PhET Tips for Teachers — Projectile Data Lab

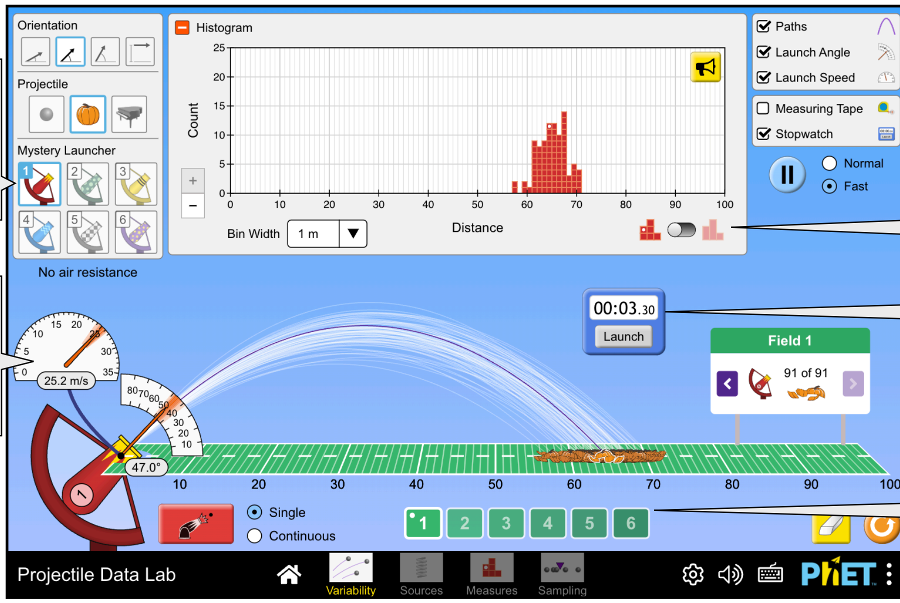
The ***Projectile Data Lab*** simulation allows students to engage in hands-on data collection and analysis through the context of projectile motion.

Variability Screen

Launch projectiles with different orientations and mystery launchers, and investigate the resulting distributions of speed, angle, and distance. Measure flight time and range with realistic uncertainty.

EXPLORE different mystery launchers

VISUALIZE distributions of speed and angle



REPRESENT data as blocks or bars

MEASURE flight time

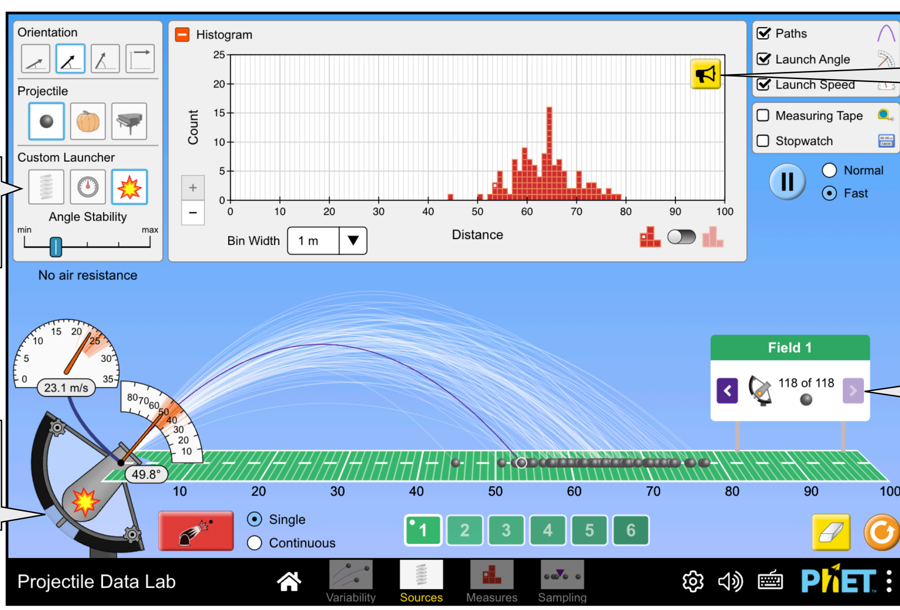
CREATE different data sets

Sources Screen

Use the custom launcher to see how physical properties of the apparatus affect the variability of speed and angle. See how the combination of these affects the resulting distribution of distances.

