Session 5

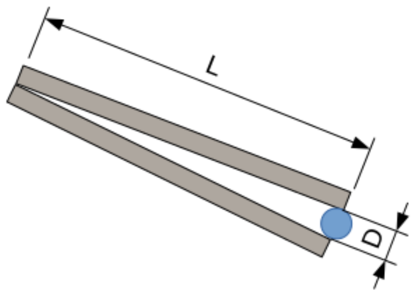
Exercise 1: Destructive interference: Anti reflection coating

A thin layer of a transparent material with a refractive index $n = 1.3$ is designed to operate as an anti-reflection coating on a material with a refractive index $n = 1.5$. Derive the thickness d of the anti-reflection layer to suppress reflections at a wavelength of 600 nm in vacuum.

Hint: Refer to the script of module 3, pages 39 to 43 and module 5, pages 5 to 29.

Exercise 2: Constructive interference: Diameter of a thin cable

The diameter of very thin cables can be measured with the support of interference patterns. The figure below shows the configuration with two tilted transparent plates of length $L = 20$ cm, where the tilt angle and thereby the distances between the two plates is defined by the cable diameter D. The configuration is illuminated with a Natrium-Lamp with $\lambda = 590$ nm and 19 stripes occur from interference. What is the core diameter D?



Hint: The 19-th stripe is not on the edge of the plate but no 20th stripe occurs. Refer to page 292 in OPTICS, E. Hecht or to the script of module 5, page 31.

Exercise 3: Resolution criteria: Imaging and resolution limit

a) How big is the distance between two objects on the moon to be resolved by the human eye? The diameter of the eyes' pupil shall be $5 mm$, the wavelength of the light 600 nm and the distance between moon and earth 380000 km.

b) How big is the distance if the objects are observed with a telescope of diameter 5 m?

Hint: Refer to the script of module 5, pages 75 to 79.

Exercise 4: Destructive interference: Maximise transmittance of a camera lens

A camera lens made of glass with $n = 1.6$ is covered by a thin layer with $n = 1.38$ to suppress reflections and maximise the transmittance at $540nm$ wavelength. Simplify the lens surface and assume a plane surface and assume the thin layer to be of constant thickness.

a) Derive the thickness of the layer d to suppress the first order diffraction maxima.

b) At what wavelength occurs the higher order destructive interference?

c) How is the reflectivity affected for $\lambda = 400\ nm$ and $\lambda = 700\ nm$?

Hint:

a) Use the formula of diffraction maxima and examine the first order destructive interference. Let $m = 0$ (first order destructive interference).

b) Derive the wavelength for destructive interference $m \geq 1$. c) Use the formula for the irradiance of interfering sources from the course material and examine for destructive interference at the given wavelengths.

Exercise 5: MATLAB exercise: Transmittance and Reflectance of a Fabry-Perot resonator

Given a layer of thickness d and refractive index n_1, surrounded by a medium with a refractive index n_0 on the incident side and n_2 on the transmitted side of the layer. A plane wave with a wavelength λ passes the layer at an angle θ, creating an infinite series of reflections. Absorption is neglected.

a) Write a function to return the incident, reflected and transmitted amplitude in a vector from an infinite series of reflections in a Fabry-Perot resonator

b) Write a function to return the Transmittance and Reflectance for the Fabry-Perot resonator. Use the results in a).

c) Plot the normalized reflected E_r/E_0 and transmitted E_t/E_0 amplitude as well as the normalized reflected I_r/I_0 and transmitted I_t/I_0 irradiance for a silicon layer of thickness 0.1λ and $\lambda = 850\ nm$ in air ($n_0 = n_2 = 1$) over a range $\theta = 0...89.99$. Perform a variation in die layer thickness of $0.1\lambda,\ 0.5\lambda,\ 1\lambda,\ 2\lambda...5\lambda$

d) Verify the conditions for an anti-reflection coating

Hints:

a) Refer to the script of module 3, pages 30 to 33 and derive the formula for the reflected amplitude from an equivalent approach.

b) Refer to the script of module 3, pages 34 and derive the Transmittance and Reflectance from an equivalent approach.

c) -

d) Refer to the script of module 3, pages 39 to 43.