

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

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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

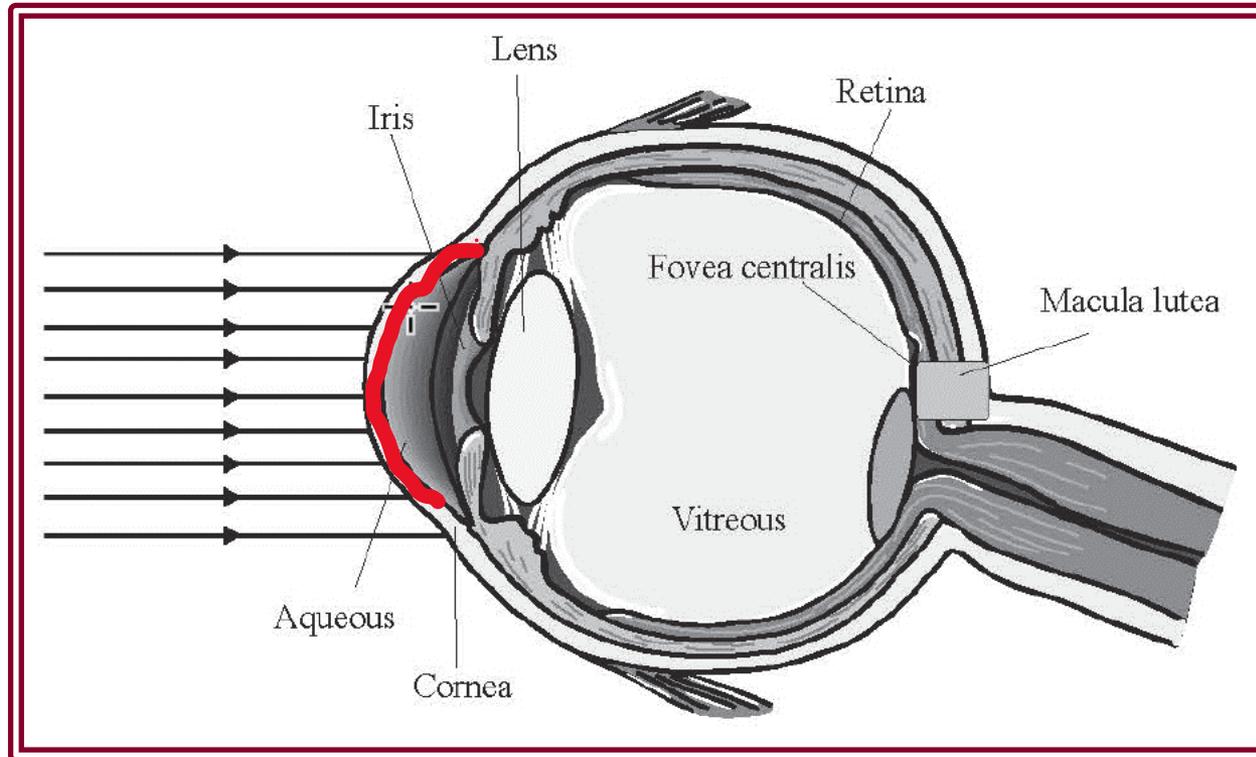
Light and the Eye

- When the environment dictates, wearing proper protective equipment (PPE) for eye safety is essential
- Wearing laser safety eyewear is only safe to a point
- One must know the laser power, wavelength, mode of operation and the PPE limits
- Most injuries are caused by the not following the safety training



