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Student Exploration: Golf Range

Vocabulary: acceleration, air resistance, gravity, hang time, launch angle, projectile motion, trajectory, vector, velocity

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. You are in a contest with your friends to see who can drive a golf ball the farthest. Should you hit a "line drive" (low to the ground) or a shot with a very high angle? Explain.

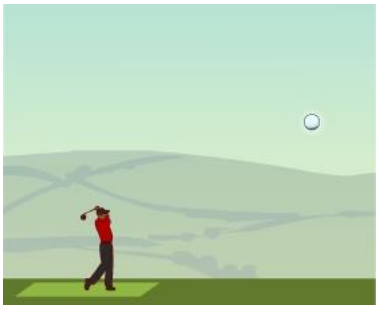
   I would try to hit the ball with a decently high angle. If we were playing in space with no air resistance, then I would aim to hit the ball with a 45 degree angle. However, using the assumption that the contest will be taking place on Earth, degree angles slightly higher and lower than 45 may also be best in order to compensate for factors that will slow the ball down (reduce trajectory) such as air resistance.

Golf drives travel much farther than Major League home runs. Why might this be?

Golf drives travel farther than homes runs because of the difference in size between the types of balls used. Golf balls are smaller and denser whereas baseballs are consequently larger and less dense. Additionally, the grooves on a golf ball help keep it in the air longer by reducing air resistance, in comparison to the average baseball, further contributing to the change in distance.

Gizmo Warm-up

Have you ever hit a hole-in-one? You will have a chance to do that in the *Golf Range* Gizmo, where you will see how a variety of factors affect the path of a golf ball. The movement of objects such as a ball through space is called **projectile motion**.



1. Press **Play** ( ). Did the ball go too far, the right distance, or not far enough? The ball did not go far enough :_)

2. Click **Reset** ( ). Move the $v_{initial}$ and θ *sliders* to adjust the **velocity** and **launch angle** until you get a hole-in-one. (With the Gizmo sound on ( ) you will hear "Hole in one!")

   What were the velocity and launch angle values? The initial velocity was 65m/s whereas the launch angle was 45 degrees.

3. Can you get holes-in-one using other combinations of $v_{initial}$ and θ? If so, give an example.

   Yes, there are tons of different possible combinations of initial velocity and launch angles. For example, when the initial velocity is 68 m/s and the launch angle is 30 degrees, a hole-in-one is also accomplished.

Activity A: **Maximum distance**	Get the Gizmo ready: • Click **Reset** and check that **Atmosphere: Air** is selected. • Set $v_{initial}$ to 75 m/s and θ to 45.0 degrees.	

Question: What launch angle will produce the longest drive?

1. Form hypothesis: What launch angle do you think will yield the longest drive? [1]
   I believe that the launch angle that will result in the longest drive will be 45 degrees.

2. Experiment: Turn on the **Show grid** checkbox. With the velocity set to 75 m/s, experiment with a variety of launch angles until you find the one that yields the longest driving distance. [2]
   A. What launch angle produced the longest drive?
      The launch angle of 45 degrees produced the longest drive however with the inability to zoom in, 40 degrees often seemed to result in nearly the same distance.
   B. How far did the ball travel?
      From the graph, the ball seemed to travel 376.3 m in horizontal distance.

3. Observe: Click **Reset** and turn on **Show paths**. Click **Clear paths**. Take a swing with the optimum launch angle. The curved path the ball takes through the air is its **trajectory**. [1]
   Look closely at the trajectory. Does it appear symmetrical?

   On first glance the ball appears symmetrical however, on closer inspection it is not.

   The curve is slightly steeper on the right than on the left as a result of **air resistance**.

4. Experiment: Click **Reset**, then select **Atmosphere: None**. As before, use trial and error until you find the launch angle that produces the longest drive. [4]

   A. What launch angle produced the longest drive?
      With no air resistance, a launch angle of 45 degrees produced the longest drive.

   B. How far did the ball travel?
      From the graph, the ball seemed to travel 575.5 m in horizontal distance.

   C. Why do you think the ball traveled farther in this situation?
      I believe that the ball traveled farther in this situation than the former one because of a lack of air resistance. With atmosphere set to none, the ball is no longer impacted by a negating force and is thereby able to travel further.

5. Extend your thinking: The Moon has much less gravity than Earth and has an extremely thin atmosphere. How would these factors affect the trajectory of a golf ball on the Moon? [2]
   Since the moon has a lower gravity in comparison to that of the Earth's, there is less force acting on the golf ball in the downward direction. This will result in the golf ball's trajectory going higher and farther than if it were to be hit with the same force on Earth.