So I would now like to consider systems in which the total momentum of the system is zero.

And show that L, the angular momentum, is independent of the choice of point A. So let's consider this.

Let's draw a picture here and let's make our system a bunch of discrete particles, particle one particle two.

And let's call this the j-th particle.

And let's just choose a point A right here, and let's choose a point B right there.

And I'll show that L for this system about A is going to be equal to L of the system about B.

In order to make an angular momentum diagram we have the momentum Pj of this particle.

And likewise, for all the other particles.

And I'll draw a vector R A,j Likewise, for B I'll draw the vector R B,j.

And I'm also going to draw a vector from B to A. I'll make that capital.

This vector is a constant because the points A and B, here, A and B are fixed points.

Now let's calculate the angular momentum about A for the system.

It's the sum of j goes from 1 to n of the vector R A,j cross Pj.

And I can use the angular momentum of the system about B is j goes from 1 to n of R B,j cross Pj.

Now I'll use the vector triangle, that the vector from B to j is equal to the vector from B to A plus the vector from A to j.

So we have that R B,j is equal to the vector from B to A plus the vector from A to j.

And I'll substitute that into our expression for the angular moment about B. So the angular momentum about B is the sum j goes from 1 to n of R B,A plus R A,j cross Pj.

Now the vector product distributes over vector addition.

So this is two sums.

So let's write them both out.

J goes from 1 to n of R B,A cross Pj plus the sum j goes from 1 to n of R A,j cross Pj.

Now already you're seeing that this term is the angular momentum of the system about A. This term is the interesting one.

R P,A is a constant vector.

No matter which particle I choose, one, two, the j-th particle, this vector is always the same.

So I can pull it out of the sum and I get R B,A cross product the sum of j goes from 1 to and of Pj.

Now we've already recognized this term as the angular momentum of the system about A.

And this is just the total momentum of the system.

So we have equal to R B,A cross the total momentum of the system plus the angular momentum of the system about A.

And that's the angular momentum of the system about B.

So this is our general result about how angular momentum differ between two points.

But now, if P system equals to zero, the first term is zero, then L of the system about B is equal to the L of the system about A. We've proved our proposition that if the total momentum of the system is zero then the angular momentum doesn't depend on the point we choose.

Now what's interesting here is that the reference frame moving with the center of mass, by definition, has P in that frame, let's call it the system.

And this is the cm frame is zero by definition.

So this is one more reason why the center of mass reference frame is an important reference frame.

Because in the center of mass reference frame, the total momentum, by definition, is zero.

And therefore, the angular momentum is independent of any point that you choose in that reference frame.

And so we can say that the system, when we talk about a system's angular momentum, we're referring to the angular momentum in the center of mass reference frame.