Practical activity to experience the weight of an object on the surface of different planets - teacher notes

Purpose of activity
By undertaking the activity, it is intended that pupils will develop their substantive knowledge of gravitational forces and the factors that can affect the size of the gravitational force acting on an object.

Risk assessment
A risk assessment should be completed before undertaking any science practical work or demonstrations. The information outlined in this guidance contains advice for how to work safely in and out of the classroom, however, risk assessments are the responsibility of the individual school. Please contact a local or wider advisory service, such as CLEAPSS, on all aspects of health and safety for further support.

Task B

Equipment
Four empty and identically shaped plastic soft drink bottles (or other suitable containers that can be filled, sealed and made to look identical). Each should be filled with dry sand (or similar) to give the following masses:

- 270 g (Venus)
- 300 g (Earth)
- 120 g (Mars)
- 780 g (Jupiter)

The bottles should then be sealed and painted so they look identical and so that the differences in their contents cannot be seen. Each should be labelled with the name of a different planet, but do not label the masses as well!

Empty space in each bottle could be filled with expanding foam or polystyrene filler to try to prevent internal movement as much as possible, giving the impression of solid objects.

Method
Pupils are asked to imagine that the object is taken to four different planets – Venus, Earth, Mars, and Jupiter. They are asked to predict how they think the weight (size of the gravitational force at the surface) of the object will compare on the different planets, given information about each planet's size (see image on next page).

Pupils should then be asked to explain why they think their prediction will be correct, allowing them to verbalise their current ideas. For pupils with incorrect ideas at this stage, the upcoming experience is intended to provide a memorable refutation which leads to a change in their long-term memory.

Venus:
(0.8 of Earth's mass)

Earth:

Mars:
(0.1 of Earth's mass)

Jupiter:
(300× Earth's mass)

Pupils should then be invited to experience how the object feels on different planets by lifting each object in turn and making a qualitative comparison or arranging them in order of increasing weight.

There is some scope for imaginative role–play when deciding how to present this activity to a class. You could pretend to take the class to each planet, with the object being taken out of a box each time to create the illusion of it being the same object then, at the end, bring out all objects to compare (somewhat knowingly giving the game away).

An alternative approach could be to assign each corner of the room to be a different planet and allow groups of pupils to visit each one in turn to experience lifting the appropriate object there. If resources allow, multiple sets of the four containers could be given to small groups. You should select the approach you feel is most appropriate for your class.

Ask pupils individually, or use a whole-class discussion, to establish an agreed order of 'heaviness' and come up with an explanation that correctly relates a greater weight to a stronger gravitational force at the surface of a larger mass planet.

Teacher note
Pupils may wonder why the force experienced on the surface of Jupiter is only 2.6× the force felt on the surface of Earth, when Jupiter has a mass of about 300× the mass of Earth (to 1 s.f.). This is because the size of the gravitational force felt by an object at the surface of a planet actually depends on both the mass and the radius of the planet.

[For the mathematically minded: the equation studied at A-level is $F = GMm/r^2$ hence the gravitational force experienced at the surface of a planet is directly proportional to the planet's mass and inversely proportional to the square of the planet's radius. As Jupiter has 320× the mass and 11× the radius of Earth, the force at its surface is $(320/11^2)\times$ greater than the force experienced at the surface of Earth, which is approximately 2.6×].

At this stage, a qualitative understanding is all that is needed. This quantitative reasoning is not included in the lesson resources.

Health and safety
Advise pupils to take care handling the objects especially those that feel heavy.