Key Stage 3 – Exoplanet calculator

Pupil worksheet

Life beyond our Solar System

Is life beyond our own planet? How can we find distant worlds that might support living things?

Sophisticated instruments search our galaxy for signs of **exoplanets**, the planets that orbit stars other than our Sun. Scientists, and people like you, analyse data to predict which planets are perfect for life.

Conditions for life

Let us assume that exoplanet life needs liquid water. If the surface temperature of an exoplanet is too high, water exists as vapour. If the temperature is too low, water exists as ice. For water to exist as liquid, the exoplanet temperature must be just right.

How can we predict the temperature of an exoplanet? Temperature depends on three variables – the temperature of its star, its distance from this star, and whether or not it has an insulating atmosphere.

Scientists expect to find life-supporting exoplanets in the **habitable zone** around a star, also called the **Goldilocks zone**. This is the range of distances from the star which could include planets on which water could be liquid.

Your task – Exoplanet calculator

You will use data from the Kepler space telescope to draw graphs and do calculations to work out which of four exoplanets are in the habitable zones of their stars.

Here is an outline of the stages you will follow.

Step 1
Analyse graphs from the Kepler space telescope to work out exoplanet orbital times.

↓

Step 2
Use data from the Solar System to plot a graph of orbital time versus distance from star.

↓

Step 3
Use graphs to estimate distances from exoplanets to their stars.

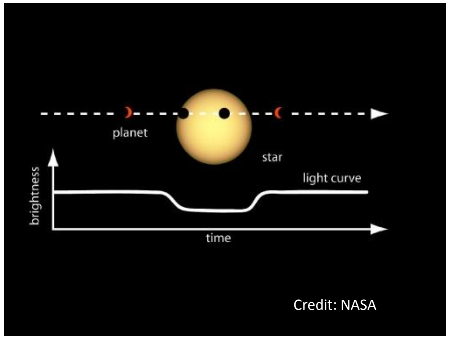
↓

Step 4
Use data from step 3, and star temperature data, to decide if the exoplanets are in their stars' habitable zones.

Key Stage 3 – Planet calculator

Step 1: exoplanet orbital times

Scientists use the Kepler space telescope to observe stars. The telescope monitors the brightness of 100,000 stars.



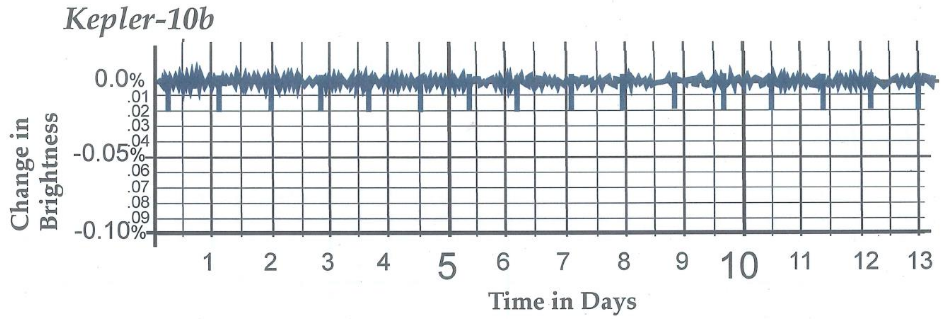
Sometimes the telescope detects a dip in the brightness of light from a star. This could be because the star has a planet. When the planet passes in front of, or **transits**, the star it blocks some light from that star.

If the brightness dips regularly scientists can be more confident that the star has a planet. The planet blocks light from the star every time its orbit takes it between the star and telescope.

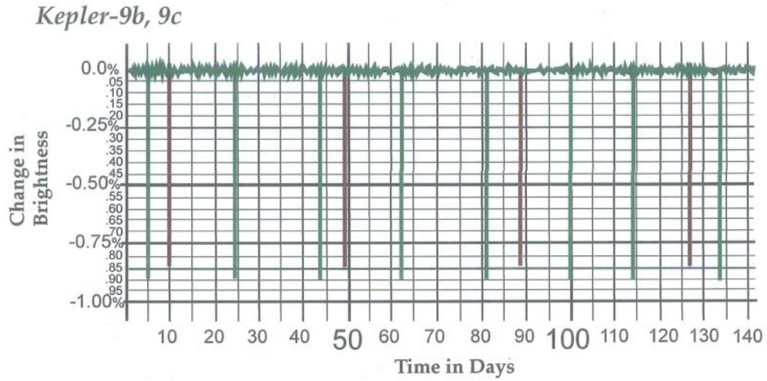
The graphs on this page are light curves from Kepler. Each downward spike shows a dip in brightness. Each dip in brightness represents one transit of the planet in front of the star. The time between transits is the **orbital time** of the planet.

