

**Indian Hills Community College
presents the series
Basics of Photonics Fundamentals
(lasers & optics)**

FRANK REED – PRESENTER
frank.reed@indianhills.edu
641.777.3538

"This material is based upon work supported by the National Science Foundation under Grant No. 1800935." "Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation."

Life. Changing.

WELCOME & THANK YOU FOR YOUR INTEREST

Greetings

- I am Frank Reed, Indian Hills's Grant Director & Principal Investigator for the *Developing Photonics Education in Iowa's Rural Secondary Schools* National Science Foundation Grant.
- I have been in the photonics (**lasers and optics**) field since 1989 when I graduated from Indian Hills and have been with IHCC since 1996.
- I do hope you enjoy and learn from these presentations.
- The presentations will cover the following.
 - 1. Motivation, Light and the Nature & Properties of Light**
 2. Optical Components
 3. Basic Laser Safety
 4. Geometrical (RAY) Optics
 5. Physical (WAVE) Optics
 6. Principles of Lasers

Motivation

- Currently the U.S. laser & optics industry is growing by leaps and bounds,
 - Or as we like to say “at the speed of light”.
- The medical/bio-science area is the fastest growing followed closely by manufacturing.
 - These two areas will impact each of us on a personal basis.
- Nationally, there are ~2000 entry level photonics technician positions per year with ~20% filled.
- IHCC’s Laser & Optics 2020 graduates received an average starting salary of \$61,800.00.
- To increase the number of these technicians, WE must market lasers & optics to our students.
- 70% of technicians working in U.S. photonics industry say that their jobs are intellectually challenging and have no worries about joblessness.
- IHCC’s NSF ATE Grant has the main objective of increasing the number of Photonics Techs in the U.S.
- One way to do that is to introduce teachers to the world of photonics.
 - Therefore, this opportunity is provided for you to learn more about lasers & optics with hope that you will include it in your course work.

Motivation



Albia High School



Centerville High School



Davis County High School

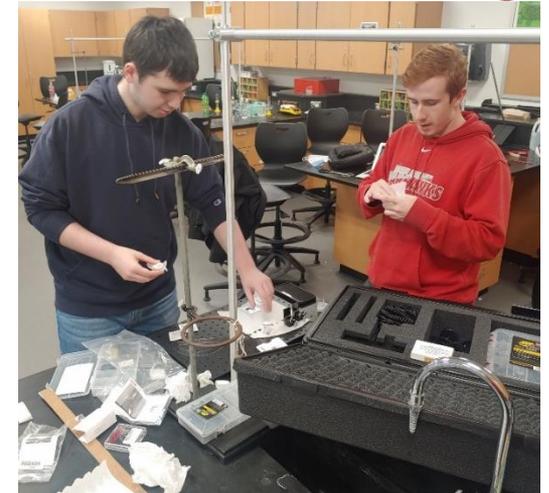
Hybrid (online & hands-on) High School Photonics Training



Davis County High School



Ottumwa High School



North Mahaska High School

Overview of Optical Components & Handling

- Optical Materials & Properties
- Components and Equipment
- Optical Quality
- Care & Cleaning of Optics

Optical Materials & Properties

Properties of Materials

A transparent optical medium such as a window, prism, or a lens requires:

1. Low absorption of light while passing through it
2. Low reflection loss of light incident on its interfaces (surfaces)
3. Low refraction of the transmitted light (smaller refractive index)
4. Minimum distortion of light while passing through—due to imperfections in the material or the surface finish
5. A high damage threshold to laser radiation
6. Minimal optical degradation due to temperature, water vapor or other “hostile” environmental conditions

Optical Materials & Properties

- Index of Refraction
- Absorption
- Transmission
- Surface reflection
- Thermal, Mechanical & Chemical

Index of Refraction

- The ratio of the speed of light in a vacuum to the speed of light in a different medium
- Light speed decreases when entering a transmissive material.
 - Light in a vacuum travels $\sim 3.0 \times 10^8$ m/s.
- Unitless and always >1 ; indicated by the letter “n”.
 - $n = 1$ is for vacuum and accepted for air (1.0003).
- Varies inversely with wavelength.
 - When more energy is exerted, the more work (ray bending or light speed changing) is done.
 - Shorter wavelengths have higher photon energy and thus do more work making their index of refraction higher in all materials.
 - **NOTE:** all properties of optical materials vary with wavelength.

