We'd like to analyze a physics problem called the rocket problem, in which we have a continuous mass transfer.

Let's see what we mean by that.

Let's consider a rocket launching.

So here's a classic example of a rocket that's launching off in a gravitational field.

As a rocket starts at rest, it starts to burn fuel, and ejects the fuel backwards.

And as the ejected fuel backwards is producing a thrust on the rocket-- and you can see, as the rocket starts to rise-- it's starting to accelerate upwards as fuel is ejected backwards.

Now, this process goes on for some time interval.

And a lot of fuel is ejected backwards during that time interval.

In this particular case, we could analyze the situation from the ground frame of the rocket-- from the ground frame of the earth-- and the fuel is ejected backwards relative to the rocket, rocket moves up forward.

So how do we analyze this situation?

If we just looked at the rocket when the rocket initially launched, the mass of the rocket is the dry mass of the rocket plus all the fuel in there.

It's at rest.

In a state much later on, the mass of the rocket has decreased and the speed has increased.

But we can't just compare this initial to this final state, because throughout this process, there was a continuous mass transfer.

Fuel was ejected backwards.

So how do we analyze these types of continuous mass transfer problems?

And the key is, again, identifying states.

So, for a continuous mass transfer problem, we always have to choose a reference frame.

So here, in our example, we were choosing the ground frame of the earth.

And then, we want to identify two states.

We don't want to identify the initial and the final states.

We want to pick two arbitrary states that are separated by a small time interval.

So we can take a state at time t.

And then our second state occurs at a small time afterwards, time t plus delta t.

And what we want to do is now represent the state changes by momentum diagrams.

And that will lead us to a differential equation, which is called the rocket equation.

And that's how we'll analyze all continuous mass transfer problems.

In applying the momentum principle, our first thing is just to choose a reference frame.

So in our example, we're going to choose the ground frame of the earth as a reference frame.

Now, the next step is the key to these processes.

Instead of choosing some initial state where the rocket is at rest and some final state much later on, we want to choose two states that are separated by a small time interval, delta t.

So our first state, at time t.

And our second state, we choose at time t plus delta t.

Now, the next step is that we have to identify what is our system.

And so in this case, our system is going to be the mass of the rocket at time t.

That mass is the dry mass of the rocket plus all the fuel that's still in the rocket at time t.

And this mass will stay the same between times t and t plus delta t, even though some of the mass has been ejected downward.

So our next step is to look at that mass conservation of the system.