BBC Bitesize – Physics

Episode 2 - Kinetic energy and gravitational potential energy

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: And I'm Ellie Hurer, a bioscience PhD researcher. Just a reminder that we're covering lots of different aspects of energy in this series, so make sure you take a look at the rest of the episodes too.

JAMES: Okay, let's get started. Today, we're talking about the types of energy that stretch things, get us moving, and bring us back down to earth. Elastic, kinetic, and gravitational potential energy. Woo!

When an object is in motion, it has energy in its kinetic energy store. So a football flying in the air, a car driving down the street, a leaf falling down from a tree. They are all in motion, so they possess kinetic energy.

ELLIE: And you can calculate the kinetic energy of a moving object using an equation. So grab your pen and paper to write this one down.

Kinetic energy equals 0.5 multiplied by mass multiplied by speed squared. Let me repeat that in case you didn't get the chance to write it down. Kinetic energy, which is measured in Joules equals 0.5 multiplied by mass, which is measured in kilograms, multiplied by speed squared, and speed is measured in metres per second.

JAMES: Yeah, so let's say it's a really nice day and I decide to ride my bike through the park, and I want to measure my kinetic energy store, a reasonable thing to do. I would take 0.5 and multiply it by me and my bike's combined mass of 100 kilograms. Then, I would multiply that by my speed, which is 5 metres per second. So, 5 squared is 25. So, 0.5 times 100 times 25, to get the answer 1,250 joules.

ELLIE: So, the next thing we want to talk about is gravitational potential energy. In our Bitesize Physics 'forces' series, we give gravity its own episodes, so be sure to go and listen to that after this.

JAMES: Yeah, but just as a quick explanation, gravitational potential energy is the energy an object has because of its position above the surface of the earth.

ELLIE: In other words, gravitational potential energy happens when an object is lifted from the ground. The higher it is, the more gravitational potential energy. Also, the greater the mass of the object, the more gravitational potential energy.

JAMES: Many things around us have gravitational potential energy. Things like a balloon flying in the air will eventually fall.

When we jump, we end up back on the ground. And when we throw confetti up into the sky, it floats back down.

ELLIE: And to calculate the amount of gravitational potential energy an object gains by being raised above the ground level, we use a specific calculation. So I think it's time to grab your pen and paper again.

JAMES: Gravitational potential energy equals mass multiplied by gravitational field strength, multiplied by change in height. The gravitational field strength of any object on earth is 9.8 newtons per kilogram

ELLIE: Gravitational potential energy is measured in joules. Mass is measured in kilograms. Change in height is measured in metres. And gravitational field strength is measured in newtons per kilogram.

JAMES: Should we apply that to a real-life example?

ELLIE: I think so.

JAMES: Yeah, okay.

ELLIE: So, on a scale of 1 to 10, how good are you at juggling?

JAMES: I'd go with a solid 2.1.

ELLIE: In that case, I won't give you the fire baton.

JAMES: Okay, let's just practise with one baton. No flames?

ELLIE: Sounds good.

JAMES: OK, so to calculate the gravitational potential energy of the baton as it flies in the air, because that's what I do on the weekends. We would need to know its mass and change in height.

ELLIE: And we're going to make this a calculation for you to figure out, so grab your pen and paper.

JAMES: Right, let's say the baton has a mass of 2 kg and you throw it up 3 m in the air. If the equation is gravitational potential energy equals mass, multiplied by gravitational field strength, multiplied by change in height, what would be the gravitational potential energy of the baton?

ELLIE: If you missed the measurement or the equation, be sure to rewind 30 seconds. But we'll give you a few moments to pause, write that down, and calculate it.

JAMES: Okay, so hopefully you've had a few moments to work that one out, but let me explain how we would calculate that. So to find out the baton's gravitational potential energy, you would multiply the mass, that's 2 kilograms, by the earth's gravitational field strength, that's 9.8 newtons per kilogram, by the change in height, that was 3 metres. To get the answer, drumroll please 58.8 joules.

ELLIE: That is the gravitational potential energy of the baton when it's at its maximum height. But while it's still going up there is a transfer from the kinetic energy store to the gravitational potential energy store. The kinetic energy store decreases as the gravitational potential energy store increases.

JAMES: And when the baton is on the way down, the opposite happens as the gravitational potential energy store decreases and the kinetic energy store increases. The transfer is really important to remember as it often comes up in exam questions. So again, if you haven't already, be sure to write that down.

ELLIE: And now for the final part of this episode, let's talk about elastic potential energy.

JAMES: Elastic potential energy is the energy objects' store if they are stretched or squashed. You can calculate it using an equation, of course you can. So get your pen and paper out one last time, hopefully you haven't taken them.

ELLIE: Are you sure it's one last time?

JAMES: I don't know, I can't, don't hold me to that.

Elastic potential energy equals 0.5 multiplied by the spring constant multiplied by extension squared. So the spring constant measured how stiff the spring is. The larger the spring constant, the stiffer the spring and the more difficult it is to stretch. An extension is the way the length of an elastic object changes when you stretch or you compress it.

So let me repeat that formula again. Elastic potential energy, measured in joules, equals 0.5 multiplied by the spring constant, measured in newtons per meter, multiplied by extension squared. An extension is measured in metres.

ELLIE: Let's apply it to a spring, and we were lying, because you need to grab your pen and paper, again, so you can write these calculations out.

So let's say this spring in your hand has a spring constant of 3 newtons per meter, and it's extended by, let's say, 50 centimetres. How would you calculate its elastic potential energy, if the equation is elastic potential energy equals 0.5 multiplied by the spring constant, multiplied by extension squared.

JAMES: If you missed a measurement, there are quite a few in there or the equation. Be sure to just rewind 30 seconds. Super easy, but we'll give you a few moments to pause. Write that one down and calculate it.

ELLIE: Okay. Did you get a chance to try and work it out? I'll walk you through it step by step, so don't worry.

First, let's convert the extension into metres. So 50 centimetres is equal to 0.5 metres. The equation uses extension squared, so we would do 0.5 multiplied by 0.5, which is equal to 0.25. To calculate its elastic potential energy, you would take 0.5 and multiply it by 3, and then multiply it by 0.25. And this would give you the answer of 0.375 joules.

JAMES: But, a really important thing to remember is that the equation only applies when the limit of proportionality has not been exceeded. And the limit of proportionality shows the maximum amount of force that can be applied to an object before it changes shape permanently.

ELLIE: And if you want to learn more about elasticity, be sure to head over to the ‘forces’ series of Bitesize Physics to hear more.

So James, I think it's time we do a recap because there was a lot going on in this episode.

JAMES: There was.

ELLIE: So the three key facts that we covered today are: the formula to calculate kinetic energy, which is kinetic energy is equal to 0.5 multiplied by mass, multiplied by speed squared.

The formula to calculate gravitational potential energy is mass, multiplied by gravitational field strength, multiplied by height.

And finally, the formula to calculate elastic potential energy is 0.5 multiplied by spring constant, multiplied by extension squared.

JAMES: And hey, this is just the start. We're going to be diving into a range of other types of energy transfer as the series goes on, starting with thermal in the next episode about specific heat capacity. So be sure to keep listening.

ELLIE: So guys, 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 to this as you revise.

BOTH: Bye!