Let's examine the velocities of objects in the center of mass reference frame.

So we have object 1 and object 2.

And we have CM.

And we have r1 prime.

And we have r2 prime.

And recall that we found that the position vector, r1 prime, was equal to the reduced mass over mu m1 times the relative position to r1, 2.

I'll draw that up here, r1, 2 from 2 to 1.

And just to remind you, r1 minus r2.

And likewise the position vector r2 prime is minus mu m2 over r1, 2.

Well, now we can differentiate the positions in the center of mass frame.

And we find that the V1, which is, of course, the derivative of the position, is just mu over m1 V1, 2.

And V2 prime is equal to mu over m2 with a minus sign V1, 2.

Now the significance of this result is that the velocity of the object in the center of mass frame is equal to some constant times the relative velocity.

Likewise, velocity V2 prime in the center of mass frame is also proportional to a constant.

And it's in minus the relative velocities.

So the significance of this result is that when we looked at an elastic one-dimensional collision, we already have the result that the relative velocities, V1, 2 initial, is minus the final relative velocity.

And we also know from what we saw that the relative velocity is independent of the reference frame.

So this condition about relative velocity is true in any reference frame.

And in particular, it's true in the center of mass frame.

So what that shows us is that these conditions, this statement, is that the magnitude of the relative velocity is

constant.

And the conclusion is because in the center of mass frame, V1 prime is proportional to the relative velocity.

That tells us that in a center of mass reference frame that the initial velocity of object 1 in the center of mass frame is equal to the final velocity of object 1.

So the quantity, the speed of objects 1 and objects 2 in an elastic collision in the center of mass reference frame do not change magnitude.

We can call this quantity V2 prime and likewise V prime 2 initial is equal to V2 final prime V2 prime.

And this will make our analysis of collisions in the center of mass reference frame very easy.

Two objects, when they're colliding in the center of mass reference frame, their speeds do not change.

Only the direction of their velocities change.