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| **Category** | Optics |
| **Subcategory** | Geometric Optics |
| **Concept Name** | The Law of Reflection |
| **Description** | The **Law of Reflection** is where if a ray of light could be observed approaching and reflecting off a flat mirror |
| **Formula** |  |
| **Drawing/Animation** | <http://www.physicsclassroom.com/mmedia/optics/lr.cfm>: create an animation of where one ray of light reflects off a flat surface |
| **Relevant Tags** | #reflection #light #mirror #rays |

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| **Category** | Optics |
| **Subcategory** | Geometric Optics |
| **Concept Name** | The Law of Refraction (Snell’s law) |
| **Description** | **Refraction** is the bending of the path of a light wave as it passes across the boundary separating two media. |
| **Formula** | where **Θi** ("theta i") = angle of incidence  **Θr** ("theta r") = angle of refraction  **ni** = index of refraction of the incident medium  **nr** = index of refraction of the refractive medium  $n\_i\sin\theta\_i=n\_r\sin\theta\_r$ |
| **Drawing/Animation** |  |
| **Relevant Tags** | #refraction #light #rays #incidence #angle |

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| **Category** | Optics |
| **Subcategory** | Geometric Optics |
| **Concept Name** | Reflection on a spherical mirrors |
| **Description** | **Spherical mirrors** can thought of as a portion of a sphere that was sliced away then silvered on one of the sides to form a reflecting surface.  **Concave** mirrors silvered on the inside of the sphere and **convex** mirror are silvered on the outside of the sphere |
| **Formula** | Mirror equation:  do is object distance, di is image distance and f is focal length  Magnification equation:  where the image height (hi) and object height (ho)  Mirror equation:$\frac{1}{f}=\frac{1}{d\_o}+\frac{1}{d\_i}$  Magnification equation: \M=\frac{h\_i}{h\_o}=\-frac{d\_i}{d\_o} |
| **Drawing/Animation** | An animation where light is reflected off a concave and convex mirrors  Concave mirror:<http://www.physicsclassroom.com/mmedia/optics/rdcma.cfm>  Convex mirrors: <http://www.physicsclassroom.com/class/refln/Lesson-4/Ray-Diagrams-Convex-Mirrors> |
| **Relevant Tags** | #Spherical #mirrors #Convex #Concave #magnification #image |

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| **Category** | Optics |
| **Subcategory** | Geometric optics |
| **Concept Name** | Type of Lenses |
| **Description** | A **converging lens** is a lens that converges rays of light that are traveling parallel to its principal axis. They can be identified by being relatively thick across their middle and thin at their upper and lower edges.  A **diverging lens** is a lens that diverges rays of light that are travelling parallel to its principal axis. They are identified by being relatively thin across their middle and thick at their upper lower edges. |
| **Formula** | Lens equation where f=focal length, do object distance and di image distance  magnification equation  Mirror equation:$\frac{1}{f}=\frac{1}{d\_o}+\frac{1}{d\_i}$  Magnification equation: \M=\frac{h\_i}{h\_o}=\-frac{d\_i}{d\_o} |
| **Drawing/Animation** | <http://www.physicsclassroom.com/class/refrn/Lesson-5/Converging-Lenses-Ray-Diagrams> for converging lens ray diagrams  <http://www.physicsclassroom.com/class/refrn/Lesson-5/Diverging-Lenses-Ray-Diagrams> for diverging lens ray diagrams |
| **Relevant Tags** | #lens #converging #diverging #light #rays |

