4.5.4 Newton's third law

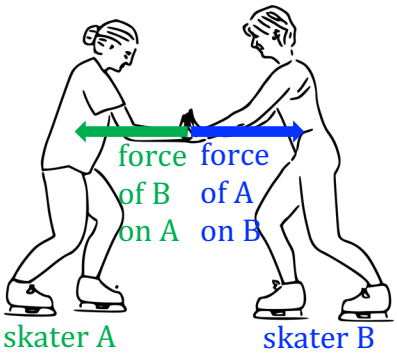
videos

Newton's third law states:

If object A exerts a force on object B, then object B exerts an equal and opposite force on object B. The forces are of the same type.

We can see that forces always come in pairs. We call them "third law pairs".

Consider the following situation:



If the skater A pushes against skater B, skater B will accelerate to the right according to newton's second law ($a = \frac{F}{m}$).

However, the skater A will accelerate to the left because there is an equal and opposite force acting on this skater.

The forces, in this case, are "contact forces". These arise from an electrostatic repulsion between electrons in the surface of the hands on the skaters.

(1) How will the motions of the two skaters compare if - i) the skaters are the same mass?, ii) skater A is more massive than skater B? Explain your answers.

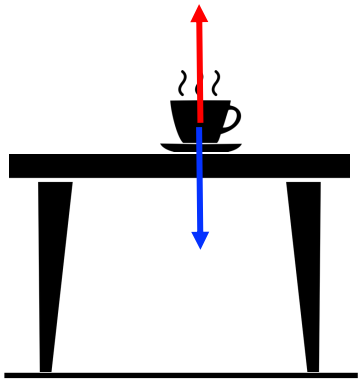
(2) What will happen to the motion of the two skaters once their hands are no longer in contact? (assume that friction is negligible)

Identifying third law pairs

Students often find it difficult to identify third law pairs. The confusion often arises because students forget to consider that third law pairs need to be of the same type of force (e.g. electrostatic/gravitational/etc.).

To identify third law pairs we need to consider what two objects the forces are acting between and make sure that they are of the same type.

Consider a cup at rest on a table sitting on the ground:



(3) What are the two forces acting on the cup?

(4) The cup is stationary, so what can we say about the magnitude of the two forces?

Students may incorrectly identify the weight of the cup and the normal reaction of the table on cup as a third law pair. The problem with this is that the forces are of different types. Weight is gravitational and the normal reaction is electrostatic. The weight of the cup arises from the gravitational attraction of the Earth on the cup. The corresponding third law pair for the weight of the cup is the gravitational attraction of the cup on the Earth.

One method to identify third law pairs is to use the following system:

object A	object B	type
cup	Earth	gravitational
cup	table	electrostatic
table	Earth	gravitational
table	Earth	electrostatic

First, identify the interacting bodies, object A and object B. Secondly, identify the type of force. Then substitute into the following to identify the third law pairs:

The object A exerts a(n) type force on the object B. The object B exerts a(n) type force on the object A. The forces are equal in magnitude and opposite in direction.

Let us take the cup/Earth system as an example.

"The cup exerts a gravitational force on the Earth. The Earth exerts a gravitational force on the cup. The forces are equal in magnitude and opposite in direction."

(5) In the same way as the example, above, work out the third law pairs for the other systems in the table.

(6) There is a third law pair not represented in the table. What is it, and why is it absent?