# Physics –Forces – The Glider Project

| | Mystery (inertia) Stations (Newton's 1st) | Carts & Masses (Newton's 2nd) | Force Meters (Weight & Hooke's Law) |
|---|---|---|---|
| Student Experience | Students visit various inertia demonstrations around room, and must determine what they all have in common (concept of inertia is not discussed until end of lesson). | Students attach various masses to a string connected to a cart. The mass falls, students determine the acceleration of the cart, and discover the relationship between force, mass, and acceleration. | Students create their own force meters using an elastic material (from the T4T cart) and calibrate them by hanging known masses. |
| T4T Material | Bowling ball, table tennis ball, pennies, tablecloth, dishes | T4T cart, string, set of weights | Elastic material from cart, vinyl window blind, set of weights |
| Big Idea | Newton's 1st Law. An object in motion will continue in motion with constant velocity unless acted upon by a net external force. | Newton's 2nd Law. $\mathbf{F}_{net} = m\mathbf{a}$. | Weight: $\mathbf{F}_g = m\mathbf{g}$<br>Hooke's Law: $\mathbf{F}_s = -k\mathbf{x}$ (honors physics only) |
| Connection to Culminating Activity | The glider's inertia causes its resistance to acceleration when launched. | A net external force on an object will cause it to accelerate, which explains the glider's acceleration during launch. | The force meters are essentially scaled-down versions of the glider launcher that will be used in the culminating project. |
| CA Standards | PH1. b. | PH1. c. | -- |
| Next Gen. Sci. Standards | -- | HS-PS2-1. | -- |
| Time | One 55-min period | Two 55-min periods | One 55-min period |

*CA Standards:*

| | |
|---|---|
| PH1. b. | *Students know* that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law). |
| PH1. c. | *Students know* how to apply the law $F = ma$ to solve one-dimensional motion problems that involve constant forces (Newton's second law). |
| PH1. d. | *Students know* that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law). |

| | Tug-of-War (Newton's 3rd) | Force Stations (FBDs) | Glider Engineering (Culminating Activity) |
|---|---|---|---|
| Student Experience | Students use their force meters to investigate systems where forces oppose each other. They predict force meter readings before testing. | Students visit stations around the room and "draw the forces." Then, FBDs are introduced, and students create correct FBDs for each system. | Students create a glider to be launched by a rubber band or gravity-driven launcher. The glider must achieve a minimum launch velocity, but avoid too great an acceleration (so the "pilot" doesn't black-out). If using rubber band, teacher provides students with average force exerted by the launcher. |
| Material | Student-made force meters. | T4T cart materials, simple machines. | T4T cart materials |
| Big Idea | Newton's 3rd Law. $\mathbf{F}_{A,B} = -\mathbf{F}_{B,A}$ | Free-body diagrams help depict the forces acting on a system. | $\mathbf{F}_{net} = m\mathbf{a}$ $v^2 = v_0^2 + 2a\Delta x$ |
| Connection to Culminating Activity | -- | Students will create a FBD of the glider-catapult system. | -- |
| CA Standards | PH1. d. | -- | -- |
| Next Gen. Sci. Standards | -- | -- | HS-PS2-1 |
| Time | One 55-min period | One 55-min period | Five to eight 55-min periods |

# Activity Guide for Forces Unit

**Prior Knowledge:**

- Students know how to solve problems that involve constant speed and average speed. ($v = \Delta x/\Delta t$)
- Students know how to solve problems that involve constant acceleration and average acceleration ($a = \Delta v/\Delta t$)
- Students know how to solve for the acceleration $a$ of an object starting at rest ($v_0 = 0$) and traveling a given distance $\Delta x$ for an amount of time $t$. (Use $\Delta x = v_0 t + \frac{1}{2} a t^2$.)
- Students know how to solve for the final velocity $v$ of an object starting at rest ($v_0 = 0$) and undergoing a constant acceleration $a$ for a distance $\Delta x$. (Use $v^2 = v_0^2 + 2a\Delta x$.)
- Students know that a gravity will accelerate a falling object at 9.8 $m/s^2$.