

## 1.4 Forces at a distance

### Learning objectives

After this topic you will be able to:

- describe the effects of a field
- describe the effect of gravitational forces on Earth and in space.

### Link

You can learn more about electrostatic forces in P2 1.1 Charging up

### Foul Fact!

The strongest gravitational field in the Universe is made by a black hole. It is called a 'black' hole because even light cannot escape from its gravitational field. If you stood close to a black hole, the force of gravity on your feet would be much bigger than the force of gravity on your head. You'd be stretched. This is called 'spaghettification'.

### Key Words

magnetic force, electrostatic force, field, weight, mass, kilogram (kg), gravitational field strength

If you let go of your pen and it moved upwards you'd be very surprised. We are so familiar with the force of gravity that sometimes we don't even think of it as a force.

### Gravitational forces

A gravitational force acts on a diver jumping off a diving board. It is a non-contact force. There are other types of non-contact force.

Magnets exert a **magnetic force** on magnetic materials or other magnets without touching them. If you rub a balloon you can pick up bits of paper with it. This is an electric or **electrostatic force**. Magnetic and electrostatic forces are non-contact forces.



▲ A magnet picks up filings.



▲ A balloon rubbed on your jumper attracts a baby's hair.

### A Identify three forces that act at a distance.

### Force fields

In physics a **field** is a special region where something experiences a force. There is a magnetic field around a magnet where magnetic materials experience a force. There are gravitational fields where things with mass experience a force.

Gravitational, magnetic, and electrostatic fields have something in common. As you get further away from the mass, magnet, or charge, the field gets weaker. Contact forces only act when the objects are touching each other. Non-contact forces act at any distance, even if the objects are not touching.

### B Describe what is meant by a field.

### What do I weigh?

You can use a newtonmeter to find the **weight** of an apple. The Earth pulls the apple downwards. Measuring the weight of the apple means measuring the force of the Earth on it.

### What is the difference between weight and mass?

Weight is a force so it is measured in newtons (N). **Mass** is the amount of 'stuff' something is made up of. It is a measure of how hard it is to get something to move. Mass is measured in **kilograms** (kg).



◀ An apple has a weight of about 1 N.

### Units of mass

Smaller masses are measured in grams (g).

There are 1000 g in 1 kilogram (kg).

Convert these masses into grams: **a** 2 kg **b** 3.5 kg **c** 0.4 kg

Convert these masses into kilograms: **d** 4700 g **e** 250 g

You can calculate weight using an equation.

weight (N) = mass (kg) × **gravitational field strength,  $g$**  (N/kg)

On Earth gravitational field strength is about 10 N/kg.

This means that, if your mass is 50 kg, for example, then your weight on Earth is:

$$\begin{aligned} \text{weight} &= 50 \text{ kg} \times 10 \text{ N/kg} \\ &= 500 \text{ N} \end{aligned}$$

Gravitational field strength is different on other planets and stars. Your weight would be different on different planets because  $g$  would be different.

The Apollo astronauts could jump much higher on the Moon because  $g$  on the Moon is about one sixth of  $g$  on Earth.

### C State the unit of mass and the unit of weight.

### What would happen to my weight in space?

Imagine blasting off from the Earth in a spacecraft. As you move away from the Earth the gravitational field gets weaker. If you stood on scales in the spacecraft the reading would be less than it would be on Earth.

The amount of 'you' would not change. Your mass stays the same. It is the force of the Earth on you, your weight, that is less.

### Summary Questions

- Copy and complete the sentences below.

Some forces act a distance. The force of gravity acts on things that have \_\_\_\_\_. A balloon has an \_\_\_\_\_ force when you rub it. You can feel a \_\_\_\_\_ force between two magnets. Your weight is a \_\_\_\_\_ and is measured in \_\_\_\_\_. Your \_\_\_\_\_ is the amount of stuff you are made up of and is measured in \_\_\_\_\_.

(7 marks)
- Explain one reason why your weight on Jupiter is 2.7 times your weight on Earth.

(3 marks)
- Describe what happens to the force of gravity as you move away from the Earth.

(1 mark)
- Imagine the first Olympic Games conducted on the Moon in a specially designed dome. Use the ideas on this page to state and explain which sports would produce new records, and which would not.

(6 marks)