Physics > Big idea PES: Earth in space> Topic PES1: Solar System and beyond

Key concept (age 11-14)

PES1.2: Gravity

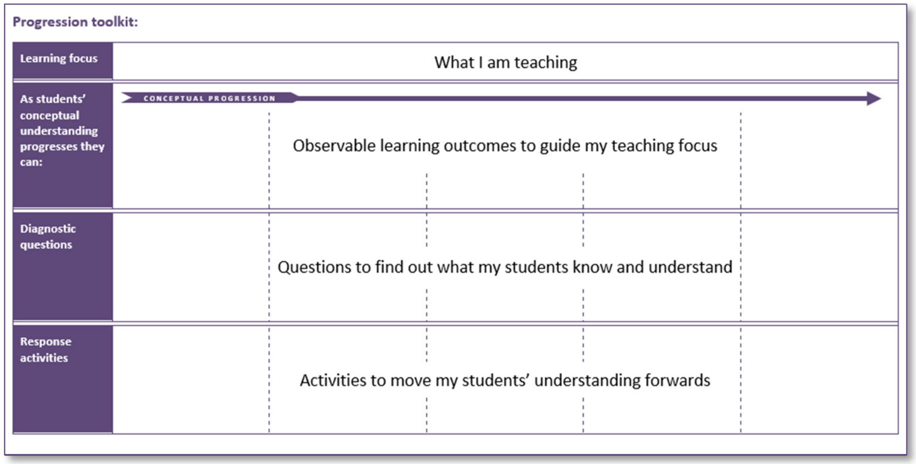
What's the big idea?

A big idea in physics is of Earth in space. This is important because we live on the Earth and it is the only planet that we know to have abundant and complex life. Understanding how the Earth and space systems interact, how they affect us, and how we affect them is vital for our survival. Exploring our origins and our place in the universe feeds the intrinsic curiosity of humans and develops a sense of wonder.

How does this key concept develop understanding of the big idea?

This key concept helps to develop the big idea by building on the observation that gravity acts at a distance, and to establish a general understanding of gravity as an attractive force that is exerted by all astronomical bodies and which extends through space.

The conceptual progression starts by checking understanding that the force of gravity acts on all objects close to the Earth. It then supports the development of basic ideas about the nature and causes of gravity in order to enable understanding of how gravity acts on planets to keep them in their orbits.



Using the progression toolkit to support student learning

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

Progression toolkit: Gravity

Learning focus	Gravity is the force that holds the Solar System together				
As students' conceptual understanding progresses they can: (CONCEPTUAL PROGRESSION →)	Describe how gravity acts on objects near to the Earth	Describe how gravity acts towards the centre of the Earth (or other astronomical body)	Describe how gravity increases with the mass of a planet (or other astronomical body)	Explain how we know gravity exists in space and describe how its force of attraction decreases with distance **B**	Explain how gravity pulls planets and moons around in their orbits **B**
Diagnostic questions	Newton's apple	Climbing	On the Moon	Sun trap	
Response activities		Caving	Different weight?	Modelling gravity	

Key:

B Bridge to later stages of learning

What's the science story?

Gravity

All objects are attracted to the centre of the Earth by the force of gravity, so an object that is free to fall moves towards the Earth. So, at all locations on Earth, our perception of 'down' is always towards the centre of the Earth. Gravity is an example of a force that can act between two objects even though they are not touching. (Gravity is an attractive force between all objects with mass).

Close to the Moon, the nearest massive object is the Moon itself. All objects on or near the Moon are attracted to it by the force of gravity, and 'down' is towards the centre of the Moon. Similarly, near a planet …

The greater the mass of a planet, the bigger its gravitational attraction. The gravitational attraction of the Sun is greater than that of any planet because it has more mass.

The gravitational force between two objects gets weaker as they (their centres of mass) get further apart. This weakening is gradual and there is *no* sudden cut-off beyond which the force ceases to act. The force of gravity from planets and other astronomical bodies is felt, albeit weakly, in space. Planets orbit the Sun and moons orbit planets because of the force of gravity.

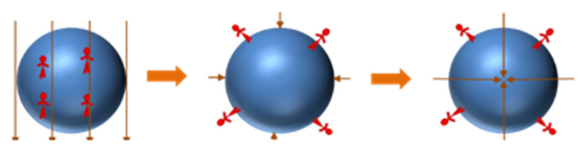
What does the research say?

Gravity is often covered at schools within topics about forces and this can limit students' understanding of gravity in relation to the Earth and the Solar System (Lelliott and Rollnick, 2009).

It has been found that students do not always think that a force is needed to make something fall (Stead and Osborne, 1980; Ruggiero et al., 1985; Driver et al., 1994). Another common misunderstanding is that if an object is not moving, there is no force acting on it (Driver et al., 1994).

A widespread view of gravity amongst 11-to-17-year-olds, is that it is a 'holding' force rather than a pulling force. This thinking is bound up with the idea that gravity is linked to the atmosphere, and with air pressing down to stop things floating away (Stead and Osborne, 1980; Driver et al., 1994). This can lead to the misunderstanding that there must be air for there to be gravity. This has implications for thinking about gravity acting in space, on other planets and on the Moon.

At age twelve Nussbaum (1985) found most students hold the idea that there is an absolute 'down' that is independent of the Earth. He also found that by age fourteen most students believe gravity pulls towards either the surface of the Earth or towards its centre. At sixteen just 20% of students hold the accepted science view that gravity pulls objects towards the *centre* of the Earth. Most other students say gravity acts towards the *surface* (Baxter, 1989).



Children's notions of the direction of down in relation to the Earth (Nussbaum, 1985; Driver et al., 1994)

A small minority of students describe gravity as 'holding us vertical' (Stead and Osborne, 1980; Driver et al., 1994).

It was found, in a study of what students understand about how gravity changes away from the surface of the Earth, that a third of 14-year-olds (n=257) think that gravity decreases with height, and many think it decreases far more quickly than it actually does. Another third of these 14-year-olds think that gravity *increases* with height (Stead and Osborne, 1980). Here students may be confusing the force of gravity with the store of gravitational energy, which does increase with height. Interestingly many of these students think that gravity only increases with height *inside* the Earth's atmosphere (Driver et al., 1994).

In their study Stead and Osborne (1980) also found that it is common for eleven-year-olds to think that gravity only relates to the Earth. At age thirteen (n=258) 44% do not think there is gravity on the Moon, and they commonly think that not all planets have gravity. 81% of 13-year-olds and 75% of 14-year-olds in the study do not think there is gravity in space (Stead and Osborne, 1980; Driver et al., 1994).

The progression toolkit for gravity reminds students that gravity acts on all objects near to the Earth. Students begin by identifying places where the force of gravity acts and by describing the direction in which it acts. By applying their understanding of the nature of gravity to new situations, students are given the opportunity to consolidate their scientific understanding. Modelling the force of the Earth's gravity on the Moon challenges students to think about how the Earth's gravitational pull extends into space and how it pulls the Moon to keep it in its orbit.

Guidance notes

Calculating weight = mass x gravitational constant has been deliberately left out of this key concept because at this stage many students will not have developed the skills, in their maths lessons, to use equations that include units. (Calculating weight is covered in topic PFM3: More about force.)

References

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