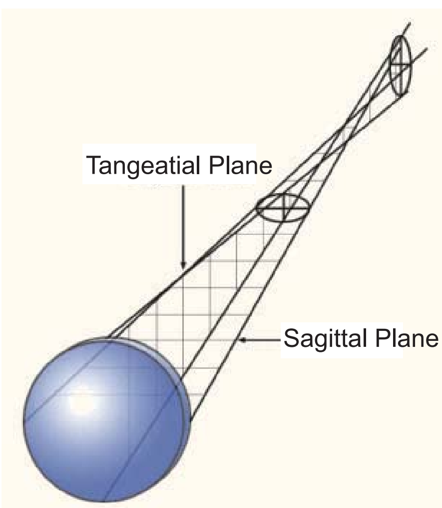
GCL-11 Cylindrical Lenses

CYLINDRICAL LENSES

Cylindrical Lenses

Cylindrical lenses focus or expand light in one axis only. They can be used to focus light into a thin line in optical metrology, laser scanning, spectroscopy, laser diode, acousto-optic, and optical processor applications. They can also be used to expand the output of a laser diode into a symmetrical beam.

Astigmatism



An optical system with astigmatism is one where rays that propagate in two perpendicular planes have different foci. If an optical system with astigmatism is used to form an image of a cross, the vertical and horizontal lines will be in sharp focus at two different distances.

There are two distinct forms of astigmatism. The first is a third-order aberration, which occurs for objects (or parts of objects) away from the optical axis. This form of aberration occurs even when the optical system is perfectly symmetrical. This is often referred to as a "monochromatic aberration", because it occurs even for light of a single wavelength. This terminology may be misleading, however, as the amount of aberration can vary strongly with wavelength in an optical system.

The second form of astigmatism occurs when the optical system is not symmetric about the optical axis. This may be by design (as in the case of a cylindrical lens), or due to manufacturing error in the surfaces of the components or misalignment of the components. In this case, astigmatism is observed even for rays from on-axis object points. This form of astigmatism is extremely important in vision science and eye care, since the human eye often exhibits this aberration due to imperfections in the shape of the cornea or the lens.

Applications

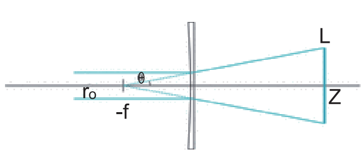


Figure A

A. Generating a Line of Light from a Collimated Laser

A common application of cylindrical lenses is shown in Figure A. A collimated laser beam of radius r_o is incident upon a cylindrical plano-concave lens of focal length, f. In this figure, the radius of the laser beam is exaggerated for clarity. The laser beam will expand with a half-angle θ of r_o/f. The laser beam will appear to be expanding from a virtual source placed a distance f behind the lens. At a distance z after the lens, there will be a line with thickness $2r_o$ (ignoring expansion of the Gaussian beam) and length

$L = 2 (r_o/f)(z+f)$

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If z is large compared to f, then we have an expansion ratio that is very close to z/f. This is not an imaging problem; we are projecting the laser beam into a line at a particular distance. The length of the line is simply proportional to z.

If the thinnest possible line is required, a second lens, this one a cylindrical plano-convex lens of focal length ~ z, can be inserted into the system just before or after the plano-concave lens. When oriented on the orthogonal axis, it will focus the laser at the screen onto which the line is projected.

Circularizing the Beam from a Laser Diode

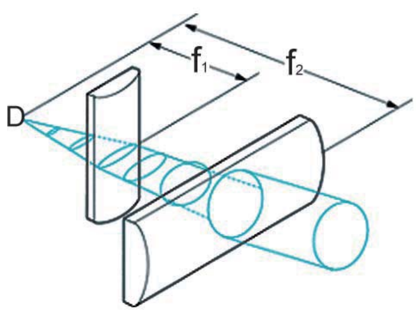

Figure B

The output of a laser diode diverges in an asymmetrical pattern, making collimating the beam a challenge. Cylindrical lenses can be used to circularize the beam. Consider a laser diode with beam divergence of θ1 & θ2 = 10° & 40°. Any attempt to collimate this beam with spherical optics would result in collimation in one direction only, with a diverging or converging beam in the other direction. With cylindrical optics the problem can be approached as two one-dimensional problems. The simplest solution would be to collimate the beam in one dimension with a single cylindrical lens, then collimate the orthogonal dimension with a second cylindrical lens (see Figure B).

A few observations will guide the selection and placement of the lenses:1) To achieve a symmetrical beam shape, the ratio of the focal length of the two lenses should be approximately equivalent to the ratio of the beam divergences: $\theta_1/\theta_2 = 10°/40° = f_1/f_2$.

2) First, to order, the laser diode is approximated by a point source, so the lenses should be placed at a distance equal to their respective focal lengths from the source to create a collimated output.

3) The principal planes of the two lenses should be spaced at a distance apart equal to the difference of their focal lengths $f_2 - f_1$. The actual spacing between plano surfaces of the lenses is $BFL_2 - BFL_1$. As with spherical lenses the convex surfaces should face the collimated rays to minimize aberrations.

4) Because of the rapid divergence of the laser diode beam, care must be taken to make sure the beam width at each lens does not exceed the lens clear aperture. Since each lens is placed one focal distance from the laser diode, the maximum beam width at each lens (d_1 and d_2) can be determined from the following equations: $d_1 = 2f_1(\tan(\theta_2/2))$, and $d_2 = 2f_2(\tan(\theta_1/2))$

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Accessories

GCM-04 Self-Centering Lens Holders
GCM-05 Adjustable Self-Centering Lens Holders
GCM-0801 Lens/Mirror Mounts
GCM-0802 Small Lens/Mirror Holders
GCM-0803 Standard Lens/Mirror Holders
GCM-0805 Medium Lens/Mirror Holders
GCM-0814 Lens/Mirror Holder with Base
GCM-0823 Kinematic Corner Lens/Mirror Holders
GCM-0831M Kinematic Off-center Lens/Mirror Holders
GCM-0808 Kinematic Lens/Mirror Lockable Holders
GCM-0818 Kinematic Corner Lens/Mirror Lockable Holders
GCM-0828 3D Kinematic Lens/Mirror Lockable Holders
GCM-0838 3D Kinematic Corner Lens/Mirror Lockable Holders
GCM-0809 Vertical Drive Kinematic Lens/Mirror Holders
GCM-0819 Gimbal Lens/Mirror Holders
GCM-0829 Compact Gimbal Lens/Mirror Holders
GCM-2501 4D Lens/Mirror Holders with Pedestal
GCM-2511 4D Lens/Mirror Holders
GCM-10 Kinematic Cylindrical Lens Holders