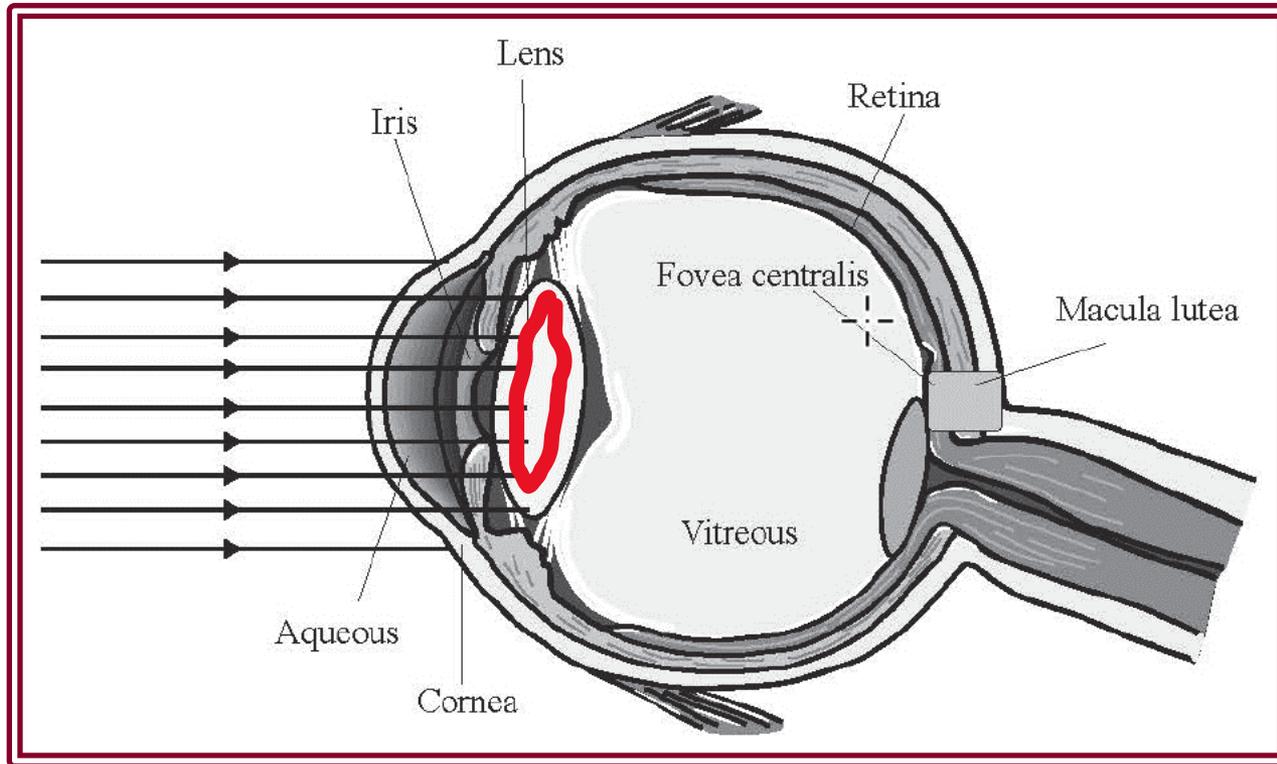
The Eye

- Infrared: 1400 – 10000 nm
- Ultra Violet: 100 – 315 nm
- Absorbed mainly in the **cornea**



