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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.

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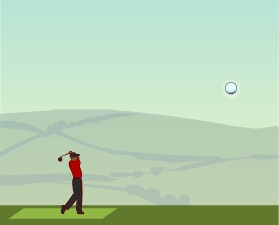
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1. Golf drives travel much farther than Major League home runs. Why might this be?

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**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** (Play ). Did the ball go too far, the right distance,

or not far enough? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Click **Reset** (Reset). Move the **vinitial** and **θ** sliders to adjust the **velocity** and **launch angle** until you get a hole-in-one. (With the Gizmo sound on (sound) you will hear “Hole in one!”)

What were the velocity and launch angle values? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Can you get holes-in-one using other combinations of **vinitial** and **θ**? If so, give an example.

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| **Activity A:**  **Maximum distance** | Get the Gizmo ready:   * Click **Reset** and check that **Atmosphere: Air** is selected. * Set ***vinitial*** to 75 m/s and ***θ*** to 45.0 degrees. | 2nd |

**Question: What launch angle will produce the longest drive?**

1. Form hypothesis: What launch angle do you think will yield the longest drive? [1] \_\_\_\_\_\_\_\_\_
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]
3. What launch angle produced the longest drive? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. How far did the ball travel? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. 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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. 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]
2. What launch angle produced the longest drive? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How far did the ball travel? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Why do you think the ball traveled farther in this situation? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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1. 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]

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