What is the difference between a scalar and a vector? It's a huge difference. A scalar is uniquely determined by one number. Temperature is a scalar. One number is all it takes. Mass, your weight, that's a scalar. Power, energy, those are scalars. The speed of your car is a scalar. One number tells it all. The size of my shoes, which in United States, I think, is 11 to 12 and in Europe 44 to 45. But in all these cases, one number tells the entire story. And that is not the case with vectors.

Vectors have a magnitude and they have a direction. So you cannot characterize a vector by simply one number. You need more than one number. Examples of vectors that we will see in this course are for instance, velocities, acceleration, force, momentum, angular momentum, torque, impulse, and position vector. The position of an object in three dimensional space cannot be characterized with one number.

So a vector needs more than one number to specify it. It has a magnitude and it has a direction. Let us examine a vector A, and I will write an arrow over the vector to indicate that-- this is an arrow over the A to indicate that it is a vector. Some books write an A in bold, which then means it's a vector. I will not do that because I can't write bold. So I will always use the notation A with a arrow over it. And let's examine a vector in three dimensions. For instance, three dimensional space.

Let's make a drawing. x, y, z. And we have a vector A like so. This is A, and I will project this A onto the xy plane. And then I will further project it onto the y-axis. We call this A of y. I project it onto the x-axis, which is A of x. And I will project it onto the z-axis, which is A of z. We call this a Cartesian coordinate system. Three numbers uniquely define this vector. The numbers Ax, Ay, and Az uniquely define this vector. And the vector notation that you may see in certain books are as follows: A or some books write you an A in bold. And then they may simply give you these three components: A of x, A of y, and A of z.

I will not do that. I prefer a different notation. I will write almost always that A with an arrow over it is the x-component of A in the direction of x. This is the unit vector in the plus x direction. Plus A of y unit vector in the y direction plus A of z unit vector in the z direction. So what I have here, I have literally written down this vector A in terms of the sum of three vectors. x roof is the unit vector in the x direction, y roof is the unit vector in the y direction, and z roof is the unit vector in the plus z direction. And so this is a vector in the x direction. Of course, if a of x is negative, then it would be in the negative x direction. And this is a vector in the y direction. And this is a vector in the z direction. And the sum of these three vectors make up A.

Some books prefer instead of the x roof i roof for x, j roof for y and k roof for z. I will not use that, but you will see it very often. And some books may even prefer a bold i, a bold j, and a bold k. So you'll see all kinds of possibilities. This is the one that I will prefer. What now is the length of this vector, which we often refer to as the magnitude of that vector.

For that we have various notations. Some books simply write an A, not in bold. Some books write the vector notation with two bars on either side, indicating it is the magnitude of that vector. And some books simply write an A with two bars on either side. I may use either one of these three as it suits me. In any case, the magnitude of that vector-- all of the lengths of that vector equals the square root of Ax squared plus Ay squared plus Az squared. This itself, by the way, is a scalar. It is one number. I'll give you an example.

Let's have a velocity vector and the velocity vector is given by 3x roof plus 2y roof minus 4z roof.

What this means is that if we assume that distances are always measured in meters and times are measured in seconds. It means that the component in the x direction is plus 3 meters per second. The component of the velocity in the y direction is also plus-- and it is in this case, plus 2. The component of the velocity in the z direction is 4 meters per second. But it is in the minus z direction.

The magnitude of this velocity vector equals the square root of 3 squared, which is 9. Plus 2 squared, which is 4. Plus minus 4 squared, which is 16. So that's the square root of 29 meters per second. This is the speed, and so this is a scalar.