 Depth study: Modelling energy efficient houses

Module 3: Waves and Thermodynamics

This document references the [Physics Stage 6 Syllabus](https://syllabus.nesa.nsw.edu.au/physics-stage6/) © 2017 [NSW Education Standards Authority (NESA)](http://syllabus.nesa.nsw.edu.au/copyright/) for and on behalf of the Crown in right of the State of New South Wales.

Outcomes

Working scientifically

* PH12-1 develops and evaluates questions and hypotheses for scientific investigation
* PH12-3 conducts investigations to collect valid and reliable primary and secondary data and information
* PH12-4 selects and processes appropriate qualitative and quantitative data and information using a range of appropriate media
* PH12-7 communicates scientific understanding using suitable language and terminology for a specific audience or purpose

Knowledge and understanding

* PH12-14 describes and analyses evidence for the properties of light and evaluates the implications of this evidence for modern theories of physics in the contemporary world

Learning across the curriculum

Cross-curriculum priorities

* Sustainability

General capabilities

* Critical and creative thinking
* Information and communication technology capability
* Literacy
* Numeracy

Teacher notes

To apply knowledge of thermodynamics to produce an energy efficient house.

The focus of this task is to use mathematical based computer modelling to design a house, identifying and justifying the materials that the house is to be manufactured from.

Students will increase their depth of understanding of:

* the meaning of
* application of conduction and possibly other heat transfer techniques
* the flow of thermal energy
* planning the use of ICT models to test a hypothesis
* identifying patterns in data
* communicating their understanding of their results to an application

Suggested Timeline

This depth study can be timetabled for a minimum of 8 hours with scope to timetable up to 15 hours.

* 2-5 hours: Use of simulation software to raise skill level with software
* 2-3 hours: Background research, identifying the thermal properties of different materials that may be used
* 3-5 hours: Designing and running simulations of design parameters for house
* 1-2 hours: Completion of design report as recommendation for house design

Resources

Students need access to [Energy2D](http://energy.concord.org/energy2d/), which is free downloadable software to simulate thermal flow

It also may be used as simulations that can be viewed or edited online, using Java. It is suggested students use the downloaded version

[Tutorial of using the software](https://youtu.be/M2kSU06829g) (duration 13:28)

Task

Synopsis

You have been asked by your family to design a house that will maintain its temperature, by reducing the heat loss during winter and resisting warming up during summer. The materials being used will be tested for their thermal properties. After selecting the materials, you then need to check the house will have appropriate thermal characteristics. Based on your modelling, you then need to supply a report to your family with your recommendations.

Instructions

You require a copy of [ENERGY2D](http://energy.concord.org/energy2d/), this may be downloaded

1. Using the ENERGY2D software, [run through the tutorial](https://youtu.be/M2kSU06829g)

During the tutorial make notes on how to use the simulation software, including how to change thermal properties.

1. Carry out five thermal conduction experiments on:
   * Thermal Conductivity
   * Conduction Area
   * Temperature Difference
   * Conducting Distance
   * Specific Heat

Write these experiments up using an appropriate scientific format, including:

* + Scientific research question
  + Hypothesis
  + Aim
  + Methodology
  + Results
  + Discussion
  + Conclusion

In your discussion, you should relate your results to

You may wish to carry out other thermal testing, such into convection and radiation

1. Carry out background research on materials that may be used in the manufacture of houses. This research should include thermal properties, like the thermal conductivity and density, which will be required for testing the materials.

You should include the option of at least two possible building materials.

Remember to include referencing to sources of information using an appropriate format. An example of a referencing format is Harvard.

1. Design experimental simulations that test your choice of materials and/or other design concepts. Write up these investigations using an appropriate scientific format of:
   * Background research
   * Scientific research question
   * Hypothesis
   * Methodology
   * Results
   * Discussion
   * Conclusion
2. Test the energy efficiency of your house design.
3. Write up your report for your family to justify your house design. This should include appropriate diagrams and quantitative measurements.

