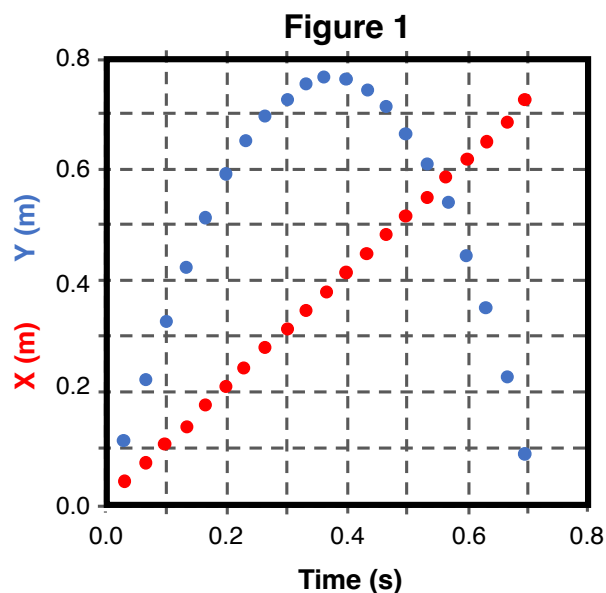


## Up and Down

A physics teacher does a demonstration to illustrate principles of projectile motion. The demonstration involves a cart that is equipped with a spring-loaded launcher and a plastic ball. When the cart is at rest, the ball is launched straight upwards and lands back in the cart. Then the teacher sets the cart in motion at a constant speed. At a point along the track, an electronic trigger activates the launcher and the ball is given an upward push. The motion of the cart and the launched ball is captured on video. The video is analyzed using video analysis software. Among the information provided by the video analysis is information regarding the position and the velocity of the ball. **Figure 1** shows the horizontal position ( $x$ ) and the vertical position ( $y$ ) of the ball as a function of time. The origin of the graph corresponds to the release location of the ball.



In physics, velocity is a quantity that refers to how fast an object is moving and the direction the object is moving. The direction is often represented on diagrams by a *vector arrow*. The direction of the arrow indicates the direction the object is moving. And the length of the arrow indicates how fast the object is moving. For objects with both horizontal and vertical motion, the horizontal and vertical velocity are represented by separate arrows.

The video analysis software produces the graphic shown in **Figure 2**. The position of the ball at regular intervals of time is represented by a dot. The vector arrows represent the horizontal velocity ( $v_x$ ) and vertical velocity ( $v_y$ ) of the launched projectile. The constant speed cart is shown positioned just below the ball for the last position shown on the diagram. When the ball finally falls to launcher height, it lands in the launcher.

