Module 7: The Nature of Light

Electromagnetic Spectrum

Inquiry question: What is light?

Students:

- investigate Maxwell's contribution to the classical theory of electromagnetism, including:
  - unification of electricity and magnetism
  - prediction of electromagnetic waves
  - prediction of velocity
- describe the production and propagation of electromagnetic waves and relate these processes qualitatively to the predictions made by Maxwell's electromagnetic theory
- conduct investigations of historical and contemporary methods used to determine the speed of light and its current relationship to the measurement of time and distance
- conduct an investigation to examine a variety of spectra produced by discharge tubes, reflected sunlight or incandescent filaments

- investigate how spectroscopy can be used to provide information about:
  - – the identification of elements
- investigate how the spectra of stars can provide information on:
  - – surface temperature
  - – rotational and translational velocity
  - – density
  - – chemical composition

Light: Wave Model

Inquiry question: What evidence supports the classical wave model of light and what predictions can be made using this model?

Students:

- conduct investigations to analyse qualitatively the diffraction of light
- conduct investigations to analyse quantitatively the interference of light using double slit apparatus and diffraction gratings $d\sin\theta = m\lambda$

- analyse the experimental evidence that supported the models of light that were proposed by Newton and Huygens
- conduct investigations quantitatively using the relationship of Malus' Law $I = I_{\max} cos^2\theta$ for plane polarisation of light, to evaluate the significance of polarisation in developing a model for light

Light: Quantum Model

Inquiry question: What evidence supports the particle model of light and what are the implications of this evidence for the development of the quantum model of light?

Students:

- analyse the experimental evidence gathered about black body radiation, including Wien's Law related to Planck's contribution to a changed model of light

  $$-\lambda_{\max} = \frac{b}{T}$$

- investigate the evidence from photoelectric effect investigations that demonstrated inconsistency with the wave model for light

- analyse the photoelectric effect $K_{\mathrm{max}} = hf - \phi$ as it occurs in metallic elements by applying the law of conservation of energy and the photon model of light,

Light and Special Relativity

Inquiry question: How does the behaviour of light affect concepts of time, space and matter?

Students:

- analyse and evaluate the evidence confirming or denying Einstein's two postulates:
  - – the speed of light in a vacuum is an absolute constant
  - – all inertial frames of reference are equivalent (ACSPH131)
- investigate the evidence, from Einstein's thought experiments and subsequent experimental validation, for time dilation $t = \frac{t_0}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$ and length contraction $l = l_0\sqrt{\left(1-\frac{v^2}{c^2}\right)}$, and analyse quantitatively situations in which these are observed, for example:
  - –observations of cosmic-origin muons at the Earth's surface
  - –atomic clocks (Hafele–Keating experiment)

–evidence from particle accelerators

–evidence from cosmological studies

- describe the consequences and applications of relativistic momentum with reference to:

  – $p_v = \frac{m_0 v}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$

  – the limitation on the maximum velocity of a particle imposed by special relativity (ACSPH133)

- Use Einstein's mass–energy equivalence relationship $E = mc^2$ to calculate the energy released by processes in which mass is converted to energy, for example:

  – production of energy by the sun

  – particle–antiparticle interactions, eg positron–electron annihilation

  – combustion of conventional fuel