

B.2.1 Pop and Drop

Key Concepts:	Velocity Components Vectors Ballistic Motion
Materials:	Spring gun Two drilled steel balls Support rod and clamp Carpenter's level Two large flat pieces of wood
Set Up Time:	
Time Estimate:	

Set Up And Display

Mount the gun on a support rod to a table in front of the lecture bench since the horizontal ball will be launched 3-4 meters. A thick support rod should be used to reduce vibrations. The gun should be mounted as high as will permit easy use. The gun box must be level, or the vertical paths of the balls will not be equal and false conclusions will be drawn.

When the spring is cocked, the rear of the shaft protrudes past the end of the box. One of the balls is placed over the shaft, with the hole in the ball giving a good fit. The other ball is placed in front of the cocked shaft. There is a small depression on the gun box that serves to hold the ball. There are two positions for cocking the spring; maximum compression gives more impressive results. When the spring is released, the ball in front of the cocked shaft is fired horizontally with zero initial vertical velocity. The other ball has its support removed and it is free to fall with zero initial vertical and horizontal velocity. Both balls hit the floor at the same time, because they start with the same vertical components.

Because of the horizontal separation between the two points of impact, it is hard to see that both balls hit at the same time. It is easier to hear that they do. The two large flat pieces of wood of equivalent thickness are used to amplify this sound, with the unfortunate effect of amplifying secondary bounces. Point out it is the first impact that is important. The board placement is trivial for the vertically dropped ball, but the horizontal board has to be placed by trial and error. It is crucial that the gun box be level so that both balls fall through the same distance with zero initial vertical velocity.

Explanation

Each ball can be described in terms of two components of direction: horizontal and vertical. More importantly, position, velocity and acceleration in one of these directions is not coupled to the other. The separation of horizontal position on vertical motion is quite obvious. If you drop equal balls from each hand each held at shoulder height, no one will be surprised that they land at the same time. The fact that the velocities are separate is a bit less intuitive.

This demonstration sets two balls at slightly different horizontal positions, but equal vertical position. One ball is given a horizontal velocity and both start with zero vertical velocity. Gravity provides the sole acceleration and it is oriented vertically. Because both balls have the same vertical starting conditions of height, velocity, and acceleration, they take the same time to fall from the gun to the floor. The horizontal velocity has no effect on the vertical motions.

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