Absorption

- The loss of light energy as it passes through a material, generally due to light converting to other energy forms.
- As the thickness of a material increases, the absorption increases exponentially.
 - Therefore the transmission decrease exponentially.
- Indicated by an Absorption Coefficient – the rate at which a material absorbs light.
- Transmissive optics like lenses, prisms, and windows, absorption must be near 0% and transmission must be near 100%.
- Without absorption, **no material processing would be possible.**

Transmission

- Ratio of the amount of light exiting an optic to the amount of incident light.

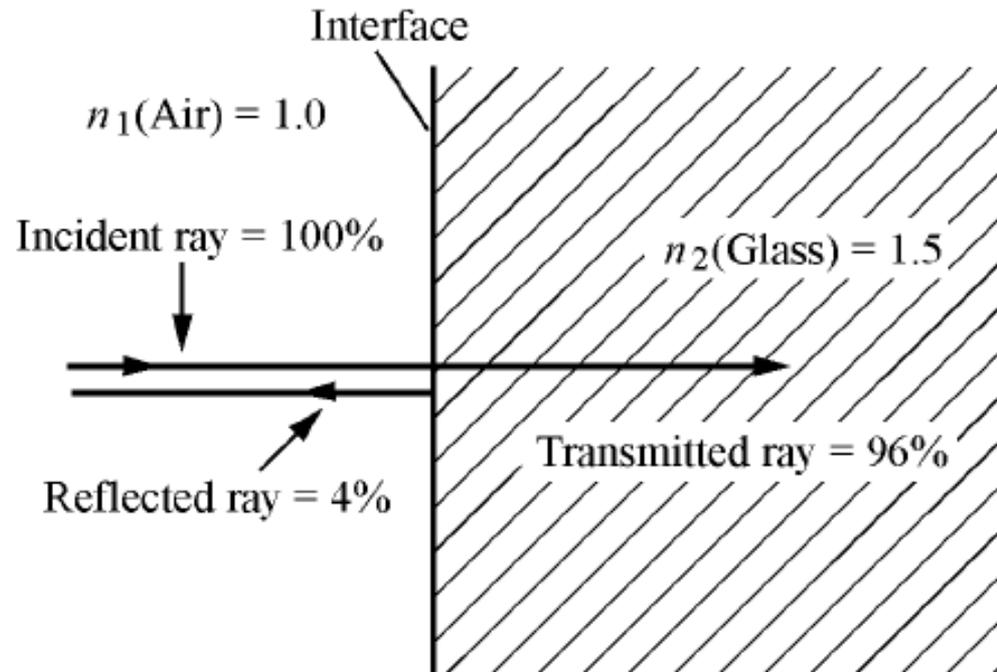
$$T = \frac{P_{out}}{P_{in}}$$

- Indicated by Optical Density: a measure of the transmittance through an optical medium.
 - Specified at various wavelengths.
 - Laser safety eyewear must be of a particular OD before it protects you from diffuse reflections.

$$T_{\lambda} = 10^{-OD} \quad OD = \log_{10} \frac{1}{T_{\lambda}}$$

Surface Reflectivity

- Reflections take place at nearly every optical interface.
- Depends on wavelength and index of refraction.
- Uncoated optics reflect too much light: approximately 4% of the incident light at an air to glass interface.



