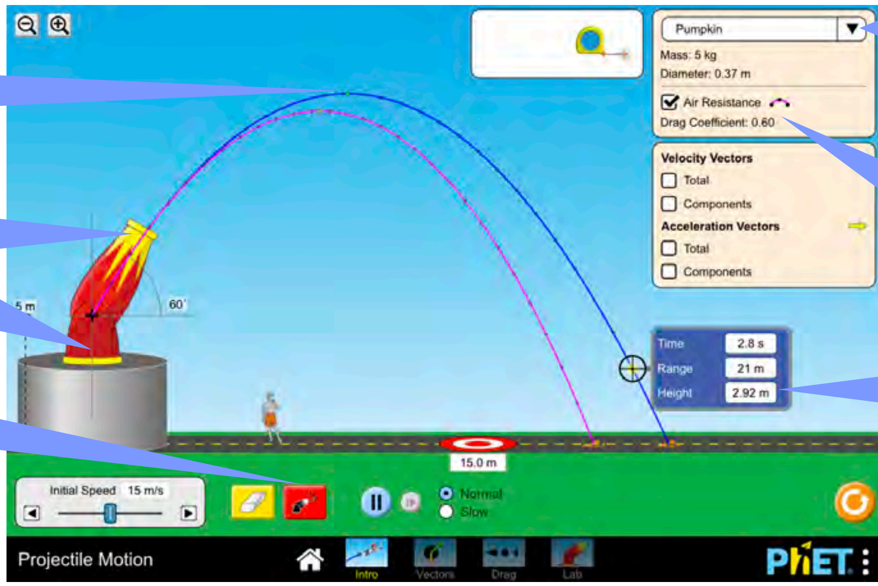
Projectile Motion

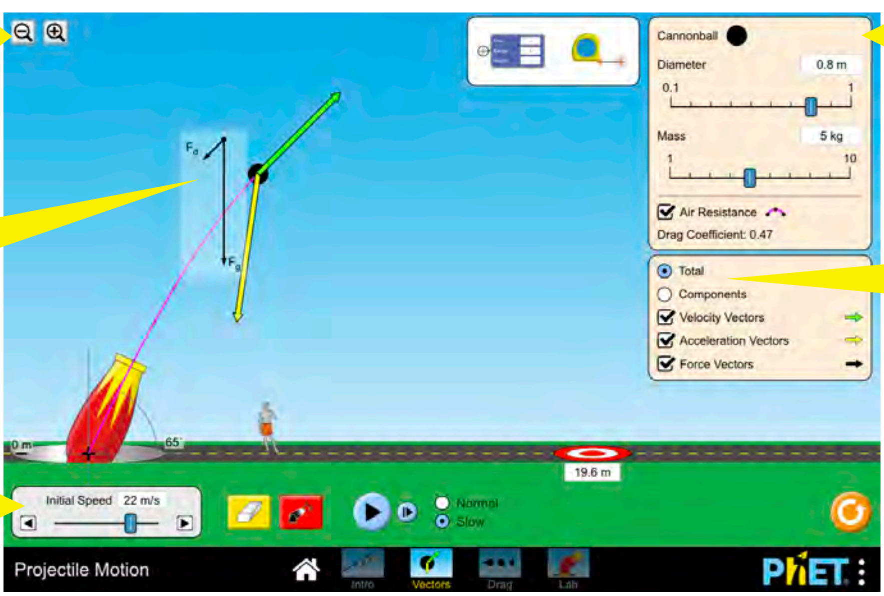
Intro Screen

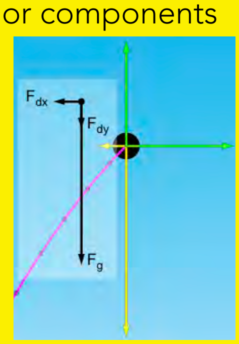
Investigate the the factors that affect a projectile's trajectory, such as angle, height, initial speed, and air resistance.



