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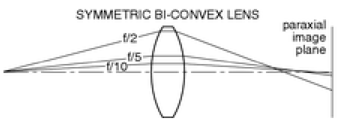
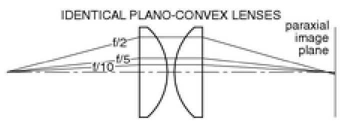
Lens Selection Guide

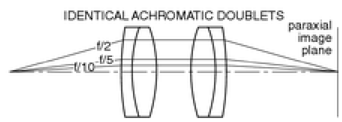
Selecting the proper lens for your application requires making a number of choices. A few of the many considerations include: lens shape, conjugate ratio, f/number, transmission, wavefront distortion, scattered light, anti-reflection coating, and cost. The information in this section will help you compare the available choices from Newport.

Lens Shape

Choosing the right lens type is important in minimizing optical aberrations. Generally, when working at or near infinite conjugate (collimated light on one side of the lens) a plano-convex/concave lens or achromatic doublet lens is best. When working at finite conjugates close to 1:1, a bi-convex/concave lens is more ideal. Sometimes using two lenses at infinite conjugate back-to-back provides even better performance at conjugates near 1:1.







Positive Lenses

Conjugate Ratio (object/image)	Plano-Convex	Bi-Convex	Achromatic Doublet	Cylindrical Plano-Convex
Infinite	Ø	D	◊	Ø
10:1	Ø	D	◊	Ø
5:1	Ø pair	Ø	◊ pair	D
1:1	Ø pair	Ø	◊ pair	D

D–Good

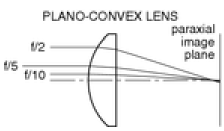
Ø–Better

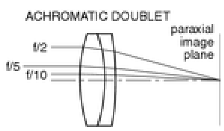
◊–Best

Negative Lenses

Conjugate Ratio (object/image)	Plano-Concave	Bi-Concave	Cylindrical Plano-Concave
Infinite	◊	D	◊
10:1	◊	D	◊
5:1	D	◊	D
1:1	D	◊	D

When using a positive lens to focus a collimated beam, the f/number the lens is operating at becomes important. At f/10 or greater, the lens shape is not that critical to spot size. At f/2, an achromatic doublet provides the smallest focused spot while the other lens shapes will not be diffraction limited.





Positive Lenses

f/#	Plano-Convex	Bi-Convex	Achromatic Doublet	Cylindrical Plano-Convex
f/10	◊	◊	◊	◊
f/5	Ø	D	◊	Ø
f/2	D	D	◊	D

Plano-convex lenses are most useful for focusing parallel rays of light to a point, or line in the case of a cylindrical lens. The asymmetry of these lenses minimizes spherical aberration in situations where the object and image are at unequal distances from the lens. The optimum case is where the object is placed at infinity (parallel rays entering lens) and the image is the final focused point. Although infinite conjugate ratio (object distance/image distance) is optimum, plano-convex lenses will still minimize spherical aberrations up to approximately 5:1 conjugate ratio. For optimum performance, the curved surface should face the largest object distance or the infinite conjugate.

Bi-convex lenses are functionally similar to plano-convex lenses in that they have a positive focal length and focus parallel rays of light to a point. Both surfaces are spherical and have the same radius of curvature, thereby minimizing spherical aberration in situations where the object and image are at equal or near equal distances from the lens. When the object and image distance are equal (1:1 magnification), not only is spherical aberration minimized, but also coma and distortion are identically canceled. As a guideline, bi-convex lenses perform with minimum aberration at conjugate ratios between 5:1 and 1:5. Outside this magnification range, plano-convex lenses are usually more suitable.

Plano-concave and bi-concave lenses bend parallel input rays so they diverge from one another on the

output side of the lens and hence have a negative focal length. While the output rays do not actually cross to form a point, they do appear to be diverging from a virtual image located on the object side of the lens. At absolute conjugate ratios greater than 5:1 and less than 1:5, plano-concave lenses are very near the best form lens to reduce spherical aberration, coma, and distortion. As with plano-convex lenses, the curved surface should face the largest object distance or the infinite conjugate (except when used with high-energy lasers where this should be reversed to eliminate the possibility of a virtual focus). At absolute conjugate ratios closer to 1:1, bi-concave lenses are usually more suitable.

