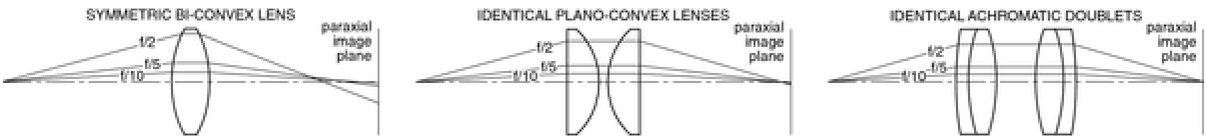
Spherical & Aspherical Lens Selection Guide

Given the available variety of choices, specifying and selecting the proper lens for any given application can be a challenging task. There are a few features to take into consideration when choosing your lenses, including conjugate ratio, lens shape, f/number, lens material, transmission, wavefront distortion, scattered light, types of coating, and cost. This guide will help you compare the available options Newport has to offer.

Lens Shape

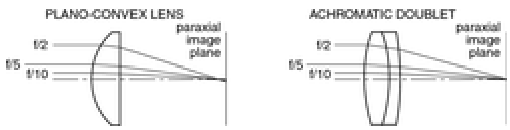
Choosing the right lens shape is critical in order to minimize the optical aberrations. Multiple lenses can be used where one singlet can cancel the aberration caused by another. Generally, when working at or near infinite conjugate (collimated light on one end of the lens), a plano-convex/concave lens or achromatic doublet lens will work best. When working at finite conjugates close to 1:1 ratio, a bi-convex/concave lens would be 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	Δ	◇	Ø
10:1	Ø	Δ	◇	Ø
5:1	Ø pair	Ø	◇ pair	Δ
1:1	Ø pair	Ø	◇ pair	Δ

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.



f/#	Plano-Convex	Bi-Convex	Achromatic Doublet	Cylindrical Plano-Convex
f/10	◇	◇	◇	◇
f/5	Ø	Δ	◇	Ø
f/2	Δ	Δ	◇	Δ

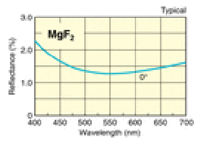
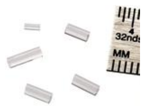
Negative Lenses

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

Selecting a Spherical or Aspherical Lens

Click **Spherical & Aspherical Lenses** to shop or browse all of our standard models, or select a product family below for more information. We also offer a wide variety of **Lens Mounts**.

BK 7 Lens Families		Coating Types	Diameters	Lens Shape	Clear Aperture
	BK 7 Precision Plano-Convex Lenses	MgF_2 (400-700 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.25 to 3.0 in.	Plano-Convex	≥central 90% of diameter
	BK 7 Precision Plano-Concave Lenses	AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.5 to 2.0 in.	Plano-Concave	≥central 90% of diameter
	BK 7 Precision Bi-Convex Lenses	AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.25 to 2.0 in.	Bi-Convex	≥central 90% of diameter
	BK 7 Precision Bi-Concave Lenses	AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.25 to 2.0 in.	Bi-Concave	≥central 90% of diameter
UV Fused Silica Lens Families		Coating Types	Diameters	Lens Shape	Clear Aperture
	UV Fused Silica Precision Plano-Convex Lenses	AR.10 (245-440 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.25 to 2.0 in.	Plano-Convex	≥central 90% of diameter
	UV Fused Silica Precision Plano-Concave Lenses	AR.10 (245-440 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.25 to 2.0 in.	Plano-Concave	≥central 90% of diameter
	UV Fused Silica Precision Bi-Convex Lenses	AR.10 (245-440 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.5 to 2.0 in.	Bi-Convex	≥central 90% of diameter
	UV Fused Silica Precision Bi-Concave Lenses	AR.10 (245-440 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm) AR.33 (1064 nm)	0.25 to 2.0 in.	Bi-Concave	≥central 90% of diameter
	Meniscus Lenses	AR.11 (266 nm) AR.13 (355 nm) AR.27 (532 nm) AR.33 (1064 nm)	2.0 in.	Meniscus	≥central 90% of diameter

