MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mechanical Engineering

2.71/2.710 Optics
Spring 2012

Quiz 1

Monday, March 12, 2012

PLEASE DO NOT TURN OVER UNTIL EXAM STARTS

DURATION: 60min (9:35–10:35)

TOTAL PAGES: 3

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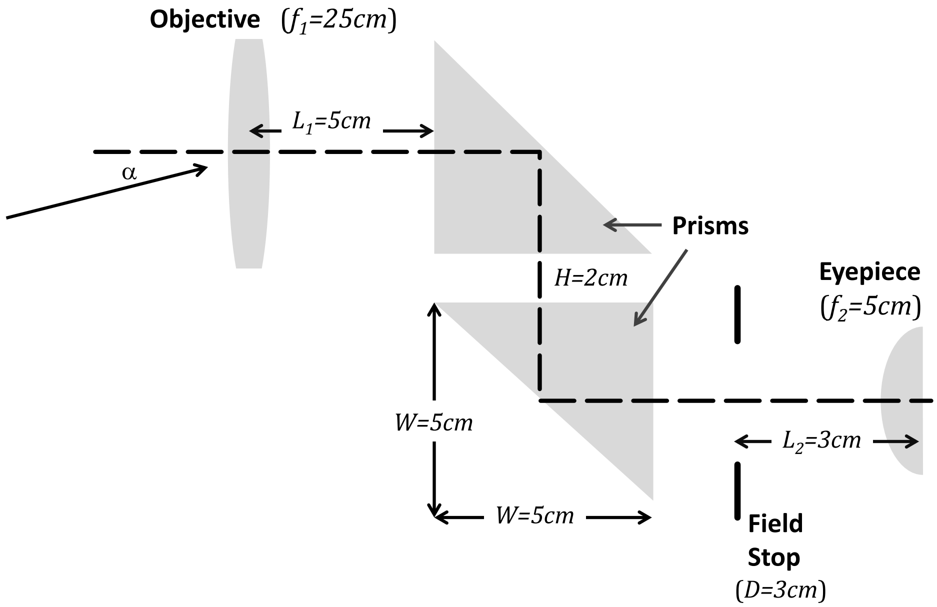
1. **A Binocular.** The simplified optical diagram of an arm of a binocular can be considered as a telescope, which consists of two lenses of focal lengths f_1 = 25cm (objective) and f_2 = 5cm (eyepiece). The normal observer's eye is intended to be relaxed and the nominal focal length of the eye lens is taken to be f_{EL} = 40mm. **The first prism is placed 5cm away from the objective and the two prisms are separated by 2cm.**



a) (10%) In order to make the binocular compact, a pair of 45° prisms (5cm wide) are used, each of them is designed for total internal reflection of incoming rays. Estimate the index of refraction needed to meet such a requirement under paraxial beam approximation.

b-e) Assume the index of refraction of both prisms is 1.5.

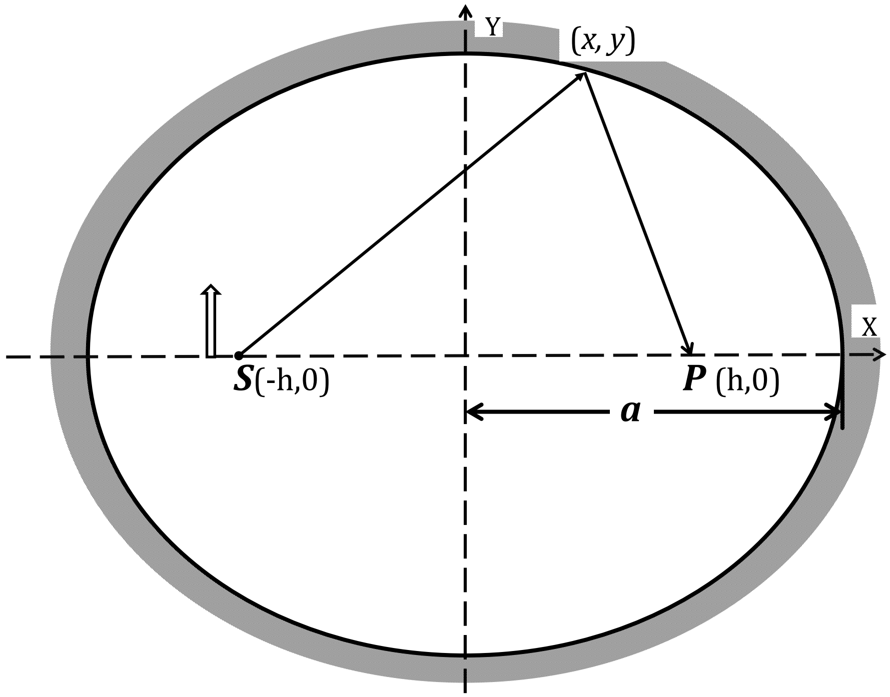
b) (15%) Please estimate the distance from the eyepiece to the back side of the second prism.

c) (20%) If two distant objects are separated by 10^{-3}rad to an observer with naked eye, how far apart (in units of length) will the images form on the observer's retina when the observer is using the binocular?

d) (15%) An aperture (D=3cm) is placed inside the binocular, at a distance of 3**cm** to the left of the eyepiece. Please locate the Entrance Window and Exit Window, and calculate the Field of View.

e)(extra credit **10%)** Where is the optimum location of the observer's eye pupil in the configuration described by **d)**?

2. **Reflection from a concave cavity.** Figure 2 shows a reflective cavity made of concave mirrors, with light source ***s***. The cavity is designed to reflect all rays leaving the source **s** to a point ***p*** *along* the long axis of the cavity.



a) **(10%)** Following Fermat's principles, the optical path length from ***s*** to ***p*** on any point (x, y) on the reflective cavity should be a constant. Please show such a constant is $\mathbf{2a}$**,** the length of the long axis of the cavity.

b) **(15%)** Using Cartesian coordinates, please prove that any point (x, y) on the reflective cavity must satisfy the following relationship:

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Where $2h = |SP|$ is the distance from **s** to **p**, and $b = \sqrt{a^2 - h^2}$ is the length of the short axis of the cavity. Therefore, the cavity is an *ellipse*.

c) **(15%)** Assume the cavity is large enough so you can go in, and a small object is placed on the left side of the source ***s,*** *as* shown by the arrow in Figure 1. Use ray tracing, please locate the first reflected image of the object. Is it real or virtual?

GOOD LUCK!

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Spring 2014