What to do

- ➢ Work out the orbital times for the four planets whose light curves are given. Give your answers in days, to one decimal point, for example 8.1 days. Write your answers in the boxes.



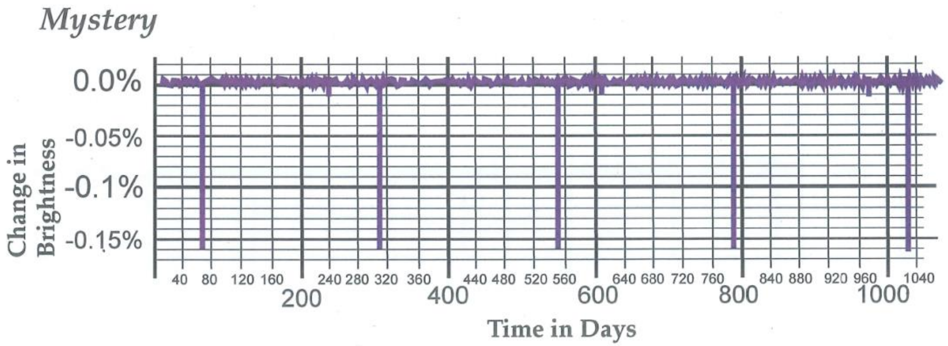
Orbital time for Kepler-10b = _______ days



This graph shows the orbital times of two planets:

- The green, longer lines are for Kepler-9b
- The brown, shorter lines are for Kepler-9c

Orbital times: Kepler-9b = _______ days; Kepler-9c = _______ days



Orbital time for mystery exoplanet = _______ days

Key Stage 3 – Planet calculator

Steps 2 and 3: exoplanet distances from stars

Kepler discovered a relationship between the orbital time of a planet and the distance from its star.

What to do

- For the first four planets of our own Solar System, plot a graph of orbital time (y-axis) versus distance (x-axis). Use the data in the table.

Planet	Distance from Sun (Astronomical Units)	Orbital time (Earth years)
Mercury	0.39	0.24
Venus	0.72	0.62
Earth	1.00	1.00
Mars	1.52	1.88

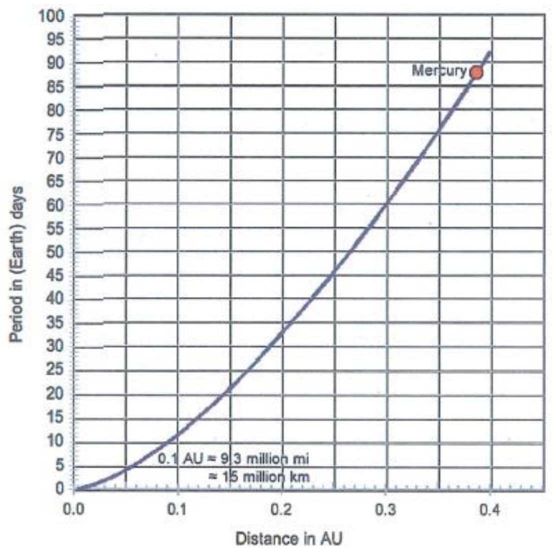
- Extrapolate your graph to (0,0).
- Stick your graph in the box on the right. You might need to fold it.
- For each exoplanet, choose one graph on this page to estimate the distance of the exoplanet to its star. Write your answers in the table.

