Sample virtual program: Year 11 Physics – investigating waves

Students are guided in completing a short investigation and submitting their results, along with responses to several questions.

## Outcomes

* PH11-10 - explains and analyses waves and the transfer of energy by sound, light and thermodynamic principles
* PH11/12-4 - selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
* PH11/12-6 - solves scientific problems using primary and secondary data, critical thinking skills and scientific processes

Outcomes referred to in this document are from [Physics Stage 6](https://educationstandards.nsw.edu.au/wps/portal/nesa/11-12/stage-6-learning-areas/stage-6-science/physics-2017) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2017.

|  |  |
| --- | --- |
| Guiding question:  | How can the motion of objects be described and predicted? |
| What are your students going to learn? (Objectives) | Students will develop their understanding of the universal wave model, $v=fλ$ and apply this to analyse longitudinal and transverse waves. They will understand waves as carriers of energy and will also develop their data processing and mathematical modelling skills.  |
| How are they going to learn it? (Resources and Strategies) | Students will explore wave motion by viewing and interacting with wave simulations. They will collect and plot data to validate the relationship, $v=fλ$. Simulations are from [Acoustics and vibration animations](https://www.acs.psu.edu/drussell/Demos/waves/wavemotion.html) and the interactive activity is [Wave on a string from PhET](https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html). |
| Time for completion | 1 lesson |
| How are you going to know that they learned it? (Success criteria) | Students will be able to describe waves using correct scientific terminology, including wavelength, frequency, velocity, transverse and longitudinal. They will be able to plot a scatter graph of two variables and recognise the significance of the shape of this graph when determining the relationship between variables.  |
| Collecting evidence of student learning (Verification) | Students will produce a graph of their data, and respond to a short set of questionsThe graph and responses could be submitted via e-mail, Google Classroom or Microsoft Teams to the teacher for feedback.There is an [online version of this activity](https://teacher.desmos.com/activitybuilder/custom/5e7171f70dd76d12dd23c92d) that can be completed by students using the desmos. To share the activity and collect feedback from students:* log in to the site using their school Google account (@education.nsw.edu.au)
* select “Create Class Code” and click code to generate a link that can be shared with your students.
 |
| Differentiation including HPGE | Adapting product – students seeking opportunities for extension could be asked to develop a mathematical model for the relationship between tension and wave velocity for the simulated string. Adapting process – if there are difficulties in accessing or interacting with the online simulation, a complete data set can be provided. |
| Feedback (Evaluation) | Teachers can provide feedback via the submission pathway (e-mail, Google Classroom or Microsoft Teams) to students on their progression towards the learning outcomes. |
| Communication | Students and teachers can interact either synchronously (Google Hangouts, Microsoft Teams) or asynchronously (email) to provide ongoing feedback and support to students for their learning. |

**Resources:**

[PhET Wave on a string](https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html)

A simple, but engaging wave simulator. The simulation can be accessed on most smartphones and through internet browsers. The simulation can be used by students to investigate a range of wave behaviour including basic properties of waves, reflection and standing waves.

[Learn desmos](https://learn.desmos.com/coronavirus)

Further learning on using Desmos to share and create digital activities for your students to complete.

[PHYSCLIPS waves and sound](https://www.animations.physics.unsw.edu.au/waves-sound/oscillations/index.html)

This site contains a wide range of notes, animations and videos on topics relating to waves and sound. The content is presented at a high level and would be most suited for students seeking to deepen their understanding of related physics concepts.

## Lesson sequence

|  |  |  |
| --- | --- | --- |
| Session | Learning Sequence | Evidence of learning |
| 1 | Share the attached activity description with students. The activity sheet introduces the activity and provides definitions of the important terms used to describe waves. * view [animations of different wave types](https://www.acs.psu.edu/drussell/Demos/waves/wavemotion.html) including transverse, longitudinal and water waves. For each wave type, compare the motion of the wave to the motion of the particles that carry the wave.
* access the [wave on a string](https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html) interactive activity. The initial settings used in this investigation our outlined in the student materials.
* measure and record the wavelength of waves with a range of frequencies. The wave equation, $v=fλ$, is applied to calculate the wave velocity. **Note:** Students should be encouraged to consider the units of measurement at this point. Whilst SI units are generally preferable, using cm for distance measurements rather than the SI unit of meters is far more convenient. However, the wave speeds calculated would then be in cms-1 rather than ms-1.
* investigate the relationship between frequency and wavelength, students by first predicting, and then plotting, wavelength versus frequency using graph paper, excel or using the provided [desmos activity](https://teacher.desmos.com/activitybuilder/custom/5e7171f70dd76d12dd23c92d).
* investigate the relationship between tension and wave speed by repeating their data collection using a higher or lower string tension.
* Submit completed tables, graphs and responses

**Note:** Tension is later considered as one of the physical characteristics affecting the formation of standing waves in strings.  | Students:* can describe waves using correct scientific terminology.
* can record collected data neatly in a table
* can plot a scatter graph of two variables
* use the shape of a graph to justify a relationship between variables
* identify that increasing string tension results in increased wave speed
 |

### Student materials - Task

You will be investigating the properties of waves using in interactive simulation. This will require you to collect data, graph and analyse your results.

