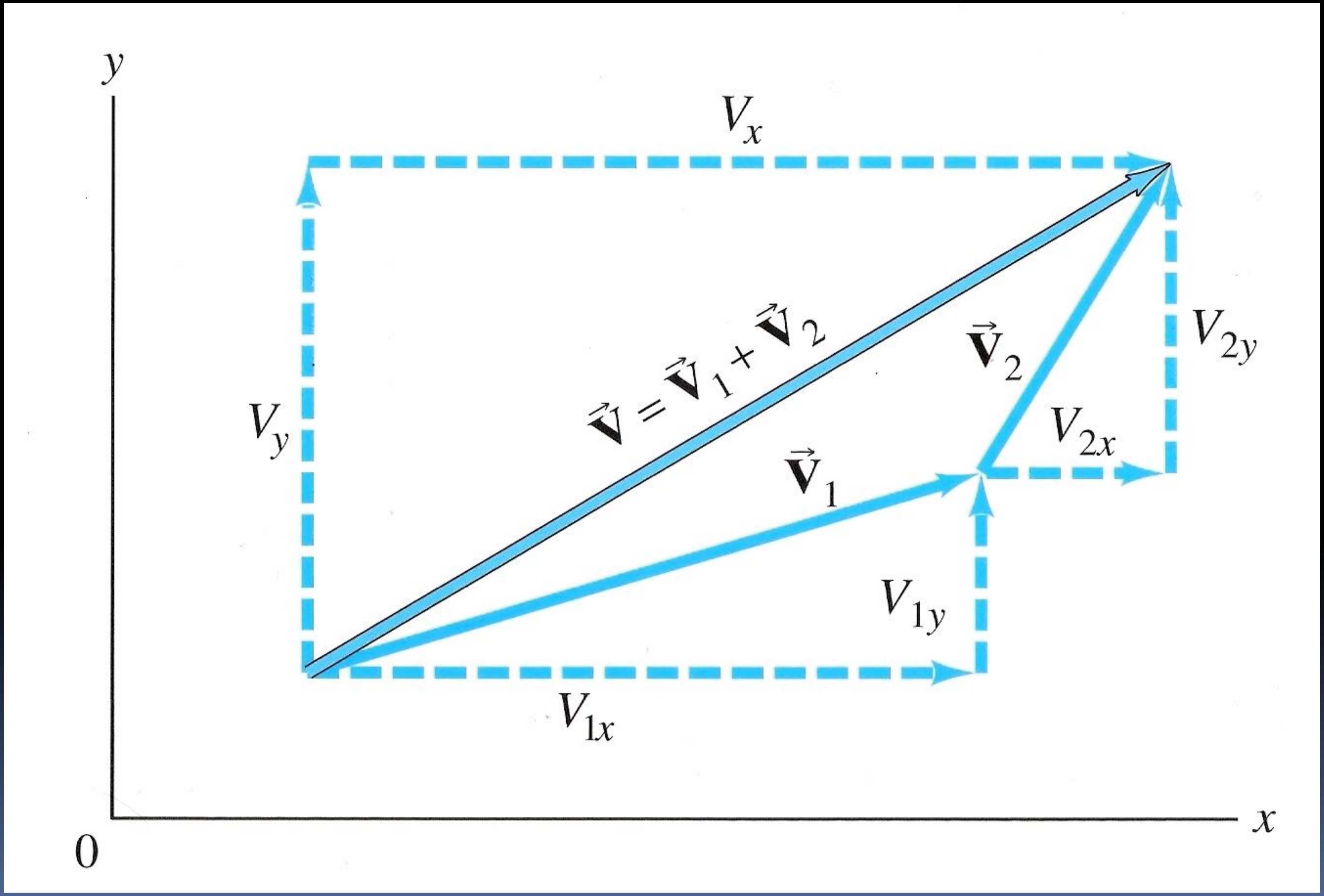
$$\sin\theta = \frac{V_y}{V}$$

$$\cos\theta = \frac{V_x}{V}$$

$$\tan\theta = \frac{V_y}{V_x}$$

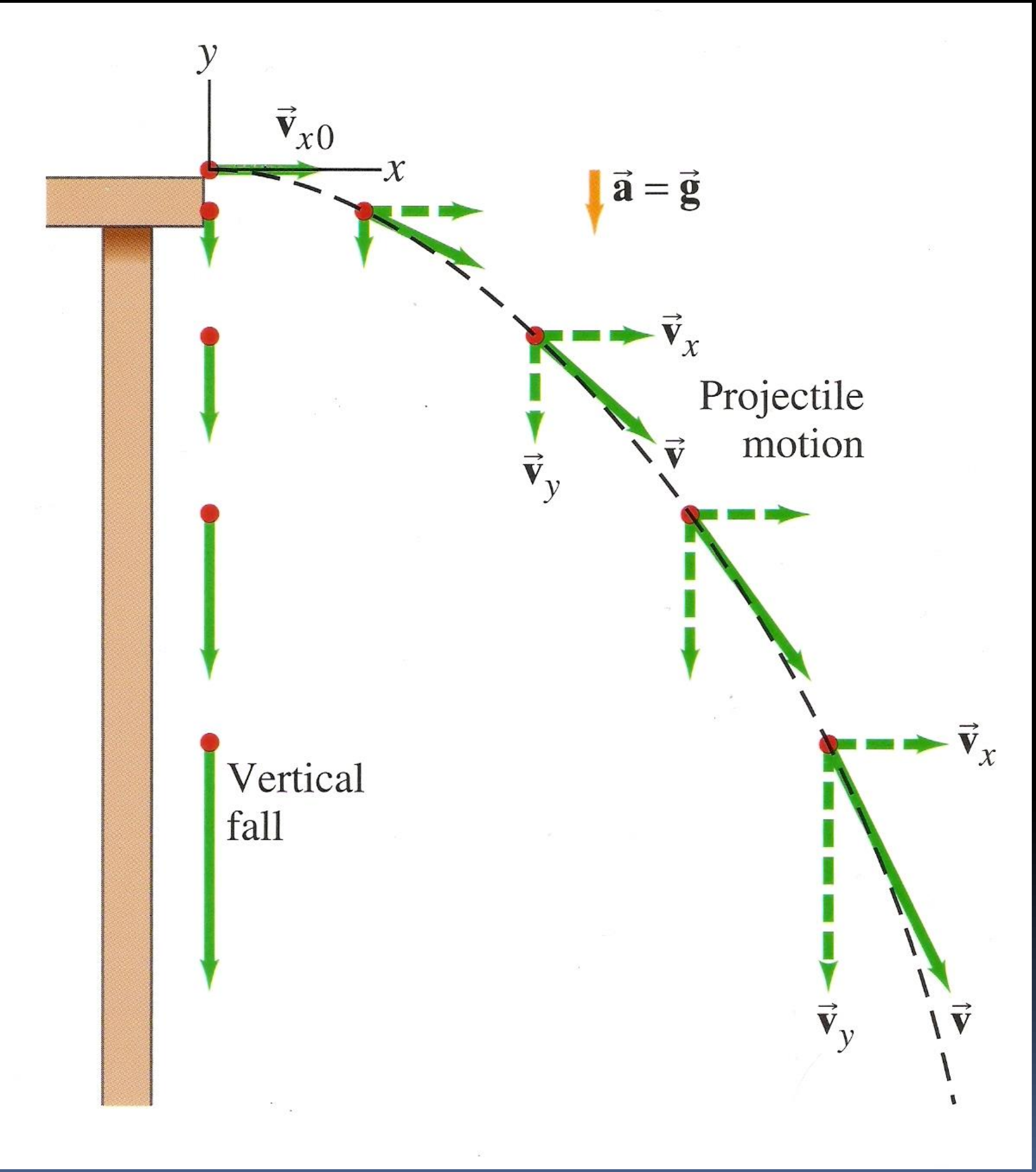
