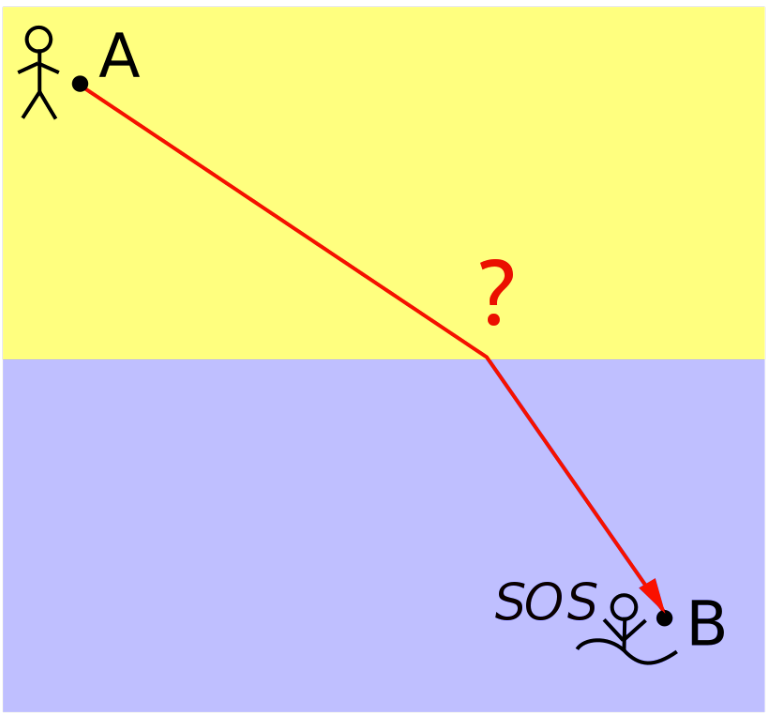
Homework – 1 ; Exercise 1

Fermat's Principle

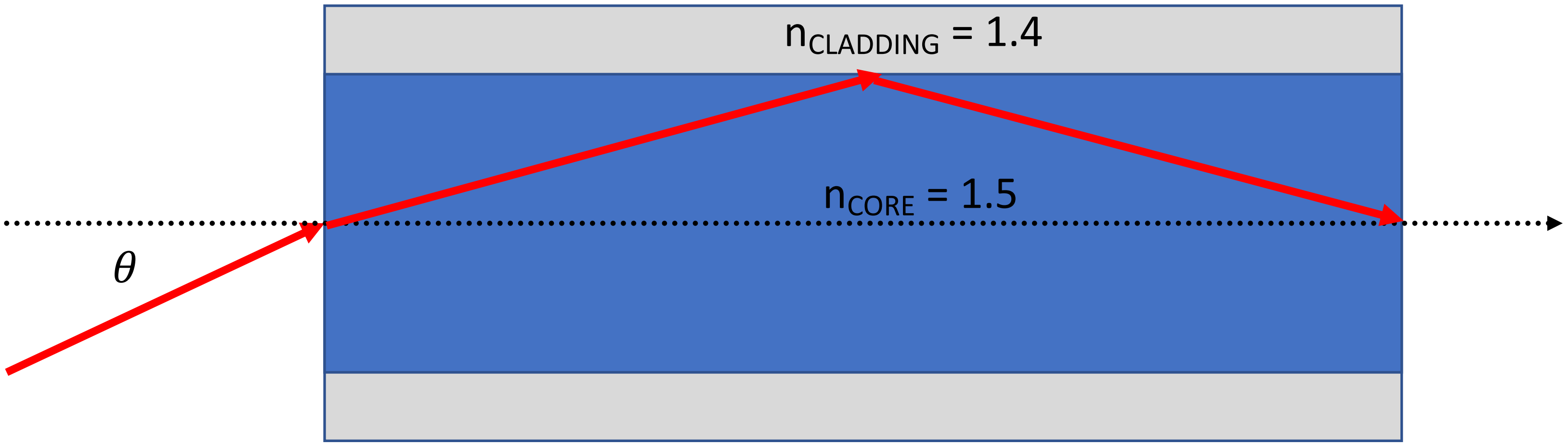


Lifeguard Alice can run at speed v_r on the beach and swim at speed v_s in the water, with $v_r > v_s$.

