

In **Vector Addition: Equations** students experiment with vector equations and compare vector sums and differences. Customize the base vectors or explore scalar multiplication by adjusting the coefficients in equation.

The screenshot shows the PhET simulation interface for "Vector Addition: Equations". It features a central coordinate plane with a grid. A vector  $\vec{f}$  is shown in black, and its components are represented by pink vectors  $3\vec{d}$  and  $4\vec{e}$ . The interface includes several control panels:

- SHOW/HIDE vector data:** A panel on the top left with a minus sign icon and a text input field for  $|\vec{f}|$  (31.1) and  $\theta$  (31.8). Below it are three equation type buttons:  $\vec{d} + \vec{e} = \vec{f}$ ,  $\vec{d} - \vec{e} = \vec{f}$ , and  $\vec{d} + \vec{e} + \vec{f} = 0$ . A coefficient input field shows  $3\vec{d} + 4\vec{e} = \vec{f}$ .
- CHOOSE equation type:** A panel on the left with a minus sign icon and a dropdown menu.
- ADJUST coefficients:** A panel on the left with a minus sign icon and input fields for coefficients.
- SNAP to integer coordinates:** A panel on the left with a minus sign icon and two modes:  $\langle x, y \rangle$  (left) and  $\langle r, \theta \rangle$  (right).
- Component style:** A panel on the right with checkboxes for  $\vec{f}$ , Values,  $\Delta\theta$ , and a grid. Below are four component style icons: right triangle, parallelogram, and projection-like.
- Base Vectors:** A panel on the right with a minus sign icon and input fields for  $|\vec{d}| = 5$ ,  $\theta_d = 0$ ,  $|\vec{e}| = 5$ , and  $\theta_e = 55$ .
- SEE base vectors in the graph:** A panel on the right with a minus sign icon and a checkbox.

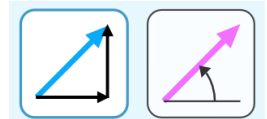
At the bottom right, there is a small inset showing two base vectors  $\vec{b}$  and  $2\vec{b}$ .

## Insights into Student Use

- The difference between the Cartesian and polar coordinate modes is subtle, and some students may not pick up on the difference on their own.
- If students are given opportunity to explore the sim without explicit directions, they will discover which vector representation makes the most sense for them. They may use different representations for different problems.

## Complex Controls

- There are two snapping modes — Cartesian (left) and polar (right). In Cartesian mode, the vectors snap to integer  $\langle x, y \rangle$  values. In polar mode, the vectors snap to integer  $\langle r, \theta \rangle$  values with the angle adjusting in steps of  $5^\circ$ .



## Model Simplifications

- The tail of the vector is restricted to the bounds of the graph. To prevent overly large vectors, the tip of the vector cannot be stretched beyond the bounds of the graph. However, the tip of the vector is allowed to escape the graph when translating the vector.
- The vector labels are grabbable and can be used to translate the vectors within the graph. This may be particularly useful for touch devices with smaller screens.
- The goal of the projection-style component view is to collect the components along the axes. It is not meant to show true projection onto the axes.
- Vectors  $\mathbf{c}$  and  $\mathbf{f}$  are always calculated from the values of the other vectors in the equation.

## Suggestions for Use

### Sample Challenge Prompts

- Describe a vector in your own words.
- Compare and contrast the component styles.
- Describe what happens to a vector when it is multiplied by a scalar.
- Arrange vectors graphically to represent vector addition or subtraction.
- Compare the outcomes of each vector equation.

See all published activities for Vector Addition: Equations [here](#).

For more tips on using PhET sims with your students, see [Tips for Using PhET](#).