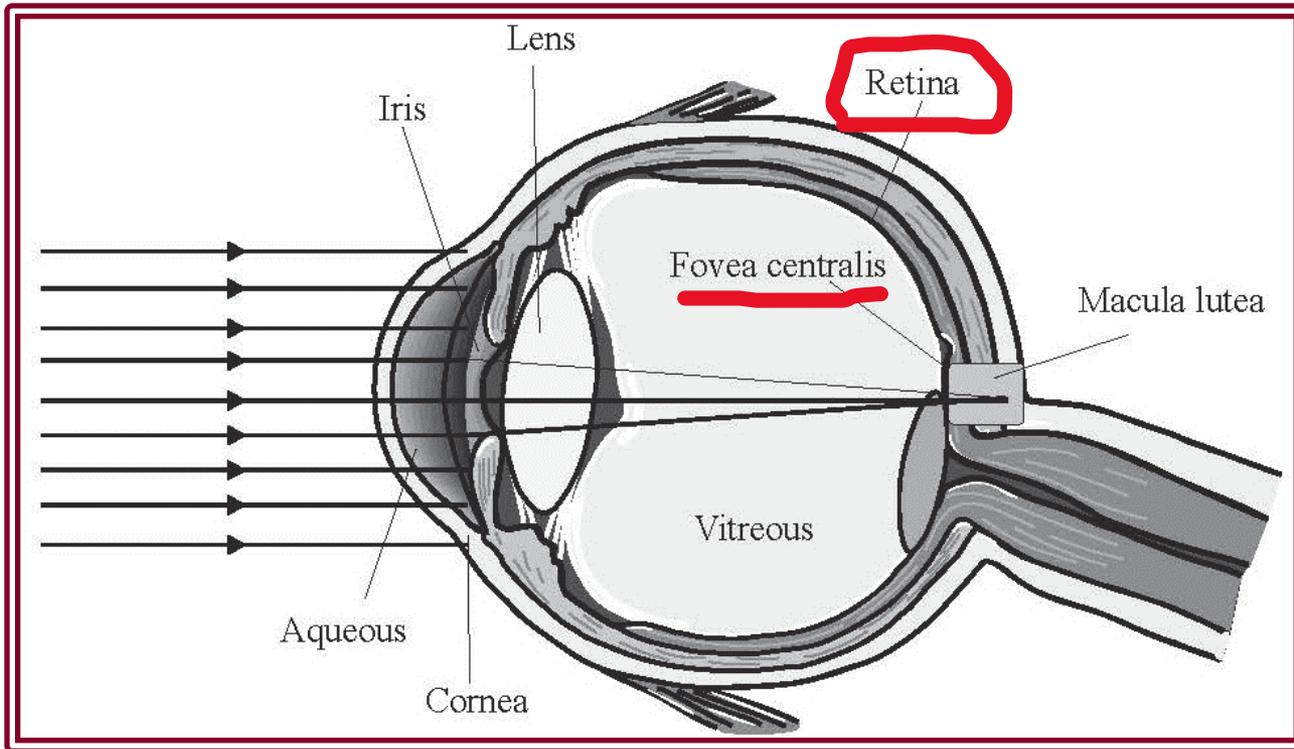
The Eye

- Infrared: 700 – 3000 nm
- Ultra Violet: 315 – 400 nm
- Absorbed mainly by the **lens**
 - **Cataracts**



