Special Precautions

Drs. Jeong Seop Shim and Som Mitra
Otto York Center
for Environmental Engineering and Science

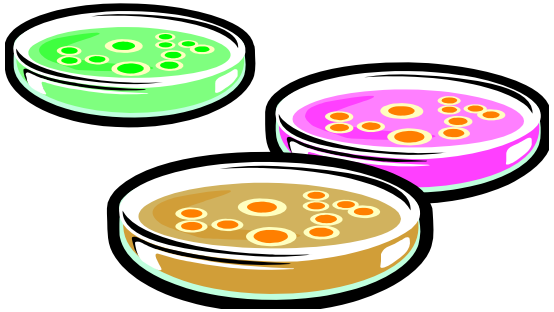
New Jersey Institute of Technology

Biological Safety

PPE for Biological Safety

When treating biological agents and/or rDNA, the following PPE must be used:

- Gloves
- Lab Coat
- Shoe Covers
- Safety Glasses
- Respirator



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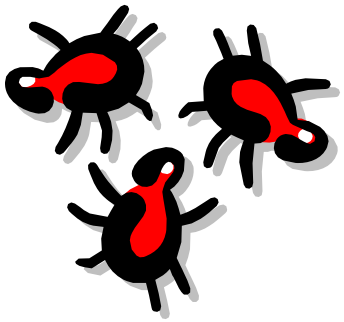
Biohazardous Waste

- Any waste with infectious and/or biological nature
- It can cause physical or health hazards in humans, animals, plants or environment.
- This includes recombinant DNA and other genetically altered organisms and agents.



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Biological Waste Disposal

- Laboratories must segregate biological wastes from other wastes.
- Certain biological materials must be treated (usually by autoclaving) before entering the waste stream; some must be incinerated
- If you do not have the above, contact the NJIT-HSD (x3086 or x3059) .

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Autoclave

- Opening door at end of liquid cycle:
  - Wear eye and face protection.
  - Stand behind door when opening it.
  - Slowly open door only a crack to allow residual steam to escape.
  - Keep face away from door as it opens.

Autoclave: Continued

- Removing liquids at end of cycle:
  - Wait 5 min. before removing liquids.
  - Liquids removed too soon may be super-heated and boil up and out of container.
  - Aim mouth of flask away from face.
  - Don’t knock flask against bench.

Biological Wastes: Sharps

- When sharps containers are full, close the top and request a waste pickup to the NJIT-HSD.
- Do not overfill.
- Use hard-sided, leak-proof commercial sharps containers for disposal of sharps.
- Sharps containers must be immediately accessible (arms length)
- Sharps should not be re-sheathed, broken, bent or otherwise manipulated before disposal in a sharps container.

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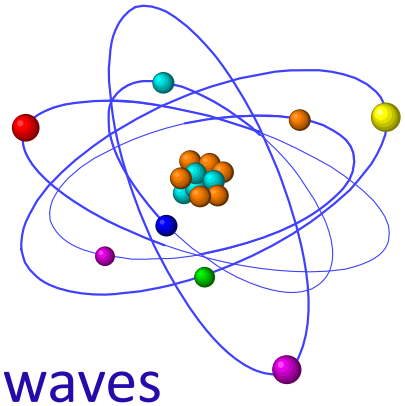
Radiological Safety

What is Radiation?



Radiation: energy in motion, electromagnetic waves

Radioactivity: spontaneous emission of radiation from the nucleus of an unstable atom

Isotope: atoms with the same number of protons, but different number of neutrons

Radioisotope: unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified

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Ionizing Radiation vs. Non-Ionizing Radiation

- Occurs from the addition or removal of electrons from neutral atoms
- Examples:
  - α **Alpha**
  - β **Beta**
  - γ **Gamma (X-ray)**
  - **n** **Neutron**

- A radiation that is not as energetic as ionizing radiation and cannot remove electrons from atoms or molecules.
- Examples: light, lasers, heat, microwaves, and radar

