Learning Outcomes in Focus

Contextual strand: PW3

Students should be able to *investigate* patterns and relationships between physical observables.

INVESTIGATE: Observe, study or make detailed and systematic examination, in order to establish facts and reach new conclusions

Nature of science: NoS1

Students should be able to *appreciate* how scientists work and how scientific ideas are modified over time.

Learning Intentions

As this activity relates to many learning outcomes, including those above, be sure to decide on the specific Learning intentions you have for your class if they are to engage with this activity.

Introduction and Teacher Background

Students will use a light sensor at the beginning of this activity. A light sensor is an electronic device used to detect light. They usually consist of a photoelectric cell which converts light energy into electrical energy. (You might see links to PW5 and PW6). While the unit LUX is in fact itself a derived unit (Lumen m^{-2}), it is a measure of the light intensity as perceived by the human eye and so students will explore light intensity in lux as a physical observable and investigate its relationship to distance from a source and varied obstacles.

In the second half of this activity students will try to apply what they have learned to analyse data from the NASA Kepler mission. While in the initial part of the activity variation in light intensity was achieved by allowing a pendulum to swing over and back in front of a light source, a similar pattern, including regular drops in light intensity, would also be achieved as a planet rotated around a star.

Recall that a solar system consists of a large star, such as our sun, and the planets with their moons that orbit it. In 2009 a space observatory, named in honour of Kepler, was launched by NASA to discover more about other solar systems in our galaxy. Kepler, consisting of a telescope to focus light and light sensors, is pointed away from our sun and is about 96 million miles away from earth, focusing on distant stars.

The light sensors on Kepler measure the luminosity of this distant star. But imagine what will happen if this star is at the centre of a solar system. How will a planet moving between Kepler and this star impact on the readings at Kepler? And if this planet is orbiting that distant star, what pattern should be observed over time? You might like to discuss this before you begin.

Data from Kepler is presented as part of this activity, which students are asked to analyse to identify patterns and relationships (NoS 4) and in so doing they get practical experience of how scientists work to make sense of the data collected by Kepler (NoS1).

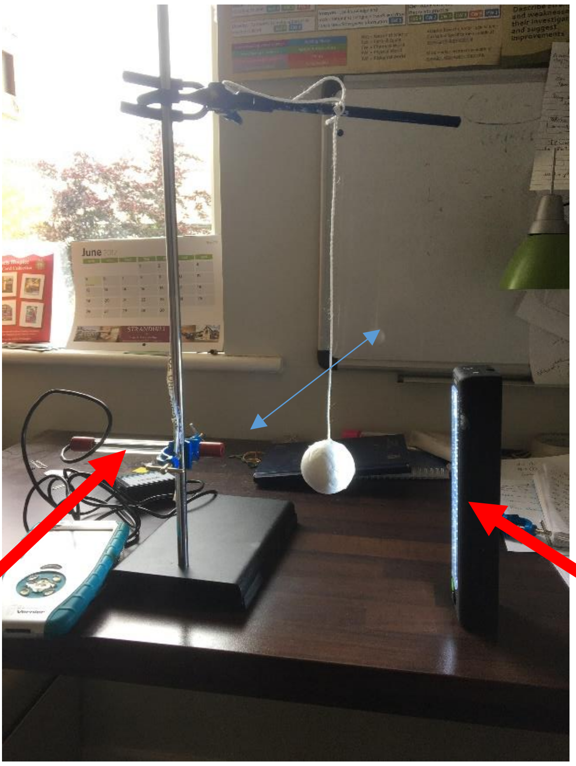
Students can find out more about Kepler by following this link:
https://www.nasa.gov/mission_pages/kepler/main/index.html

They might also like to read about what the plans are now for Kepler, which is running out of fuel.
https://www.space.com/41099-kepler-space-telescope-hibernation.html

