We would like to now apply the momentum principle to examples of recoil.

So recall that the momentum principle is that the external force causes the momentum of the system to change.

Now, this is a vector equation.

So for example, if the external force in the x direction is 0, then the momentum of the system in the x direction, let's say, the final momentum will be equal to the initial momentum.

I would like to now apply the momentum principle to an example of recoil.

In our recoil example, we have a person jumping off a cart.

So let's just look at how this example can work if we draw momentum diagrams.

So suppose we choose a ground frame.

And in that ground frame, we have a cart and a person.

A person is standing on the cart.

And this is t initial.

And here, they are at rest.

Now, the person we're going to assume to jump horizontally off the cart, and the cart will recoil in the opposite direction.

So after the jump, we can describe this picture.

The person is moving with the velocity, v. The cart is moving with vc.

And the person has jumped with the velocity vp.

Now, suppose I choose a different reference frame.

That instead of choosing a ground frame, as a reference frame moving with the velocity vc.

You can imagine that maybe I have a car here and you're inside that car moving with velocity vc, and you're looking at this picture.

Then, what would our momentum diagrams look like?

Well, if I'm moving in a car this way and in the ground frame the initial picture is the person in the cart is at rest.

Then, in my moving frame, it actually looks as if the cart and the person are moving in the opposite direction.

So let's write that this way.

Here's the initial picture, t initial.

And in this frame, the person and the cart are moving with vc minus vc.

I put an arrow here to indicate that it's opposite the direction of vc there.

But their velocity is minus the velocity of the reference frame.

After the jump-- so here's the person now.

The cart is at rest, why?

Because we're in the reference frame moving with vc.

So if you're in a car and you're moving at the same speed that the cart has with the ground frame, then in your frame, this cart looks like it's at rest.

What about the person jumping off?

Well, let's write it this way.

So this is the velocity.

I'm going to use a symbol, u.

Now, u-- this is what do we mean by that.

This is the velocity of the person in the moving frame that's moving with velocity vc-- that's the velocity of the person as seen by a car.

Sometimes we call this the velocity of the person relative to the cart.

What does that word relative to the cart mean?

Well, you can see in this picture.

In this moving frame, the cart is at rest, and the person jumps with the speed u velocity u relative to the cart.

So these are momentum diagrams for a ground frame in which the person in the cart started at rest, the person jumps off.

I can put an arrow here, but it's really information is in that vector.

The cart is moving.

In a frame moving with the velocity of the cart, then what does my picture looks like?

Well, the cart and the person initially are moving opposite directions.

Again, you're moving this way.

The cart looks like it's moving that way if you're inside the car.

And the final state, person, cart is at rest and the person is jumping with the velocity u relative to the cart.

Now, our question now is how do we relate these two velocities, u and vp?

What are u and vp?

vp is the velocity of the person in the ground frame.

And u is the velocity of the person in the moving frame.

Well, we've already seen our equation for how to get velocities in different frames.

We have that vp equals the relative velocity of the two frames plus the velocity in the moving frame.

So what we have is, this is the velocity of the person-- let me just clean that up-- of the person in the ground frame.

v is the relative velocity of the two frames.

So here we have that v is the velocity of the cart, because you're in a frame moving with vc with respect to the ground.

And u is the velocity of the person in the moving frame.

So this is how we can show the same type of interaction in two different reference frames.

Next, we'll figure out what these velocities are.