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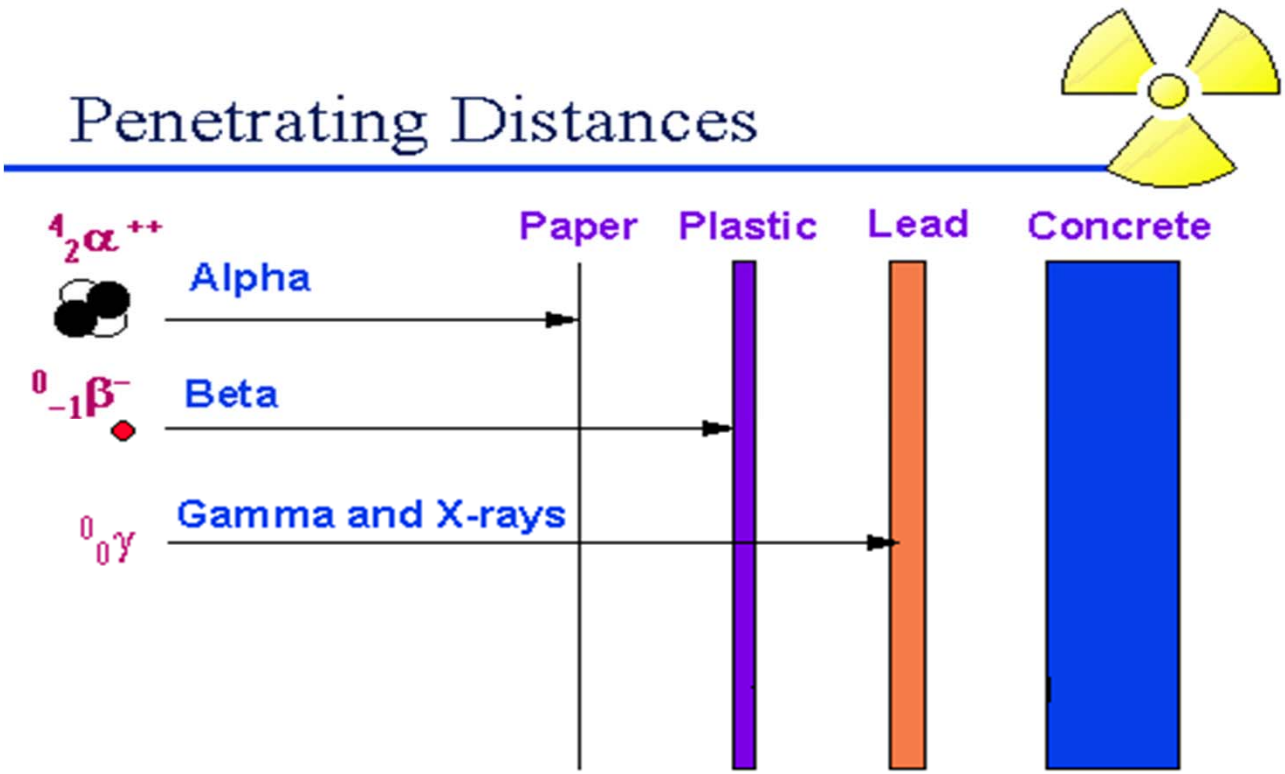
Ionizing Radiation



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Annual Radiation Exposure Limits

Occupationally Exposed Worker:

	rem	mrem
Whole body	5	5000
Eye	15	15,000
Shallow	50	50,000
Minor	0.5	500
Pregnant Worker	0.5*	500*

*9 months

General Public: 100 mrem/year or 2mrem/hour

A **rem** is a large dose of radiation, so the **millirem** (**mrem**), which **is one thousandth of a rem**, is often used for the dosages commonly encountered, such as the amount of radiation received from medical x-rays and background sources.

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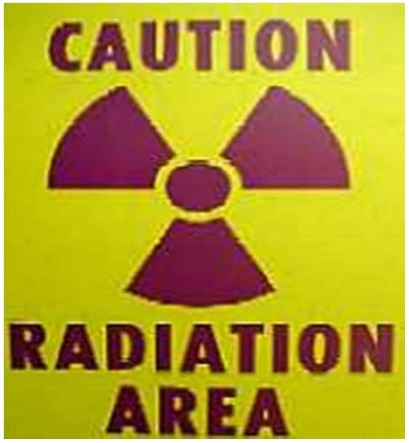
How to know if there is a radiation source or radiation area- Symbols?

"CAUTION RADIATION AREA"



“CAUTION RADIOACTIVE MATERIALS"

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Summary of Biological Effects of Radiation

- Radiation may…
  - Deposit Energy in Body
  - Cause DNA Damage
  - Create Ionizations in Body
  - Leading to Free Radicals
- Which may lead to biological damage

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Protecting Ourselves from External Exposure

- Adhere to the three cardinal rules of external radiation protection:
  - **TIME**
  - **DISTANCE**
  - **SHIELDING**

TIME
Less Time = Less Exposure

DISTANCE
Greater Distance = Less Exposure

SHIELDING
More Shielding = Less Exposure

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Laser Safety

Laser

LASER - *acronym* stands for:

