Lesson 18

PROJECTILE MOTION

Teaching Time:

Projectile Possibilities

When you throw a ball, the ball becomes a projectile in physics terms. A ball hit with a bat, a football thrown by a quarterback, a golf ball hit with a golf club, a tennis ball hit with a tennis racquet, a ping-pong ball hit with a paddle, and even a bullet fired from a gun are all examples of projectile motion. In this lesson, we will learn some interesting characteristics concerning projectiles and how they move.

Scripture

They were archers who, using either their right or left hand, could [throw] stones [with a sling] or [shoot] arrows with a bow.

(1 Chronicles 12:2a)

Projectiles

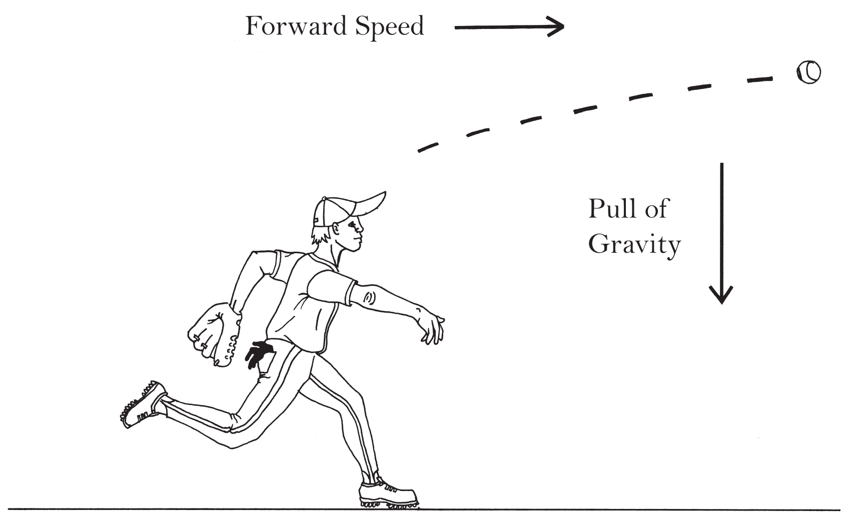
We have already mentioned a few good examples. You might be getting the idea that a **projectile** is something that can be sent flying through the air. That is a pretty good way to define a projectile. What makes a projectile different from other objects in motion is that fact that a projectile doesn't have any way of accelerating itself after it is sent flying. When a bullet is fired from a gun, or when a tennis ball is struck with the racquet,

Name It!

projectile
An object that can be sent flying through the air and has no way of accelerating itself after it is sent flying.

Additional Notes

that's all the acceleration there will be. So, we can say that a projectile is an object in motion that will not be accelerated further, except by the force of gravity. Can you think of other examples of projectiles? Remember the definition—there can't be any engines attached. Therefore, airplanes can't be projectiles, unless the engine stops running. How about a bird? Birds are not projectiles because they flap their wings and accelerate.



Projectile Motion

Now that we have a good idea about what qualifies as a projectile, let's explore the motion of a projectile. You may have had some experiences that will help you understand projectile motion. What happens when a golf ball is hit with a golf club? Does it keep going into orbit around the earth or perhaps fly up and hit moon? Of course it doesn't. We know from experience that projectiles, once thrown, hit, or otherwise launched, will eventually fall back to Earth. That is because there is no force that can act on the projectile once it's in motion except for gravity. We have already learned that gravity is a force that pulls objects toward Earth. Therefore, we can be confident that projectiles will fall to Earth. What we aren't sure of is how quickly they will fall.

Projectile Speed, Distance, and Gravity

Once launched (accelerated), the forward speed achieved by the projectile will not increase. The speed may decrease a little due to friction from the air on the projectile. We are going to ignore air friction in order to help us understand the principles of projectile motion. Let's consider the path of a ball that is thrown. The ball moves in the direction we throw it and that doesn't change. It goes in that direction for a certain distance. The distance it travels depends on three factors. The first is the speed achieved by the projectile. In other words, how hard did you throw the ball? A harder throw gives the ball more speed, and this determines how far the ball is able to travel horizontally in a particular direction. The second factor is the force of gravity pulling the ball down toward the earth. Gravity causes the ball to go vertically—in other words, to be pulled down. The third factor is the angle of launch. For example, did you aim down, level, or up when you released (launched) the ball from your hand? If you threw the ball at an angle that aimed the ball slightly more than level (aimed high), you were applying a force to the ball against the force of gravity. This means that the ball will achieve a distance above the ground that will require more time for it to return to the earth from gravity. The longer it can stay in the air, the longer it has to continue in the direction you threw it. The path that the projectile follows from the time it leaves your hand until it comes down or is caught is called its trajectory. **Trajectory** is defined as the path of a projectile.