Vectors Screen

View the drag and gravitational forces in a free-body diagram, and explore how the velocity and acceleration are affected by air resistance.

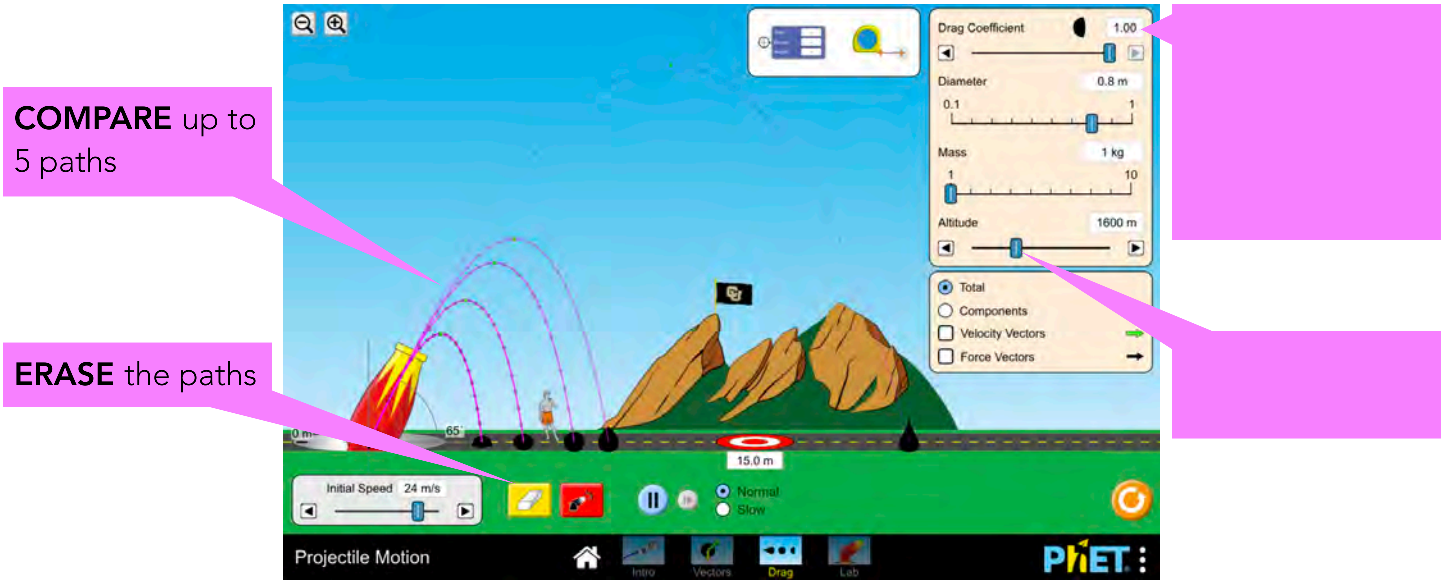




Rouinfar, August 2017

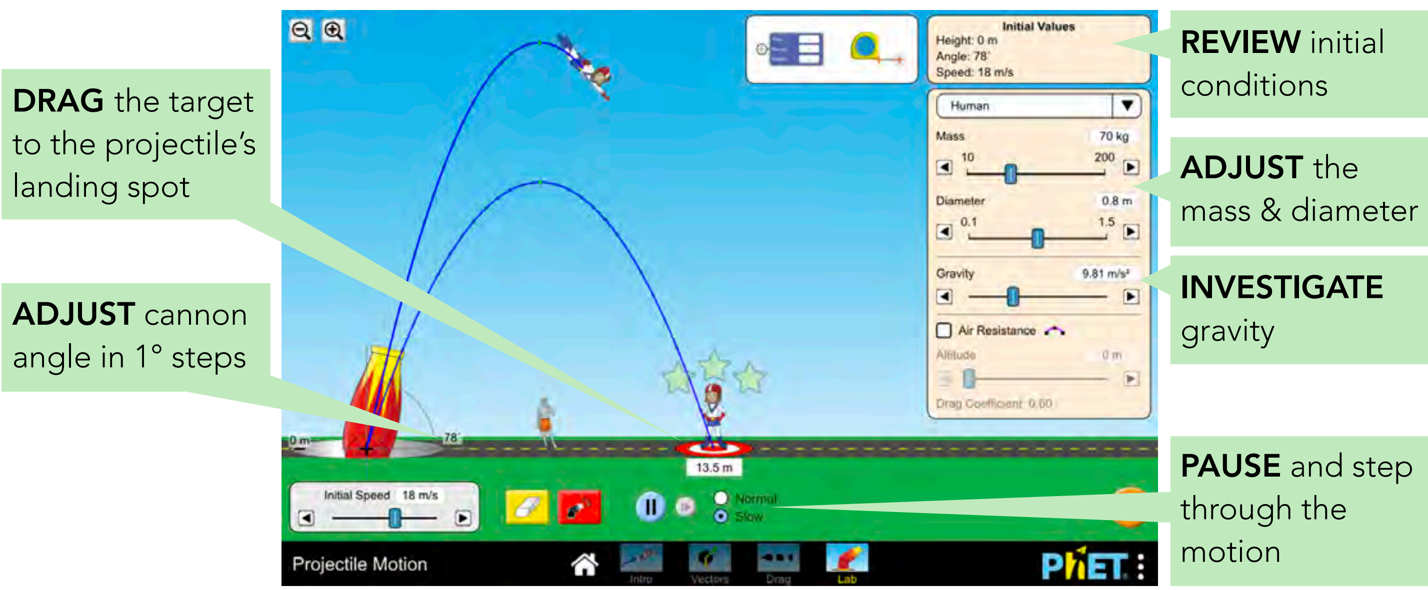
Drag Screen

Determine the factors that affect the drag force, and observe the relationship between the drag force and the velocity.



Lab Screen

Explore the effects of adjusting the projectile's parameters, and investigate the influence of gravity.



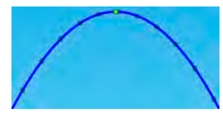
Model Simplifications

- The cannon has crosshairs to mark the initial location of the projectile.
- Changes in air resistance, altitude, and gravity apply immediately and will affect all projectiles mid-flight.
- Vectors are drawn from the center of the image, which may deviate slightly from the center of mass. For better visibility, the vectors do not scale with the zoom level.

- The drag force is modeled used quadratic drag ($F_{drag} \propto v^2$) which is valid in the high Reynold's number limit appropriate for macroscopic objects like baseballs. Linear drag (Stoke's Law) is only valid in the very low Reynold's number limit (like micron-sized droplets in air).
- The drag coefficient depends on the Reynolds number, which we have assumed to be a constant.
- The drag coefficient also depends on the geometry of the object, so benchmark projectiles (e.g. baseball, car) do not have an adjustable drag coefficient.
- The cross-sectional area of the projectiles is approximated to be a circle, and its area is determined by the diameter.
- Items that stay tangent to the trajectory while in motion (e.g. football, tank shell) are assumed to have the appropriate aerodynamics or weight distribution that leads to this behavior.

Complex Controls

- Up to three projectiles can be queued up if fired while paused.
- The tracer tool can measure the time, range, and height of the projectile at any dot along the path. The black dots are drawn in 0.1s intervals, and the green dot represents the apex.



- The "Custom" projectile on Lab screen allows users to enter precise values for the mass, diameter, gravity, altitude, and drag coefficient. The acceptable range for these values will be displayed at the top of the keypad.

- The cannon sits on a pedestal with an adjustable height. To cue this behavior, the canno on the Intro screen starts at 10 m, and has arrows on the height label that will disappear once the cannon's height is adjusted.