GIZMOS STUDENT EXPLORATION: GOLF RANGE – UPDATED ANSWER KEY

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.

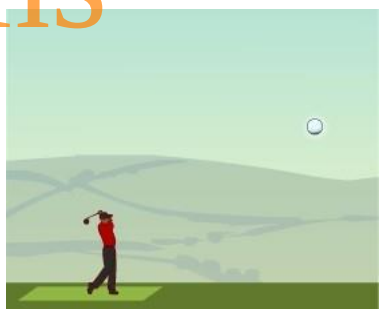
   You should hit a line drive to get the highest horizontal velocity, which will cause the ball to go farther before the force of gravity brings it back to the ground.

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

   Major League home runs require the baseball to have more vertical velocity than the golf drives require on the golf balls.

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? **Not 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?
   Velocity = 65m/s and the Launch Angle = 65 degrees.

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

   $V_{initial}$ = 68m/s and θ = 30 $v_{initial}$ = 82m/s and θ = 18 $v_{initial}$ = 100m/s and θ = 11.5

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? **40.0 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.

   A. What launch angle produced the longest drive? **43.0 degrees**

   B. How far did the ball travel? **375 meters**

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**.

   Look closely at the trajectory. Does it appear symmetrical? **No, not entirely symmetrical, but close.**

   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.

   A. What launch angle produced the longest drive? **45 degrees**

   B. How far did the ball travel? **575 meters**

   C. Why do you think the ball traveled farther in this situation? **Without the air resistance pushing back on the golf ball, the ball was 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?

   With the lower gravity and thin atmosphere on the moon, a golf ball would travel farther because the gravity would be pulling the golf ball to the surface as strongly as it would on Earth and the velocity of the ball wouldn't be slowed down as much due to it not moving through as much air particles.

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