Micro-optics

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Exercise 7

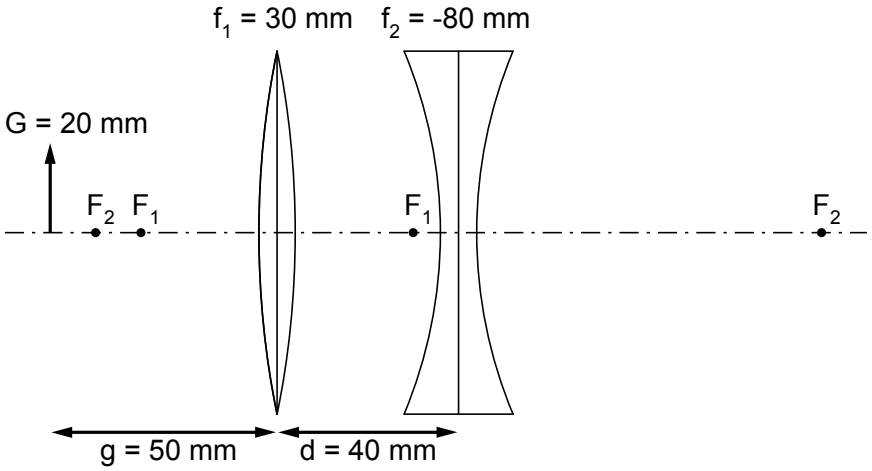
Prof. Hans Zappe

Tutors: Dr. W. Mönch, Dr. A. Seifert

Discussion sections: Dec 19 & 20, 2007

1 Two-Lens System (40)

Consider the two-lens system shown in the figure. It consists of two thin lenses: one is bi-convex ($f_1 = 30$mm) and the other bi-concave ($f_2 = -80$mm).



- Construct the image of the object G (height $G = 20$mm, distance from the mid-point of the first lens $g = 50$mm) as generated by transmission through both lenses. Provide a big, clear, precise, and to-scale drawing on a separate A4 sheet; a sloppy drawing will result in a significant deduction of points!!
- Is it possible to obtain the same imaging effect by a single lens only? If so, indicate the position on the optical axis and the focal length of that lens.

2 Biconvex lens (40)

2.1 Focal length (10)

Describe and sketch an experiment with a suitable test sequence for the determination of the focal lens of a thin biconvex lens.

2.2 Bessel method (10)

An accurate method for determining focal length was proposed by F.W. Bessel. For a sufficiently large distance between object and image (screen), two lens positions can be found which generate a real image.

- Do these images have $M > 1$ or $M < 1$?
- How are these two lens positions correlated?
- What is the minimum distance between object and image?

2.3 Derivation of Bessel's formula (20)

If s denotes the distance between object and image and e is the distance between the two lens positions for real and focused images, derive the following relation:

$$f = \frac{s^2 - e^2}{4s}$$

3 Focal lens and radius of curvature (20)

The radius of curvature of a mirror is related to its focal length by $R = 2f$. The radius of curvature can either be determined by a measurement of the focal length or directly by e.g. a surface scanning coordinate measuring device (CMD). Let us now compare these approaches for a lens.

- Give an expression for the radius of curvature of a symmetric lens.
- Which problems might occur? Why can the results from the focal length measurement and from the CMD differ?
- Which physical effect is responsible for possibly wrong radii of curvature?
- Why does the thin lens formula not depend on refractive index?