BBC Bitesize – Physics

Episode 4 – Forces and elasticity

ELLIE: Hello and welcome to the BBC Bitesize Physics podcast.

JAMES: The series designed to help you tackle your GCSE in physics and combined science. I'm James Stewart, I'm a climate science expert and TV presenter.

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

Before you listen, just a reminder that you can listen to the whole series or find an episode that you want to focus on. Whatever works for you.

JAMES: Okay, let's get started. Today we are going to be talking about forces and elasticity.

So, when you apply more than one force to a stationary object, it can either compress, stretch, or bend. And when something is stretched, compressed, or bent, there is always more than one force acting on it.

ELLIE: Imagine a spring. If you push both ends, it compresses. If you pull it from both sides, it stretches. And if you try to get the ends to meet, it bends.

JAMES: Exactly! And when you bend, stretch, or compress an object, you cause it to deform, which means changing its original form. And there's more than one type of deformity.

ELLIE: Right, so the first type is called elastic deformity. That's when it returns to its original shape once the force has been removed from it. For example, a spring usually bounces back after I push it down.

JAMES: Yep, and the other type is called inelastic deformity. That's when an object stays deformed even after you stop applying force to it.

ELLIE: For example, if you pull the ends of a spring really far apart so it breaks, then it won't go back to its original form.

JAMES: Wait Ellie, I've got a joke for you. What did the worker at the rubber band factory say when he was fired?

ELLIE: I have no idea.

JAMES: Oh snap. I think we're there. Are we there?

ELLIE: Dad joke! Okay, well, whether it's elastic or inelastic deformity, when you apply a force to an object, you can extend it. So let's move on to the next topic, extension.

JAMES: Extension is the way the length of an elastic object changes when you stretch or compress it.

ELLIE: The extension of a spring is directly proportional to the force you apply to it. Force is proportional to extension. That means that when you double the force, you double the extension. And if you half the force, you half the extension.

Another term for proportional you might hear is linear relationship, they mean the same thing. The extension has a linear relationship with the force.

JAMES: So force is proportional to extension until the object reaches its limit of proportionality, which is the maximum amount of force that can be applied to an object before it changes shape permanently.

ELLIE: When an object is elastically deformed and returns to its original form, there's a linear relationship between force and extension. That means, as force increases, extension also increases. If you pull the spring, so a pull force, the spring extends in length.

JAMES: Beyond this, when an object is inelastically deformed, there's a non-linear relationship between force and extension.

This basically means that as the force increases, the extension still increases. But a little bit slower, not at a proportional rate. And it might eventually stop increasing entirely if it has gotten as long as it can be. Now the equation we use to calculate that force is: force equals spring constant multiplied by extension.

The spring constant is a measure of the stiffness of a spring. Think of it like how much force has to be applied to make it stretch by a certain amount. And the units of spring constant are newtons per metre, or capital ‘N’ slash lowercase ‘m’.

ELLIE: So the higher the spring constant, the stiffer the object is because it needs more force to be applied to it in order to stretch.

JAMES: Yeah, we talked about work done in the last episode actually, which you can always go back and listen to. Ellie, how does that apply to elasticity?

ELLIE: When a force compresses or extends a spring, it does work and stores elastic potential energy in the spring. And if the spring hasn't been inelastically deformed, the work done on the spring will equal the amount of energy transferred into its elastic potential energy store.

JAMES: That was a mouthful, well done.

So how then do you calculate the work done on an elastic object? I'm going to keep testing you. How do you figure out how much elastic potential energy is stored in an object when you stretch or compress it?

ELLIE: With our final equation of the day, grab that pen and paper again, and let's write it out.

Elastic potential energy equals 0.5 multiplied by the spring constant, multiplied by extension squared. So let me repeat that again. Elastic potential energy equals 0.5 multiplied by the spring constant, multiplied by extension squared. Oh, that was a mouthful.

JAMES: You've earned a day off after that. Shall we do that as a real world example? This might make it a little bit easier. So, again, pen and paper if you want to write this one out.

If a spring had the spring constant of three newtons per metre, and it was stretched until extended by 0.4 metres, you would square the extension of 0.4, then multiply this by the spring constant of 3. And then multiply this by 0.5 to get an answer of 0.24 joules.

ELLIE: Wow, that's definitely something that needs to be written down.

JAMES: Thank you, yep. Put that on a t shirt.

ELLIE: So, I hope this helped everyone listening to better understand elasticity.

JAMES: And I think you should have a prize for saying elasticity 17,000 times.

ELLIE: Thank you.

JAMES: Yep. Um, let's recap the three points. The main things that we covered in today's episode. There are two types of deformation. Elastic and inelastic deformation.

Elastic deformation is when the object goes back to its original shape when the force is removed. And inelastic deformation is when it changes shape permanently. Now, the equation to calculate force in a spring is force equals spring constant multiplied by extension. And finally, the equation to calculate elastic potential energy, is elastic potential energy equals 0.5 multiplied by spring constant, multiplied by extension squared.

ELLIE: Smashed it, James.

That's the key points you need to know about elasticity. In the next episode of BBC Bitesize, we're going to dig into displacement, distance and speed.

JAMES: Oh, they're hard words, just keep on coming, don't they? Thank you for listening to Bitesize Physics. If you found this helpful, and I hope you did, please do go back and listen again, and make some notes, and always come back here as many times as you want to help you revise.

ELLIE: There's also lots more resources available on the BBC Bitesize website, so be sure to check it out.

JAMES: One, two, three.

BOTH: Bye!