$$V^2 = V_x^2 + V_y^2$$

Adding Vectors Using Components

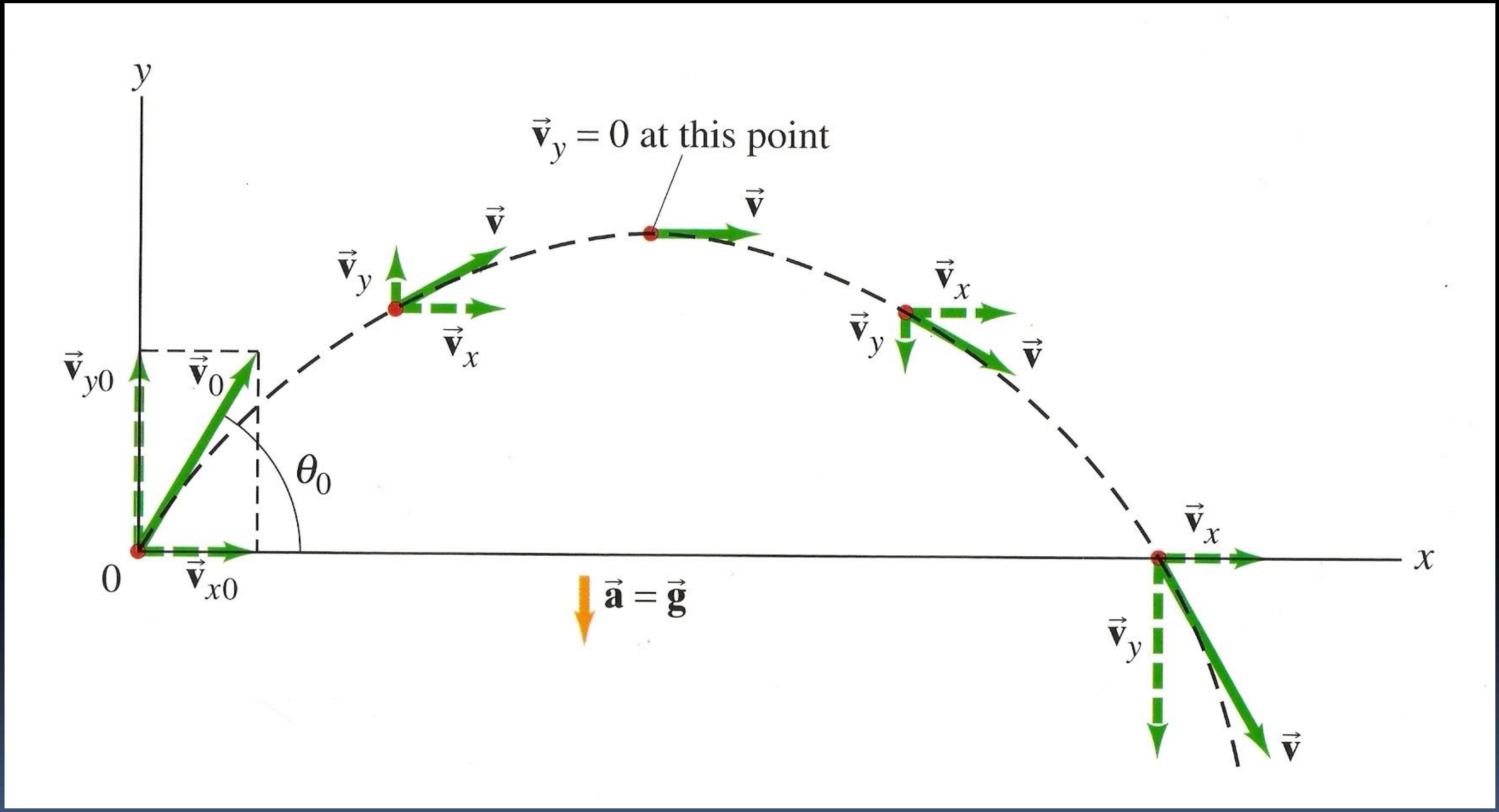


PUTTING IT ALL TOGETHER

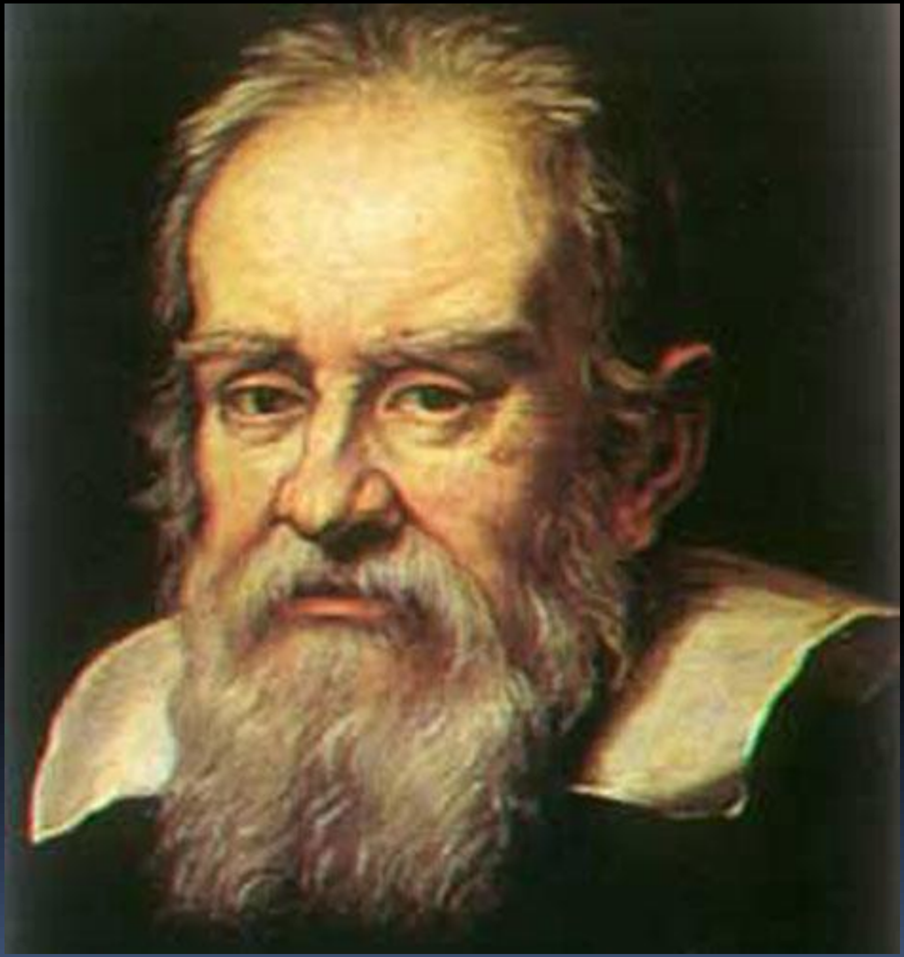
