Ready, Set, Jump!

Target Audience

High school

Time Estimate

45–60 min

Objective(s)

- Conduct an investigation to measure hang time accurately.
- Analyze and interpret a force vs. time graph to identify patterns of motion.
- Use digital tools to determine the maximum height of a vertical jump from the hang time.

Prepare for the Lesson

Materials

Materials for each group of students

- ☐ Computer or Chromebook™
- ☐ Go Direct® Force Plate

Safety Information

Take care to set the force plate in an area free from obstructions. Students need to wear shoes that will allow them to jump and land safely.

Preparation Instructions

Please note: Force plates that shipped before June 2024 had firmware with two data-collection modes: "Physics" and "Physiology." Starting in June 2024, all Go Direct Force Plates are shipping with updated firmware that eliminates the different modes. If you received force plates before June 2024, you should update the firmware.

To update the firmware, first update Graphical Analysis to v.6.2 or newer and then refer to https://www.vernier.com/til/4013

Data Collection and Analysis Tips

1. Graphical Analysis uses kinematics equations to approximate the jump height by calculating the distance traveled by the jumper's center of mass. Students who have studied kinematics should be able to explain how jump height is determined from half of the hang time value using the constant acceleration model, $\Delta y = v_0 t + 1/2 a t^2$, where $v_0 = 0$ m/s (i.e., starting at the top of the jump until they land on the force plate).

2. When considering ways that a jumper can increase their jump height, students need to remember that the body is not a point particle. Students may offer solutions like bending the knees to get higher, but that doesn't change the motion of the center of mass of the body. The calculated jump height is only that of the center of mass.

3D Elements in the Lesson

Science and Engineering Practices	• **Analyzing and interpreting data** [DATA-H1] Analyze data using tools, technologies, and models (e.g., computational, mathematical) in order to make valid and reliable scientific claims. • **Planning and carrying out investigations** [INV-H4] Select appropriate tools to collect, record, analyze, and evaluate data. • **Obtaining, Evaluating, and Communicating Information** [INFO-H5] Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
Crosscutting Concepts	• **Patterns** PAT-H4 Mathematical representations are needed to identify some patterns. • **Stability and change** SC-H2 Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Codes for the elements come from *The NSTA ATLAS of the Three Dimensions* (Willard, 2020) and the elements are described in *A Framework for K−12 Science Education* (NRC, 2012).

Performance Expectation(s) from NGSS

This lesson builds towards

HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press

TEKS

TEKS Physics	4A - Analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student.

Connecting to Students' Cultures and Backgrounds

Student Culture Focus

Connect instruction to students' homes, neighborhoods, communities, and cultures as appropriate, and provide multiple opportunities for students to support their learning with questions and ideas from their own funds of knowledge. For instance, students should use their own funds of knowledge in initial 3D ideas questions. Funds of knowledge may include connection to track events such as high jump, or long jump, or perhaps even advanced jump roping.

Varied Classroom Discourse Strategies

Help all students make productive contributions to classroom discourse by providing for individual thinking time and small group sharing before whole group discussion.

Multiple Ways to Learn

Provide multiple access points and modalities for students to learn. For instance, students can construct understanding through use of the SEPs using various modalities, including reading both text and diagrams; writing, drawing, and gesturing to develop models; and speaking and listening through argumentation and evidence-based discourse. Provide support for all students to make thinking visible in ways that are less dependent on English language proficiency.