Formulas & Guidelines

The information on this page is a compilation of basics intended to assist you in selecting the best optical components and systems for your specific applications.

Points of Magnification

- As numerical aperture increases, depth of field decreases and resolution increases.
- As magnification increases, field of view decreases.
- As magnification increases, more light may be needed.
- Magnification is developed in two ways – different lenses create different magnifications at the camera, or camera and monitor combinations develop magnification between themselves.

Magnification at the Camera

All cameras have a fixed sensor size. This means that no matter how large the image is at the sensor plane, the camera will only "look at" the portion of the subject equal to the sensor size. What the camera "sees" is called the field of view. The lens, or lens system, of the camera controls the magnification at the camera sensor. The lower this magnification, the larger the field of view.

Magnification at the Monitor

When the camera image is displayed on a monitor for viewing, there is further magnification. The diagonal of the camera sensor is expanded to the diagonal of the monitor. Consider this example: A 1/2" camera is being used with a 13" monitor. The 8 mm diagonal of the camera will expand to 13" (330.2 mm) for a magnification of 41.3X. In practice, the camera is actually overextended in order to overfill the monitor and prevent dark edges. There is no recognized industry standard, however, a 5-10% increase in magnification resulting in a 5-10% loss in field of view can be assumed.

Camera Format	Monitor Size (diagonal)				
	9"	12"	13"	20"	27"
1/4"	57.2X	76.2X	82.6X	127X	171.5X
1/3"	38.1X	50.7X	55.0X	84.6X	114.1Xs
1/2"	28.6X	38.1X	41.3X	63.5X	85.7X
2/3"	20.8X	27.7X	30.0X	46.2X	62.3X

Useful Formulas

Resolution in Line Pairs	Depth of Field	Conversion Factors
Millimeters: (3000 x N.A.)/mm Inches: (75,000 x N.A.)/inches	Millimeters: .0005/N.A. ^{2} Inches: .00002/N.A. ^{2}	1 Inch = 25.4 Millimeters 1 Meter = 39.37 Inches 1 Micron = 0.001 Millimeters

Definition of Terms

Depth of Field	The distance allowing acceptable image definition to be maintained without refocusing
Depth of Focus	The distance along the optical axis at which the image is in focus.
Distortion	A variation in magnification across the field of view.
Field of View	The area visible through a lens or a lens system.
Magnification	A measure of the apparent differences in size between the object and the image.
Matching Pixel Size	Matching pixel size is that which will permit the minimum feature size to overlap two pixels.
Resolution (lp/mm)	A measurement of the ability of an optical system to reproduce (transfer) various levels of detail from the object to the image, as shown by the degree of contrast (modulation) in the image.
N.A. Image (high or low mag.)	Measurement at the image point of the largest cone of light rays that are exiting the optical system.
N.A. Object (high or low mag.)	Measurement at the object point of the largest cone of light rays are entering the optical system.
Object to Image Distance (O-I)	The total distance from the object to the sensor inside the camera.
Resolution	The ability of a lens system to image closely spaced points, lines and object surfaces as separate entities.
Resolvable Features (microns)	Measurement of lens system's ability to image closely spaced points, lines and object surfaces as separate entities.
Working Distance (W.D.)	The clearance or distance between the object and the first surface of a lens system. Affects the users’ ability to image and manipulate the sample at the same time.