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| **Category** | Optics |
| **Subcategory** | Nature of Light |
| **Concept Name** |  |
| **Description** | Light behaves like waves in its propagation and in the phenomena of interference and diffraction; however, it exhibits particle-like behaviour when exchanging energy with matter as in the Compton and photoelectric effects |
| **Formula** | Photon Energy Formula: E=h/v **mathjax= \E=\frac{h}{v}**  Where   * E= Photon energy * h=6.626 x 10 -34 J⋅s the Planck Constant * v= frequency of the Photon   Relations between Wavelength, Frequency and speed  In air: C=λ\*v **mathjax= \C=\lambda\v**  In media: u=c/n. λ=c/(n\*v) **mathjax: \u=\frac{c}{n} \lambda=\frac{c}{nv}**  Where   * c=speed of light(3.0 x 10 8 m/s) * λ=wavelength * v=frequency |
| **Drawing/Animation** |  |
| **Relevant Tags** | #light #waves #diffraction #particle #wavelength #frequency |

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| **Category** | Optics |
| **Subcategory** | Optical Instrumentation |
| **Concept Name** | Stops, Pupils, and Window apertures |
| **Description** | An aperture is an opening or hole where light travels through. Apertures are used to control Image brightness and limit a Field of View. There are three general types of apertures.   * Stops * Pupils * Windows   From the general apertures, there are specific subtypes of apertures designed for different roles.  To control Image brightness, you would use Stops and Pupils. More specifically:   * Aperture stop (AS) - The real element which limits the amount of light rays passing through an optical system * Entrance Pupil (EnP) - the optical image formed by the aperture stop, as 'seen' before hitting the stop itself * Exit Pupil (ExP) - the optical image formed by the aperture stop, as 'seen' after hitting the stop.   Before we continue, we must introduce the concept of Chief Rays/Principle rays. Chief rays is a ray that start at the edge of the object, and passes through the centers of the Entrance pupil, Aperture stop, and the exit pupil.  To control Field of View, you would use Stops and windows. More specifically:   * Field stop (FS) - The real element which reduces the angular field of view formed from an optical system. * Entrance Window (EnW) - the optical image formed by the fieldstop, as 'seen' before hitting the stop itself * Exit Window (ExW) - the optical image formed by the aperture stop, as 'seen' after hitting the stop . |
| **Formula** | N/A |
| **Drawing/Animation** | Limiting brightness: |
| **Relevant Tags** | Apertures, Stops, Windows, Pupils, Chief |

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| **Category** | Optics |
| **Subcategory** | Optical Instrumentation |
| **Concept Name** | Prisms |
| **Description** | Condition of Minimum deviations: The ray for which the deviation is a minimum traverses the prism symmetrically, that is, parallel to its base |
| **Formula** | Deviation Angle  δ =θ +θ − (θ ′+θ ′) =θ +θ − A  δ =θ + sin− n − sin θ sin A− sinθ cos A – A  mathjax: \delta=\theta+\theta-\(theta'+theta')=\theta+theta-A  \delta=\theta+\sin-\n-\sin\theta\sin\A-\sin\theta\cos\A-A  Dispersion  (dn/dλ)=-(2B)/(λ^3)  \(frac{dn}{d\lambda})=-\frac{2B}{lambda^3}  Resolving Power  R=(λ /(Δλ)min)=b((dn)/(dλ))  \R=frac{lambda}{(\Delta\lambda)min)=\b(frac{dn}{\d\lambda}) |
| **Drawing/Animation** |  |
| **Relevant Tags** | #prism #minimum #deviations #ray #parallel |

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| **Category** | Optics |
| **Subcategory** | Optical Instrumentation |
| **Concept Name** | Cameras |
| **Description** | ??? |
| **Formula** | s\_1 = {:s\_0f(f+Ad):}/{:f^2+Ads\_0:}  s\_2 = {:s\_0f(f-Ad):}/{:f^2-A^2d^2s\_0^2:}  DepthOfField = {:2Ads\_0(s\_0-f)f^2:}/{:f^4-A^2d^2s\_0^2:} |
| **Drawing/Animation** |  |
| **Relevant Tags** | Camera |

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| **Category** | Optics |
| **Subcategory** | Optical Instrumentation |
| **Concept Name** | Simple Magnifiers and Eyepieces |
| **Description** | Angular magnification M: the ratio of the retinal image as seen through the instrument over the size of the retinal image as seen by the unaided eye at normal viewing distance  Eyepieces or Oculars: To reduce transverse chromatic aberration, two lense are most often used. |
| **Formula** |  |
| **Drawing/Animation** |  |
| **Relevant Tags** | #image #magnification #eyepieces #lenses |