Thermal, Mechanical & Chemical

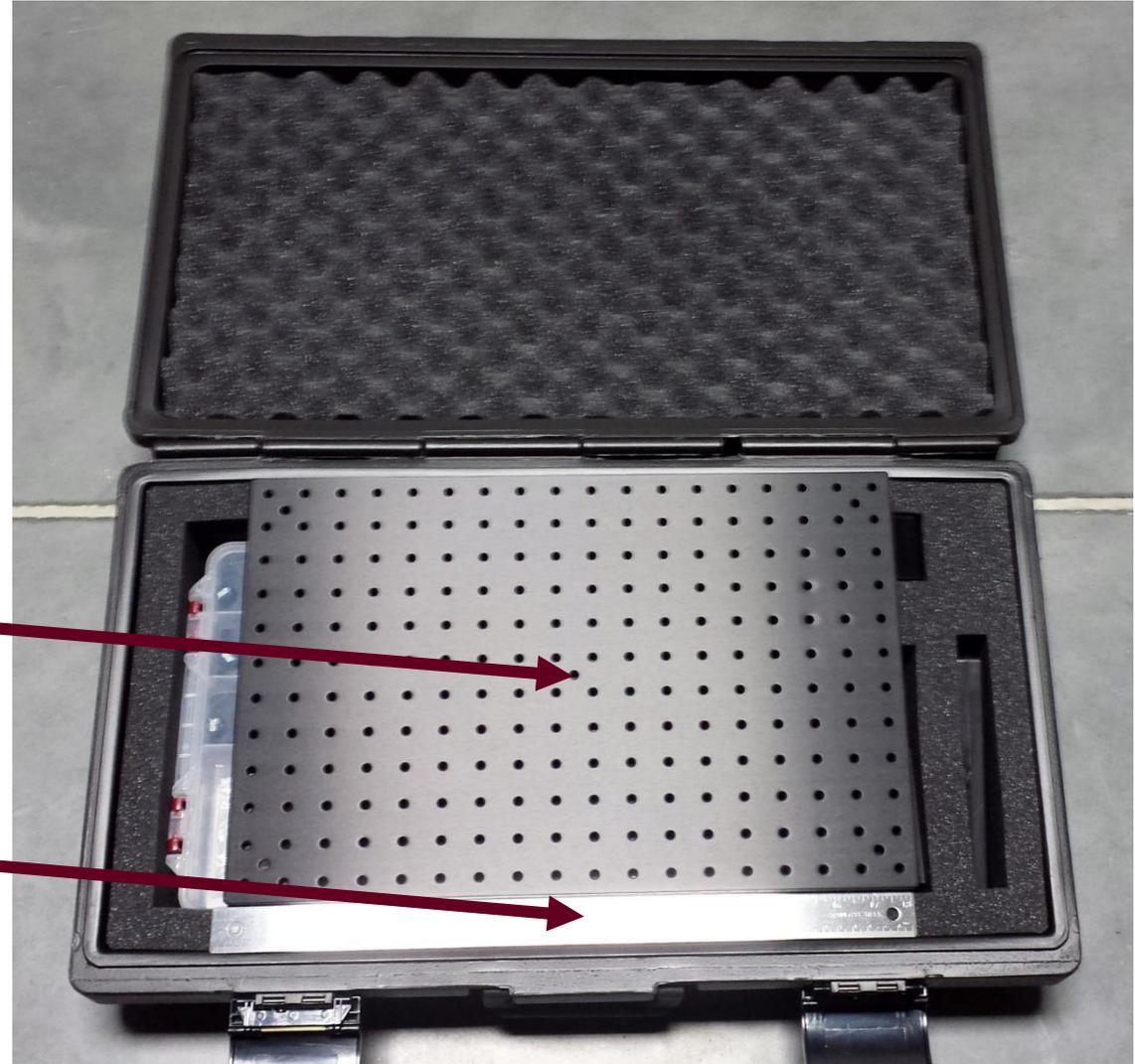
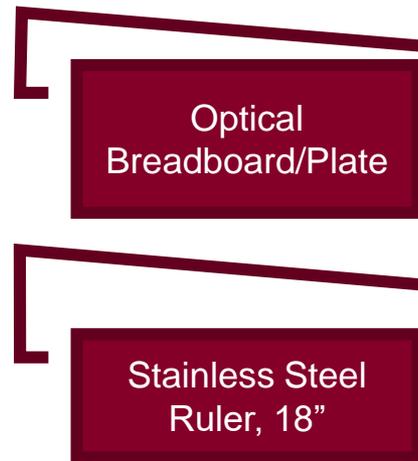
- Thermal:
 - Extreme heat or cold and rapid changes in temperature can cause temporary or permanent changes.
 - Minimal to no changes are required.
 - Without optical systems there would be no lasers or laser processing, etc.
- Mechanical:
 - Stress on an optical component can result in distortion in its material and therefore its surface.
- Chemical:
 - Chemical damage to optical elements is caused mainly by the chemical's ability to etch or dissolve the window material. Such as the effect of acetone on plastics

Components & Equipment

- The following is the Photonics Kit used in IHCC's dual credit Photonics Fundamentals course both at the college and high schools.
- This course is available for High School Juniors & Seniors.