Two Dimensional Projectile Motion

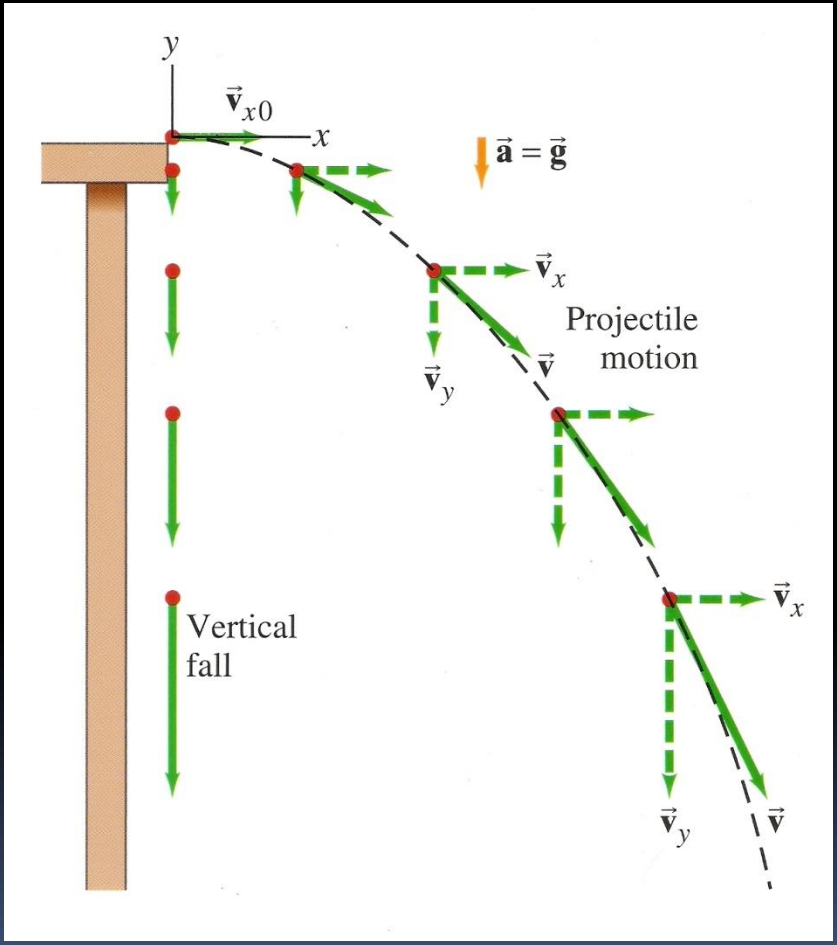


Two Dimensional Projectile Motion



Thanks, Galileo



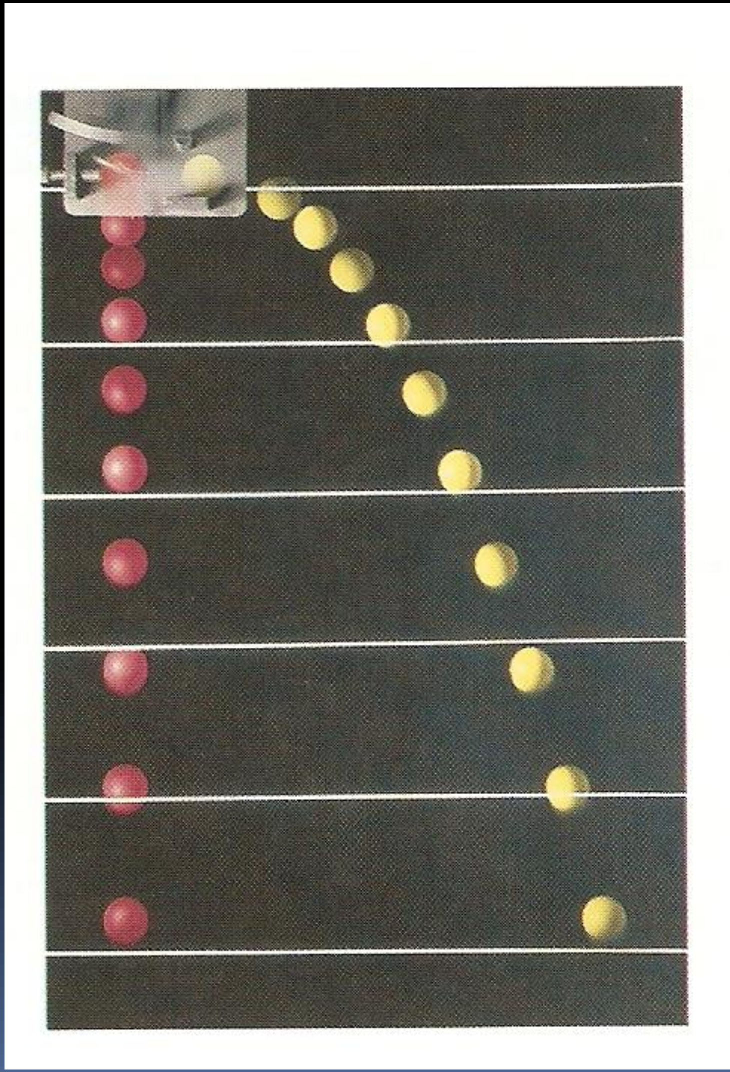


