Motion of Projectile

by

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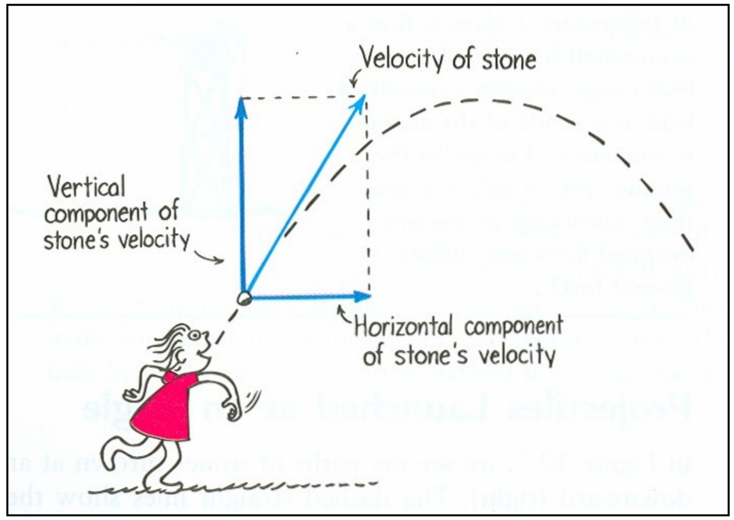
P2.1h Identify the changes in speed and direction in everyday examples of circular (rotation and revolution), periodic, and projectile motions.

P2.1E Describe and classify various motions in a plane as one dimensional, two dimensional, circular, or periodic.

Items:

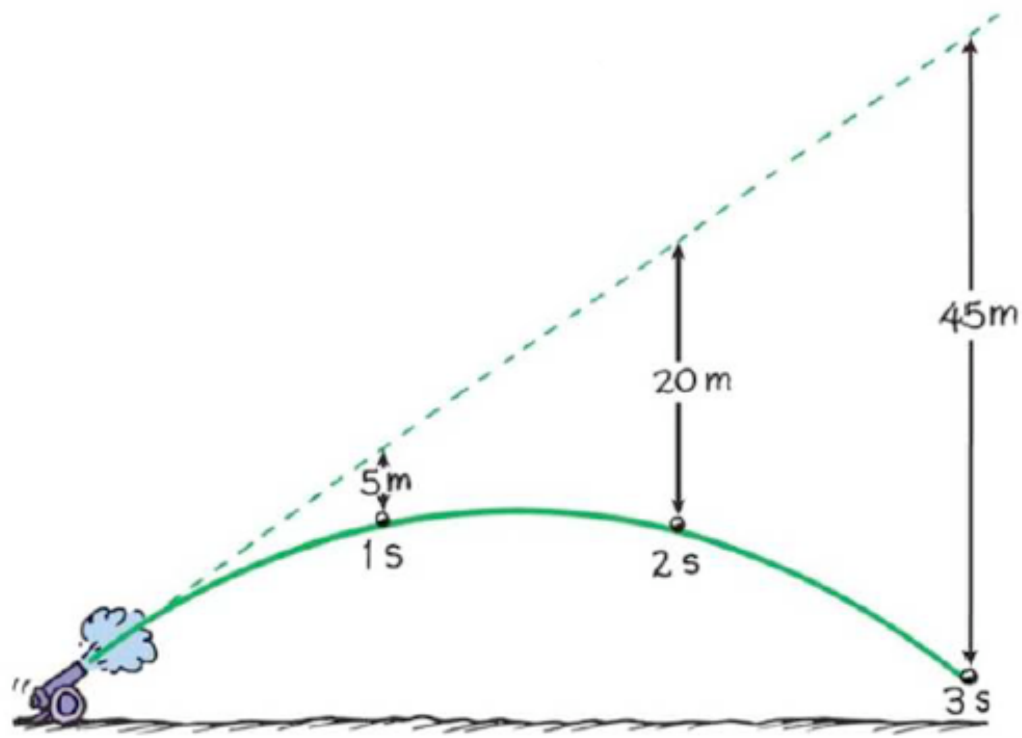
1. Projectile.
2. Projectile Launched at an Angle.
3. Symmetry in the Motion of Projectile.

