



As you can see, the vector (the thick black arrow) does not change when we rotate the coordinate system. Its components change as the coordinate system rotates from  $\Delta x = x_0$  and  $\Delta y = y_0$  to  $\Delta x = x_1$  and  $\Delta y = y_1$ , but its length stays exactly the same. What happens is that the  $\Delta x$  and  $\Delta y$  components both change in such a way to maintain the same length for the vector. Quantities that do not change as you twist and turn the coordinate systems are called *invariant quantities* or *invariants*. So the length of a vector is an invariant but the magnitudes of its components (i.e., the  $\Delta x$  and  $\Delta y$ ) are not. One of the main aims of physics is to discover laws which are invariant, which do not depend on what coordinate system you slap down on your space.

What does any of this have to do with relativity? In Special Relativity, the stage for everything is not the normal 3-d Euclidean world we learned in high-school geometry. It turns out that the space that Special Relativity lives in is a 4-dimensional space with the 3 normal spatial coordinates and an extra coordinate involving time (recall the space and time diagrams with the world lines that we drew in class; we will review that concept