Let's Begin

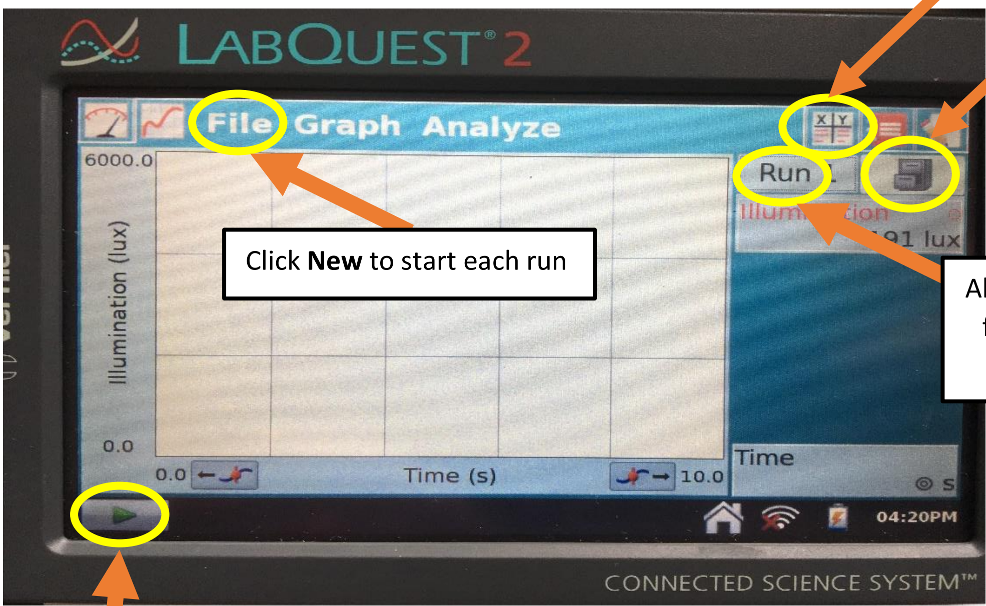
To begin, turn on the logger, attach the light sensor to the *labquest* or *data logger* and experiment with covering the sensor or exposing it to a bright light source to see what happens to the reading.

Now set up your equipment as shown in the photograph below. The polystyrene ball pendulum should be in a position to oscillate between the sensor and the lamp.



Simple Guidelines for the Operation of the Labquest or Logger Pro

Click this icon to allow data collected to be plotted as collected



You will find your table of results here

Save your run by clicking on the filing cabinet

Click **New** to start each run

All your runs can be found by clicking here

Start/Stop data collection

When you have a graph, you can use the stylus to explore values on the graph

Student Activity Sheet

1. Allow the small polystyrene ball to oscillate over and back between the lamp and the light sensor. Set the lab quest to collect data. Save the run and in the space below, sketch a picture to show the general shape of graph achieved. Discuss in your group what it shows.

2. Replace the small ball pendulum with the larger one. Repeat the process as in step 1. In the space below, sketch the pattern occurring in the graph. Discuss in your groups what it shows.

3. Now compare the two graphs. Look at values as well as shape. (Use the stylus to explore the values). How do the graphs differ? How are they similar? Can you explain the differences or similarities? Record any points below.

Extension Activity:

Can you now choose one pendulum to work with? Investigate the changing lux values of the swinging pendulum when the pendulum is **close** to the light source versus when it is **further away** from the light source. Discuss your findings in your group.

Investigating Part Two

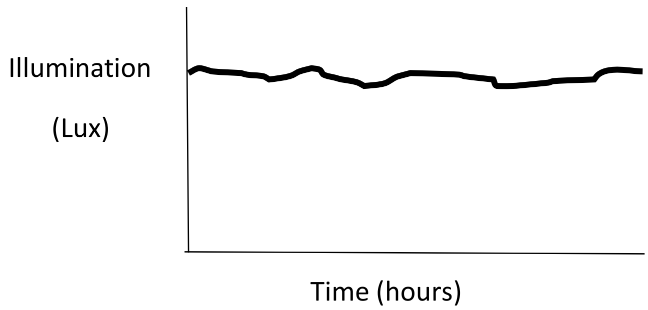
Jeremiah Horrocks Makes First Observation of the Transit of Venus