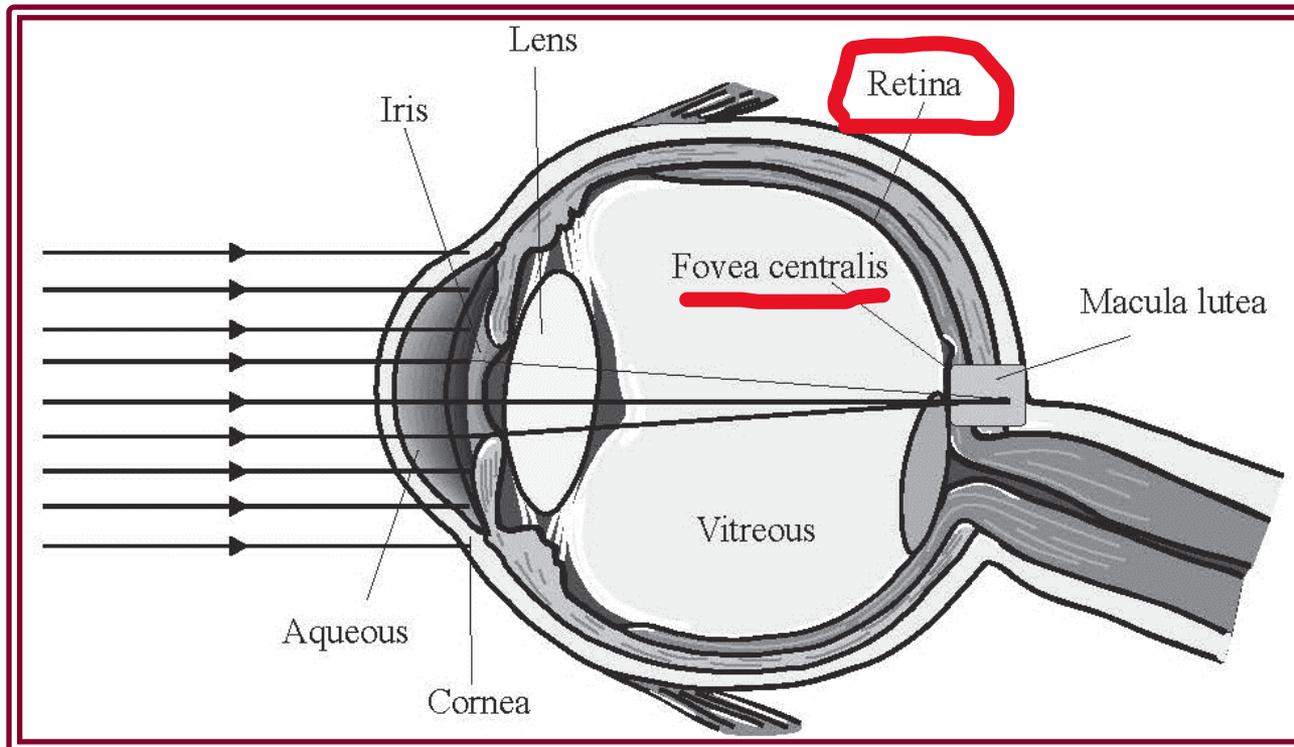
The Eye

- Visible (400 – 700 nm) and Infrared: 700 – 1400 nm
- Focused onto the **retina**.
- Straight line viewing focuses onto the **Fovea**
 - Area of most detailed vision



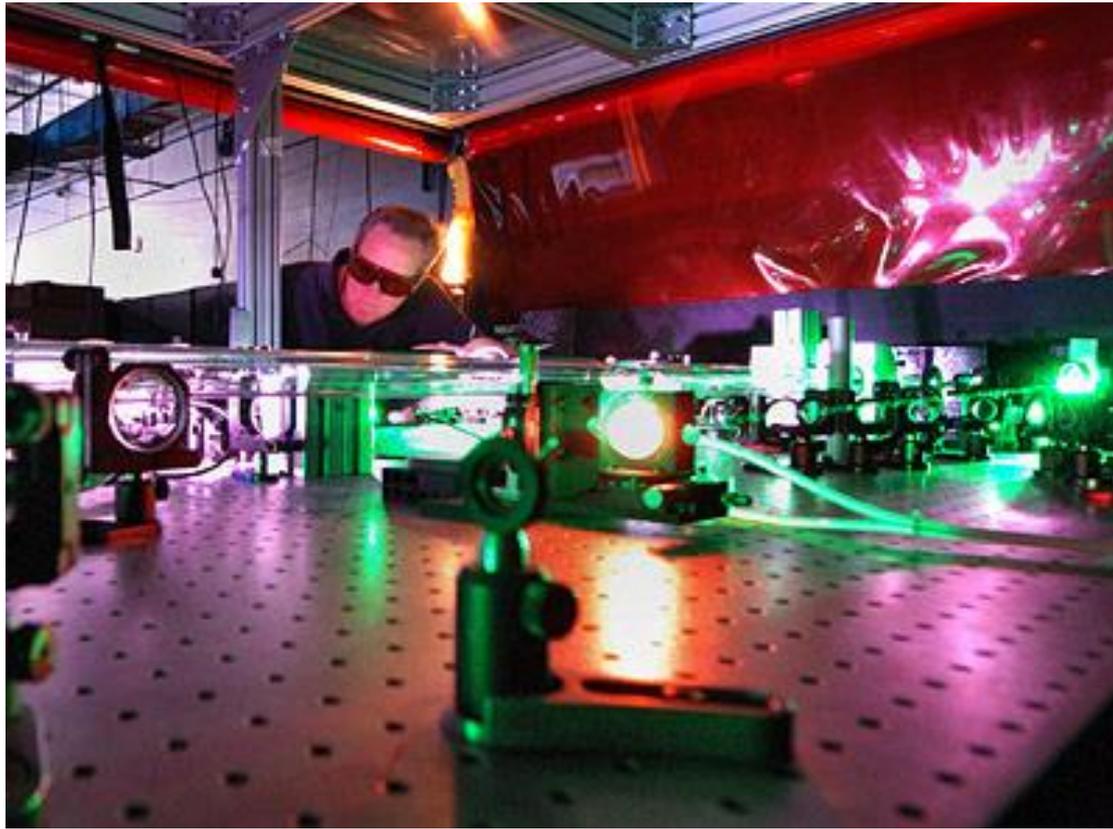
The Eye

- Capable of causing a white burn on retina
- Burn on outside of macula: effect on vision is small
- Burn on inside of macula; effect is much greater

