Newton's third law states that forces always come in equal and opposite pairs.

One way we can write that is if you imagine two objects, object one and object two, the force exerted by object one on object two is equal and opposite to the force exerted by object two on object one.

This makes explicit that real forces always arise from a physical interaction.

For any force in a problem, you should always be able to identify the other member of the interaction pair.

Newton's third law is the most subtle and sometimes the most confusing of his three laws of motion so I'd like to do an example that will help clarify how to think about it.

So I'm going to pick a very extreme example.

Let's imagine the collision between a marble moving this way and a train moving that way.

And so we'll say that the mass of the train-- I'll write that as "m sub train"-- and the mass of the marble is m sub marble.

And obviously, the mass of the train is much larger-- I'm going to write that as several greater-than signs-- much, much larger than the mass of the marble.

And so the question I want to consider is, at the instant that these two objects collide, which experiences the greater force?

So think about that yourself for a moment.

In terms of outcomes, clearly, the marble will be smashed by the train whereas the train will not be noticeably affected by the marble.

So your intuition might therefore suggest that it's the marble that feels the greater force.

But that's incorrect because Newton's third law tells us that forces come in equal and opposite pairs.

And what that tells us is that each object will exert an equal but oppositely directed force on the other.

Now I chose a very extreme example to capture your attention.

But that might seem like a surprising result but Newton's third law tells us that the forces on each object are going to be equal and opposite.

But just because the forces are equal doesn't mean that the motion will be equal.

The accelerations of the two objects are vastly different because of their different masses.

And the accelerations and the forces are related by Newton's second law, F equals m a.

So if I write that in terms of the acceleration, the acceleration of the marble, "a marble," is equal to the force divided by the mass of the marble whereas the acceleration of the train is equal to-- so since I wrote "F" for the force acting on a marble, I'm going to write minus F for the force acting on the train.

So that's minus F divided by the mass of the train.

And so if I want to look at the ratio, how big is the acceleration of the marble divided by the acceleration of the train?

And let's take the absolute value so we're just talking about magnitudes here.

That's going to be equal to the mass of the train divided by the mass of the marble.

But the mass of the train is much, much, much larger than the mass of the marble so the right-hand side here is a very, very big number.

And that tells us that relative to the acceleration of the train, the acceleration of the marble is going to be enormous.

Even though the force experienced by each object is identical, because of their different masses, their accelerations will be very different.

So that gives us an example of what we mean by Newton's third law, in terms of the interaction pair and equal and opposite forces acting.

I want to reiterate that for any force in a problem, you should always be able to identify the other member of the interaction pair.

So forces always come in pairs.

It's important to keep in mind that these force pairs don't both act on the same object.

They never act on the same object.

The interaction pair always involves a pair of objects, two different objects.

And let me just make that explicit with an example.

The example I'll consider is, imagine a person standing on the ground.

What are the forces acting on this person?

I'll draw the force diagram here, say.

There's gravity, mg, acting downwards and there's a normal force upward exerted by the ground.

And those two balance to give a net force of zero, which is why the person is standing on the ground and not sinking down into the ground, for example.

Now, you might look at gravity and the normal force and wonder if those are an interaction pair.

And they're not because notice that these two forces are both acting on the same object, the person.

The interaction pair always comes from realizing what is exerting the force on the object.

So let's look at each of these in turn.

Gravity is exerted by the Earth.

So if the Earth-- and this means really the entire Earth-- exerts a force mg on the person, Newton's third law tells us that the person exerts a gravitational force on the entire Earth of mg upwards.

Now, that might seem remarkable to you if you're just standing around on the floor that you are exerting a gravitational force on the planet but you are.

However, this is like the example we just talked about a moment ago.

The masses are extremely different even though the forces are the same.

So the acceleration of the Earth due to this person's mass is negligible because the Earth is so much more massive than the person.

But Newton's third law tells us that there is a tiny acceleration on the Earth due to the person.

That is the third law pair for gravity.

mg downward exerted by the Earth on the person is paired with mg upward on the Earth exerted by the person.

Now, for the normal force acting on the person, that force is exerted by the ground.

So the ground exerts an upward force N on the person.

Newton's third law tells us that that means that the person must exert a downward force N on the ground.

That is the interaction pair for Newton's third law for the normal force.