Exoplanet	Orbital time (Earth days) *(Copy your values from Step 1)*	Estimated distance from the exoplanet to its star (Astronomical Units) *(Use the graphs)*
Kepler-10b		
Kepler-9b		
Kepler-9c		
Mystery planet		

www.oxfordsparks.net/planet

Stick your graph here

Graph of orbital time versus distance from star (for orbital times shorter than two years)



Graph of orbital time versus distance from star (for orbital times shorter than 100 days)

Key Stage 3 – Planet calculator

Step 4: star temperatures and habitable zones

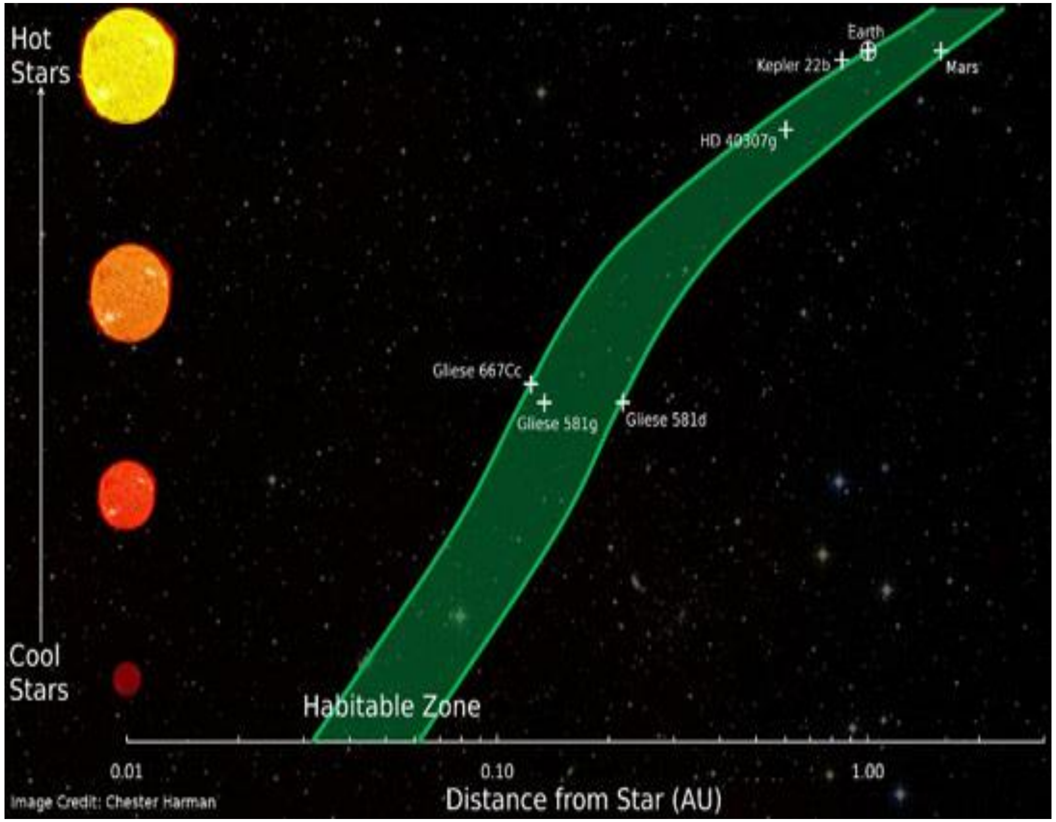
You have estimated the distances of exoplanets from their stars. But are the exoplanets in the habitable zones of the stars?

What to do

- The table gives the temperatures of four stars, including Kepler-9 and Kepler-10. Exoplanet Kepler-10b orbits star Kepler-10. Kepler-9b and Kepler-9c orbit star Kepler-9.

Star	Approximate temperature (°C)
Kepler-9	6000
Kepler-10	6000
Gliese-581	3800
Sun	6000

- Estimate where to plot the three exoplanets on the diagram on the right. Clue: look at the position of Earth on the diagram, and the temperature of the stars in the table. Your teacher will show you how to use the x-axis scale.
- Write down whether each of the planets Kepler-9b, Kepler-9c and Kepler-10b is in the habitable zone of its star, or not. Are those that are not in the habitable zone too hot or too cold for water to exist as liquid?
- The mystery exoplanet orbits a star with a temperature of 6000 °C. Is it likely to be in the habitable zone of its planet?
- Suggest other factors that might affect whether an exoplanet can support life, apart from whether or not it is in the habitable zone of its star.



This diagram shows the habitable zone distances around different types of stars. Some exoplanets that could be habitable are also shown.