CUSTOMIZE launch apparatus

SEE INSIDE custom launcher



HEAR the distribution

NAVIGATE through data

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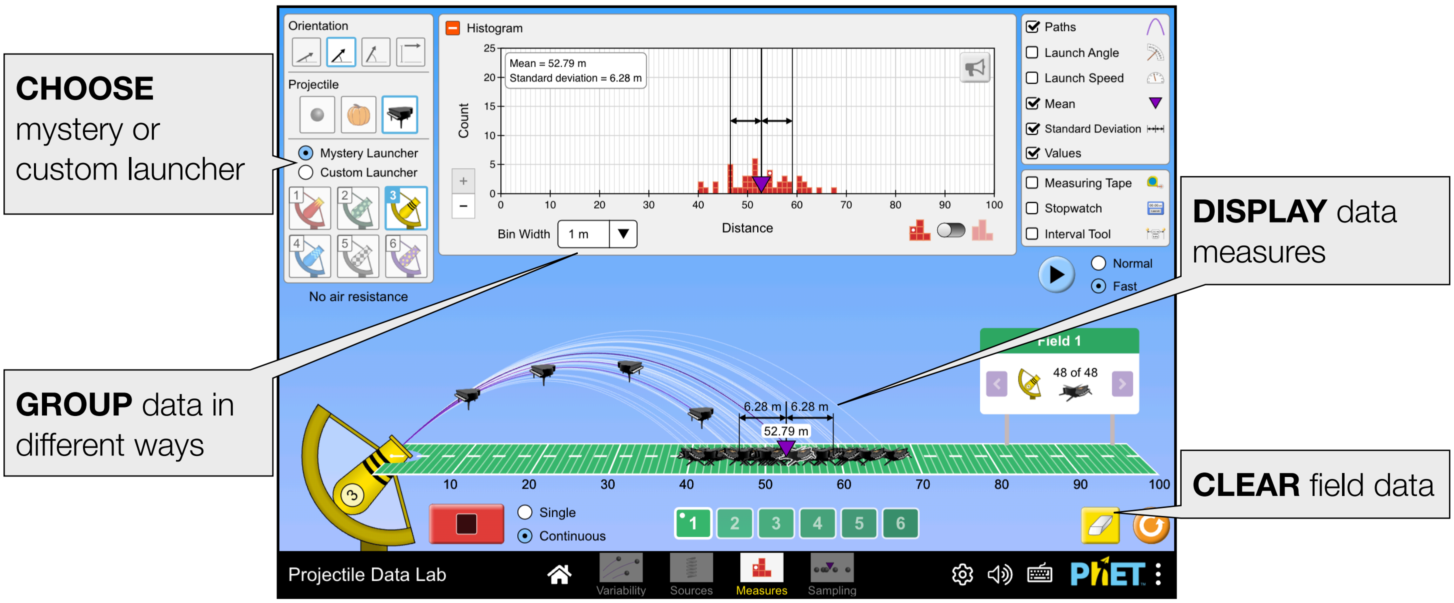
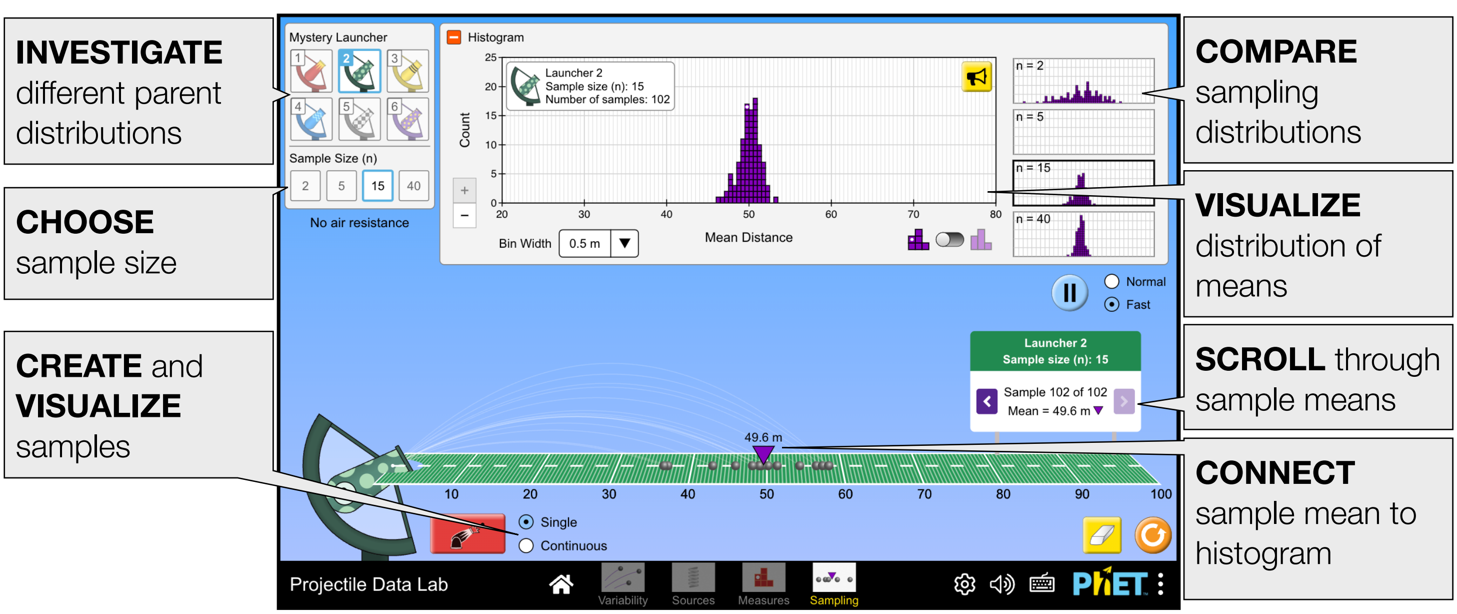
Measures Screen

