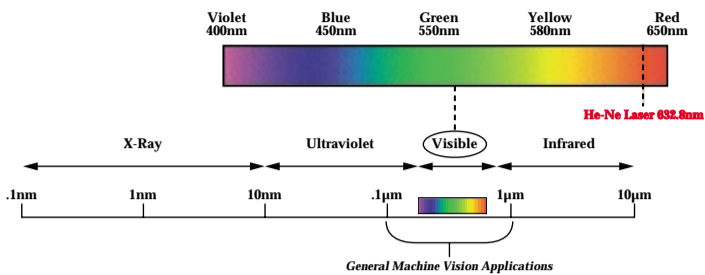


# See the Difference Membership Makes

## Lighting and Optics Reference Guide

### Electromagnetic Spectrum



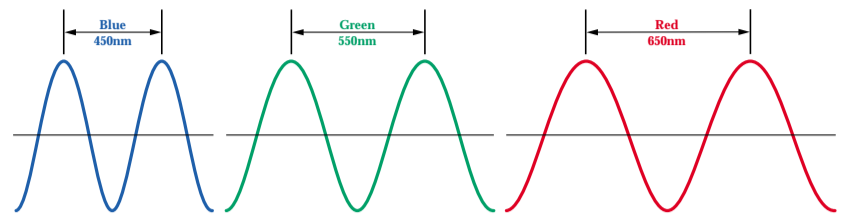
SHORTWAVE UV = 255nm  
LONGWAVE UV = 366nm

"Lighting and optics are 80% of most vision applications."

LASER = LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION

"If you can't see it in the monitor then the vision system probably can't either."

### Wavelengths of Primary Colors

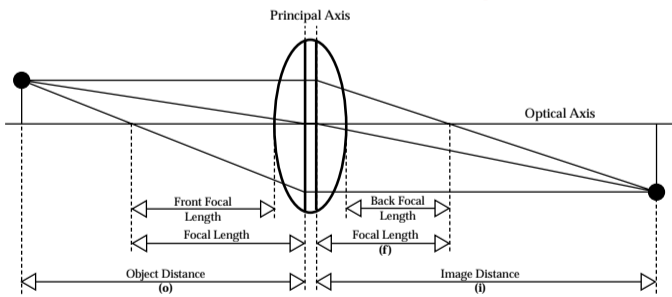


INFRARED = The part of the electromagnetic spectrum with wavelengths longer than visible red light but shorter than microwaves.

