# *Back and forth* **Teacher background notes**

**In this investigation, energy transformation and energy conservation are investigated by analysing the motion of a pendulum.**

## [Australian Curriculum: Science links](http://assist.asta.edu.au/resource/3637/back-and-forth-cle-year-10)

## Learning intentions

Students will be able to:

* explain that one or more different forms (or types) of energy can be present at the same time
* understand how one form of energy can be transformed into other forms and vice versa
* identify that the total amount of energy remains constant (total energy is conserved)
* identify and describe the relationship between the length of a pendulum and its period
* identify and describe the relationship between the mass and angle of release of a pendulum and its period
* draw conclusions based on evidence
* identify sources of error
* identify improvements that could increase the reliability of data
* communicate science ideas using appropriate language and representations.

## Suggested time for this CLE

The time needed to complete the *Back and forth* CLE will depend on the depth of the prior knowledge of students, the time to perform the investigations and any time to follow up with any further extension activities. Allow 2–4 hours.

## Prior conceptual knowledge

Science / Year 8 / Science Understanding / Physical sciences

Content description

*Energy appears in different forms including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems* [*(ACSSU155)*](http://www.australiancurriculum.edu.au/Curriculum/ContentDescription/ACSSU155)

Science / Year 9 / Science Understanding / Physical Sciences

Content description

*Energy transfer through different mediums can be explained using wave and particle models* [*(ACSSU182)*](http://www.australiancurriculum.edu.au/Curriculum/ContentDescription/ACSSU182)

## New concepts to be introduced

A simple pendulumconsists of a mass or ‘bob’ attached by a string to a pivot point, which is the centre of rotation. As the bob is lifted and released, the pendulum moves and sweeps back and forth in a circular arc. One full movement, from left to right *and back again*, is called a ‘period’.

Pendulums are great ways to visualise energy transformations and energy conservation within a closed system. When a pendulum is displaced from its ‘rest’ or ‘equilibrium’ position, where it doesn’t move, work has been done on the bob and so it has gravitational potential energy(GPE). This is the energy an object has because of its position (height) within the Earth’s gravitational field. When an object has gravitational potential energy it is subject to a restoring force due to gravity, a force that will accelerate it back towards the Earth’s surface. When the bob is released, the restoring force combined with the bob’s mass causes it to oscillateabout the equilibrium position, swinging back and forth. As the bob begins to move, its GPE is transformed into kinetic energy(KE), the energy of motion. When the pendulum passes through its equilibrium or rest position (when the string is vertical), the GPE it has ‘lost’ has been transformed into KE. As it continues to swing and move upward on the next arc, the KE is transformed back into GPE.

The pendulum system ‘loses’ thermal energy due to air resistance and heat loss within the string itself. This energy leaks out of the system into the surrounding environment. The pendulum’s oscillation repeats itself until the pendulum eventually stops swinging. If all the energy types could be measured at every point of the pendulum’s motion, the total energy would remain constant.

start and end

GPE

GPE

KE

gradual transformation from GPE to KE

gradual transformation from KE back into GPE

minor loss of energy as thermal energy due to air friction and as the string bends

pivot point

**Figure 1**

A mathematical analysis of a pendulum’s motion may be challenging for year 10 students nevertheless, it is a good example of the practical use of algebra. The steps below require mathematical skills that most year 10 students should have and understand.

A pendulum swings with a specific period, which depends mainly on its length and not on the mass of the bob or the angle of release. The physics relationship that determines the pendulum’s motion is given by:

Where T = period of the pendulum swing, measured in seconds (s)

L = length of the pendulum, measured in metres (m)

g = acceleration due to gravity (~ 9.8 ms-2at sea level)

squaring this equation gives:

and rearranging this equation to make ‘g’ the subject gives:

This form of the relationship between T and L will be revisited in the extension part of the pendulum investigation, but it can be seen that by measuring L and T for a pendulum, a value for the acceleration due to gravity on Earth (g) can be determined and compared to the theoretical value of 9.8 ms-2 at sea level.

## Possible misconceptions

|  |  |
| --- | --- |
| **STUDENTS MAY THINK…** | **INSTEAD OF THINKING…** |
| that the period of a pendulum is affected by its mass. | the period of a pendulum is independent of its mass—different mass pendulums of the same length will have the same period. |
| that the period of a pendulum is affected by its angle of release. | the period of a pendulum is independent of its angle of release. |
| that the motion of a pendulum has nothing to do with gravity. | the motion of a pendulum is caused and controlled by gravity—length being the other dependent variable that affects the period of a pendulum. |

## Links to further information

In 1851, the French scientist Jean Foucault suspended a 67-metre pendulum from the dome of the Pantheon in Paris. When the pendulum was set in motion, Foucault observed that the plane of the pendulum’s swing appeared to rotate—360˚ clockwise in about 32 hours. In reality, the swing of the pendulum remained on the same plane, and the Earth rotated underneath it. This was the first demonstration of the rotation of the Earth that did not depend on observation of the skies.

‘The Foucault Pendulum’, UNSW School of Physics website, <http://www.animations.physics.unsw.edu.au//jw/foucault_pendulum.html>