Ray Optics problem n°1

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Immersion microscope objective

- ✓ *Includes: structure of a microscope objective, conjugate points for a spherical surface, perfect imaging aplnetic points, calculation of transverse magnifications*

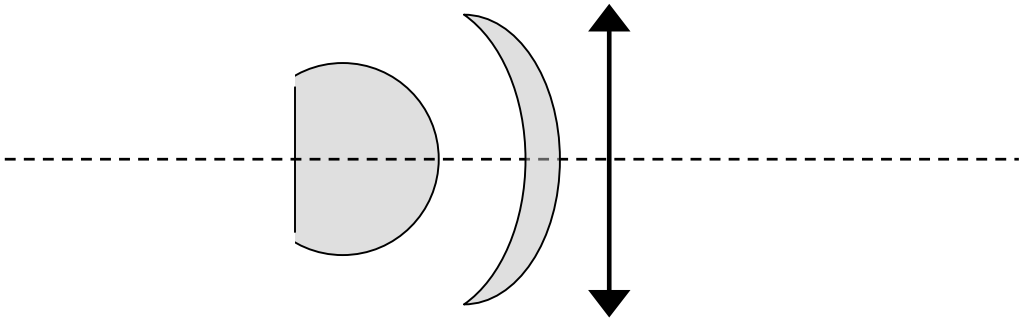
A microscope should allow observation of very small objects. This requires several criterions that will have to be taken into account in the design :

- Large numerical aperture $nsin\alpha$ (see resolution of an optical system limited by diffraction)
- Almost perfect imaging in the vicinity of the observation point

The objective that we will study consists of :

- A hyperhemispheric lens : index 1,5 - radius 3 mm - thickness 4 mm
- A converging meniscus (index 1,5) made of two surfaces: S1, radius of curvature 10 mm, and S2, radius of curvature 7,5 mm
- A converging thin lens, considered perfect, located 0,5 mm to the right of the last surface

The observed object, located on the optical axis of the objective, is immersed in a liquid with index 1,5.



1. How does an immersion objective work (explain the role of each surface) ? Can it perform perfect imaging ?
2. What must be the distance between the object A and the hyperhemispherical lens ? Where is the intermediate image A'_{in} formed by that first lens ? Make a drawing with a scale 1:10.
3. Calculate the lateral magnification for the two conjugate points through the hyperhemispheric lens. What can be said about the image quality in the transverse plane? Is the system aplanetic for the conjugate planes that we considered ?
4. Trace the ray from A that has the largest angle with respect to the optical axis. Calculate the maximum angle between the ray emerging from the hyperhemispheric lens and the optical axis.
5. Place correctly on your drawing the converging meniscus. What is the position of the second intermediate image A''_{in} ? Is Abbe sine condition satisfied for the combination {hyperhemispheric lens + meniscus} ?
6. Calculate the transverse magnification for the two conjugate points through the meniscus and the maximum angle for the emerging rays after the meniscus.
7. The final image given by the objective is located 150mm from the thin lens. Calculate the focal length of that thin lens, then the lateral magnification of the whole objective. Calculate the maximum angle of the emerging rays.