Gravity and Motion of Objects



Without gravity, you could throw a stone and it would follow a straight line path at a constant speed. But in the real world, if you throw a stone, it falls to the ground because of the gravity. The velocity of the stone can be resolved into horizontal and vertical components.

With no gravity, the projectile would follow the straight-line path (dashed line). But because of gravity, it falls beneath this line the same vertical distance it would fall if it were released from rest.



Motion of Projectile

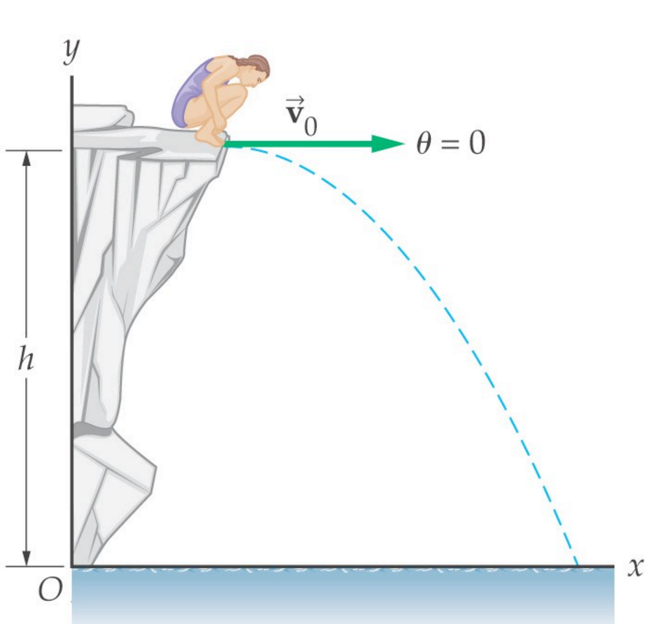
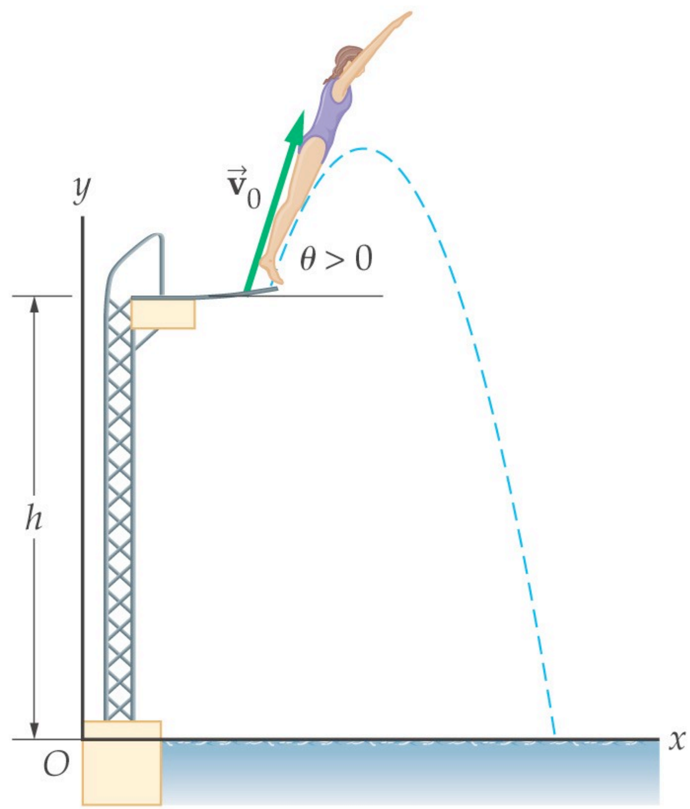
Projectile motion is the motion of objects moving in two dimensions (horizontal and vertical) under the influence of gravity.

