Preview

Objectives

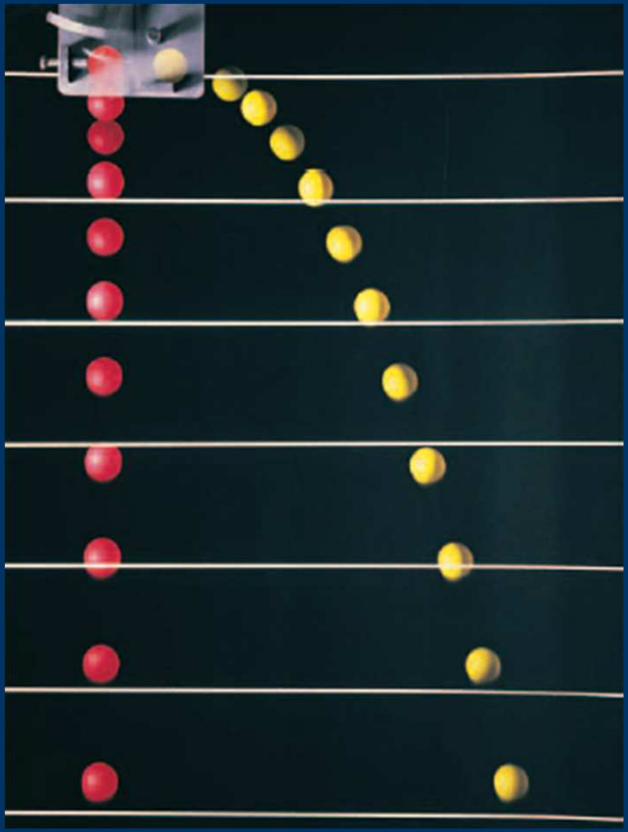
- **Recognize** examples of projectile motion.
- **Describe** the path of a projectile as a parabola.
- **Resolve** vectors into their components and **apply** the kinematic equations to **solve** problems involving projectile motion.

Projectiles

- Objects that are thrown or launched into the air and are subject to gravity are called **projectiles.**
- **Projectile motion** is the curved path that an object follows when thrown, launched,or otherwise projected near the surface of Earth.
- If air resistance is disregarded, projectiles follow **parabolic trajectories.**

Projectiles, *continued*

- **Projectile motion is free fall with an initial horizontal velocity.**
- The yellow ball is given an initial horizontal velocity and the red ball is dropped. Both balls fall at the same rate.
  - *In this book, the horizontal velocity of a projectile will be considered constant.*
  - *This would not be the case if we accounted for air resistance.*



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Projectile Motion

Click below to watch the Visual Concept.

Visual Concept

Kinematic Equations for Projectiles

- How can you know the displacement, velocity, and acceleration of a projectile at any point in time during its flight?
- One method is to resolve vectors into components, then apply the simpler one-dimensional forms of the equations for each component.
- Finally, you can recombine the components to determine the resultant.

End of Slide

Kinematic Equations for Projectiles, *continued*

- To solve projectile problems, apply the **kinematic equations** in the **horizontal and vertical directions.**
- In the **vertical** direction, the acceleration **a_y will equal $-g$** ($-9.81\ m/s^2$) because the only vertical component of acceleration is free-fall acceleration.
- In the **horizontal** direction, the acceleration is zero, so the **velocity is constant.**

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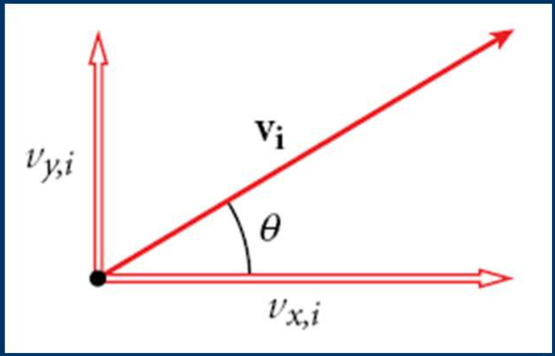
Kinematic Equations for Projectiles, *continued*

- **Projectiles Launched Horizontally**
  - The initial vertical velocity is 0.
  - The initial horizontal velocity is the initial velocity.

- **Projectiles Launched At An Angle**
  - Resolve the initial velocity into *x* and *y* components.
  - The initial vertical velocity is the *y* component.
  - The initial horizontal velocity is the *x* component.