- Light
- Amplification by the
- Stimulated
- Emission of
- Radiation

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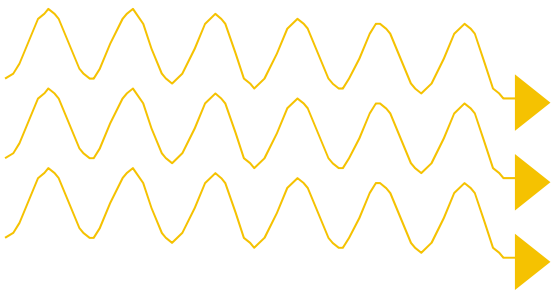
Laser Light

Laser light *has three characteristics that are different from ordinary light.*

1. The **monochromatic** property of laser light means it is **all one wavelength**.
2. The **directional** property of laser light means that the beam spreads very slowly.
3. The **coherent** property of laser light means that all the light waves are **in phase**.

The combination of these three properties makes laser light focus 100 time better than ordinary.



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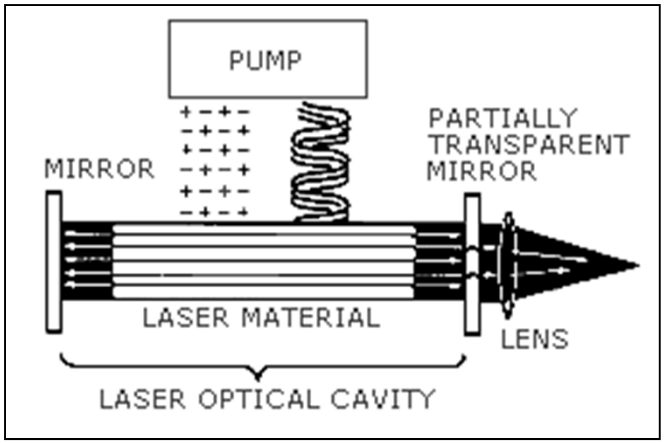
How a Laser Works

A laser consists of an optical cavity, a pumping system, and a lasing medium.

- The **optical cavity** contains the media to be excited with mirrors to redirect the produced photons back along the same general path.
- The **pumping system** uses various methods to raise the media to the lasing state.
- The **laser medium** can be a solid (state), gas, liquid dye, or semiconductor.



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Laser Media

- Solid state lasers
- Gas lasers
- Excimer lasers (a combination of the terms excited and dimers) use reactive gases mixed with inert gases.
- Dye lasers (complex organic dyes)
- Semiconductor lasers (also called diode lasers)

There are different safety hazards associated with the various laser media.

Laser Classification

- To classify a laser, need to know:
  - Laser wavelength
  - Exposure duration
  - Viewing conditions

Types of Lasers

Laser can be described by:

- which part of the electromagnetic spectrum is represented:
  - Infrared
  - Visible Spectrum
  - Ultraviolet

- the length of time the beam is active:
  - Continuous Wave
  - Pulsed
  - Ultra-short Pulsed

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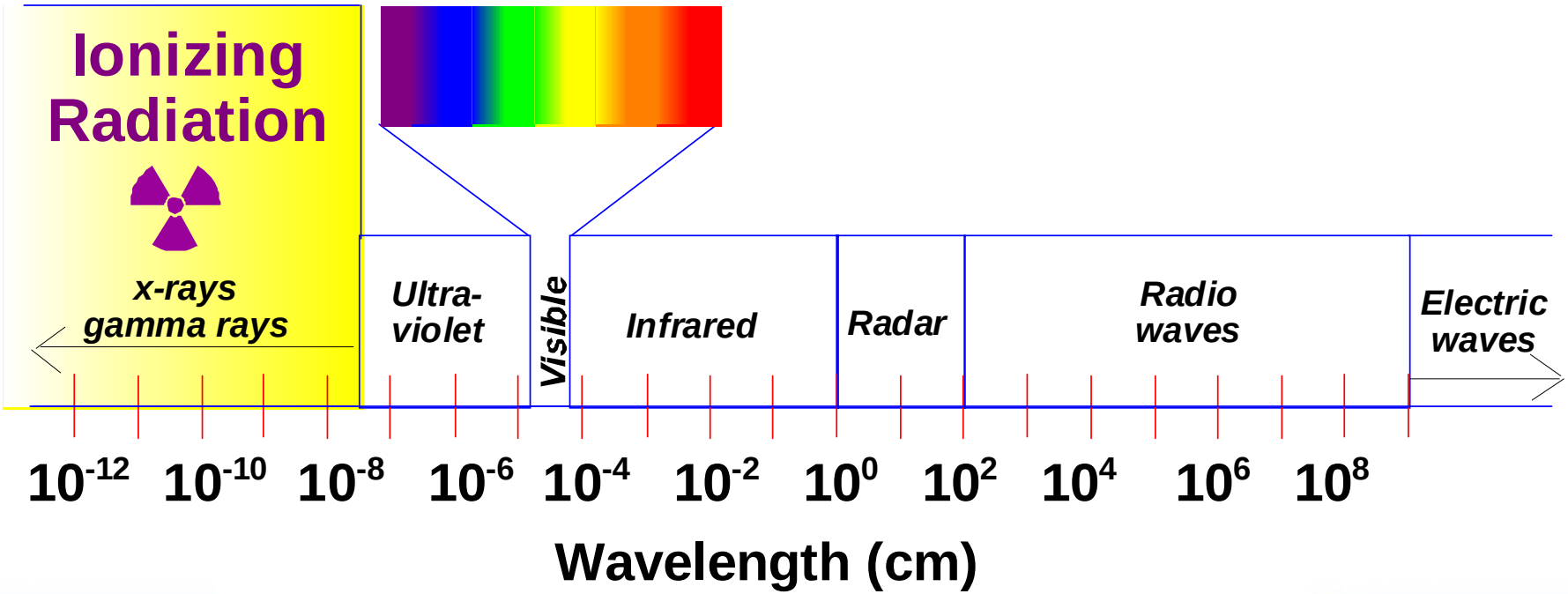
Electromagnetic Spectrum

