BBC Bitesize – Physics

Episode 7 – Newton’s Laws of Motion

JAMES: Hello, and welcome to the BBC Bitesize Physics podcast.

ELLIE: The series designed to help you tackle your GCSE in Physics and combined science.

JAMES: I’m James Stewart and I’m a climate science expert and TV presenter.

ELLIE: And I’m Ellie Hurer, a bioscience PhD researcher.

JAMES: And the great thing about doing it this way is you can rewind this podcast whenever you want. So, if there's an equation, then you're like, what on earth are they talking about? Go back, listen again, make some notes, listen on your dog walk on the commute, before you go to bed, whatever works for you, we are happy to be your guides.

And whilst you're here in the BBC Sounds app, have a listen to our other podcasts, where we cover loads more topics you need to understand for your physics GCSE, as well as lots of other subjects too. We've got you covered.

ELLIE: So James, if I say the name Isaac Newton, what's the first thing that comes to your head?

JAMES: Apples. I think, apples. He's the guy that discovered gravity when he started thinking about the apples that were falling from the trees right above his house. Is that right?

ELLIE: Yep, that's right. And if you want to learn more about gravity, be sure to go back and listen to episode 2 of this podcast, which is all about that force that keeps our feet on the ground.

JAMES: But today we're going to talk about something else. Sorry, Isaac. Newton's three laws of motion. Let's go to his garden and begin.

ELLIE: Newton's first law of motion is that a resultant force is required to change the motion of an object.

JAMES: What is a resultant force?

ELLIE: I'm so glad you asked. A resultant force is the combined effect of all of the forces acting on an object. For example, if an apple was falling downward off a tree, the resultant force is downwards. Hitting it with a cricket bat would change its motion.

JAMES: I did wonder why you brought a cricket bat with you. So the act of hitting the apple with that cricket bat causes a change in the resultant force on the apple, which causes a change in its motion?

ELLIE: Yeah, exactly. Newton's first law states that if an object is stationary and the resultant force starts to act on it, that object will start moving.

ELLIE: But, if the resultant force acting on an object is zero, and the object is stationary, the object remains stationary.

JAMES: So, if an apple is on the ground, and no other forces act on it, it stays on the ground. For example, if the force of weight acting from the centre of the apple straight down is 70 Newtons, and the force of the normal contact force, or reaction force, of the ground pushing up on the apple is 70 Newtons, then the resultant force is zero newtons. So the apple just stays still.

ELLIE: Yes, and then if an object is moving, Newton's first law states that the moving object will keep moving with the same velocity if the resultant force is zero. This means its speed and direction will stay the same if the resultant force is zero.

JAMES: So a falling apple will keep falling at the same velocity if the forces are balanced.

ELLIE: That's right, and we can apply it to a car too. When a car is travelling at a steady speed, the resistive forces, like air resistance, balance out the forces driving the car forward. And this is important to remember because people get this wrong all the time. If the resultant forces are zero and the object is already moving, it will keep moving with the same velocity.

JAMES: So according to Newton's first law, the velocity of an object will only change if a non-zero resultant force acts on that object.

ELLIE: Here's another example for you. If someone stopped pressing the accelerator pedal in the car, then the push force from the car would become less than the air resistance and friction.

JAMES: Then there is a resultant force in a direction opposing movement, so the car would begin to slow down.

ELLIE: And that tendency of an object to stay stationary or in uniform motion unless a resultant force acts on an object is called inertia.

JAMES: Okay, let's move on to Newton's second law. Get out of this apple orchard, it's raining.

ELLIE: So, Newton's second law states that the larger the force acting on an object, the more it accelerates. And the greater the mass of an object, the less it will accelerate.

JAMES: What's really important to know about this law is that the acceleration of an object is proportional to the resultant force. So let's imagine you're pushing a trolley down a supermarket aisle.

In this case, the resultant force is the way the trolley is being pushed. So if you double the size of the push forwards, the acceleration also doubles.

ELLIE: And if you were to put more groceries into the trolley, let's say two boxes of cereal, things would change a little.

JAMES: Yeah, exactly, because acceleration is also inversely proportional to the mass of an object. So even if the push force was the same, you'd actually accelerate less, because the mass in the trolley has increased. For example, if the mass in the trolley doubles, you put loads of groceries in there, the acceleration would halve. Okay, it's time to try and make that an equation. So grab your pen, grab your paper. Let's write this down.

ELLIE: The equation to calculate resultant force is: resultant force equals mass, multiplied by acceleration, which is written as uppercase 'F' equals lowercase 'm' multiplied by lowercase 'a'. Force is measured in newtons, mass is measured in kilograms, and acceleration is measured in metres per second squared.

JAMES: Let's move on to Newton's third law. Newton's third law is that whenever two objects interact, the forces they exert on each other are equal and opposite. Every action has an equal and opposite reaction.

ELLIE: Right, so let me give you an example.

Let's say you're at a theme park and decide to get into the dodgem cars. The force of weight would act down from the car onto the ground. This is equal and opposite to the force of the ground pushing back up from the ground onto the car.

JAMES: And according to Newton's law, the two forces must be acting on different objects and be the same type and size.

ELLIE: But what would happen if your friend spotted you in your car and sped straight over to you? And then you drove straight over to them until you bumped into each other?

JAMES: Ellie, spoilers, spoilers, hang on. That's where we need to start getting into the topic of momentum. We'll do that in the next episode, I promise.

But for now, all you need to be able to do is apply Newton's third law to objects that are at equilibrium. Which means the forces acting on them are balanced.

ELLIE: Let's sum up today's episode. Newton's first law is that a resultant force is required to change the motion of a moving or stationary object. Newton's second law is that the resultant force on an object is proportional to the acceleration of the object. And last but not least, Newton's third law is that whenever two objects interact, they exert equal and opposite forces onto each other.

So now you know all about Newton's laws. In the next episode, we're going to be exploring, drumroll please… momentum!

JAMES: Thank you for listening to Bitesize Physics. If you found this helpful, go back and listen again and make some notes so you can come back here whenever you want and revise away.

BOTH: Bye!