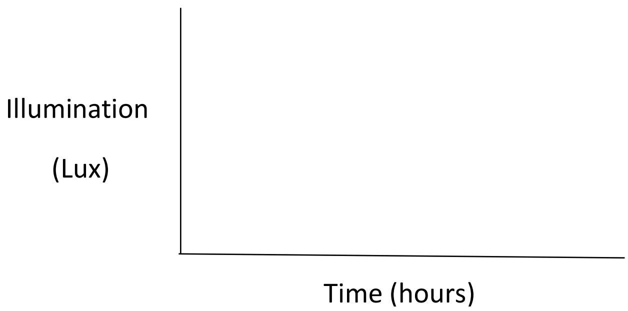
A transit of Venus across the Sun takes place when the planet Venus passes directly between the Sun and Earth.

An Englishman, Jeremiah Horrocks, made the first European observation of a transit of Venus from his home in Much Hoole, England, in the winter of 1639. Horrocks had read about Johannes Kepler who predicted transits in 1631 and 1761, and a near miss in 1639 when Venus would pass very close to the Sun, but not actually in front of it.

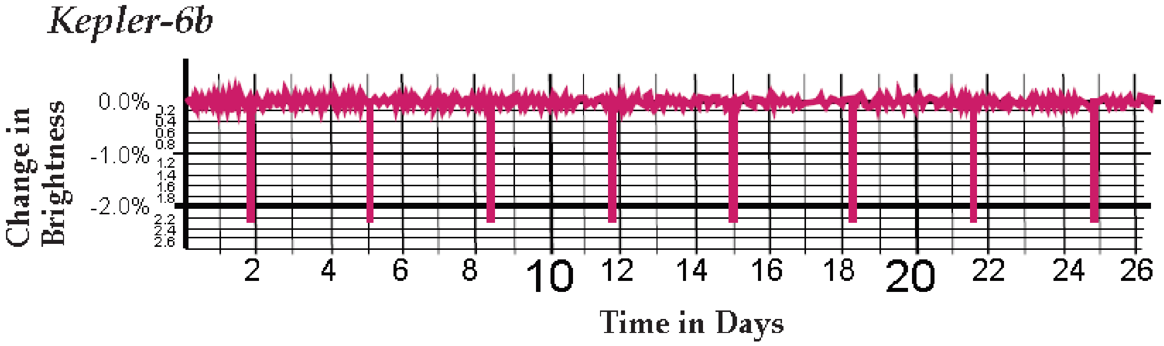
Horrocks made corrections to Kepler's calculation for the orbit of Venus and predicted that 1639 would not be a near miss, but an actual transit. He was uncertain of the exact time but calculated that the transit would begin about 3:00 pm. He focused the image of the Sun through a simple telescope onto a card, where the image could be safely observed. After watching for most of the day with clouds obscuring the Sun often, he was lucky to see the transit as clouds cleared at about 3:15 pm, just half an hour before sunset. The observations allowed him to make a well-informed estimate as to the size of Venus, but more importantly, using geometry, to calculate the distance between the Earth and the Sun which had not been known accurately at that time. He was the first of many people who used transit observations to try to determine the distance from the Sun to the Earth.

The story above shows how scientists began to explore our solar system. Nowadays scientists have more advanced equipment like the equipment you were using in your investigation and they can detect the light coming from distant stars. If the sketch on the left shows the illumination of a star over a period of time, then use the space on the right to sketch what might happen if a planet passed between the star and the light sensor and then moved on.