#### Activity 1: Wave behaviour

Read the following passage from Christian, V. B. H. (1984). Rainbows, snowflakes, and quarks: physics and the world around us. New York: McGraw-Hill.

Waves are a curiously futile kind of motion, and therein lies their fascination. They move on relentlessly in perfect illustration of Heraclitus's maxim that nothing endures but change - all is flux and reflux without beginning or end.

**Waves on the shore, for example, flow in hour after hour, day after day, century after century, but water does not accumulate on the beach nor is the ocean depleted.**

In an ocean wave, the water molecules bob up and down, back and forth, returning over and over again to their starting positions. The ears of wheat and the fabric of a flag are not carried away by the wave motion, yet the waves themselves continue to surge inexorably forward. In contrast, the motion of a ball or a bullet has a beginning and an end; at the conclusion of the motion, an object has left one point and arrived at another.

Where else might you see the wave motion described in the above passage? If not the wheat or the fabric, what is it that is carried forward by waves?

Watch these [animations of longitudinal waves and transverse waves](https://www.acs.psu.edu/drussell/Demos/waves/wavemotion.html). Use the animations and information provided to complete the following table.

|  |  |  |
| --- | --- | --- |
| Wave | Description of wave motion | Description of particle motion |
| Longitudinal |  |  |
| Transverse |  |  |

#### Activity 2: Some definitions

**Wavelength** is the distance between two adjacent wave crests (or between any set of two corresponding points in consecutive waves e.g. from trough to trough).

**Amplitude** describes the maximum displacement from the equilibrium position.

The graph below shows the wavelength and amplitude of a wave. On the same set of axes, draw a wave with an amplitude and wavelength twice that of the one shown.



#### Activity 3: Collecting data

1. Access the [wave on a string](https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html) interactive
2. Set to "oscillate", select "No End" and set "Damping" to none so that the simulation produces a continuous stream of pulses.
3. For five different frequencies, use the ruler provided to measure the wavelength of the wave produced. Record the frequencies and wavelengths in a table provided:
4. Wave speed is calculated by multiplying frequency and wavelength ($v = fλ$).
5. Calculate the wave speed for each pair of frequencies and wavelengths. Record these values in your table.

##### Results

|  |  |  |  |
| --- | --- | --- | --- |
| Trial | Frequency (Hz) | Wavelength (cm) | Wave speed (cms-1) |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |
| 5 |  |  |  |

Describe any patterns in the wave speeds calculated from your data in the space below.

Using the data you collected, plot wavelength versus frequency on the provided graph paper. Alternatively, [open a new desmos graph](https://www.desmos.com/calculator), add a table using the ‘+’ icon and create your graph there. Your completed graph can be copied a picture using the share button.



From the information on your graph, which of the following terms best describes the relationship between wavelength and frequency? (directly proportional, quadratic, inversely proportional, no relationship)

Show that this relationship is true by rearranging the universal wave equation or by explaining the results.

#### Activity 4

Repeat the data collection outlined in steps 1-5 above, using a higher or lower string tension. Draw and record your data in an appropriate table.

**Tension** is force that is transmitted through a rope, string, cable or wire. It is directed along the length of the rope and pulls equally on the objects at each end. [Lumen physics](https://courses.lumenlearning.com/physics/chapter/4-5-normal-tension-and-other-examples-of-forces/) describes tension and other forces.

Considering the data you collected, what affect does changing the tension have on the wave speed?

Why do you think that tension does NOT appear in the universal wave equation, v = fλ?

### Sample data for students unable to access the lesson resources

Table 1: Data collected for high tension setting

|  |  |  |  |
| --- | --- | --- | --- |
| Trial | Frequency (Hz) | Wavelength (cm) | Wave speed (cms-1) |
| 1 | 3.0 | 2.1 |  |
| 2 | 2.5 | 2.5 |  |
| 3 | 2.0 | 3.1 |  |
| 4 | 1.5 | 4.2 |  |
| 5 | 1.0 | 6.2 |  |
| 6 | 0.5 | 12.4 |  |

Table 2: Data collected for low tension setting

|  |  |  |  |
| --- | --- | --- | --- |
| Trial | Frequency (Hz) | Wavelength (cm) | Wave speed (cms-1) |
| 1 | 3.0 | 0.4 |  |
| 2 | 2.5 | 0.5 |  |
| 3 | 2.0 | 0.6 |  |
| 4 | 1.5 | 0.8 |  |
| 5 | 1.0 | 1.2 |  |
| 6 | 0.5 | 2.4 |  |