Name: **Date:** **Class:**

Horizontal Projectile Launcher Competition
Answer Key

Learning objectives:

By the end of this project, you will be able to:

- Use the engineering design process to assess, design, plan, build, test, and improve a solution to a real-world problem.
- Describe the relationship between height, initial velocity, and the distance a projectile will travel.

Materials:

- Arduino UNO w/ USB cable
- computer with Arduino IDE
- 2 infrared proximity sensors
- 1 RGB LED
- 6 female-to-male Dupont wires
- Arduino holder
- materials for projectile launcher
  - cardboard, plastic containers, PVC pipes, popsicle sticks, etc.
  - springs, rubber bands or other elastic material, air pumps, etc.

Step 1: Ask

- What do we want to design?
  A horizontal projectile launcher

- What are the project requirements and limitations?
  This can vary based on your classroom limitations. In my classroom, I will have these:
    - Must be smaller than 12 in x 12 in x 12 in (ensures a ‘desktop’ design)
    - Must launch the projectile horizontally (necessary for consistency among groups and to use with speed detector)
    - Bouncy ball as the projectile (all groups use the same projectile)
    - Must not be a ramp (this was used in the activity leading into this project)

- What is our goal?
  To launch our projectile farther than all other groups.

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Step 2: Research

List at least three sources and a brief description of what ideas/information you gathered from each source:

Answers will vary.

Step 3: Imagine

Brainstorm ideas for your design with your group. Each member should contribute at least one idea. Each idea should be listed below with a short pro/con list.

Some ideas to help if kids are struggling. (Remind students of the requirements and limitations as they work through this)

- spring-loaded launcher
- rubber band launcher
- slingshot
- pneumatic launcher
- rotational/flywheel launcher
- electromagnetic launcher
- tension/elastic band catapult
- ballista
- compressed gas launcher
- motorized arm launcher

Brainstorming Guidelines

- One conversation at a time
- Defer judgment
- Build on the ideas of others
- Stay focused and on topic
- Encourage wild ideas

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Step 4: Plan

Select one idea from your brainstorming step to become your group's design. Use the space below to sketch the design. Include measurements, notes about assembly, materials, how parts will attach, and any other vital details in your design.

Answers will vary.

Make a list of materials you will need below. Make a plan for acquiring the materials.

Answers will vary.

Step 5: Create
At this stage, you will need to start building your first prototype. It is important to collaborate during this process. It is okay to make small deviations from your original design based on observations you make or challenges you encounter during this process.

Step 6: Test and Evaluate
At this stage, your prototype should be complete. Test your projectile launcher and answer the following questions. **We will not take measurements of the launch distance until the final competition.**

- Does your launcher work?
  Answers will vary.

- Does your launcher meet all requirements and limitations?
  Answers will vary.

- Are there ways your launcher could be improved?
  Answers will vary.

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Step 7: Improve

Make any improvement you deem necessary to maximize the distance of the projectile. You can continue to test and improve as you go until it is time for the final competition.

Final Competition

At this time, all modifications must be complete. Each team will have three opportunities to launch the projectile. Track the distances in the table below:

Group	A	B	C	D	E
Trial 1 distance (m)					
Trial 2 distance (m)					
Trial 3 distance (m)					
Best (m)					

Final Question: For the winning group, use the distance measured, the standard height, and the kinematic equations to determine the initial velocity of the projectile.

y-direction:

$$d = v_i t + \frac{1}{2}at^2$$

$$h = 0 + \frac{1}{2}gt^2$$

$$\sqrt{\frac{2h}{g}} = t$$

x-direction:

$$d = v_i t + \frac{1}{2}at^2$$

$$d = v_i t + 0$$

$$d = v_i t$$

$$v_i = d/t$$