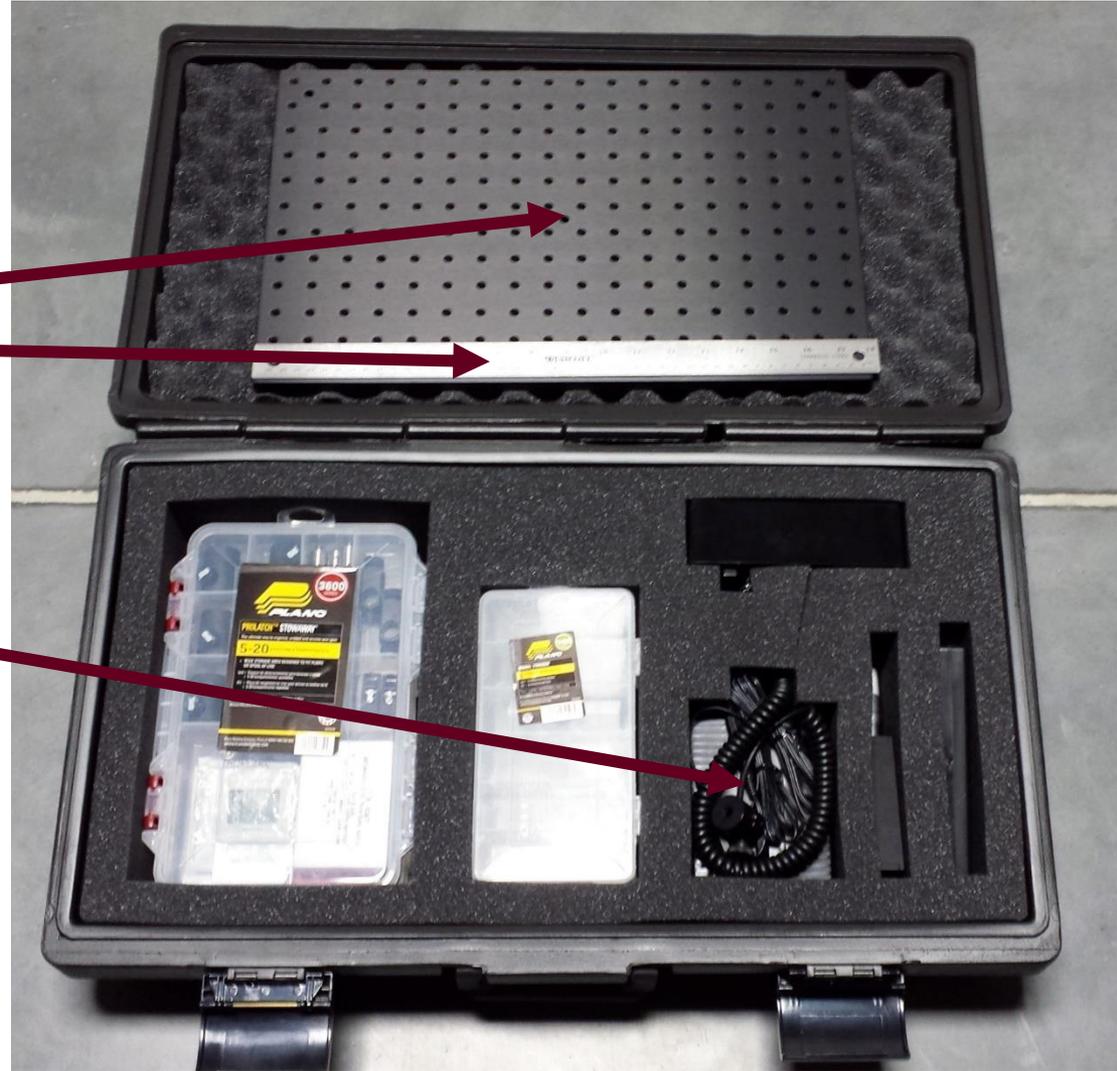
Components & Equipment



Components & Equipment

Optical
Breadboard/Plate &
45.7mm (18")
Stainless Steel Ruler

Photometer Detector
with Thumb Screw &
Cord placement



Components & Equipment



Layer 1 of the large and small storage boxes removed

Photometer Detector moved for clarification

Components & Equipment

Base, Mounting, 2" x 3" x 3/8"