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| **Category** | Optics |
| **Subcategory** | Optical Instrumentation |
| **Concept Name** | Microscopes |
| **Description** | Compound microscope: Objective + Eyepiece  Objective: form a real, inverted, magnified image-> Lateral magnification - Mo  Eyepiece: Further magnify the intermediate image-> Angular magnification - Me  The intermediate image is at or just inside of the 1st focal point fe of the eyepiece |
| **Formula** | The separation of the two lens  d=fo + L + fe  \d=\fo+\L+\fe |
| **Drawing/Animation** |  |
| **Relevant Tags** | #lens #objective #compound #microscope #eyepiece |

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| **Category** | Optics |
| **Subcategory** | Optical Instrumentation |
| **Concept Name** | Telescopes |
| **Description** | Eyepiece is located so that 1st focus overlaps the 2nd focus of objective  Nearly parallel rays of light from a distant object are collected by a positive lens--objective formed a real inverted image in its focal plane  Then the intermediate image, located at or near the focal point of eyepiece, serves as a real object for the ocular |
| **Formula** | Angular Magnification:  M=-(fo/fe)  \M=-\frac{fo}{fe} |
| **Drawing/Animation** |  |
| **Relevant Tags** | #magnification #image #parallel #rays #light #object #eyepiece |

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| **Category** | Optics |
| **Subcategory** | Coherence |
| **Concept Name** |  |
| **Description** | Coherence: For light to be coherent the phase difference must be constant. One way of achieving coherence is the pass the light through a single slit.  Incoherent: If the phase difference is not constant then the light is incoherent. An example of which is the sun’s light, which is mostly incoherent. |
| **Formula** |  |
| **Drawing/Animation** |  |
| **Relevant Tags** | #light #constant #sun |

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| **Category** | Optics |
| **Subcategory** | Diffraction |
| **Concept Name** |  |
| **Description** | Diffraction refers to the spreading out, or flaring, of a wave when it comes out the other side of an aperture. If a wave moves through an aperture whose size is similar to that of the wavelength of the wave then diffraction will occur. The similar the size of the aperture to the wavelength, the greater the flaring.  Fraunhofer Diffraction patterns can be explained if we assume that there are new waves created at every point within the edges of the apertures. The original wave that enters the aperture can be thought to be converted into many new waves within the opening. The sum of these waves is used to explain the interference patterns observed on the screen.  The single slit diffraction pattern is created when plane waves of light pass through a slit whose length is extremely long, but its’ width is close to the size of the wavelength of the light. This pattern can be created by either using just a laser or two lenses. The first lens is use to created plane waves and the second is used to focus the light on the screen.  The double slit diffraction pattern is created when plane waves of light pass through two slit whose lengths are extremely long, but there widths are close to the size of the wavelength of the light. |
| **Formula** | Single Slit  I=I\_o\frac{\sin^2\beta}{\beta^2}  \beta=\frac{1}{2}kb\sin\theta  Double slit  I=4I\_o\left(\frac{\sin\beta}{\beta}\right)^2\cos^2\alpha  \beta=\frac{1}{2}kb\sin\theta\\\alpha=\frac{1}{2}ka\sin\theta  Many slit  I=I\_o\left(\frac{\sin\beta}{\beta}\right)^2\left(\frac{\sin N\alpha}{\sin\alpha}\right)^2  where  \beta=\frac{1}{2}kb\sin\theta\\\alpha=\frac{1}{2}ka\sin\theta |
| **Drawing/Animation** |  |
| **Relevant Tags** | #laser #lenses #diffraction #wavelength #light #waves #screen |

