We've so far described abstractly what we mean by a dot product, by a definition of AB equals the magnitude of A times cosine theta, times the magnitude of B. But many times in physics problems, we actually have vectors in space and we want to see how to do this in terms of a Cartesian or any coordinate system in particular.

So let's set up a coordinate system, we'll call it Cartesian, a and j.

And now this is very important.

Let's define a vector A here, and let's have another vector in a completely different point, B. We still can take the dot product of these two vectors.

But in order-- this is our plus x, plus y.

And I'm only doing things in two dimensions.

So how do we calculate the dot product?

Well, the first thing that we want to look at is our unit vectors.

What are the dot products of unit vectors?

Well, if we take i hat dot i hat, that's the magnitude of i hat times cosine of the angle 0, times the magnitude of i hat.

And cosine of 0 is 1 and the magnitude of unit vectors are 1.

So when you dot product the unit vector with itself, you get 1.

And therefore, it's also true for the j hat. j hat dot j hat is 1.

What happens when you dot product two vectors that are perpendicular?

Well, in this case, this is 0 because the angle theta is 90 degrees.

And remember that cosine of 90 degrees is 0.

And anyway, when two vectors are perpendicular, there's no component of one vector that's parallel to the other.

So these are the essential facts that we're going to need to calculate the dot product of two vectors that are separated in space.

So the way we do that is we'll begin by drawing, writing down the vectors in Cartesian coordinates, where Ax A is a scalar and the vector part is and the unit vector.

And we have Ay j hat.

And likewise, we can write B as Bx i hat plus By j hat.

And now when we take the dot product of these two vectors, we're going to write out all the terms here so that you see them.

So here is our scalar or dot product.

We use those words interchangeably.

Now notice that we've already shown that the dot product distributes over vector addition.

And also, if you multiply a scalar by a vector, you can pull the scalar out.

So there's four terms here-- Ax i hat dot Bx i hat plus ax i hat dot By j hat plus Ay j hat dot Bx i hat.

This is a little tedious to write out.

By j hat.

And now because these are scalars, we can pull them out and the only part of a dot product that matters is how the unit vectors dot.

And that's why we have these two results.

i hat dot i hat is 1, j hat dot j hat is 1, and i hat dot j hat is 0.

So the first turn is Ax Bx.

i hat dot j hat is 0, so we don't need that.

j hat dot i hat is 0.

And finally j hat dot j hat is 1.

And so we get plus Ay By.

And that's how we define the dot product in Cartesian coordinates of two vectors.

Now, notice that if we dotted a vector, A dot with itself, that would just be Ax Ax plus Ay Ay, which is the components squared.

And that's equal to the magnitude of the vector squared.

And so we can say that the magnitude of the vector, of any vector, is you take its dot product with itself.

You take the square root, but remember we always take the positive square root, because magnitudes are positive.

And that's how we calculate the scalar product for vectors.

And many times in the application of physics, when we have physical quantities that are vectors in different places, we use vector decomposition and we use this procedure.

This is the Cartesian picture, we'll learn how to do that in polar coordinates when we need it later on.