Filter Holder, dual



Laser Diode Module, collimated, 635 nm, 1.2 mW ***



Components & Equipment

Laser Diode Power Supply, 5 VDC, 2.5 mm Phono Plug, 120 VAC

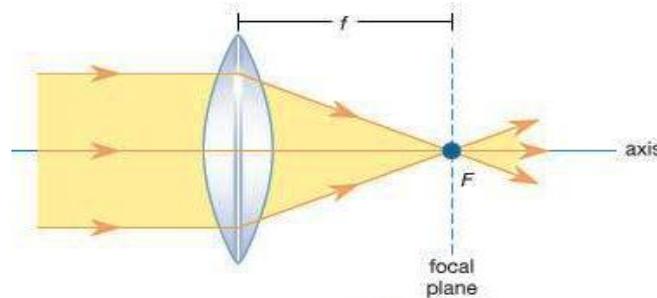


Location-Specific
Power Cord Provided

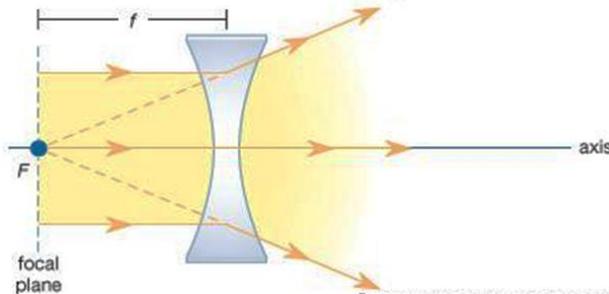


Location-Specific
Power Cord Provided

N-BK7 Bi-Convex Lens, $\text{Ø}25.4\text{mm}$, $f = 200\text{ mm}$, Uncoated

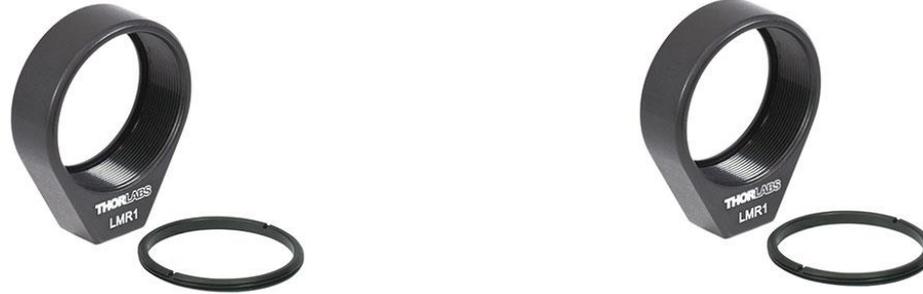


N-BK7 Bi-Concave Lens, $\text{Ø}25\text{ mm}$, $f = -25.0\text{ mm}$, Uncoated



Components & Equipment

Lens Mount, Fixed, Inside Diam=25mm



Optical Breadboard, 30.5mm x 45.7mm x 1.27mm



Right-Angle Clamp or Post Holder for 1.27mm post



Components & Equipment

Rotation Mount, Ø25mm Optics, 8-32 Tap



Rotation Stage, 6.35mm x 6.35mm



Mounted Precision Pinhole, Ø25mm, $50 \pm 3 \mu\text{m}$ Pinhole Diameter



Components & Equipment

Single Slit, Ø25mm, Mounted Slit, $100 \pm 4 \mu\text{m}$ Wide, 3 mm Long



Translation Stage, single axis, 7.6cm x 10.2cm

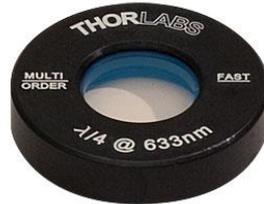


V-Clamp with Clamping Arm, Cylindrical Laser Mount, 6.35mm, **2 - piece**

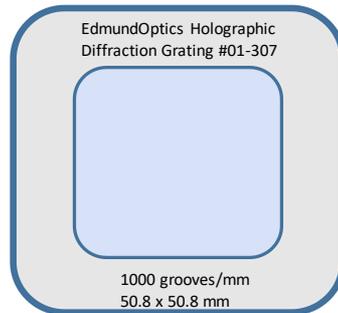


Components & Equipment

1/4 Wave Plate, Multiple Order Quartz, $\varnothing=12.7\text{mm}$, w/mount 25mm



Diffraction Grating, 1000 lines/mm



Post Holders 3.9mm x 2.54mm



Components & Equipment

Posts 3.9mm x 1.27mm, 2 - piece

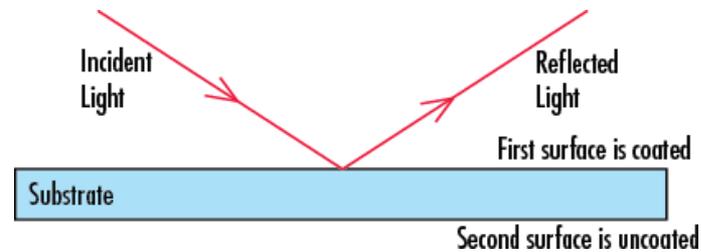


Removable "top"