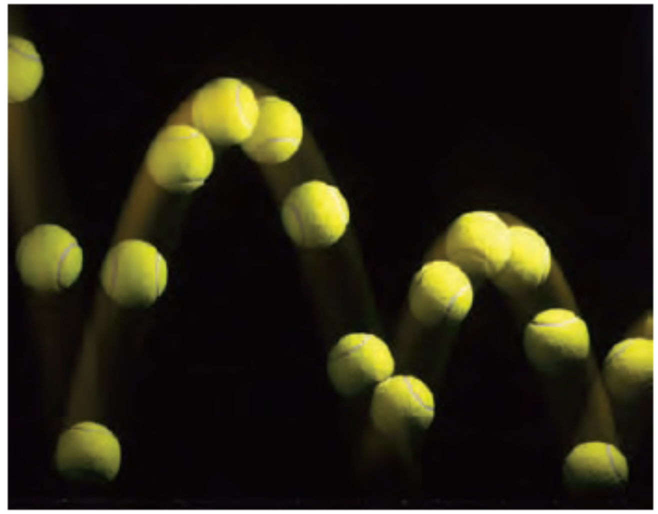
In Projectile motion, the horizontal motion and the vertical motion are independent of each other, that is neither motion affects the other.

Projectile are falling freely in the vertical direction. Under the influence of gravity alone, an object near the surface of the Earth will accelerate downwards at $9.80 m/s^2$.

Types of Projectiles

There are two types of projectiles: projectiles Launched Horizontally and projectiles Launched at an Angle. Examples are shown below.

Projectile launched horizontally **angle = 0 comparing to horizontal**	**Projectile launched at an angle** **angle > 0 comparing to horizontal**
	

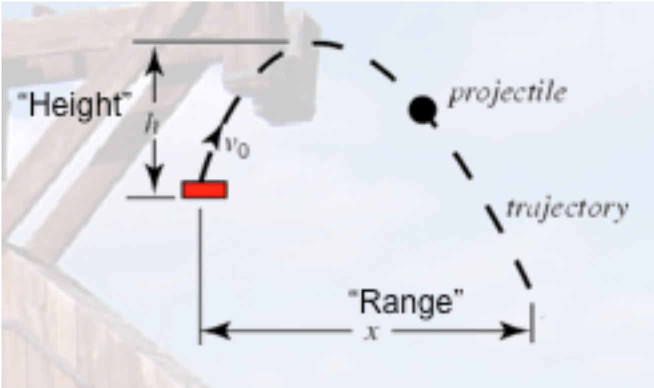


This is a stroboscopic photograph of a yellow tennis ball bouncing off a hard surface. Between impacts, the ball has projectile motion.

A few examples of projectiles include:

- a soccer ball being kicked
- a baseball being thrown
- an athlete long jumping
- water fountain

Projectile Terminology



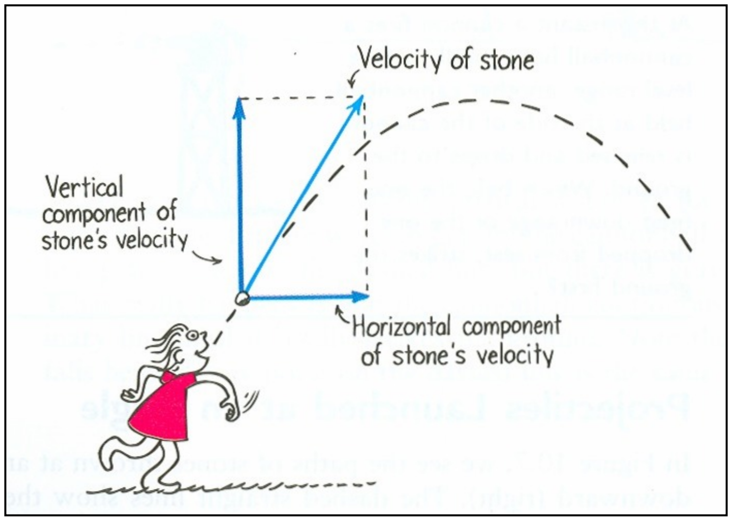
Projectile terminology

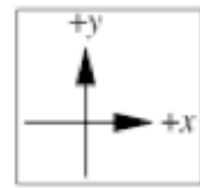
The projectile path through space is called trajectory, a curve or a parabola.

The range R is the horizontal distance the projectile has traveled when it returns to its launch height.

Velocity components for a projectile launched at an angle.

In the study of projectile motion, air resistance and the rotation of Earth are ignored. Vertical and horizontal components of velocity are used to simplify projectile motion. Throwing is stone is the air is an example of projectile launched at an angle.