What is the path that minimize the time for reaching point B and save Bob from drowning?

Hint: Similarly to lecture 1, use a proper geometrical notation and apply Fermat's principle

Homework – 1 ; Exercise 2
Total internal Reflection

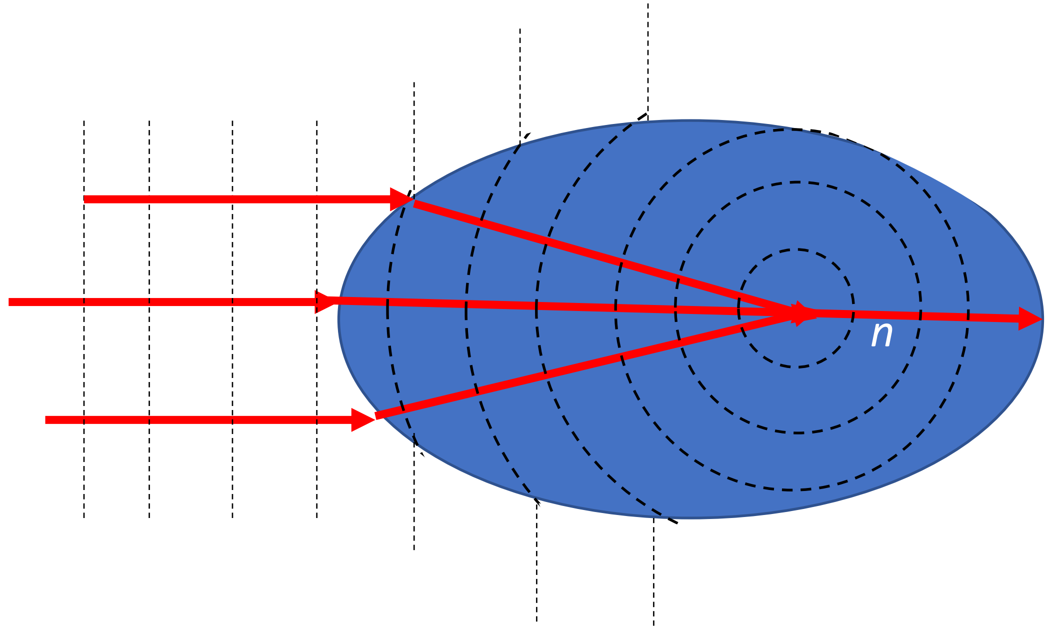


Derive the critical angle θ for which total internal reflection happens at the first interface (core-cladding).

Hint: Both Fermat's principle and Snell's law are accepted for the derivartion.

What is the numerical aperture of the fiber? Assuming a GRIN from 1.5 to 1.4 what is the trajectory of the ray in case of total internal reflection?

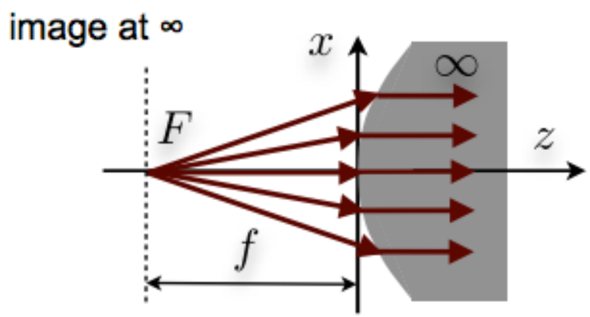
Homework – 1 ; Exercise 3
Ellipsoidal refractor



What is the dimension of the axes of an ellipsoidal refractor (*n*=1.5) which focuses a plane wave ($\lambda_1 = 1.55\mu m$) impinging on axis (rays parallel to the major axis) in its focal point *f*=25 mm? Would the same refractor perfectly focus at wavelength $\lambda_2 = 0.5\ \mu m$ considering that the refractive *n* index varies to 1.6 ? If yes why? If no, which would be the dimension of the ellipse that focus it? Would the ellipsoidal refractor be affected by any kind of aberration? Motivate your answer.

