Ray Optics problem n°2

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The ophtalmoscope

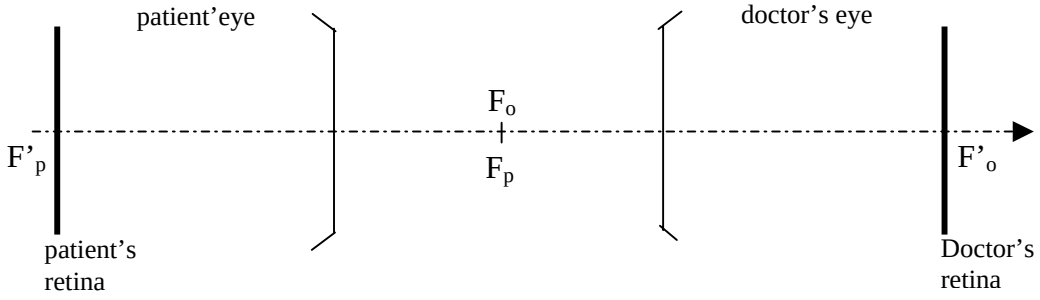
A. Simple paraxial model of the eye

We can model the eye by a single spherical surface between two media with indices n=1 (air) and n'=1.336 (aqueous humor). The distance d between the vertex of the surface and the retina is fixed for any accommodation or ametropia. It is equal to 22.3 mm.

1. Determine the radius of curvature R_1 of the surface and the power of the eye when it does not accommodate (for a normal eye). Make a drawing with a scale 2:1; position the cardinal points (vertex S, center C_1, foci F_1 and F'_1) and the plane of the retina. Construct the image of an object at infinity with angular diameter θ.
2. Same questions in the case when the eye accommodates to see an object at its near point (at 25 cm from its vertex) : you will calculate the new radius of curvature R_2 and the new power of the eye. Make a new drawing to scale showing the new cardinal points S, C_2, F_2, F'_2 and the plane of the retina.
3. Show that, for any accommodation of the eye, the size of the image on the retina depends only on the angle under which the object is seen from the vertex of the spherical surface.

B. Direct ophtalmoscopy

An ophtalmoscope is meant to observe the retina of a patient. The eye of the patient and that of the ophtalmologist are facing each other and are very close to one another. The distance between the patient's eye and the doctor's eye is such that their focal points are in the same position . The retina of the patient is lit up with an optical system not shown on the figure.



Both the patient and the doctor are emmetropic (normal eyes) and do not accommodate.

1. Explain why we can say that the doctor uses the eye of the patient as a magnifying glass. What is the power of that glass ? The doctor sees a circular burnt spot due to a laser impact with a diameter of *0.1 mm* on the patient's retina. What is the angular size of this spot as seen by the doctor ?
2. Consider now the optical system consisting of the surface of the eye of the patient and that of the doctor. Show that this optical system is afocal and calculate its transverse magnification.

The patient is very myopic. Its eye power is too large by +10 dioptries (power of 70 dioptries).

3. What is the distance between F'_p and the patient's retina in this case ?
4. Explain why it is necessary to add a lens between the patient's eye and the doctor's eye. Specify the type of lens required. Assuming the lens is placed in F_p, determine its focal length so that the doctor does not have to accommodate.