Regardless of the angle of projection, the velocity vector can be resolved into its components, as shown in the picture above. They are:

the vertical velocity component (Vy) and

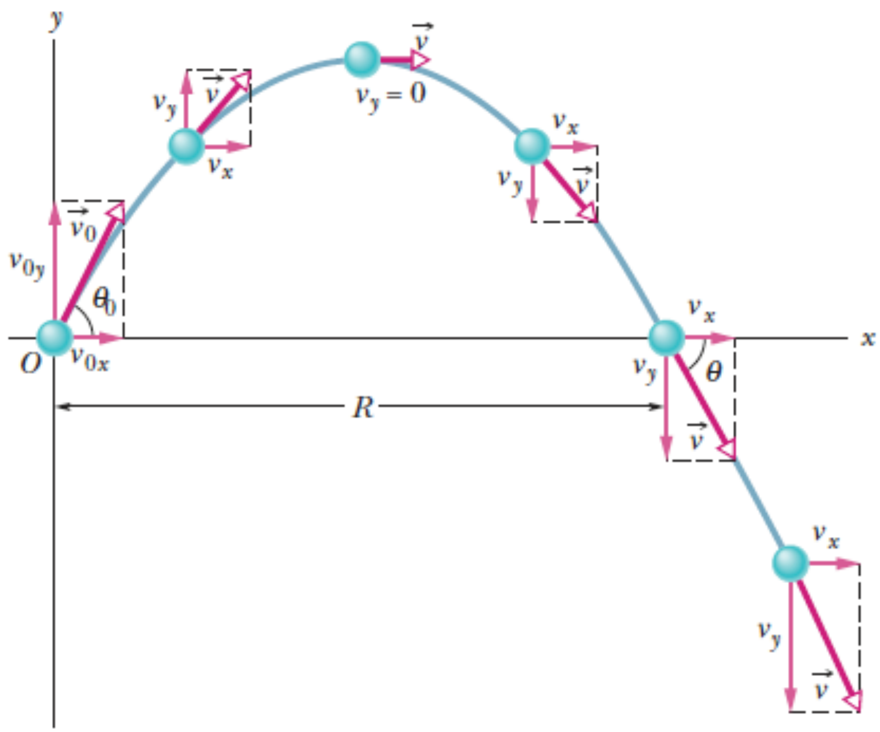
the horizontal velocity component (Vx).

Theory: After an object is projected:

The horizontal velocity component (Vx) remains constant.

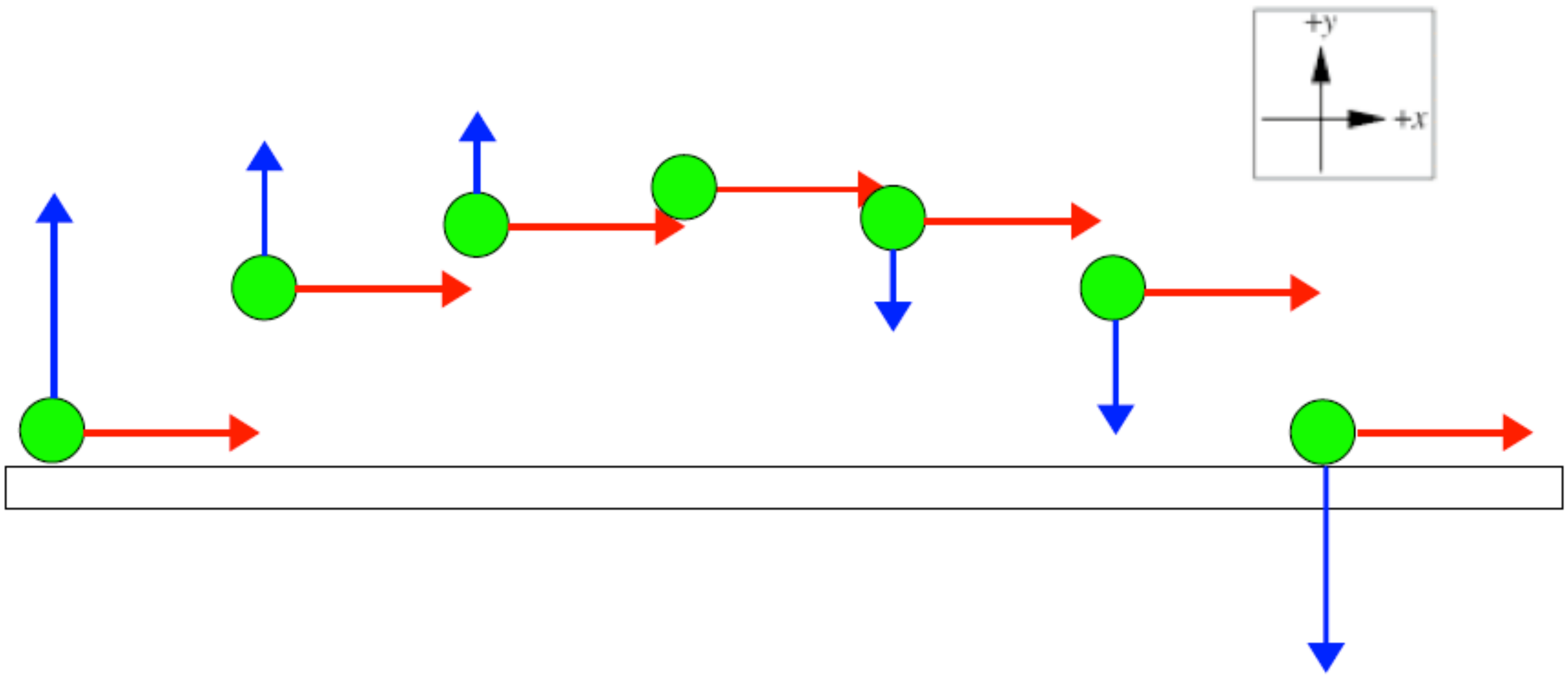
The vertical velocity component (Vy) change due to gravity.