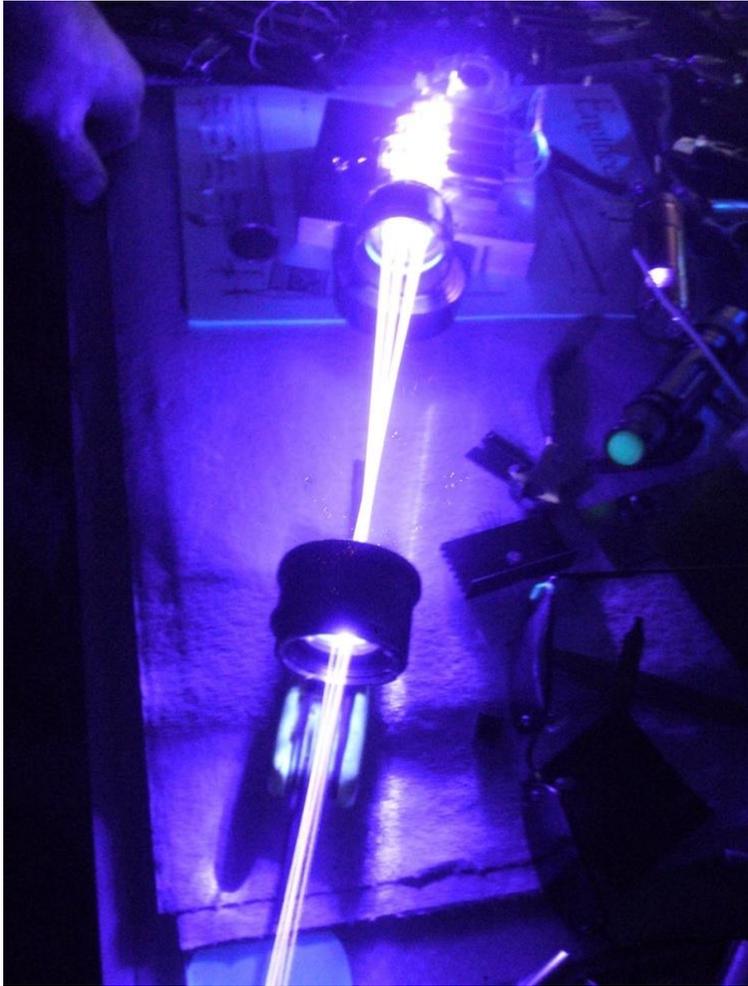


Pulsed Lasers

- Pulsed lasers cause lines of laser burns on the retina
- Pulses create shockwaves that rupture blood vessels
- Permanent destruction of the macular is possible



Irradiance



- Power density of a beam
- Smaller the diameter of the beam the greater the irradiance
- Laser light focused by a lens increases the irradiance significantly
- A human eye (lens) can easily increase irradiance of a beam by 10,000!

$$\text{Irradiance} = \frac{\text{Power}}{\text{Area}}$$

Skin Effects

- The skin is more apt to be exposed to laser light
- Two effects of laser light on the skin
 - Thermal Injuries
 - Surface burns from high power beams
 - Deeper burn penetration at 10000 nm wavelength
 - Tissue vaporization by focused beams
 - Photochemical Injuries
 - Sunburn from scattered UV
 - Possibility of skin cancer from long term UV exposure such as suntanning

Class 1

- Safe during normal use
- Incapable of causing injury
- Low power or enclosed beam



Nd:YAG Laser Marker

Label not required
May be higher class during
maintenance or service

Class 2



- Staring into beam is eye hazard (DUH!)
- Eye protected by aversion response
- Visible lasers only
- CW maximum power 1 mW

