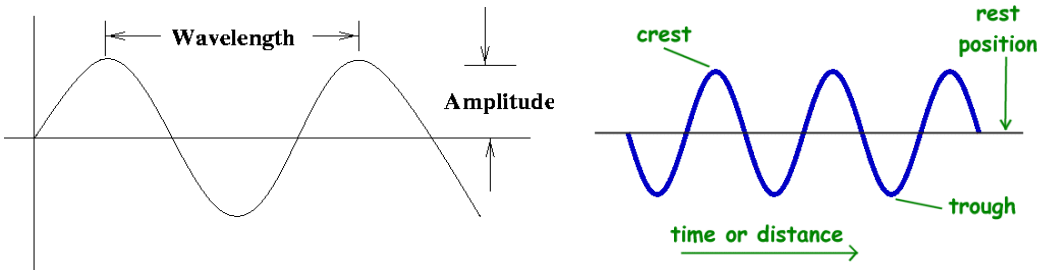
04. The principles (of waves and optics) behind holography

Two physical phenomena are related to holography, interference and diffraction of light waves [1]. Both of them consist the principles of the technique. *So first of all, it is important to find out what a wave is and what are its basic properties*. As a wave is considered any "disturbance that travels through a medium from one location to another", and as a medium is consider any substance that can function as a carrier of the wave [2]. Every wave is consisted of high points (crests) and low (troughs) and it is characterized by a height (amplitude), a length between two high points (wavelength), and also a period (the time that a complete wave need to pass from a location) a frequency (the number of waves that pass from a location in a second) as well as a speed (the horizontal speed of a point on a wave which is measured in meters per seconds) [3] [4].



There are two main types of waves, the mechanical and the electromagnetic waves [5]. A mechanical wave can be produced "from a vibrating source" which allows the transmission of the disturbance from one location to the other [5]. The disturbance is transmitted through materialistic media (e.g. air, water) the so-called propagation media, while the speed, the size and the shape of the wave are depended on the type and the properties of the medium [6] [7]. An electromagnetic wave is the result of oscillation between an electric and a magnetic field, which are perpendicular to each other [8] [9]. In contrast to mechanical, electromagnetic waves have no need of a propagation medium, since they can also be transmitted through vacuum, and at the speed of light. Therefore, they are often "called electromagnetic radiation, light, or photons[1]" [9] and they are split in a range of frequencies, which consist the so called "electromagnetic spectrum" [8].

In holography the visible light is utilized in order to produce a hologram (????) so the next step is to get familiar with some basic principles and/or physical properties of light waves, namely reflection, refraction, interference and diffraction. One basic property is the reflection of light. Reflection is called the phenomenon in which a wave that falls on a reflecting surface, changes direction in such a way that the angle of the reflected wave (to the reflected surface) is equal to the angle of the incident wave [5] [10]. If the bouncing surface is rough, then the light is scattered in multiple direction, and this phenomenon is called diffuse reflection [17]. Refraction is characterized the phenomenon during which a light wave changes path (bends) when "it passes through two transparent media" which are "different in the optical density" [11] [12]. It can be also used to "analyze a beam of white light into its components" [11]. As has previously mentioned, another property of light, which is also important to the holographic process, is interference, and is the phenomenon in which two waves, that travels to the same medium, meet [13]. If the crests and troughs of the two waves coincide, a constructive interference happens, meaning that the two waves are in the same phase and thus are aggregated [13] [14]. If the aggregated waves are of opposite phase they are cancelled out,

[1] However, photons are mostly considered as particles that are included in an electromagnetic wave [5]

and destructive inference occurs [16]. Finally, the other important property of light (also related to holographic process) is diffraction, the phenomenon in which waves change direction when they "pass through an opening or around a barrier in their path" [15] and a "formation of bright and dark fringes" happens [14]. The amount of diffraction is related to the increase or the decrease of the wavelength [15].

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HOLOMAKERS PROJECT

Motivating secondary school students towards STEM careers through hologram making and innovative virtual image processing practices with direct links to current research and laboratory practices

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Declaration

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