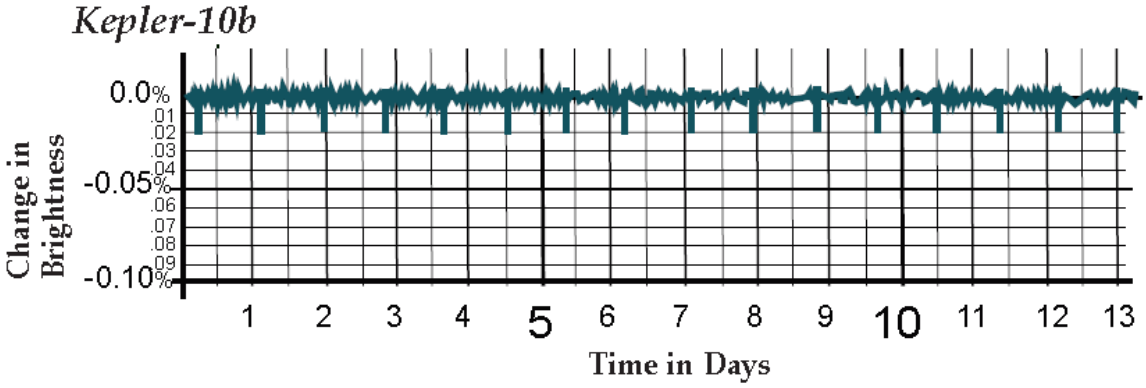


NASA's Kepler is a space-based photometry observatory launched in 2009 which measures the light coming from various stars far away from Earth. Kepler 6B and Kepler 10B are the names given to two planets which are orbiting a distant star. Study the data taken from Kepler below and use it to answer the questions that follow.



1. How does the data show that a planet is orbiting this star?

2. How long does it take this planet to orbit the star? Explain your answer

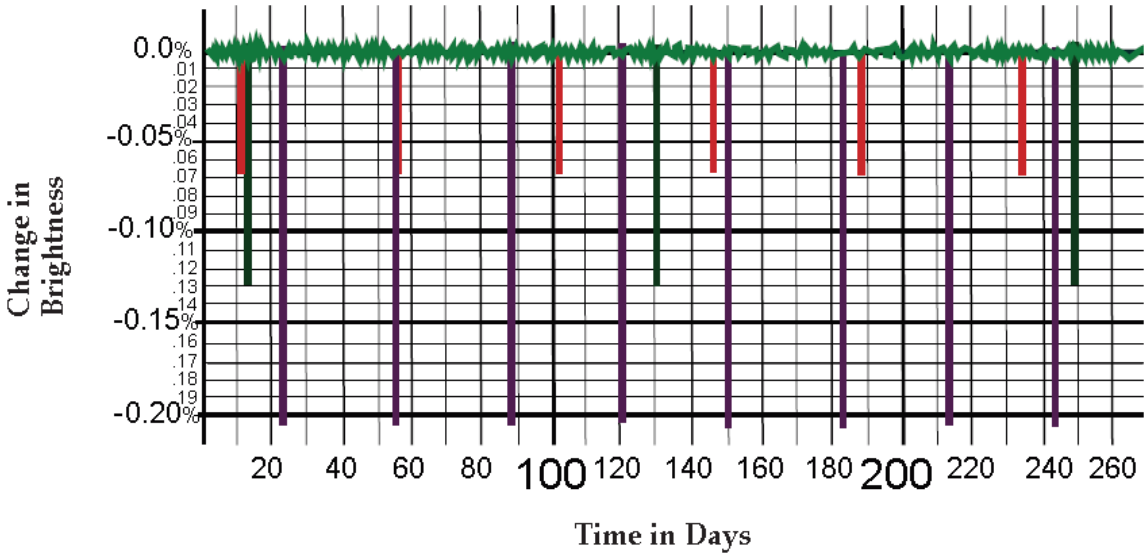


1. How long does it take for planet 10B to orbit the star? Again, explain your answer.

2. The data sets for planet 6B and 10B are quite different. Look at both sets of data and make some suggestions about how the two planets might be different. Explain your thinking by referring to the data.

Extension Activity:

Consider the data presented below which represents illumination recordings taken from a star.



Use the graph to develop a model diagram of the solar system.

Discuss with your group whether you believe your model represents all the planets in this solar system.