Module B. Colour from the Cosmos

Lesson 12: Colour, Light and Optics 1

Introduction

A large part of the beauty and value of gemstones and precious metals revolves around the interaction between light and the object. This includes not only the hue and saturation of perceived colour, but also how light is transmitted, reflected, refracted, fluoresced, and dispersed. Furthermore, it is not solely the interaction of light with matter but also the way that the human eye interprets such optical phenomena.

Light is electromagnetic radiation or energy, and can be described as behaving like both waves and particles (photon). Like all waves, light can be described by its wavelength, the distance from peak to peak or trough to trough, and its frequency, the number of wave crests (or troughs) that pass through one point in one second. Light propagates in the direction of its wave front. All electromagnetic radiation (from radio waves to X-rays) travels at a constant speed (the speed of light). So, when the frequency of light is decreased, its wavelength must increase – this is an inverse relationship. Light energy increases with increasing frequency (or decreasing wavelength). Refer to the figure and table below for more information on the parts of a wave.

Light also behaves like a particle when it travels as photon particles. More intense light would be composed of a greater number of photons with a higher frequency of incidence. For gemstones, interaction with light is best described using the wave-like approach. For those students interested in the wave-particle duality of light, a good online starting point is [Wikipedia](http://en.wikipedia.org/wiki/Light).

Anatomy of a wave.

Equation of a waveform.

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| **Parameter** | **Symbol** | **Definition (units)** |
| crest | -- | highest point of a wave |
| trough | -- | lowest point of a wave |
| wavelength | λ | distance between two successive crests or two successive troughs of a wave (nanometres or 10-9 metres, nm) |
| frequency | *f* | number of waves passing a point per unit of time (cycles per second or hertz, Hz) |
| velocity | *v* | velocity (or speed) of the wave and in this case it is the speed of light, which in a vaccuum is 3.0x10^8 m/s (meters per second, m/s) |
| amplitude | A | vertical distance between crest or trough and the equilibrium line (nanometres or 10-9 metres, nm) |

**Required Text Readings**

None

**Optional Readings**

Nassau, K. (1978) "[The Origin of Color in Minerals](https://connect.ubc.ca/bbcswebdav/pid-2559766-dt-content-rid-10494273_1/courses/SIS.UBC.EOSC.118.99C.2014WC.44220/Course_Files/moduleB/lesson12/download/Nassau-1978.pdf)", *American Mineralogist*, Vol. 63, p219-229.

**Optional online resources:**

[Causes of Color](http://www.webexhibits.org/causesofcolor/index.html), from the Institute for Dynamic Educational Advancement (IDEA).