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Sample Problem

Projectiles Launched At An Angle

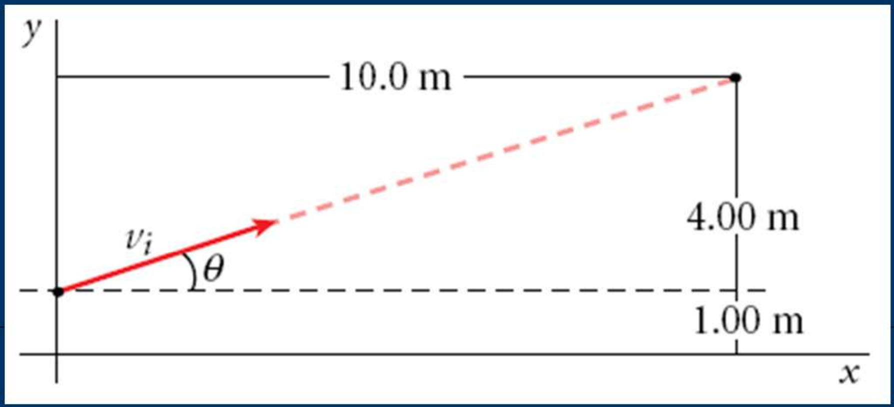
A zookeeper finds an escaped monkey hanging from a light pole. Aiming her tranquilizer gun at the monkey, she kneels 10.0 m from the light pole,which is 5.00 m high. The tip of her gun is 1.00 m above the ground. At the same moment that the monkey drops a banana, the zookeeper shoots. If the dart travels at 50.0 m/s,will the dart hit the monkey, the banana, or neither one?

End of Slide

Sample Problem, *continued*

1 . Select a coordinate system.

The positive *y*-axis points up, and the positive *x*-axis points along the ground toward the pole. Because the dart leaves the gun at a height of 1.00 m, the vertical distance is 4.00 m.



Sample Problem, *continued*

2 . Use the inverse tangent function to find the angle that the initial velocity makes with the *x*-axis.

$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{4.00 \text{ m}}{10.0 \text{ m}}\right) = 21.8°$$

Sample Problem, *continued*

3 . Choose a kinematic equation to solve for time.

Rearrange the equation for motion along the *x*-axis to isolate the unknown Δt, which is the time the dart takes to travel the horizontal distance.

$$\Delta x = (v_i \cos\ \theta)\Delta t$$

$$\Delta t = \frac{\Delta x}{v_i \cos\ \theta} = \frac{10.0 \text{ m}}{(50.0 \text{ m/s})(\cos\ 21.8°)} = 0.215 \text{ s}$$

End of Slide

Sample Problem, *continued*

4 . Find out how far each object will fall during this time. Use the free-fall kinematic equation in both cases.

For the banana, $v_i = 0$. Thus:

$$\Delta y_b = \frac{1}{2}a_y(\Delta t)^2 = \frac{1}{2}(-9.81 \text{ m/s}^2)(0.215 \text{ s})^2 = -0.227 \text{ m}$$

The dart has an initial vertical component of velocity equal to $v_i \sin \theta$, so:

$$\Delta y_d = (v_i \sin \theta)(\Delta t) + \frac{1}{2}a_y(\Delta t)^2$$

$$\Delta y_d = (50.0 \text{ m/s})(\sin 21.8°)(0.215 \text{ s}) + \frac{1}{2}(-9.81 \text{ m/s}^2)(0.215 \text{ s})^2$$

$$\Delta y_d = 3.99 \text{ m} - 0.227 \text{ m} = 3.76 \text{ m}$$

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Sample Problem, *continued*

5 . Analyze the results.

Find the final height of both the banana and the dart.

$$y_{banana,\ f} = y_{b,i} + \Delta y_b = 5.00\ \text{m} + (-0.227\ \text{m})$$

$$\boxed{y_{banana,\ f} = 4.77\ \text{m above the ground}}$$

$$y_{dart,\ f} = y_{d,i} + \Delta y_d = 1.00\ \text{m} + 3.76\ \text{m}$$

$$\boxed{y_{dart,\ f} = 4.76\ \text{m above the ground}}$$

The dart hits the banana. The slight difference is due to rounding.

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