Laser Scanners



Class 3R

Laser Pointers

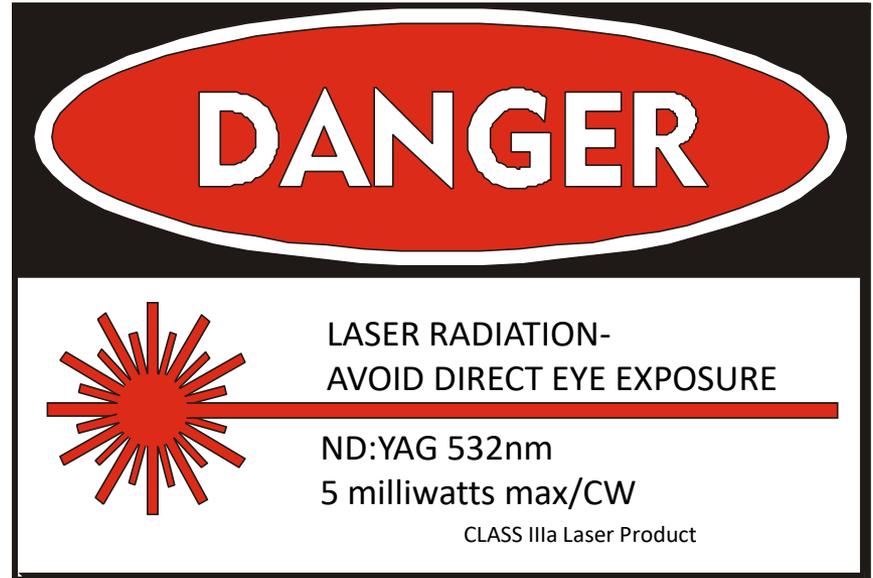


- Aversion response may not provide adequate eye protection
- CW maximum power (visible) 5 mW
- Laser must have a safety sign