Name It!

trajectory
The path of a projectile.

Additional Notes

Interesting Details About Projectile Motion

As stated, there is no change in the directional speed of a projectile once it is launched. We also know that gravity is pulling down on the projectile, bringing it to the earth. Direction and gravity are independent of one another. A ball that is thrown level, no matter how hard it is thrown, will come down in the same amount of time as a ball that is simply dropped from the same height. That may sound strange, but it is true. The same is true of a bullet fired from a rifle. Let's say you go out into the desert where it is perfectly flat and aim a rifle perfectly level (not aiming high) and pull the trigger. At the same time you pull the trigger, you drop a bullet from your hand from the same height at which you hold the gun. Which would hit the ground first? The answer is that they would hit the ground at the same time. The bullet fired will have gone fast in the direction you aimed it and would have covered a great distance, perhaps a couple thousand feet. However, it was only in flight for the time it took for gravity to pull it down.

Review It

1. A ______________________ is an object in motion that will not be accelerated further, except by the force of gravity.
2. Projectiles, once thrown, hit, or otherwise launched, will eventually fall back to ______________________.
3. Once a projectile is launched (accelerated), the forward ______________________ achieved by the projectile will not increase.
4. The distance a projectile travels depends on three factors: the speed achieved by the projectile, the force of gravity, and the ______________________ at which the projectile was launched.
5. Trajectory is defined as the path of a ______________________.

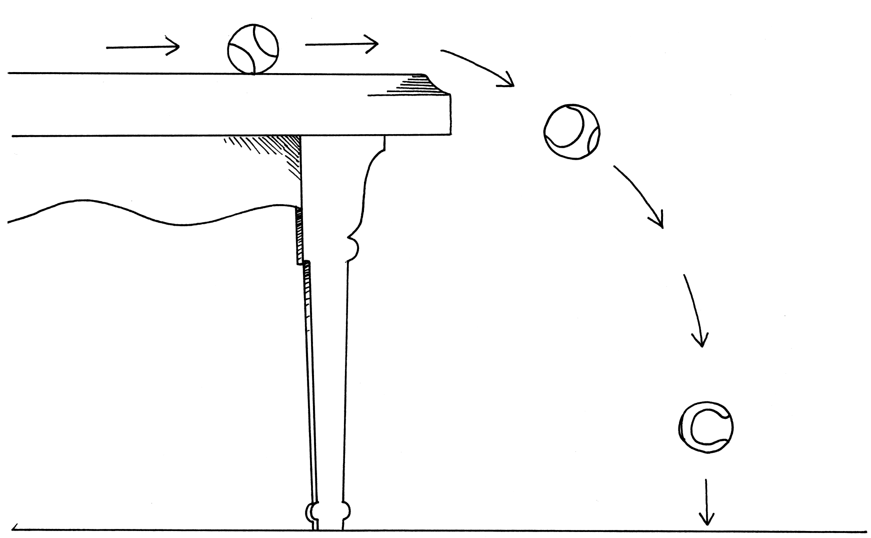
Additional Notes

Additional Notes

Hands-On Time:

Plotting Trajectories

We know from our study of gravity that dropped objects are pulled straight down. In this lesson on projectile motion, we learned that the directional speed of a projectile determines how far it will travel horizontally as it is being pulled toward the earth vertically. If you want to throw a ball a long distance, you usually release it at an angle that will work against gravity in order to achieve the longest possible time for the ball to travel vertically. What if you didn't throw at an angle, but instead threw it perfectly level? The ball's momentum (based on its mass and speed) will carry it as far as possible horizontally at the same time that it is being pulled down by gravity. In this Hands-On Time, we will determine the effect of speed on the trajectory of a projectile that is moving parallel to the ground. You and an assistant will be rolling a ball off a table several times and then plotting a trajectory for each trial.



Equipment Needed

- a tennis ball (or similar-sized rubber ball)
- kitchen table
- pencil
- ruler or tape measure

Activity

1. Measure the height of the table that will be used and write that measurement in inches on each of the four grids. Each square in the grid is equal to 1 inch.

2. Roll the ball gently across the table, allowing it to "fall" off and hit the floor.

3. Have the assisting person watch carefully as the ball hits the floor and place an object there to mark the spot.

4. Measure the distance from a spot on the floor just under the edge of the table to the spot where the ball hit the floor.

5. Write this distance in the space provided on the Trial 1 Rolled grid.

6. Repeat two more times, rolling the ball at different speeds. Write the distances in the spaces provided on the Trial 2 Rolled grid and Trial 3 Rolled grid.