Compare the mystery launchers to the custom launcher and investigate how each one is configured. Display the mean and standard deviation of distance. Use the interval tool to see the portion of data that falls within a given range.



Sampling Screen

Collect samples of different sizes and examine their distribution of means. Explore how different launch parameters create a variety of distributions as you watch the Central Limit Theorem come to life.



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Complex Controls

- The stopwatch automatically launches a projectile when started and needs to be manually stopped.
- The field sign shows projectile type, launcher, and orientation for the highlighted projectile on the field.
- On the Measures screen, the interval tool displays the portion of data within its range. Its location and width can be changed by dragging its central panel or edge handles, respectively.

Model Simplifications

- Air resistance is ignored in this sim. Differences between trajectories are entirely due to the initial speed and angle of launched projectiles.
- Launch speed and launch angle are randomly generated from normal distributions as described below:
  - The launch mechanism (spring, pressure, explosion) affects the mean and standard deviation of the distribution of launch speeds.
  - The type of projectile affects each mechanism's mean launch speed. This is meant to incorporate the role of each projectile's mass on the ability of the launcher to accelerate it.
  - The orientation affects the mean launch angle and initial height.
  - The angle stability determines the standard deviation of the launch angle.
- Launch angles cannot be above 90º for any orientation, or below 0º when launching from ground level.
- On the Variability, Sources, and Measures screens, the maximum number of projectiles per field is 500.
- On the Sampling screen, the maximum number of samples per field is 200 (regardless of sample size).