Graduate students: Additional point if you can use any ray tracing software for demonstrating the functioning of the refractor.

Homework – 1 ; Exercise 4
Hyperboloidal refractor

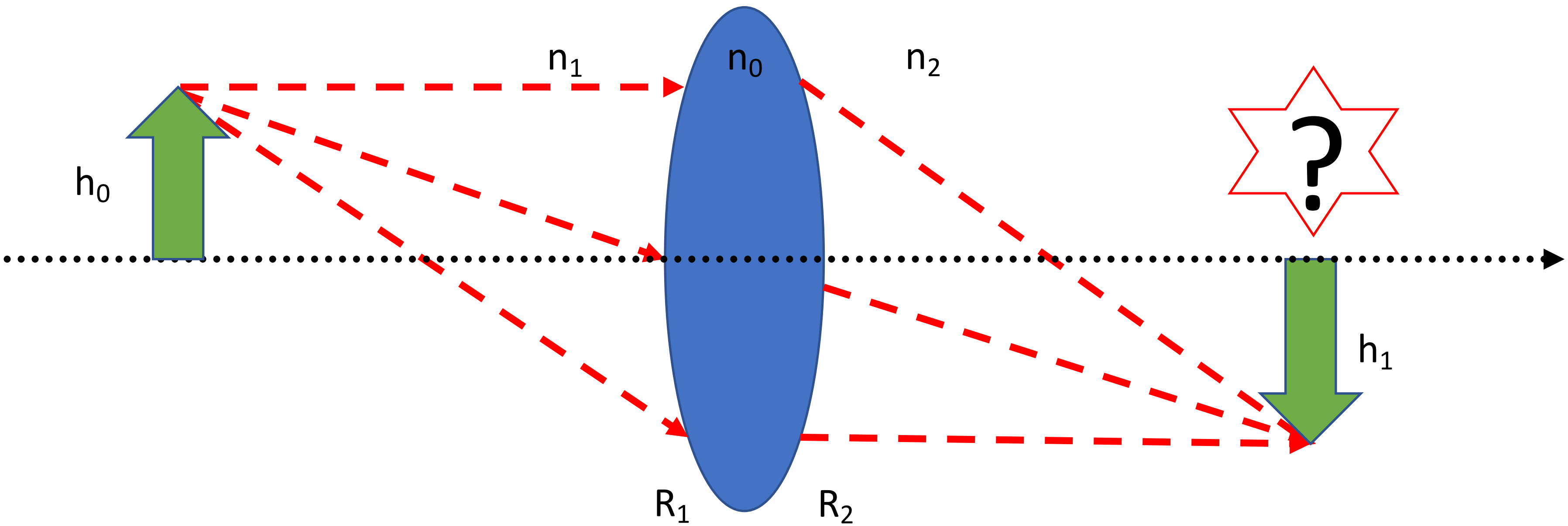


hyperboloidal refractor

$$\left(s+\frac{1}{n+1}f\right)^2-\frac{1}{n^2-1}x^2=\left(\frac{1}{n+1}f\right)^2$$

Prove that a hyperboloidal refractor is an ideal refractor that can convert a spherical wave into a planar wave, or in other words image at infinity a point object.
Hint: similarly to what was shown in slide 14 lecture 2 for a ellipsoidal refractor

Homework – 1 ; Exercise 5
Immersed lens



A lens (refractive index n_0 with a left curvature R_1 and a right curvature R_2) is immersed in two different liquids n_1 and n_2 . Under the paraxial assumption determine the focal length and power of the lens. Hint: Use ray transfer matrix.

Assuming that the lens is in air, and has a focal length of 10 mm. The object has an elevation elevation h_1 =1 is positioned at 5 mm away from the lens. What is the lateral magnification? What is the distance