Aspheric Lens Families		Coating Types	Diameters	Lens Shape	Clear Aperture
	Aspheric Condenser Lenses		Various	Aspheric	≥central 80% of diameter
	Molded Glass Aspheric Lenses	A (400-600 nm) B (600-1050 nm)	Various	Aspheric	Various
	Precision Aspheric Lenses	AR.10 (245-440 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm)	15 to 50 mm	Aspheric	≥central 90% of diameter
	Compact Aspheric Lenses	A (375-650 nm) B (625-1050 nm) C (1000-1600 nm)	Various	Aspheric	Various
Micro Lens Families		Coating Types	Diameters	Lens Shape	Clear Aperture
	Spherical Ball Micro Lenses	Uncoated	1 ,2 ,3 and 4 mm	Spherical Ball	
	Gradient Index Micro Lenses	630 nm 830 nm 1300 nm 1560 nm	1.0, 1.8 and 2.0 mm	Plano-Plano Plano-Convex Plano-Angled	≥central 90% of diameter
	Microlens Arrays	Uncoated	10 x 10 mm Square	Plano-Convex Array	
Specialty Lenses and Lens Set Families		Coating Types	Diameters	Lens Shape	Clear Aperture
	Infrared Lenses	Uncoated	0.5, 1.0, and 2.0 in.	Plano-Convex Aspheric	Various
	Broadband Corrected Triplet Lenses	Λ/4 MgF_2 @ 600 nm	30 mm Housing	Triplet	22.5 mm
	Precision Singlet Lens Sets	AR.10 (245-440 nm) AR.14 (430-700 nm) AR.16 (650-1000 nm) AR.18 (1000-1550 nm)	1.0 and 2.0 in.	Various	Various

An array of shapes and sizes are offered for most substrates, and it is important to choose the right lens type in order to minimize optical aberrations. Lenses are offered in one of the following configurations:

Plano-Convex Lenses are the best choice for focusing parallel rays of light to a single point, or a single line in the case of cylindrical lenses. This lens can be used to focus, collect and collimate light. It is the most economical choice for demanding applications. The asymmetry of these lenses minimizes spherical aberration in situations where the object and image are located at unequal distance from the lens. The optimum case is where the object is placed at infinity (parallel rays entering lens) and the final image is a focused point. Although infinite conjugate ratio (object distance/image distance) is optimum, plano-convex lenses will still minimize spherical aberration up to approximately 5:1 conjugate ratio. For the best performance, the curved surface should face the largest object distance or the infinite conjugate to reduce spherical aberration.

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

Plano-Concave Lenses are the best choice where object and image are at absolute conjugate ratios greater than 5:1 and less than 1:5 to reduce spherical aberration, coma, and distortion. Plano-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. The spherical aberration of the Plano-Concave lenses is negative and can be used to balance aberrations created by other lenses. Similar to the Plano-Convex lenses, the curvature 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) to minimize spherical aberration.

Bi-Concave Lenses are the best choice where object and image are at absolute conjugate ratios closer to 1:1 with converging input beam. The output rays appear to be diverging from a virtual image located on the object side of the lens; the distance from this virtual point to the lens is known as the focal length. Similar to the Plano-Concave lenses, the Bi-concave lenses have negative focal lengths, thereby causing collimated incident light to diverge. Bi-Concave lenses have equal radius of curvature on both side of the lens. They are generally used to expand light or increase focal length in existing systems, such as beam expanders and projection systems.

Positive Meniscus Lenses are designed to minimize spherical aberration and are generally used in small f/number applications (f/number less than 2.5). The Positive Meniscus Lenses have a larger radius of curvature on the convex side, and a smaller radius of curvature on the concave side. They are thicker at the center compared to the edges. Positive meniscus can maintain the same angular resolution of the optical system while decreasing the focal length of the other lens, resulting a tighter focal spot size. A positive meniscus lens can be used to shorten the focal length and increase the numerical aperture of an optical system when paired with another lens. For the best performance, the curved surface should face the largest object distance or the infinite conjugate to reduce spherical aberration.

Negative Meniscus Lenses are designed to be an alternative option to other negative lenses. Without causing additional spherical aberration, negative meniscus can increase the divergence of the beam, making it a good choice for beam expanding application. The Negative Meniscus lenses can be used to increase the focal length of another lens while maintaining the same angular resolution of the optical system. The Negative Meniscus lenses have a small radius of curvature on the convex side and a larger radius of curvature on the concave side. They are thinner at the center compared to the edges.

Achromats (Achromatic Doublets) consist of a positive low-index crown glass lens (low dispersion, high abbe number) element cemented to a negative high- index flint glass lens (high dispersion, low abbe number) element. The elements are chosen to cancel chromatic aberrations at two well separated wavelengths; usually in the blue and the red region of the spectrum. Achromats are used to bring two wavelengths into focus in the same image plane, thus focal length shifts are virtually eliminated across the visible wavelengths. All of our achromats are available with a single layer MgF_2 broadband or a multi-layer antireflection coating (AR.14, AR.16) for superior transmission efficiency in the broadband visible and near infrared range. These lenses are computer designed to effectively minimize spherical aberration and coma when operating at an infinite conjugate ratio. Unlike the singlet lenses, this results in a constant focal length independent of aperture and far better off-axis performance. Freedom from spherical aberration and coma means that the achromats are superior to the singlet lenses for monochromatic applications at any visible wavelength.

