Year 11 Physics - Module 3 Waves and Thermodynamics

Our goal for this term is to:

Wave motion involves the transfer of energy without the transfer of matter. By exploring the behaviour of wave motion and examining the characteristics of wavelength, frequency, period, velocity and amplitude, students further their understanding of the properties of waves. They are then able to demonstrate how waves can be reflected, refracted, diffracted and superposed (interfered) and to develop an understanding that not all waves require a medium for their propagation. Students examine mechanical waves and electromagnetic waves, including their similarities and differences.

Students also examine energy and its transfer, in the form of heat, from one place to another. Thermodynamics is the study of the relationship between energy, work, temperature and matter. Understanding this relationship allows students to appreciate particle motion within objects. Students have the opportunity to examine how hot objects lose energy in three ways: first, by conduction, and, second, by convection – which both involve the motion of particles; and, third, the emission of electromagnetic radiation. An understanding of thermodynamics is a pathway to understanding related concepts in many fields involving Science, Technology, Engineering and Mathematics (STEM).

We will achieve this by exploring the following inquiry questions:

Inquiry Question 1: What are the properties of all waves and wave motion?
Inquiry Question 2: How do waves behave?
Inquiry Question 3: What evidence suggests that sound is a mechanical wave?
Inquiry Question 4: What properties can be demonstrated when using the ray model of light?
Inquiry Question 5: How are temperature, thermal energy and particle motion related?

Timing: 6 Weeks

#	Learning Intention The goal of these lesson are to...	Lesson Activities To achieve this goal we will...	Success Criteria I will know I have achieved this goal when...
1	Inquiry Question 1: What are the properties of all waves and wave motion?	* Conduct a practical investigation involving the creation of mechanical waves in a variety of situations in order to explain: – the role of the medium in the propagation of mechanical waves – the transfer of energy involved in the propagation of mechanical waves *Conduct practical investigations to explain and analyse the differences between: - transverse and longitudinal waves - mechanical and electromagnetic waves ● construct and/or interpret graphs of displacement as a function of time and as a function of position of transverse and longitudinal waves, and relate the features of those graphs to the following wave characteristics: - velocity - frequency - Period - Wavelength - wave number - displacement and amplitude ● solve problems and/or make predictions by modelling and applying the following relationships to a variety of situations: $v = f\lambda$	1. Explain that waves involve a transfer of energy from one place to another 2. Explain the role of a medium for sound to be propagated but not for light waves. 3. Analyse the differences between transverse and longitudinal waves 4. Analyse the differences between mechanical & electromagnetic waves 5. Describe waves using graphs 6. Extract information and solve problems about waves from graphs 7. Identify features of waves - velocity, frequency, period, wavelength, wave number, displacement and amplitude 8. Describe waves using equations 9. Solve problems using the wave equations

		$f = \frac{1}{T}$ $k = \frac{2\pi}{\lambda}$ (where k = wave number)	
2	Inquiry Question 2: How do waves behave?	• Conduct an experiment to demonstrate water waves reflecting off a surface, refracting through different depths, diffracting around an obstacle and interfering (two sources). • Conduct an investigation to distinguish between progressive and standing waves • Conduct an investigation to explore resonance in mechanical systems and the relationship between: - Driving frequency - Natural frequency of the oscillating system - Amplitude of motion - transfer/ transformation of energy within the system	1. Explain the behaviour of waves in a variety of situations 2. Distinguish between progressive and standing waves 3. Define the terms *resonance, driving frequency, natural frequency, oscillation*. 4. Explain resonance in mechanical systems and analyse the relationship between the terms: driving frequency, natural frequency of the oscillating system, amplitude of motion, transfer/transformation of energy within the system
3	Inquiry Question 3: What evidence suggests that sound is a mechanical wave?	• Conduct an investigation to model the behaviour of sound in air as a longitudinal wave and explain this behaviour by relating the displacement of air molecules to variations in pressure • Conduct a practical investigation to relate the pitch and loudness of a sound to its wave characteristics • Investigate quantitatively the relationship between distance and intensity of sound • Conduct investigations to analyse the reflection,	1. Outline an investigation that can be used to model the behaviour of sound in air as a longitudinal wave 2. Explain the behaviour of sound by relating the displacement of air molecules to variations in pressure 3. Define loudness and pitch 4. Observe different wave characteristics through practical investigation and elate loudness and