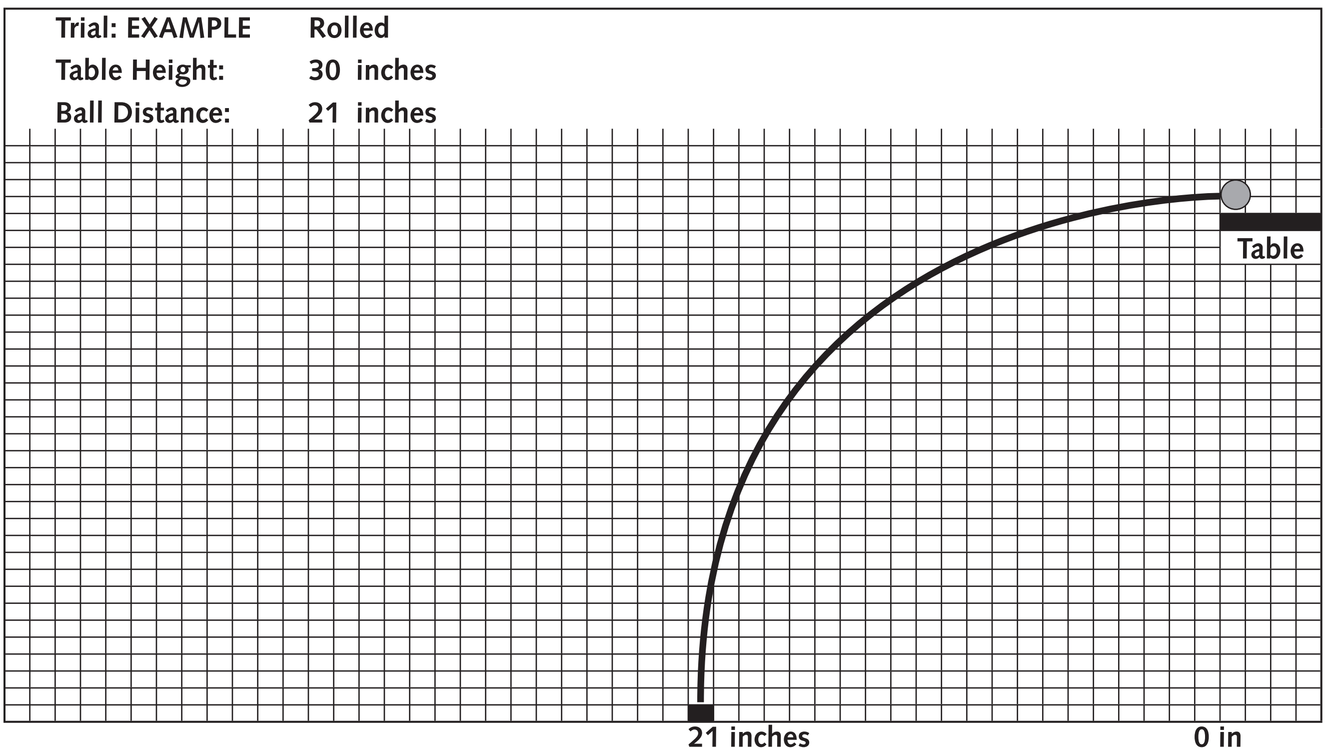
7. For a final trial, hold the ball at the very edge of the table and let it drop. Mark the spot and measure the same way as you did for the other trials. Write the distance in the Trial 4 Dropped grid.

Additional Notes

8. Mark the grids below, showing the table height. Each square represents 1 inch (see example).

9. Count each square on the grid as 1 inch and mark on each grid the distance the ball traveled (see example).

10. Finally, draw a line that depicts the trajectory in each of the four trials.



Trial: 1 **Rolled**
Table Height: **inches**
Ball Distance: **inches**

0 in

Trial: 2 **Rolled**
Table Height: **inches**
Ball Distance: **inches**

0 in

Trial: 3 **Rolled**
Table Height: **inches**
Ball Distance: **inches**

0 in

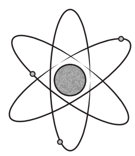
Trial: 4 **Dropped**
Table Height: **inches**
Ball Distance: **inches**

0 in

Think About It

1. Did you observe that the ball that rolled faster went farther?

2. Were you surprised to see what the trajectories looked like?



Fun Activity

Go outside and toss a ball back and forth with someone. As soon as the ball leaves the thrower's hands, it becomes a projectile. Try to visualize the path the ball is taking through the air.

Discovery Zone

Nolan Ryan set the record for the fastest pitched baseball at 100.9 miles per hour in 1974, according to the Guinness Book of Sports Records.