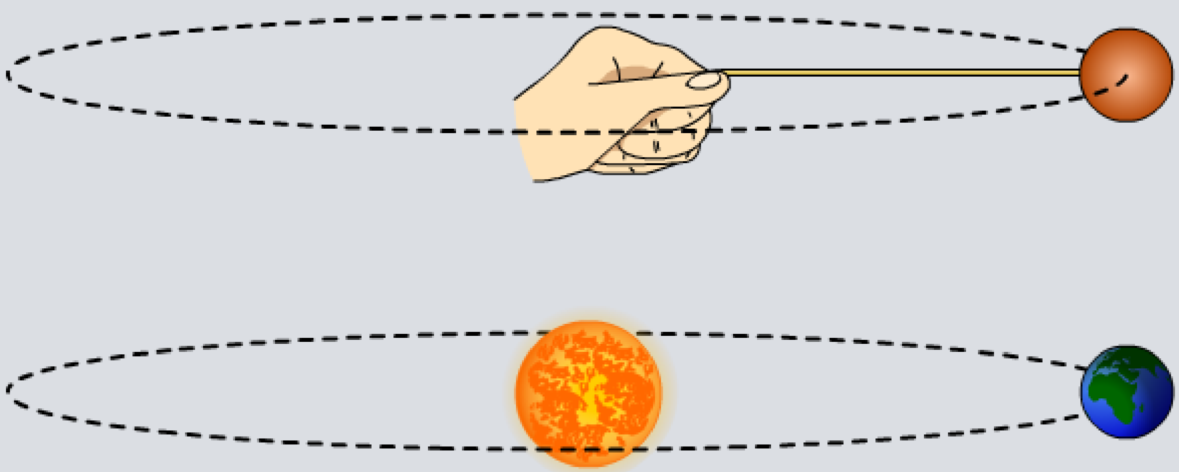
Gravity and Orbits



What is gravity?

If a skydiver steps out of a plane, which way does he move? What causes this effect?

Gravity is a universal force which attracts any mass to every other mass in the Universe.

Every mass has its own **gravitational field**, like the one surrounding Earth, but it takes two objects to make a **gravitational force**.

Gravity is a very weak force, so small objects don't stick together, but if at least one mass is very large, the effect of gravity is easy to see. Skydivers always fall back to Earth!

Factors affecting gravity

The bigger the mass, the stronger its **gravitational field**, so the Sun has a much stronger gravitational field than Earth.

But the further apart two objects are, the weaker the **gravitational forces** between them. So when a skydiver jumps out of a plane, he falls to Earth, not towards the Sun.

Gravitational fields are stronger:

- around **larger** masses
- at **shorter** distances.

The gravitational force between two objects can be increased:

- by **increasing** the size of either or both of the masses
- by **decreasing** the distance between them.

Gravitational chaos!

Every mass in the universe attracts every other. That's a lot of forces to keep track of!

But gravity is a very weak force, so most gravitational forces at the Earth's surface can be ignored.

The gravitational field of a pen, a person or even a large mountain is too weak to have a noticeable effect, so the only gravitational field you need to consider is Earth's.

Gravity at the Earth's surface

Gravitational fields get weaker with increasing distance. Do you feel any lighter on the top floor of your house than on the ground floor?

The Earth is so large that small changes in height don't affect weight, so gravitational field strength is effectively constant:

weight = mass × gravitational field strength

= mass × 10 N/kg

This applies to objects at the Earth's surface, at the top of a mountain, or even in an airplane at 30,000 feet…

…but be careful! This does **not** apply to satellites in orbit, or to the forces between planets and stars.

What are the missing words about gravity?

1. Gravity is a universal force of [? ▼] between all masses in the Universe.

2. The gravitational field of an object is [? ▼] and depends on the [? ▼] of the object.

3. The gravitational force between two objects is [? ▼] and depends on the [? ▼], and on the [? ▼].

?