		diffraction, resonance and superposition of sound waves ● Investigate and model the behaviour of standing waves on strings and/or in pipes to relate quantitatively the fundamental and harmonic frequencies of the waves that are produced to the physical characteristics (eg length, mass, tension, wave velocity) of the medium ● Analyse qualitatively and quantitatively the relationships of the wave nature of sound to explain - Beats - $f_{beat} = \lvert f_2 - f_1 \rvert$ - The Doppler effect $f' = f\frac{(v_{wave}+v_{observer})}{(v_{wave}-v_{source})}$	pitch to wave characteristics 5. Design an investigation to determine the relationship between distance and intensity of sound 6. Use appropriate graphical representations to present data 7. define reflection, diffraction, resonance and superposition 8. Conduct experiments to observe wave phenomena 9. Analyse results of investigations on reflection, diffraction, resonance and superposition of sound waves 10. Define a standing wave 11. Provide examples of where standing waves occur 12. Use correct nomenclature for wave phenomena 13. Relate quantitatively the fundamental and harmonic frequencies of waves to physical characteristics (eg length, wave, mass, tension, wave velocity) of the medium 14. Solve problems that explain beats, and the doppler effect
4	**Inquiry Question 4:** What properties can be demonstrated when using the ray model of light?	● conduct a practical investigation to analyse the formation of images in mirrors and lenses via reflection and refraction using the ray model of light ● conduct investigations to examine qualitatively and quantitatively the refraction and total internal reflection of light	1. Use ray diagrams to draw a variety of images formed using mirrors and lenses 2. Qualitatively and quantitatively describe refraction of light, using ray diagrams 3. Qualitatively and quantitatively describe total internal reflection 4. Describe the requirements for TIR, in terms of the media and critical angle 5. Apply Snell's Law

		• predict quantitatively, using Snell's Law, the refraction and total internal reflection of light in a variety of situations • conduct a practical investigation to demonstrate and explain the phenomenon of the dispersion of light • conduct an investigation to demonstrate the relationship between inverse square law, the intensity of light and the transfer of energy • solve problems or make quantitative predictions in a variety of situations by applying the following relationships to: - $n_x = \frac{c}{v_x}$	6. Explain dispersion of light using ray diagrams, linking to differential refraction 7. Explain the relationship between intensity of light and distance from the source 8. Draw and interpret graphs involving Intensity of light and distance from the source 9. Solve a range of problems related to refractive index, Snell's Law and the inverse square law
5	**Inquiry Question 5:** How are temperature, thermal energy and particle motion related?	• Explain the relationship between the temperature of an object and the kinetic energy of the particles within it • Explain the concept of thermal equilibrium • Conduct an investigation to analyse qualitatively and quantitatively the latent heat involved in a change of state • investigate energy transfer by the process of: ○ conduction ○ convection ○ Radiation	1. Identify heat is a form of energy that can be transferred or transformed 2. Describe the kinetic theory of matter 3. Explain the relationship between temperature, changes of state and kinetic energy 4. Describe the process of thermal equilibrium 5. Explain the process of thermal equilibrium 6. Describe changes of state in terms of latent heat 7. Explain the relationship between latent heat and changes of state 8. Explain convection in terms of transfer of energy between particles

		● analyse the relationship between the change in temperature of an object, and its specific heat capacity through the equation ΔQ=mcΔT (ACSPH020) ● model and predict quantitatively energy transfer from hot objects by the process of thermal conductivity ● apply the following relationships to solve problems and make quantitative predictions in a variety of situations: - ΔQ=mcΔT where *c* is the specific heat capacity of a substance – $\frac{Q}{t} = \frac{k\Delta T}{d}$ where *k* is the thermal conductivity of a material	9. Explain the process of conduction in terms of energy transfer between particles in a solid 10. Explain the relationship between the transfer of energy and the process of radiation 11. Explain the process of thermal conductivity 12. Solve problems using the thermal conductivity equation