Marking guideline/rubric

| Criteria | A | B | C | D | E |
| --- | --- | --- | --- | --- | --- |
| Question and Predicting | Develops and evaluates inquiry questions and hypotheses by identifying concepts that can be investigated scientifically.  Modifies questions and hypotheses, then retests based on evaluation | Develops inquiry questions and hypotheses that can be investigated scientifically for own investigations  Evaluates investigation | Develops inquiry questions and hypotheses by identifying concepts in example simulations  Attempts to develop inquiry questions and hypothesis for own investigations | Attempts to develop inquiry questions and hypothesis for sample investigations | Attempts to identify question and or hypothesis for example simulations |
| Planning Investigations | Designs investigations to collect data and refines investigations based on results or identifies and carries out new investigations  Justifies, evaluates the investigation plan, and modifies this investigation in response to new evidence | Designs investigations to collect data in response to a question or problem.  Justifies and evaluates the inclusion of experimental controls in investigation. | Attempts to design investigations to collect data.  Experiment is a controlled, fair test allowing the collection of reliable and valid data. | Modifies investigation to collect data in response to student’s question. | Attempts to design investigation to collect data. |
| Conducting investigations | Effectively conducts and improves investigation to collect data.  Utilises technology to evaluate the accuracy of investigations.  Selectively sources reliable secondary data and extracts relevant data and references data sources using accepted referencing style. | Recognises problems with data during simulation data collection and adapting or fixing simulation  Utilises technology to evaluate the accuracy of investigations.  Selectively sources reliable secondary data and references data sources. | Conducts demonstration and designed simulations to collect data  Utilises technology to evaluate the accuracy of investigations.  Reliably sources secondary data | Follows demonstration investigations and records results  Sources secondary data sources and acknowledges them. | With assistance, conducts a simulation by following a procedure.  Extracts secondary data sources from identified sources |
| Processing Data | Processes quantitative data by selecting effective representations for this data including calculating averages and identifying outliers. | Processes quantitative data by selecting effective representations for this data including identifying outliers. | Selects qualitative and quantitative data and selects appropriate formats to represent them. | Selects and represents qualitative and quantitative data | Selects a recognised data type presentation technique |
| Analysing Data | Thoroughly analyses a wide range of data sets and information.  Assesses data sources thoroughly and suggest methods to improve data that were not possible to achieve by the student.  Repeats investigations if data appears to have anomalies to improve data | Analyses data sets to identify relationships, patterns and trends.  Assesses data sources thoroughly and suggest improvements to data. | Analyses data sets to identify trends and relationships.  Assesses the relevance, accuracy, validity and reliability of first and secondary sourced information. | Analyses data to identify trends and relationships.  Identifies that data has some limitations. | Identifies a trend in data in a simulation |
| Problem Solving | Evaluates processes, and solves problems critically, with reference to evidence to justify reasoning.  Discusses possible alternatives to explanations.  Evaluates the use of models to explain phenomena and make predictions. | Evaluates processes and solves problems critically, with reference to evidence to justify reasoning.  Identifies possible alternatives to explanations.  Uses models to explain phenomena and make predictions. | Solves scientific problems using evidence to support critical thinking. | Objectively and critically considers second hand data for use in house. | Considers questions subjectively with scientific basis. |
| Communication | Communicates scientific understanding effectively at the appropriate level for a family discussion.  Constructs evidence-based arguments to provide a conclusion to the problem. | Communicates scientific understanding effectively and is able to construct evidence-based arguments | Communicates scientific understanding using suitable language and terminology in a range of forms. | Attempts to communicate scientific understanding in at least two different forms. | Attempts to communicate scientific understanding |
| Application of Thermodynamic knowledge | Demonstrates extensive knowledge of content and understanding of course concepts, and applies highly developed skills and processes in a wide variety of contexts | Demonstrates thorough knowledge of content and understanding of course concepts, and applies well-developed skills and processes in a variety of contexts. | Demonstrates sound knowledge of content and understanding of course concepts, and applies skills and processes in a range of familiar contexts. | Demonstrates a basic knowledge of content and understanding of course concepts, and applies skills and processes in some familiar contexts. | Demonstrates an elementary knowledge of content and understanding of course concepts, and applies some skills and processes with guidance. |