The figure below shows The path of the projectile (trajectory) that is launched at Xo = 0 and Yo = 0 with an initial velocity of Vo. R is the range.



Example 1: *Kicking a Ball.*

Suppose you kick a ball with your foot. Below is a sketch of the velocity components throughout the projectile trajectory or path of the ball. The horizontal component of the velocity (Vx) is the red arrow. The vertical component of the velocity (Vy) is the blue arrow.



- The instant the ball left your foot, gravity is pulling down on it, causing it to have less and less vertical velocity. So vertical velocity changes due to gravity. Notice how the size of the blue arrow (vector) changes.

- There will be no change in the horizontal component of its velocity. It remains constant. notice how the size of the red arrow (vector) did not change.

- When it reaches the height point of its flight, its vertical velocity is Zero.

- By the time, it reaches the ground again, it will:

    a. still be moving with its original horizontal velocity.

    b. have the same exact vertical velocity as when it left your foot.

    c. have the same exact velocity as when it left your foot.

Projectile Motion

1. The projectile has two velocity components: the vertical velocity component (Vy) and the horizontal velocity component (Vx). They are independent of each other. They do not affect each other.

2. Vertical acceleration is the acceleration along the y axis is: $a_y = 9.80 m/s^2$.
   Horizontal acceleration is the acceleration along the x axis is: $a_x = 0 m/s^2$

3. After an object is projected, the horizontal velocity (Vx) component remains constant. Vx = Vox = constant
   The vertical velocity (Vy) component is not constant. It changes due to gravity.

4. When it reaches the highest point of its flight, its vertical velocity (Vy) is Zero.

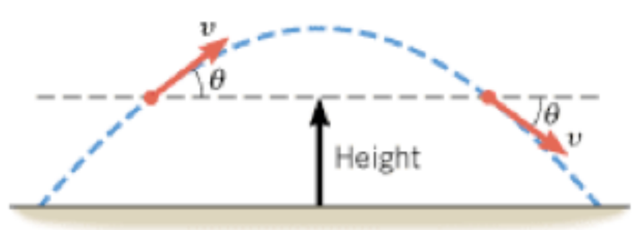
5. The range R is the horizontal distance the projectile has traveled when it returns to its launch height.