Available Optical Material For Different Lens Type

Lens Type	BK 7	UV Fused Silica	CaF_2	MgF_2	ZnSe	Crown/Flint
Spherical Lenses						
Plano-Convex	•	•	•	•		
Bi-Convex	•	•				
Plano-Concave	•	•				
Bi-Concave	•	•				
Achromatic Doublet					•	•
Cylindrical Lenses						
Plano-Convex	•	•				
Plano-Concave	•	•				
Aspherical Lenses						
Plano-Convex			•		•	

Coatings

Optical coatings are generally applied as a combination of thin film layers on optical components to achieve desired reflection/transmission ratio. Important factors that affect this ratio include the material property used to fabricate the optics, the wavelength of the incident light, the angle of incidence light, and the polarization dependence. Coating can also be used to enhance performance and extend the lifetime of optical components, and can be deposited in a single layer or multiple layers, depending on the application. Newport's multilayer coatings are incrediblely hard and durable, with high resistance to scratch and stains.

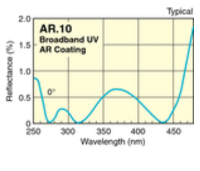
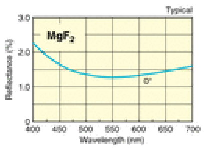
Anti-Reflection Coating (AR coating)
Newport offers an extensive range of antireflection coatings covering the ultraviolet, visible, near infrared, and infrared regions. For most uncoated optics, approximately 4% of incident light is reflected at each surface, resulting significant losses in transmitted light level. Utilizing a thin film anti-reflection coating can improve the overall transmission, as well as minimizing stray light and back reflections throughout the system. The AR coating can also prevent the corresponding losses in image contrast and lens resolution caused by reflected ghost images superimposed on the desired image.

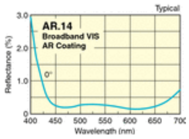
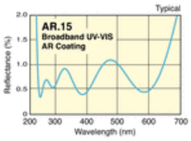
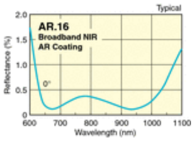
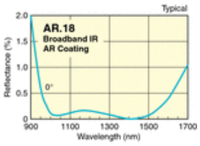
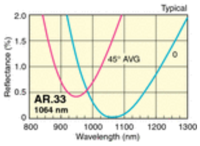
Newport offers three types of AR coating designs to choose from, the Single Layer Magnesium Fluoride AR coating, the Broadband Multilayer AR coating, and Laser Line AR V-coating. A single layer Magnesium Fluoride AR coating is the most common choice that offers extremely broad wavelength range at a reasonable price. It is standard on achromats and optional on our BK7 plano-convex spherical lenses and cylindrical lenses. Comparing to the uncoated surface, the MgF_2 provides a significant improvement by reducing the reflectance to less than 1.5%. It works extremely well over a wide range of wavelengths (400 nm to 700 nm) at angles of incidence less than 15 degrees.

Broadband Multilayer AR coating improves the transmission efficiency of any lens, prism, beam-splitter, or windows. By reducing surface reflections over a wide range of wavelengths, both transmission and contrast can be improved. Different ranges of Broadband Multilayer AR coating can be selected, offering average reflectance less than 0.5% per surface. Coatings perform efficiently for multiple wavelengths and tunable laser, thereby eliminating the need for several sets of optics.

V-coatings offer the lowest reflectance for maximum transmission. With its high durability and high damage resistance, Laser line AR V-coating can be used at almost any UV-NIR wavelength with average reflectance less than 0.25% at each surface for a single wavelength. Valuable laser energy is efficiently transmitted through complex optical systems rather than loss to surface reflection and scattering. The trade off to its superior performance is the reduction in wavelength range. AR.33 for 1064 nm is available from stock on most Newport

lenses. All other V-coating can be coated on a semi-custom basis.

Coating	Wavelength Range (nm)	Reflectance	Cost	Features
		Broadband		
	245–440	R_{avg} <0.5%	Moderate	Only available on UV fused silica lenses
	400–700	R_{avg} <1.5%	Low	Available on achromats, KPX series, and Cylindrical lenses

	430–700	R_{avg} <0.5%	Moderate	Best choice for broadband visible applications
	250–700	R_{avg} <1.5%	Moderate	Great choice for broadband UV to visible applications
	650–1000	R_{avg} <0.5%	Moderate	Excellent for NIR laser diode applications
	1000–1550	R_{avg} <0.5%	Moderate	Ideal for telecom laser diode applications
Laser Line				
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
	1064	R_{max} <0.25%	Moderate	Highest transmission at a single wavelength