One Key Finding

- How long it takes to fall down
- Time to Fall

One Key Finding

- The time it takes for an object to fall from a given height is the same whether it is simply dropped or if it begins with a horizontal velocity.



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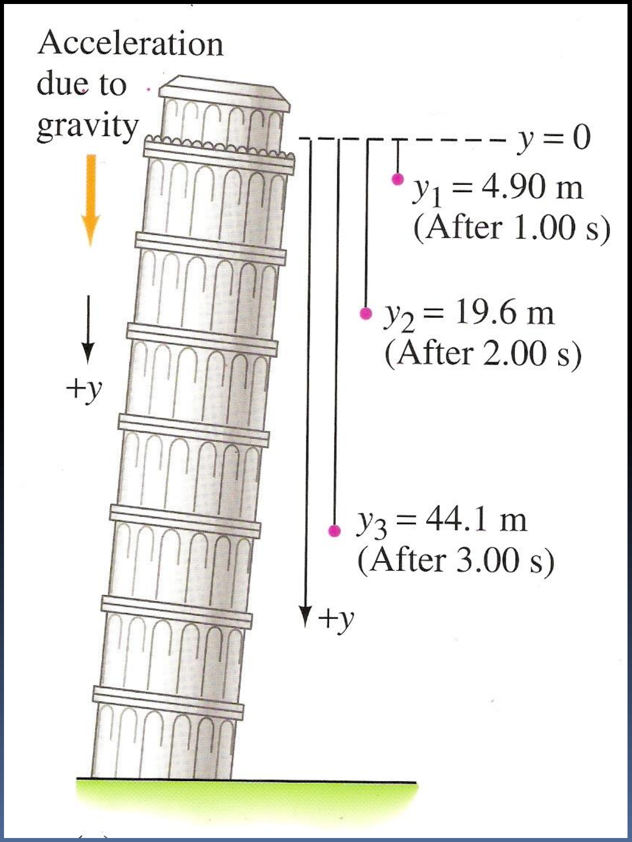