Symmetry in Projectile Motion

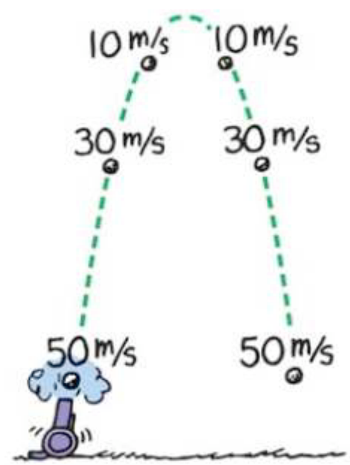
Projectiles are falling free in the vertical direction. There are certain types of symmetry:

1. The time required for a projectile to reach its maximum height is equal to the time spent returning to the ground.

2. The speed *v* of a projectile at a given height above the ground is the same on the upward and downward parts of the trajectory. The velocities are pointed in different directions.



Symmetry: The speed *v* of a projectile at a given height above the ground is the same on the upward and downward parts of the trajectory. The velocities are pointed in different directions. The cannon shown below is an example.

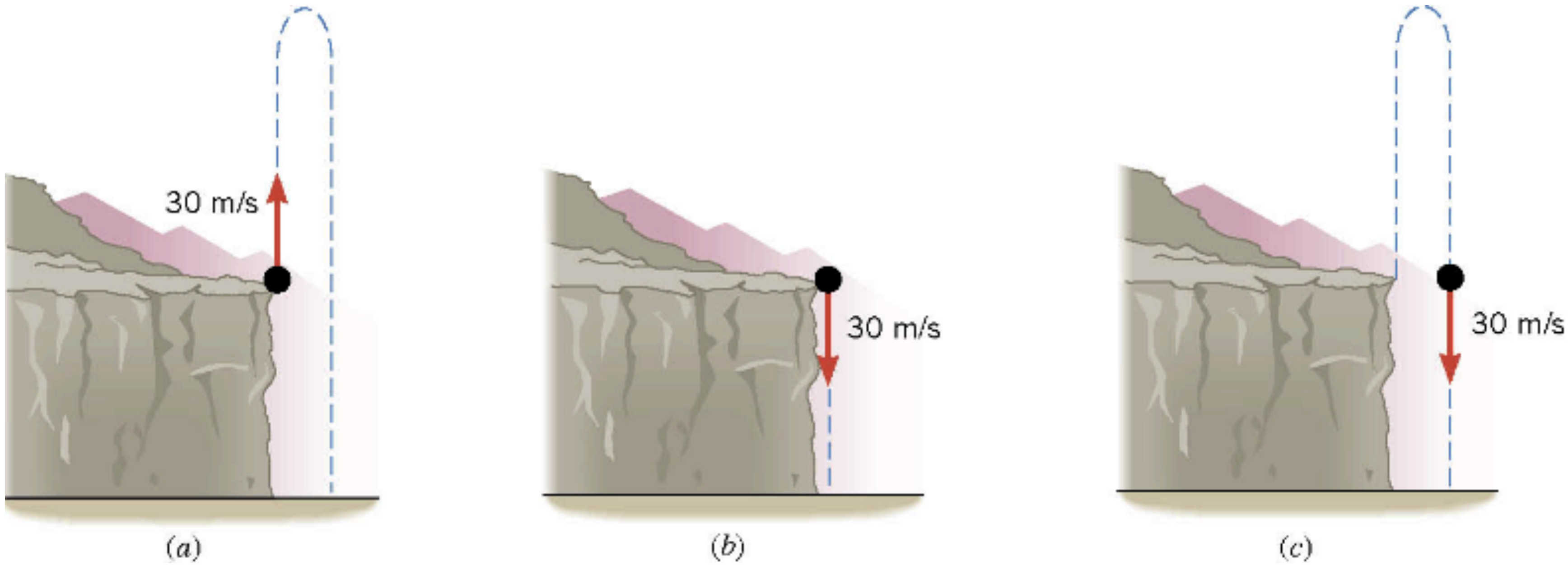


The speed lost while the cannonball is going up equals the speed gained while it is coming down. Also, The time to go up equals to the time going down.

Example 2: *Skateboarder and the Skateboard*

The skateboarder and the skateboard have the same horizontal velocity that does not change.

Example 3: *A Pellet is Fired from a Gun at the Edge of a Cliff;*



Picture (a): From the edge of a cliff, a pellet is fired straight upward from a gun. The pellet's initial speed is 30 m/s.

Picture (b): From the edge of a cliff, the pellet is fired straight downward with an initial speed of 30 m/s.

Compare the speed of both pellets when they hit the water surface.

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The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

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