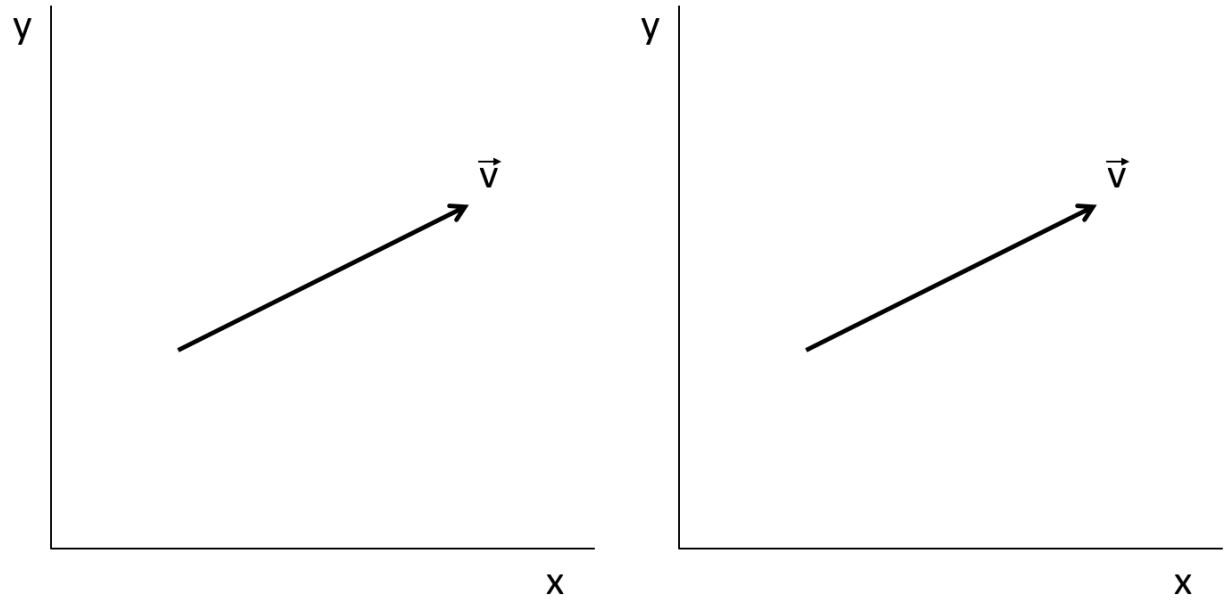
Student handout



1. In the first figure, draw the projections of $\vec{v}$ onto the rectangular basis vectors $\hat{x}$ and $\hat{y}$.
2. In the second figure, draw the projections of $\vec{v}$ onto the polar basis vectors $\hat{s}$ and $\hat{\phi}$.
3. Write the components of $\vec{v}$ as dot products:

$$v_x = \qquad\qquad v_s =$$

$$v_y = \qquad\qquad v_\phi =$$

4. Write the components of $\vec{v}$ as bra/kets: (Warning: Often, particularly in quantum mechanics settings, we will assume that all kets are states and therefore normalized so that their probability is one. We are NOT making that assumption here. Write the vector $\vec{v} = |v\rangle$ without worrying about its normalization.)

$$v_x = \qquad\qquad v_s =$$

$$v_y = \qquad\qquad v_\phi =$$

1 Instructor's Guide

1.1 Students' Task

Students work in small groups to write the components of an arbitrary vector in both dot product notation and bra/ket notation.

1.2 Student Conversations

- **Direction of the polar basis vectors:** The standard physics convention is that the tail of the vector is the point where the vector exists, but other convections exist (for example, Mathematica defaults to placing the arrow so that the middle of the arrow is at the location of the vector). Use the students to be explicit about where the vector is (tail, middle, point, etc) AND have them sketch the direction of the polar basis vectors.
- **Components as sides of a triangle:** Some students will want to draw the components as sides of a triangle. This is also correct, but it's important that the get the direction correct based on the location of the vector (tail, middle, point).

1.3 Wrap-up

- **Different representations:** Emphasize that the dot product notation and the bra/ket notation are just representations for the same thing.
- **Order of the vectors in the dot product:** For real vectors, it doesn't matter which order you write the vectors (the dot product between real vectors is commutative), but this is not going to be true to complex valued quantum state. To preserve the sign of the component, the basis vector should come first (the Hermitian adjoint of the first vector will be taken, changing the sign of the imaginary part). It doesn't matter in this case, but students should start getting used to this more careful ordering. This case be brought out in the wrap up.