C solve

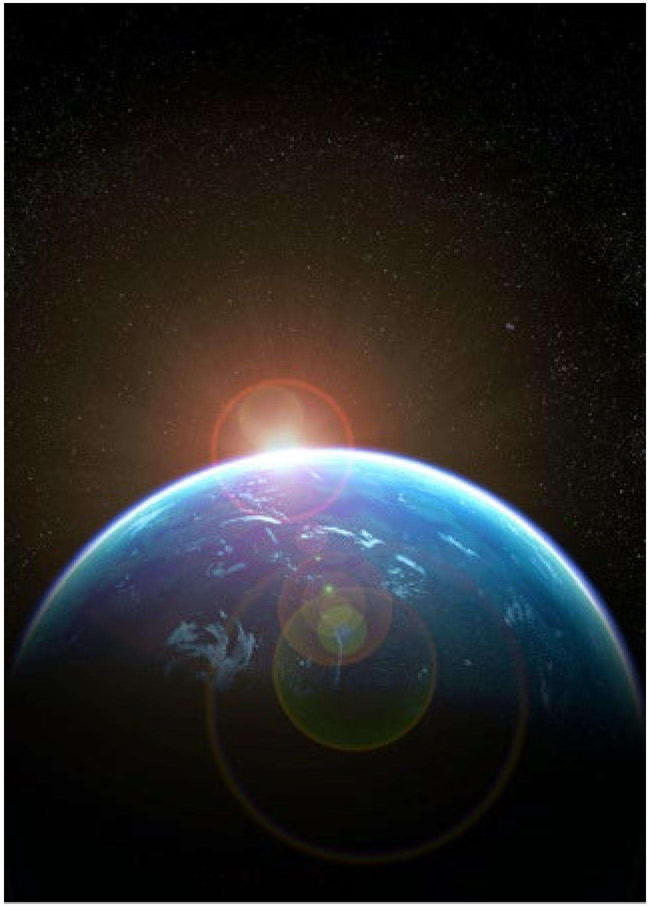
Gravity as a centripetal force

Examples of centripetal forces can be found in many everyday contexts, but what about circular motion on a large scale?

What is the centripetal force that makes orbits possible?

Unlike a mass on a string, stars and planets are not physically connected to each other, but they are attracted to each other by **gravity**.

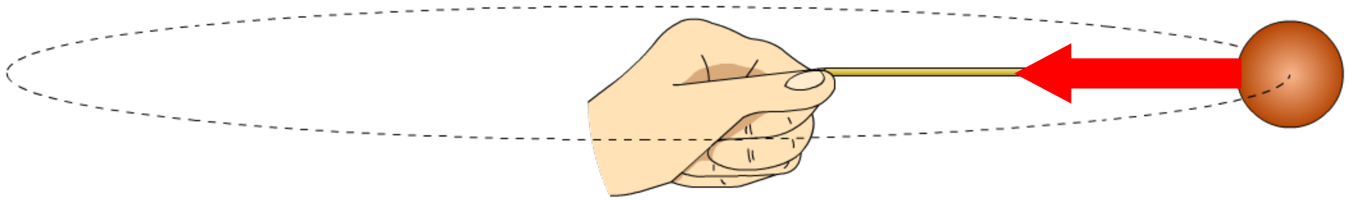
How does circular motion under gravity compare to the types of circular motion we are used to?



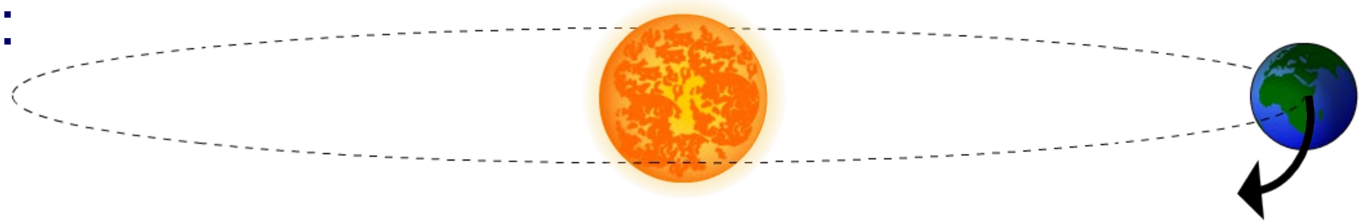
Circular motion under gravity

The centripetal force **required** to keep a planet in circular motion depends on **mass**, **radius** and **speed**. But the gravitational force that a star actually **provides** only depends on **mass** and **radius**. This means that for any specific radius, a planet must move at **one specific speed** to stay in orbit.

- When a mass on a string is swung at an increasing speed, the tension increases, while the radius remains constant:



- If a planet orbits a star at an increasing speed, the force between them **does not** increase, so it moves out of that orbit:



Circular motion under gravity

How strong is the centripetal force?

Circular motion under gravity is subtly different from other types of circular motion.

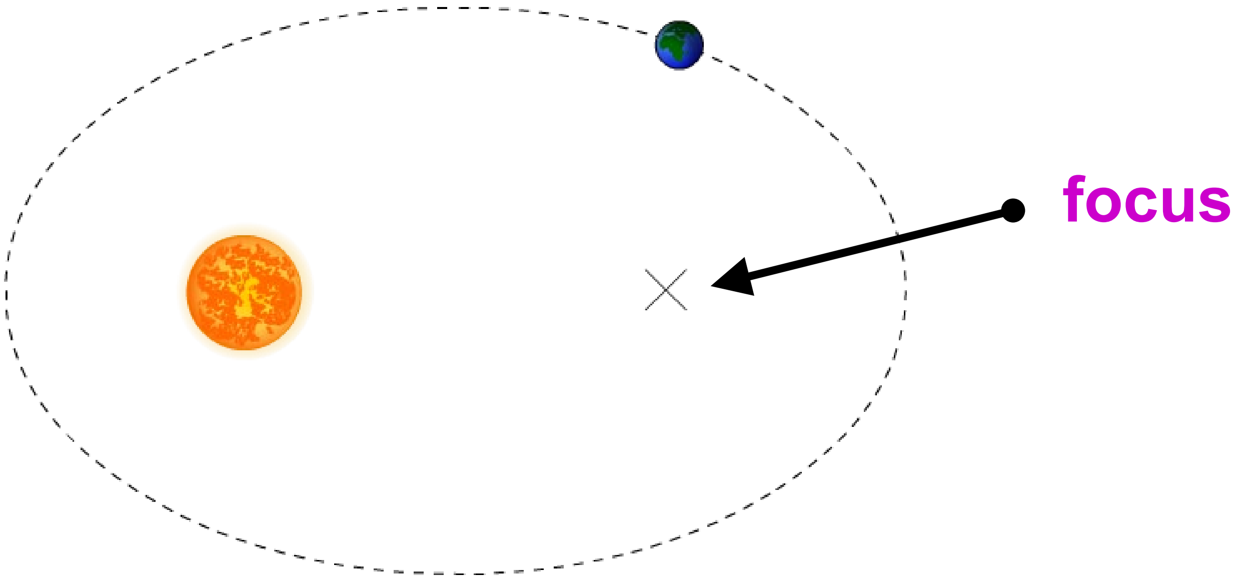
Click **"start"** to investigate how the gravitational force between a star and a planet can vary.