Insights into Student Use

- Students should be encouraged to separate their data using the field buttons located under the field.
- Unless prompted, students may not notice they can scroll through collected data using the field sign. This can be helpful in determining if a student has combined data from different launch configurations.
- Students may not realize that the sim can be run at normal or fast speed.
- For faster data collection, use 'Continuous' mode.
- The field sign can be used to scroll through projectiles and highlight their paths, making it easier to measure range or maximum height. With sound on, you can 'hear' the distribution by scrolling quickly.
- The button in the top-right corner of the histogram will play an audio representation of the distribution. See how this changes based on the data and bin width.
- The 'Auto-Generate Data' option in the Preferences menu allows for instant creation of a full data set, to help students analyze distributions more quickly.

Suggestions for Use

Sample Challenge Prompts

- Compare the uncertainty in measuring the range for the three types of projectiles.
- Rank the launchers from least to most precise. Explain how you made your ranking.
- What is the launch mechanism (spring, pressure, explosion) used for each mystery launcher? Justify your answers with evidence from the simulation.
- Describe any similarities or differences between using an orientation of 30 degrees vs 60 degrees.
- How much data falls within one standard deviation of the mean? How does this number change as the sample size increases?
- Describe the relationship between the sample size and the distribution of sample means. Explain the reason for this relationship in your own words.

Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '`?`' to the sim URL, and separating each query parameter with a '`&`'. The general URL pattern is:
`…html?queryParameter1&queryParameter2&queryParameter3`

For example, in Projectile Data Lab, if you only want to include the 1st and 2nd screens (`screens=1,2`), with the 2nd screen open by default (`initialScreen=2`) use:
https://phet.colorado.edu/sims/html/projectile-data-lab/latest/projectile-data-lab_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:
https://phet.colorado.edu/sims/html/projectile-data-lab/latest/projectile-data-lab_all.html?locale=es&screens=1,2&initialScreen=2

⚙ Indicates this customization can be accessed from the Preferences menu within the simulation.

Query Parameter and Description	Example Links
⚙ `projectileTypeAffectsSpeed` - determines whether the type of projectile affects the mean launch speed. Default is `true`.	`projectileTypeAffectsSpeed=false`
⚙ `autoGenerateData` - makes it so the launch button generates a full data data. Default is `false`.	`autoGenerateData=true`
⚙ `showStandardError` - determines whether the standard error of the mean can be displayed on the Measures screen. Default is `false`.	`showStandardError=true`
⚙ `histogramBins` - the histogram can represent data based on the width of the bin or by the total number of bins on the field. Default is `binWidth`.	`histogramBins=totalBins`
⚙ `audio` - if muted, audio is muted by default. If disabled, all audio is permanently turned off.	`audio=muted` `audio=disabled`
⚙ `launchSound` - the launch sound can represent either the initial `speed` or `angle` of the projectile, or can be turned off with `none`. Default is `speed`.	`launchSound=angle`
⚙ `playLandingSound` - causes a sound to play when a projectile lands. Default is `true`.	`playLandingSound=false`
⚙ `locale` - specify the language of the simulation using ISO 639-1 codes. Available locales are listed at the simulation page on the Translations tab. Note: this only works if the simulation URL ends in "_all.html".	`locale=es` (Spanish) `locale=fr` (French)
`allowLinks` - when `false`, disables links that take students to an external URL. Default is `true`.	`allowLinks=false`
`supportsPanAndZoom` - when `false`, disables panning and zooming using pinch-to-zoom or browser zoom controls. Default is `true`.	`supportsPanAndZoom=false`

See all published activities for Projectile Data Lab here.
For more tips on using PhET sims with your students, see Tips for Using PhET.

Blackman, Carter, Paul, April 2024