Lens Materials

For applications in the visible and infrared up to about 2.1 mm, BK 7 offers excellent performance at a good value. In the ultraviolet down to 195 nm, UV fused silica is a good choice. UV fused silica also has excellent transmission in the visible and infrared up to about 2.1 mm, better homogeneity, and a lower coefficient of thermal expansion than BK 7. CaF_2 and MgF_2 are excellent choices for deep UV or infrared applications—for custom applications, Newport can provide quotes on a build-to-print basis.

Material	Transmission Range	Cost	Features
BK 7	380–2100 nm	Low	High transmission for visible to near infrared applications, the most common optical glass
UV Fused Silica	195–2100 nm	Moderate	Excellent homogeneity and low thermal expansion, high laser damage resistance
CaF_2	170–8000 nm	High	High transmission for deep UV to infrared applications
MgF_2	150–6500 nm	High	Birefringent material, excellent for use in the deep UV to infrared

Note: Newport can provide CaF_2 or MgF_2 for custom applications only.

Optical Surfaces

The lens application drives the requirements for surface irregularity and surface quality. When preservation of wavefront is critical, l/4 to l/8 irregularity should be selected; when wavefront is not as important as cost, l/2 irregularity can be used. For surface quality, the tighter the scratch-dig specification the lower the scatter. For demanding laser and imaging systems 20-10 to 40-20, scratch-dig is best. For applications where low scatter is not as critical as cost, 60-40 scratch-dig can be used.

Surface Irregularity

Figure	Cost	Applications
l/2	Low	Used where wavefront distortion is not as important as cost
l/4	Moderate	Excellent for most general laser and imaging applications where low wavefront performance must be balanced with cost
l/8	High	For laser and imaging applications requiring low wavefront distortion, especially in systems with multiple elements

*** Unless otherwise stated, surface irregularity for Newport lenses is peak-to-valley, per surface.**

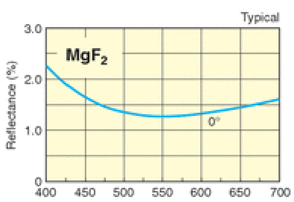
Surface Quality

Scratch-Dig	Cost	Applications
60-40	Low	Used for low power laser and imaging applications where scattered light is not as critical as cost
40-20	Moderate	Excellent for laser and imaging systems with focused beams that can tolerate little scattered light
20-10	High	For demanding laser and imaging systems where minimizing scattered light is critical

Antireflection Coatings

We offer an extensive range of antireflection coatings covering the ultraviolet, visible, near infrared, and infrared regions. Broadband multilayer coatings provide excellent performance over a broad wavelength range.

Broadband single-layer MgF_2, standard on achromats and optional on our BK 7 plano-convex spherical lenses and VALUMAX® cylindrical lenses, has very good performance over an extremely broad wavelength range at a reasonable price. Laser line multilayer V-coatings offer the lowest reflectance for maximum transmission.



Coating	Wavelength Range (nm)	Reflectance	Cost	Features
Broadband				
UV Multilayer, AR.10	245–440	R_{avg} <0.5%	Moderate	Only available on UV fused silica lenses
Visible Single-Layer MgF_2	400–700	R_{avg} <1.5%	Low	Available on achromats, KPX series, and VALUMAX® lenses
Visible Multilayer, AR.14	430–700	R_{avg} <0.5%	Moderate	Best choice for broadband visible applications
Near-IR Multilayer, AR.16	650–1000	R_{avg} <0.5%	Moderate	Excellent for NIR laser diode applications
IR Multilayer, AR.18	1000–1550	R_{avg} <0.5%	Moderate	Ideal for telecom laser diode applications
Laser Line				
V-Coat Multilayer, AR.25	488–514.5	R_{max} <0.25%	High	Highest transmission at a single wavelength
V-Coat Multilayer, AR.27	532	R_{max} <0.25%	High	Highest transmission at a single wavelength
V-Coat Multilayer, AR.28	632.8	R_{max} <0.25%	High	Highest transmission at a single wavelength
V-Coat Multilayer, AR.29	694	R_{max} <0.25%	High	Highest transmission at a single wavelength
V-Coat Multilayer, AR.33	1064	R_{max} <0.25%	Moderate	Highest transmission at a single wavelength