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| **Category** | Optics |
| **Subcategory** | Diffraction grating |
| **Concept Name** |  |
| **Description** | A diffraction grating is a device that makes periodic changes to the phase, amplitude, or both, of a light source. There are three different types, but all of them act as dispersive elements. There primary use is in measuring wavelengths and spectral analysis.  A multi slit grating is a transmission amplitude grating. A transmission phase grating has parallel notches etched into a flat and clear glass plate. If light was reflected from this type of grating then it becomes a reflection phase grating.  Every order created by a grating maybe overlapped by an order next to it. This means that wavelengths from different orders may occupy the same position on the screen. The wavelength range that does not overlap in a given order is called the free spectral range  The primary benefit of a blazed grating is that it makes use of the light of the zero diffraction order. The zero order is shifted away from the single slit diffraction envelope, or the center of the screen. |
| **Formula** |  |
| **Drawing/Animation** |  |
| **Relevant Tags** | #grating #diffraction #phase #amplitude #light #screen #wavelengths |

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| **Category** | Optics |
| **Subcategory** | Mathematical Representation of Polarized Light |
| **Concept Name** | Jones Vectors |
| **Description** | The Jones vector is a vector that describes the polarization of light. There are several types of polarization, such as Linear, Circular, Elliptical(∆φ=mπ) and random polarization.  Linear polarization is when the vector remains in a fixed direction; it is not diverting towards another non-linear path.  Circular & Elliptical polarization is when the vector rotates in the plane x,y  Random polarization is when the vector has no pattern to its path. Rather, it changes randomly as time progresses.  Having multiple jones vectors can be put into a matrix format, called a Jones Matrix. This will be explained in the next section. |
| **Formula** | Jones Vector:  C:\Users\Ryan\AppData\Local\Microsoft\Windows\INetCache\Content.Word\Capture.png  \tilde E\_0 = [[E\_{0x}],[E\_{0y}]] = [[E\_{0x}e^{ivarphi\_x}],[E\_{0y}e^{ivarphi\_y}]]  Linear polarization equation (∆φ=mπ)  Capture2 Circular polarization equations (∆φ=π/2)  Capture3  Elliptical polarization equations |
| **Drawing/Animation** | N/A |
| **Relevant Tags** | #matrix #vector #polarization #polarize ­­#jones |

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| **Category** | Optics |
| **Subcategory** | Mathematical Representation of Polarized Light |
| **Concept Name** | Jones Matrix |
| **Description** | Various optical devices may modify the state of polarization, which can be described by 2×2 Jones matrices. Such examples of these optical devices include the Polarizer, Phase Retarder and Rotator.  Linear Polarizer:  A linear polarizer is a type of device that converts unpolarised or a mixed-polarization beam of light into a single linear polarized beam of light.  Phase Retarder:  A phase retarder (AKA wave plate) is an optical device that alters the polarization state of a light wave travelling through it. It achieves this by shifting the phase between two perpendicular polarization components of the light wave.  Rotator:  The rotator has the effect of rotating the direction of linearly polarized light incident on it by some particular angle |
| **Formula** | Linear Polarizer equation:  C:\Users\Ryan\AppData\Local\Microsoft\Windows\INetCache\Content.Word\Capture5.png  M = ((cos^2theta,sinthetacostheta),(sinthetacostheta, sin^2theta))  M = ((0,0),(0,1)) ; if theta = 90^@  Phase Retarder  OPD = {(4m+1)lambda} / 4 implies Deltavarphi=+-pi/2  OPD = {(4m+1)lambda} / 2 implies Deltavarphi=+-pi  OPD = {(4m+1)lambda} implies Deltavarphi=+-2pi M = ((e^{iepsilon\_x},0),(0,e^{iepsilon\_y}))  Rotator  M = ((cosbeta,-sinbeta),(sinbeta,cosbeta)) |
| **Drawing/Animation** | Linear polarizer example:C:\Users\Ryan\AppData\Local\Microsoft\Windows\INetCache\Content.Word\2000px-Wire-grid-polarizer.svg.png |
| **Relevant Tags** | #matrix #vector #polarization #polarize ­­#jones |