DP physics—Sample unit planner 2: The greenhouse effect

Teacher(s)		**Subject group and course**	Sciences: Physics		
Course part and topic	B.2 Greenhouse effect	**SL or HL/Year 1 or 2**	Year 1, 2 SL/HL	**Dates**	

Unit description and content	**DP assessment(s) for unit**
This unit covers B.2 Greenhouse effect.	• Paper 1: Multiple-choice questions and data analysis • Paper 2: Short-answer and extended-response questions • Internal assessment

Establishing the purpose of the unit

Transfer goals *prompt students to "transfer" or apply their knowledge, skills and concepts from the unit to new/different circumstances, on their own without scaffolding from the teacher.*

The Physics guide *describes two ways to integrate topics.*

- *Concepts and themes*
- *Guiding and linking questions.*

List one to three big transfer goals for this unit. The transfer goals list will depend on the sequence of units.

Guiding questions

How does the greenhouse effect help to maintain life on Earth and how does human activity enhance this effect?

How do laws of physics constrain the theoretical output of energy sources?

Teaching and learning through inquiry

Concepts, skills and nature of science—essential understandings

Students will develop the following understandings in relation to concepts, application of skills and nature of science (NOS).

(Refer to the specific sections of the Physics guide *for details.)*

Note: This unit includes a selection of linking questions from the Physics guide*, chosen for their relevance in the teaching sequence. Further linking questions are specified in the* Physics guide*, but they do not all need to be addressed because they are not specifically assessable. Teachers and students may wish to write their own linking questions to make meaningful links between topics.*

Students will know the following content.

- Conservation of energy applied to the energy exchanged by a celestial object
- Emissivity as the ratio of the power radiated by a surface compared to the one of an ideal black surface at the same temperature:
  - emissivity = $\frac{\text{power radiated per unit area}}{\sigma T^4}$
- Albedo as a concept to quantify the average energy reflected off a macroscopic system:
  - albedo = $\frac{\text{total scattered power}}{\text{total incident power}}$
- Earth's albedo varies daily and is dependent on cloud formations and latitude:
  - Luminosity of a star, *L*, using $L = \sigma A T^4$
  - The concept of apparent brightness, *b*, as a method to determine distance to astronomical objects using $b = \frac{L}{4\pi d^2}$
- The solar constant, *S*
- The incoming radiative power is dependent on the projected surface of a planet along the direction of the path of the rays, resulting in a mean value of the incoming intensity being $\frac{S}{4}$
- The absorption of infrared radiation by the main greenhouse gases can be explained in terms of the molecular energy levels and the subsequent emission of radiation in all directions

- The greenhouse effect can be explained in terms of either a resonance model or molecular energy levels
- The augmentation of the greenhouse effect due to human activities is known as the enhanced greenhouse effect

Students will develop the following skills.

- Estimate the equilibrium temperature of a celestial object using energy balance between incoming and outgoing radiation intensity, including albedo, emissivity, and solar or other constants
- Solve energy balance problems including energy exchanged between the surface and the atmosphere of a celestial object
- Express luminosity of a star in watts or in terms of the luminosity of the Sun, $L\odot$
- Recognize methane (CH_4), water vapour (H_2O), carbon dioxide (CO_2) and nitrous oxide (N_2O) as the main greenhouse gases and that each of these has both natural and human-made origins
- Identify the burning of fossil fuels as the likely primary cause of the enhanced greenhouse effect

Teaching and learning through inquiry

Linking questions	**Learning process (in order of teaching sequence)** *Check the boxes for any pedagogical approaches used during the unit. Aim for a variety of approaches to help facilitate learning.* **Activities**
What is the mechanism to produce electromagnetic waves? (C.2) How is global warming affecting the research and development in science? (Nature of science) How can the inverse square law for light be used to calculate astronomical distances? (E.5) What relevance do simple harmonic motion and resonance have to climate change? (C.1, C.4)	Modelling the greenhouse effect Stefan-Boltzmann law Language of climate change Individual changes

Important notes
No additional higher level-specific content

Approaches to learning *Check the boxes for any explicit approaches to learning connections made during the unit. For more information on approaches to learning, refer to the* Diploma Programme Approaches to teaching and learning *website*.	Skills in the study of physics	Nature of science
☒ Thinking ☒ Social ☒ Communication ☐ Self-management ☒ Research	**Experimental techniques (Tool 1)** ☒ Addressing safety of self, others and the environment ☐ Measuring variables **Technology (Tool 2)** ☒ Applying technology to collect data ☒ Applying technology to process data **Mathematics (Tool 3)** ☒ Applying general mathematics ☐ Using units, symbols and numerical values	☒ Observations ☐ Patterns ☐ Hypotheses ☐ Experiments ☐ Measurement ☐ Evidence ☐ Theories ☒ Models ☐ Falsification ☒ Science as a shared endeavour ☒ Global impact of science

	☐ Processing uncertainties ☒ Graphing **Exploring and designing (Inquiry 1)** ☐ Exploring ☐ Designing ☐ Controlling variables **Collecting and processing data (Inquiry 2)** ☒ Collecting data ☒ Processing data ☒ Interpreting results **Concluding and evaluating (Inquiry 3)** ☐ Concluding ☐ Evaluating	

Theory of knowledge (TOK) connections *Check the boxes for any explicit TOK connections made during the unit.*	**International-mindedness**
☒ Personal and shared knowledge Climate data is shared through international collaboration. ☐ Ways of knowing ☐ Areas of knowledge ☐ The knowledge framework	**Sustainability Development Goals links** 11: Sustainable Cities and Communities 12: Responsible Consumption and Production 13: Climate Action **Creativity, activity, service (CAS) connections** ☐ Creativity ☐ Activity ☒ Service Students can link their daily activities and evaluate ways to reduce their own personal consumption. Student climate change advocacy groups.