Watch carefully to see which orbits are possible, depending on the variables you set.

start

Elliptical orbits

In 1605 Johannes Kepler used his observations of the orbit of Mars to predict that, rather than moving in perfectly circular orbits, all the planets follow **elliptical orbits** around the Sun:

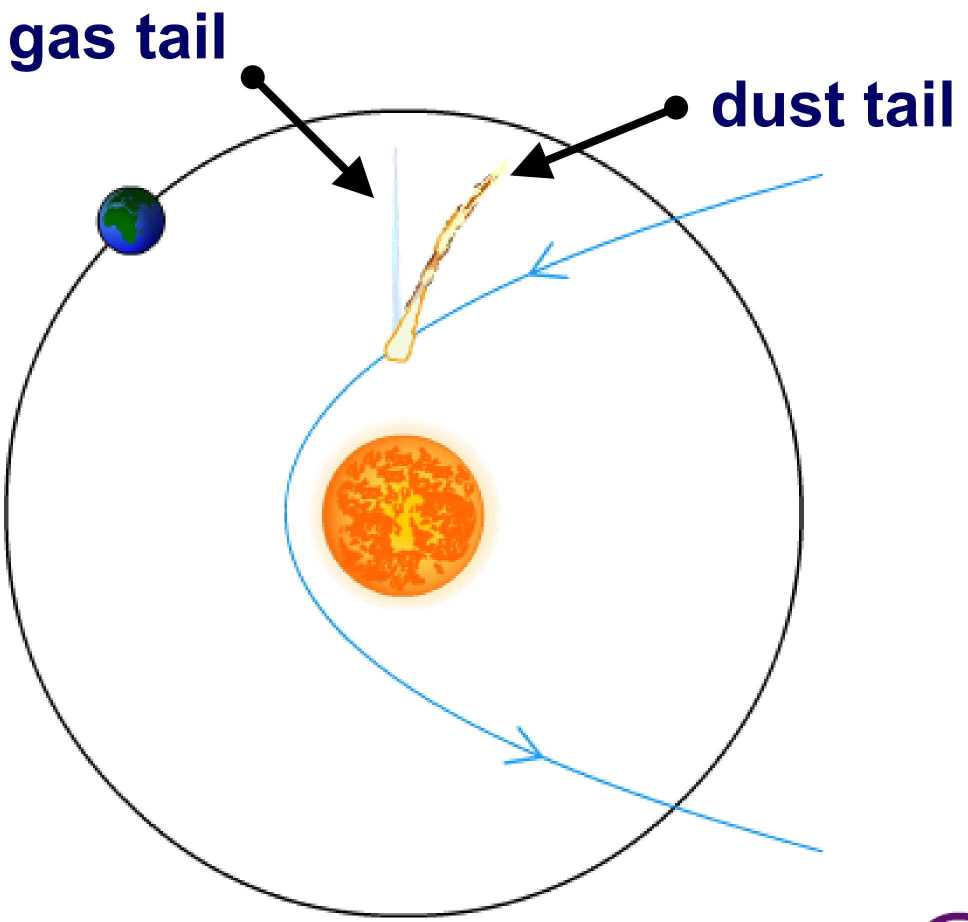


Each orbit forms an ellipse with the Sun at one **focus**.
The two focuses of an ellipse are similar to the single center of a circle.

Comets

Most of the planets travel around the Sun in near-circular orbits. Comets also travel around the Sun but in **highly elliptical orbits**.

The head of the comet is a lump of ice and dust a few kilometers across. The tail only appears when the comet is near the Sun. It consists of gas and dust which are released by the heat of the Sun.



Look at the data and answer these questions about orbits

1. Which planet has an orbital radius 30 times larger than Earth's? ?

2. How m… ake to orbit th…

3. If scie… distan… uld it take to…

Chose the correct words to complete the information about air pollution.

Click on **start** to begin.

start

?

data

C

solve