**WHAT IS HOLOGRAM?**

**Holos:** complete  **Graphos:** message  **Hologram:** the complete encoding of light information (phase + Amplitude) from a scene  **Holography:** technique to record the complete picture of an object

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**HISTORY**

Hologram is invented in 1947 by physicist Dennis Gabor. It earned him a Nobel Prize in 1971. But it is not until the 60s, they started to build hologram with light, previously was with electrons. That is because laser has not been invented yet.

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**HOLOGRAMS IN LIFE**

If you want to see a hologram, you don’t have to look much farther than your wallet. There are holograms on most driver's licenses, ID cards and credit cards. At home, they’re part of CD, DVD and software packaging, as well as just about everything sold as “official merchandise.”

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**BASIC CONCEPTS**

**Diffraction:** the bending of light around the corners of an obstacle or aperture into the region of geometrical shadow of the obstacle

**Interference:** the combination of two or more waves to form a composite wave based on the superposition principle

**Principle of superposition:** the resultant wave is calculated by taking the algebraic sum of displacements at every single point of waves

**Intensity:** the amount of light illuminating a surface

\[
I = \varepsilon_0 c \langle E^2 \rangle_I
\]

The speed of light in vacuum:

\[
c = 3.00 \times 10^8 \text{m/s}
\]

The vacuum permittivity:

\[
\varepsilon_0 = 8.85 \times 10^{-12} \text{F/m}
\]

The time average of the square of the total electric field:

\[
\langle E^2 \rangle_I = \frac{1}{T} \int E^2(r) dt
\]

**SETUP**

The intensity distribution of the interference pattern on the holographic plate records the phase and amplitude information of the object beam.

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**CALCULATION**

**Object wave function:**

\[
E_o(r,t) = A_o(r) \sin(\omega t + \phi_o(r))
\]

\(r\): position  \(t\): time  \(\omega\): angular wave number  \(A_o(r)\): the amplitude of the object wave at position \(r\)  \(\phi_o(r)\): the phase of the object wave at position \(r\)

**Reference wave function:**

\[
E_r(r,t) = A_r \sin(\omega t + \phi_r(r))
\]

**Resultant wave function:**

\[
E_s(r,t) = E_o(r,t) + E_r(r,t)
\]

\[
E_s(r,t) = A_o(r) \sin(\omega t + \phi_o(r)) + A_r \sin(\omega t + \phi_r(r))
\]

**Intensity distribution :**

\[
I_s = \varepsilon_0 c \left( \langle E_o^2 + E_r^2 \rangle \right)_I
\]

\[
I_s(r) = \varepsilon_0 c \left( \frac{A_o^2 + A_r^2}{2} + A_o A_r \cos(\phi_o - \phi_r) \right)
\]

**Final wave function:**

\[
E_f(r,t) = E_s(r,t) I_s(r)
\]

\[
E_f(r,t) = \frac{1}{2} \varepsilon_0 c A_o (A_o^2 + A_r^2) \sin(\omega t + \phi_o)
\]

\[
+ \frac{1}{2} \varepsilon_0 c A_r \sin(\omega t + 2\phi_o - \phi_r) + \frac{1}{2} \varepsilon_0 c A_o \sin(\omega t + \phi_r)
\]

1. An undiffracted beam (zeroth order) will pass directly through the hologram but will not produce an image.
2. A second beam forms the primary (virtual) image (first order) that is diffracted at the same angle as the incoming object beam that was used during recording.
3. A third beam forms the secondary (real) image (first order).