Kinematic Mirror Mount, no mirror, 25mm x 25mm



Mirror, 25.4mm x 51mm x 6mm, First Surface Mirror

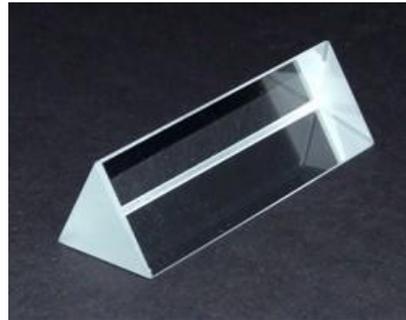


Components & Equipment

Polarizer, slide mounted



Prism, Equilateral, 25mm x 75mm

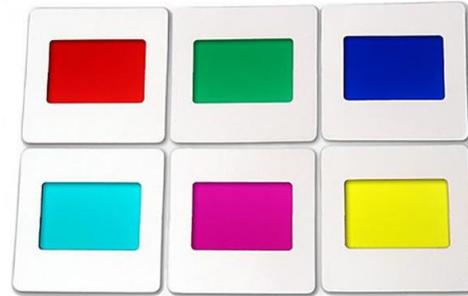


Polarizer, glass, Diam=25mm x 1.78mm

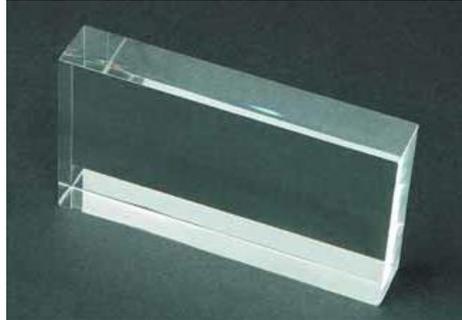


Components & Equipment

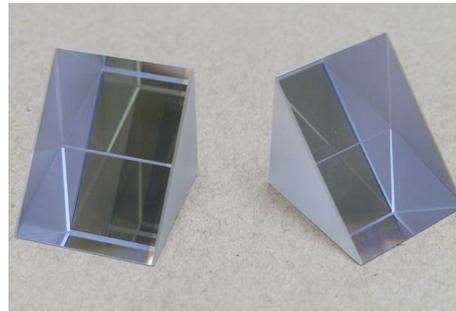
Filter **Set**, Color (RGB, CMY)



Block, Acrylic, rectangular: 75mm X 50mm X 15 mm.



