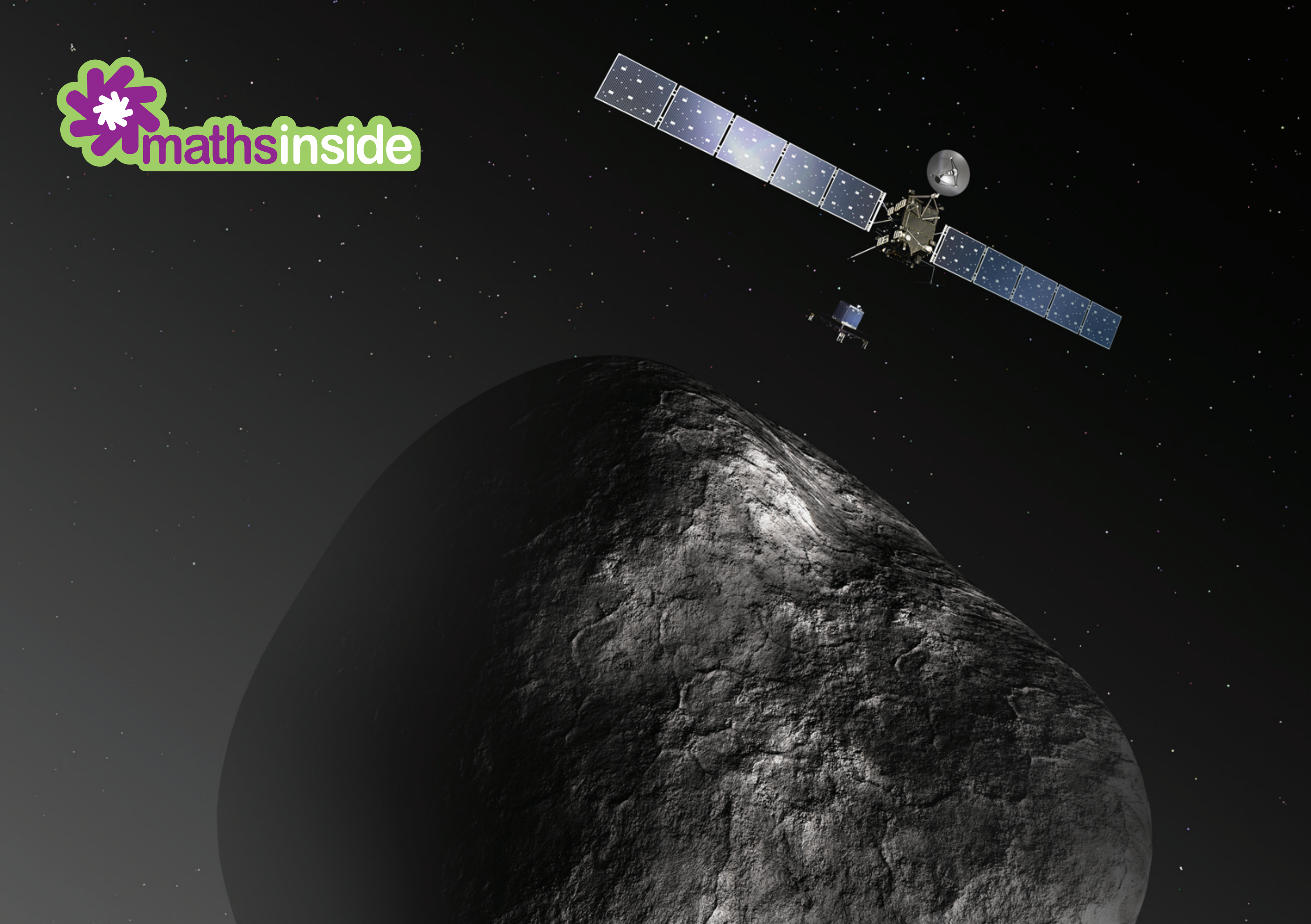
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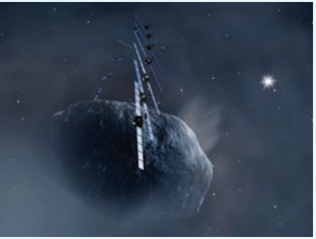
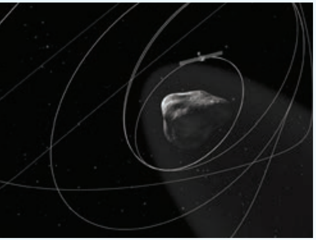
EXPLORING SPACE

with the help of mathematics





Top image: Rosetta orbiting Comet 67P/ Churyumov-Gerasimenko © ESA, AOES Medialab
Bottom image: Rosetta orbiting the comet © ESA–C. Carreau

The ESA Rosetta mission is carrying Philae, a lander which is set to be deployed to the comet Churyumov-Gerasimenko later this year. In order for the Rosetta craft to reach the comet it was launched from Earth over 10 years ago. Its flight path through the solar system was carefully modelled and planned before launch. We shall see that while it required a lot of effort for Philae to leave Earth it wouldn't take much for it to accidentally leave the comet after it has arrived.

To escape from the gravity of an object, such as a planet or a moon, you must reach a certain speed to overcome the gravity pulling you back. This speed is know as the **escape velocity**. Space ships must reach escape velocity to depart Earth and fly to their destination. Since rockets carry their own fuel they can increase their speed later and don't strictly speaking need to reach escape velocity, but it gives a very good idea of how difficult it is to leave the surface of an object.

The escape velocity for an object depends upon its mass and its size. If we assume the object is spherical then the escape velocity, V_E, is given by the following equation:

$$V_E = \sqrt{\frac{2GM}{r}}$$

where G is the gravitational constant, $G = 6.67 \times 10^{-11}$ m^3 kg^{-1} s^{-2}, r is the radius of the object in metres, and M is the mass in kilograms.

Just as astronauts are able to jump much higher when they are on the moon compared with when they are on Earth, so too the escape velocity for the moon is much lower than that of the Earth. The escape velocity for the surface of Earth is 11.2×10^3 m/s while that for the moon is 2.4×10^3 m/s. In both cases the speed is really high and so it isn't at all easy to reach escape velocity.

The predicted mass for the comet that the ESA plan to land on is 1.29×10^{13} kg. This might seem like a lot, but it is a tiny fraction of the mass of the Earth. If we assume it is spherical, the comet has a radius of 2.17×10^3 m. So the escape velocity is a mere 0.89 m/s. This is less than walking pace, and even a small push could send the lander flying off into space never to return! For this reason, the lander has a number of pieces of equipment to keep it tethered to the comet and prevent it from being lost in space.

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Front image: Rosetta and Philae at comet © ESA–C. Carreau/ATG medialab

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