Expanded Beam

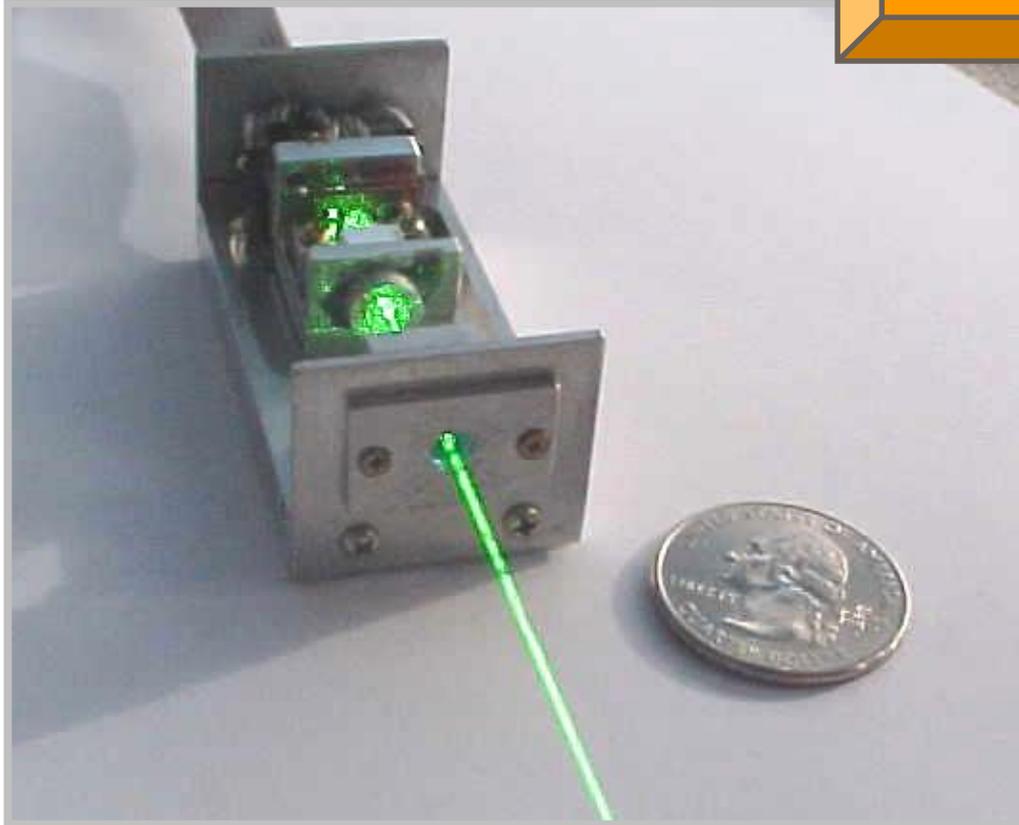


Small Beam

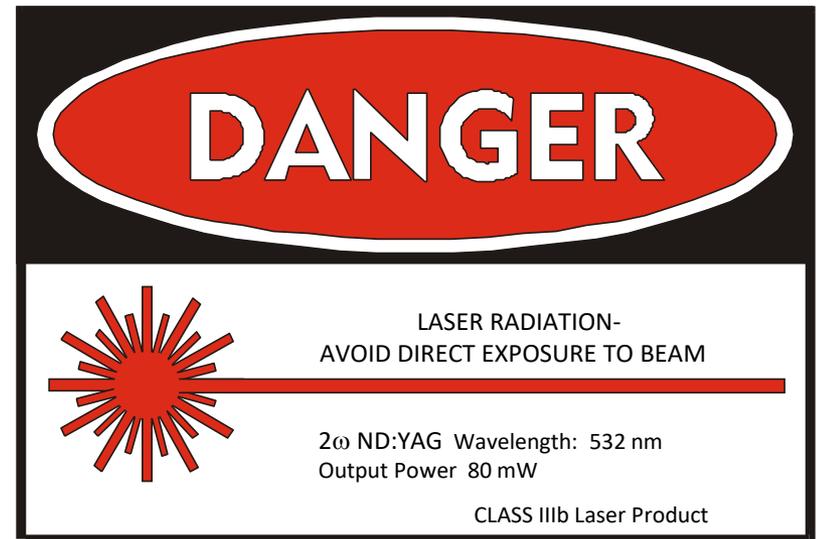


Class 3B

Diode Pumped Solid State (DPSS)
Laser with cover removed



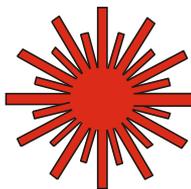
- Hazardous for direct beam viewing
- Be aware of diffuse reflection
- Visible or invisible
- CW maximum power 500 mW



Class 4

- Exposure to direct beam & diffused light is eye and skin hazard
- Visible or invisible
- CW power >0.5 W (500 mW)
- Fire hazard