Prism, Right Angle, 25mm X 25mm, K9 Optical Glass



Optical Quality

Surface Imperfections

Internal Defects

Inspection Methods and
Procedures

Spectral qualities of mirrors

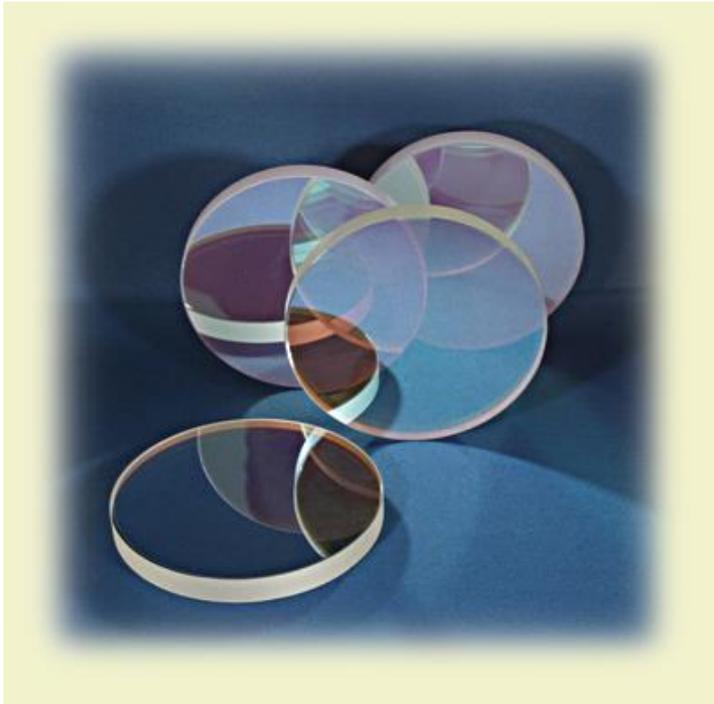
Surface Imperfections



- Scratch and dig defects: Important to be careful when handling.
- Edge chips: may create crack
- Cemented surfaces: may separate
- Surface abrasions: extreme heat or cold, improper use of chemicals, etc.
- Internal defect: inclusions (particles), bubbles, cracks, striae (variations in index of refraction).

Internal Defects

- Usually occur during the manufacturing process
- Inclusions: pieces of contamination inside of the glass.
- Interfere with the beam.
- Bubbles: air trapped in the element.
- Cracks: may occur in an optic & may travel.
- Striae: lines in an optic from index of refraction variations.



Care and Cleaning of Optics

Inspection Techniques:

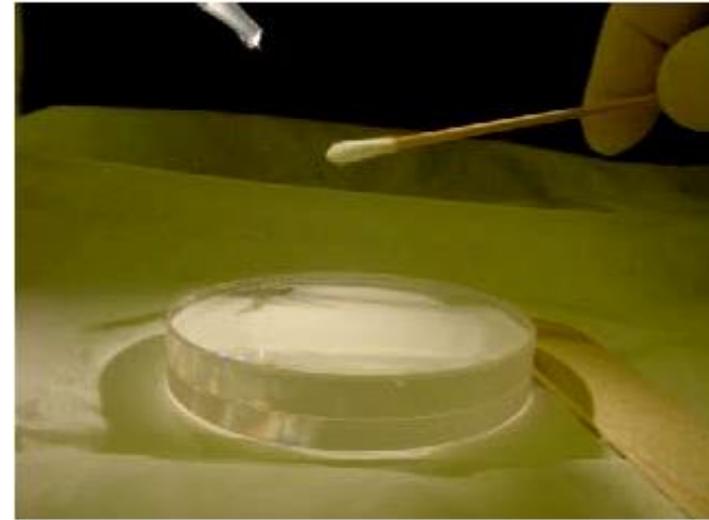
- Handle the optic carefully
- Inspect it for contamination, defects & imperfections
 - Various methods are used but all consist of light reflecting from or transmitting through the optic.
 - Think of cleaning a window at home or your glasses.



Care and Cleaning of Optics

Cleaning Methods:

- Blow off particulate
 - With clean, dry air
 - Your breath is not clean nor dry.
- Detergent method: for very dirty optics
 - Mild detergent and fingers (finger prints are like squeegees)
- Drag-wipe method:
 - Wet a cleaning tissue with cleaning fluid and drag it across the optic.
- Twist-n-wipe method (shown)
 - Use an **optical** “Q-tip”, wet with cleaning fluid and twist while wiping.
- One and done; do not reuse.



"This material is based upon work supported by the National Science Foundation under Grant No. 1800935." "Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation."



www.indianhills.edu

It is the policy of Indian Hills Community College not to discriminate on the basis of race, color, national origin, sex, disability, age (employment), sexual orientation, gender identity, creed, religion, and actual or potential parental, family, or marital status in its programs, activities, or employment practices as required by the Iowa Code §§216.6 and 216.9, Titles VI and VII of the Civil Rights Act of 1964 (42 U.S.C. §§ 2000d and 2000e), the Equal Pay Act of 1973 (29 U.S.C. § 206, et seq.), Title IX (Educational Amendments, 20 U.S.C §§ 1681 – 1688), Section 504 (Rehabilitation Act of 1973, 29 U.S.C. § 794), and Title II of the Americans with Disabilities Act (42 U.S.C. § 12101, et seq.).

If you have questions or complaints related to compliance with this policy, please contact Kristen Parks, Director of Human Resources/Equity Coordinator, 525 Grandview Ave, Ottumwa, IA 52501, (641) 683-5108; Chris Bowser, Executive Dean, Student Services, (students), (641) 683-5159; Darlas Shockley, Executive Dean, Arts & Sciences (students with disabilities), (641) 683-5174; or the U.S. Department of Education, Citigroup Center, 500 W. Madison, Suite 1475, Chicago, IL 60661, phone number (312) 730-1560, fax (312) 730-1576.