## Basic Lighting Techniques

<p><b>1) Diffuse Front Illumination:</b> Used for general top lighting.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Soft, fairly non-directional.</li> <li>Reduces glare on metallic surfaces.</li> <li>Relatively easy to implement.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Edges of parts may be fuzzy.</li> <li>Low contrast on monochlor parts.</li> </ul>	<p><b>2) Directional Front Illumination:</b> Creates shadows and will not reflect into the camera if surface is highly reflective.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Easy to implement.</li> <li>Good for casting shadows.</li> <li>Fiber optic delivery in many configurations.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>May create unwanted shadows.</li> <li>Illumination is uneven.</li> </ul>	<p><b>3) Light Tent (cloudy day):</b> Non-directional, totally diffuse top lighting that produces illumination like from a cloudy day. Good for bearings and electronic components.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Eliminates glare.</li> <li>Eliminates shadows.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Must surround workpiece.</li> <li>Can be costly.</li> <li>Size can be a problem.</li> </ul>	<p><b>4) Collimated Back Lighting:</b> Back lighting through a collimating lens so that the light rays are pseudo parallel.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Produces very sharp edges for accurate gauging.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Difficult to implement if material handling interferes.</li> <li>May be too bright for camera without neutral density filters.</li> </ul>
<p><b>5) Dark Field Illumination:</b> Incident light reflects away from the camera and illumination is created from specular reflections.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Illuminates defects.</li> <li>Provides a high contrast image in some applications.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Does not illuminate flat smooth surfaces.</li> </ul>	<p><b>6) Diffuse Backlighting:</b> Light is on the opposite side of the part as the camera and goes through a diffusing material such as lexan or opal glass.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Easy to implement.</li> <li>Creates silhouette of part.</li> <li>Very high contrast image.</li> <li>Low cost.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Edges of parts may be fuzzy.</li> <li>Difficult to implement if material handling interferes.</li> </ul>	<p><b>7) Low Angle Illumination:</b> Incident lighting almost horizontal to the surface of the part.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Shows topological defects.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Single source will produce uneven lighting across surface.</li> </ul>	<p><b>8) Polarized Front Illumination:</b> Front lighting with a polarizer on the light and a cross-polarizer on the lens.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Eliminates glare.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Reduces amount of light into the lens significantly.</li> </ul>
<p><b>9) Polarized Backlighting:</b> Polarizer and cross-polarizer are on opposite side of the part over some form of back-lighting.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Highlights certain types of features or defects in translucent materials.</li> <li>Relatively easy to implement.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Only works for birefringent features.</li> <li>Edges of parts may be fuzzy.</li> <li>Difficult to implement if material handling interferes.</li> </ul>	<p><b>10) Strobed Illumination:</b> Microsecond duration lighting used to freeze the motion of moving parts.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Crisp images with no blurring.</li> <li>Can be area, fiber optic or LED.</li> <li>Very long lifetime.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>More costly than standard sources.</li> <li>Requires accurate timing with camera.</li> <li>Must be shielded from personnel.</li> </ul>	<p><b>11) Structured Light:</b> Plane of light generated via structured white light with focusing optics, or laser line converter, used to show contour/3D information of part.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Shows 3D information.</li> <li>Produces high contrast on most parts.</li> <li>Laser frequency can be easily band pass filtered.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Lasers above 5mw pose safety issue.</li> <li>Hard to image on some metals and black rubber.</li> </ul>	<p><b>12) Coaxial Lighting:</b> Illumination is along the same path as the camera's viewing path.</p> <p><b>Advantages</b></p> <ul style="list-style-type: none"> <li>Eliminates shadows.</li> <li>Uniform illumination across FOV.</li> </ul> <p><b>Disadvantages</b></p> <ul style="list-style-type: none"> <li>Complicated to implement.</li> <li>Harsh illumination for shiny surfaces.</li> </ul>

### Parameters of a Simple Lens



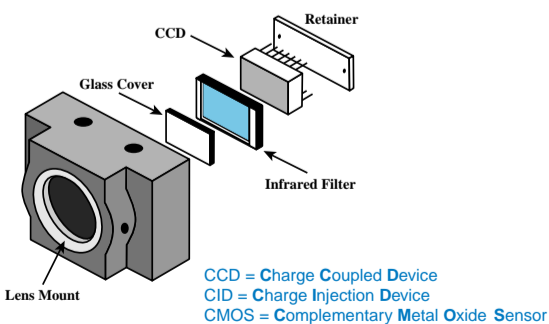
FOCAL LENGTH = Distance from focus point to principal axis.

FOV = Field Of View

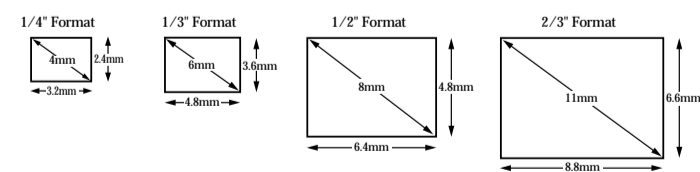
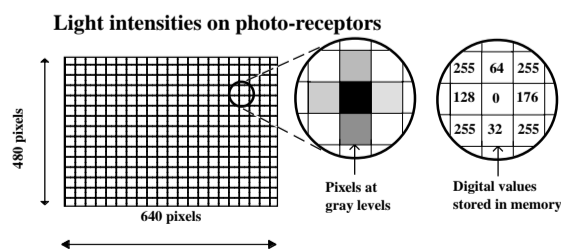
### Basic Equations of Imaging

$\frac{1}{f} = \frac{1}{i} + \frac{1}{o}$	$d.o.f. = 2 f \# c$	$f =$ Focal Length	$m =$ Lateral Magnification
$f \# = \frac{o}{a}$	$m = \frac{i}{o}$	$i =$ Image Distance	$a =$ Lens Aperture
		$o =$ Object Distance	$f \# =$ f Number
		$d.o.f. =$ Depth of Field	$c =$ Blur Circle Diameter

### Camera Construction

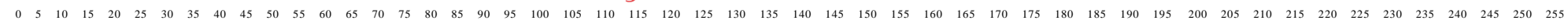


### Image Representation



PIXEL = PICTURE ELEMENT or sensor element, a single photosite.

### Gray Scale Reference Chart



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