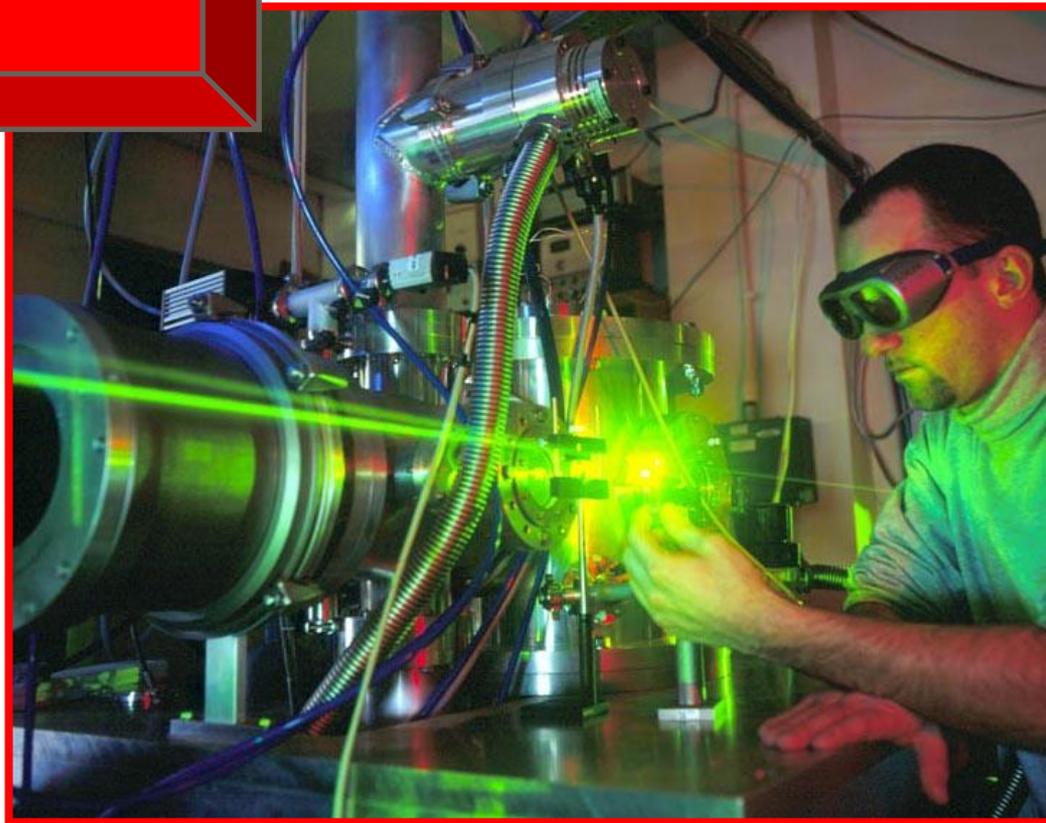
DANGER



AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION

2w Nd:YAG, Wavelength: 532 nm
Output Power 20 W

CLASS IV Laser Product



INDIANHILLS

Laser-Professionals.com

Photo: Keith Hunt -
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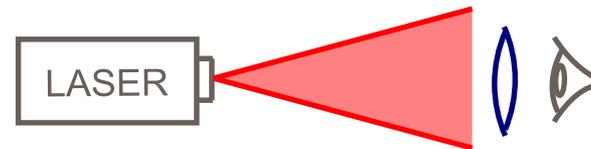
Life. Changing.

Class 1M & 2M

- M is for magnification
- Class 1M & 2M: Class 1 or 2 plus magnifying optics (lens)
 - Smaller spot size thereby increasing irradiance
- M classes apply to expanded or diverging beams



Expanded Beam



Diverging Beam

Safety Rules

- Maximum Permissible Exposure (MPE)
 - highest irradiance level a beam can reach before damage is possible
- Use the standards to know what safety equipment to use
- Know the laser's wavelength(s) and exposure duration



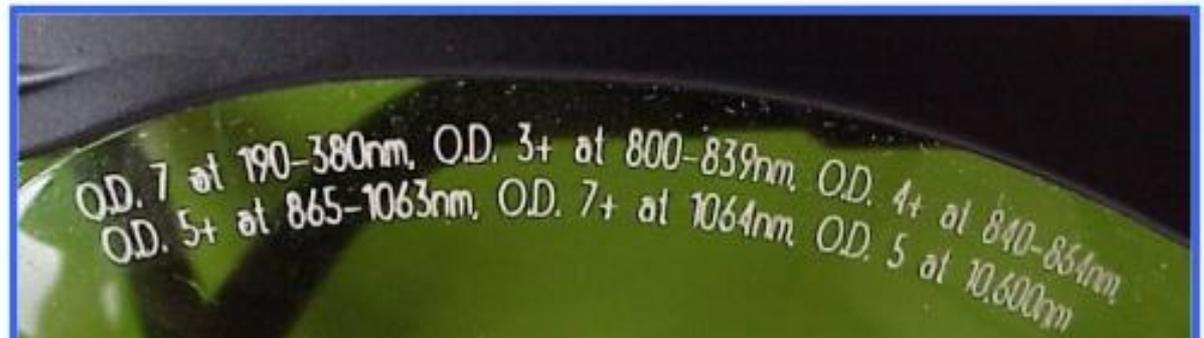
Safety Rules

- Nominal Hazard Zone (NHZ)
 - how far from the beam of a laser is a safe viewing distance
- Factors of NHZ include laser output & working parameters (power, wavelength, pulse length, etc.)
- Calculate NHZ to make sure everyone is safe



Laser Safety Eyewear

- Optical density (OD): indicates how well a material absorbs light thereby decreasing (attenuating) transmission
- OD of eyewear to exceed the OD calculated in a hazard evaluation
- OD value is on laser eyewear with relevant wavelength



Labels

- CAUTION label:
 - laser beam is visible & cannot deliver more than 1 mW through the pupil of the eye
- DANGER label:
 - laser is class 4, 3B, or 3R & can deliver more than 1 mW through a 7-mm pupil
- Laser products are labeled according to requirements of the federal standard
- Power levels indicated are often greater than what the laser can produce



Standard Operating Procedure (SOP)

- Most accidents occur during beam alignment
- Control stray reflections
- SOP's are required for any circumstance in which a worker may be exposed to a hazardous laser beam
- Hazards include light, electrical, mechanical, radiation, chemical, and laser generated air contaminants (LGACs)

American National Standard

ANSI Z39.5 - 2009

*American National Standard
for Safe Use of Lasers
in Educational Institutions*



Laser Institute
of America



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