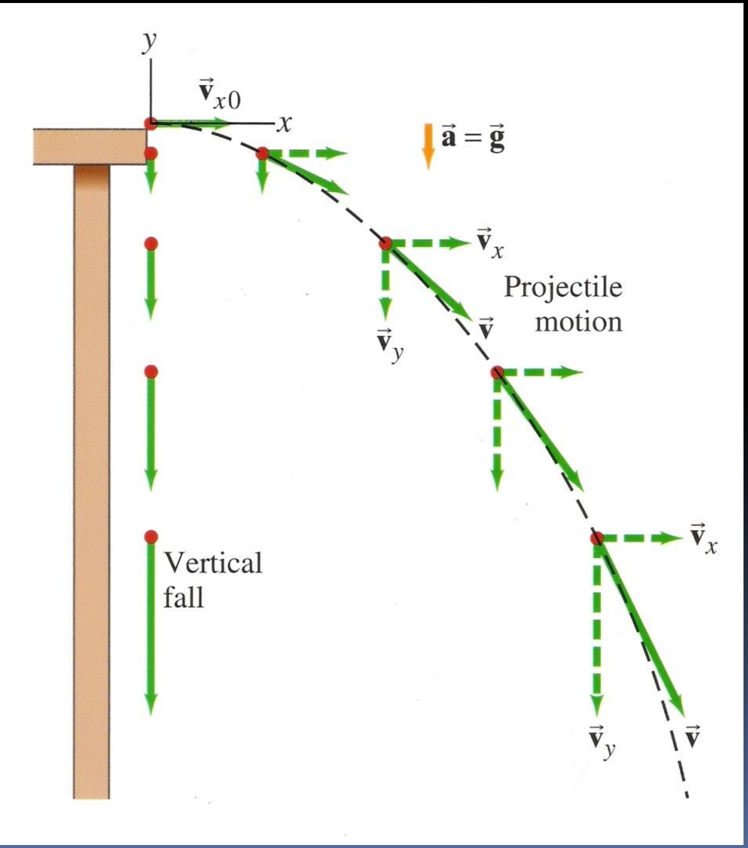

Kinematic Equations

Horizontal

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + 1/2\, a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x \left(x - x_0\right)$$

Vertical

$$v_y = v_{y0} + gt$$

$$y = y_0 + v_{y0} t + 1/2\, g t^2$$

$$v_y^2 = v_{y0}^2 + 2g\left(y - y_0\right)$$

Assumptions

- We consider its motion only after it has been projected and is moving freely through the air
  - We don’t consider the acceleration it took to reach that velocity
- We consider air resistance to be negligible
  - When the object is moving through the air, both horizontally and vertically, it doesn’t slow down due to air resistance

Make the Math Easier

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0} t + 1/2\, a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$$

$$v_y = v_{y0} + gt$$

$$y = y_0 + v_{y0} t + 1/2\, g t^2$$

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- No horizontal acceleration, horizontal velocity remains constant
- Vectors in Parabolic Motion
- Y-axis positive up, gravity negative down

$$v_x = v_{x0} + a_x t$$

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$$y = y_0 + v_{y0} t + 1/2\, g t^2$$

$$v_y^2 = v_{y0}^2 + 2g (y - y_0)$$

Kinematic Equations for Projectile Motion

$$v_x = v_{x0}$$

$$x = x_0 + v_{x0} t$$

$$v_y = v_{y0} - gt$$

$$y = y_0 + v_{y0} t - 1/2\, g t^2$$

$$v_y^2 = v_{y0}^2 - 2gy$$

Problem Solving Process – Extra Steps

1. Read the problem carefully and draw a picture
2. Choose origin and x-y coordinate system
3. ***If given an initial velocity, resolve it into x- and y-components. RIGHT NOW!!!***
4. Analyze horizontal (x) and vertical (y) motion separately
5. Continue with problem solving process for kinematic equations

Helpful Hint

The time is always determined by the height, so do a vertical problem to determine time if you need to.

Projectile Motion Simulator

MANIPULATION OF VARIABLES

Sample Problems

Rolling Off A Cliff

Shooting A Canon

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Projectile Motion Concepts

SUMMARY VIDEO

Homework

#17-33