Laser wavelengths are usually in the **Ultraviolet**, **Visible** or **Infrared Regions** of the Electromagnetic Spectrum.

The Electromagnetic Spectrum



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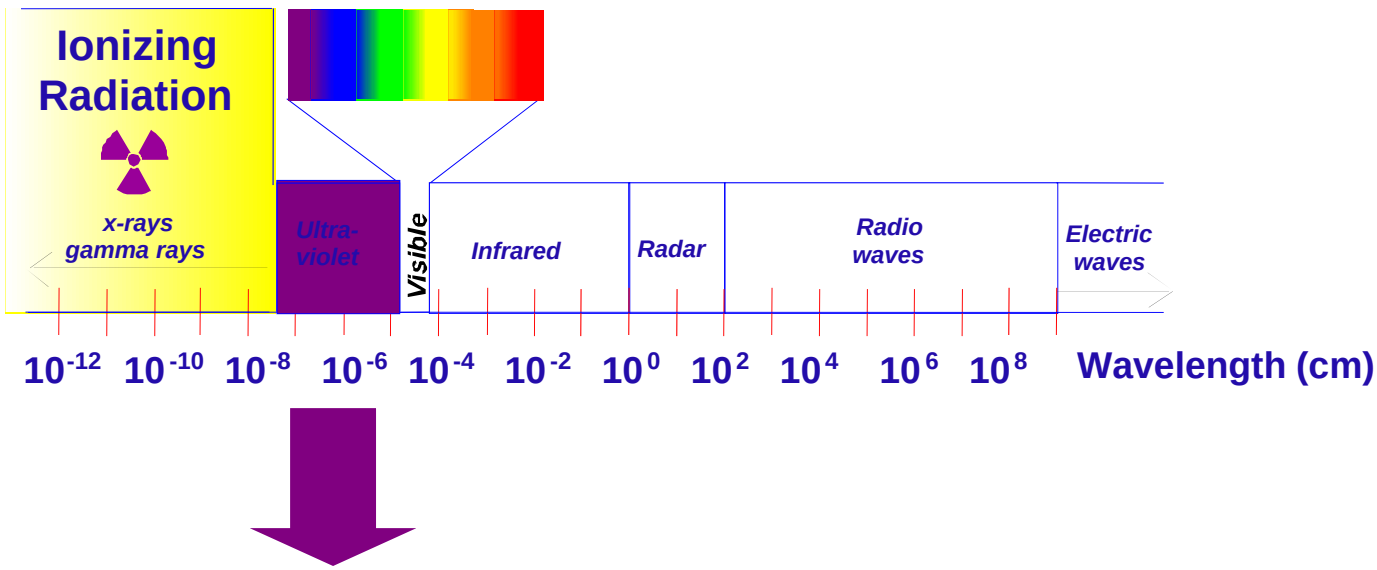
Common Ultraviolet Lasers

Ultraviolet (UV) radiation ranges from **200-400 nm**.



Common Ultraviolet Lasers						
Argon fluoride	Krypton chloride	Krypton fluoride	Xenon chloride	Helium cadmium	Nitrogen	Xenon fluoride
193 nm	222 nm	248 nm	308 nm	325 nm	337 nm	351 nm

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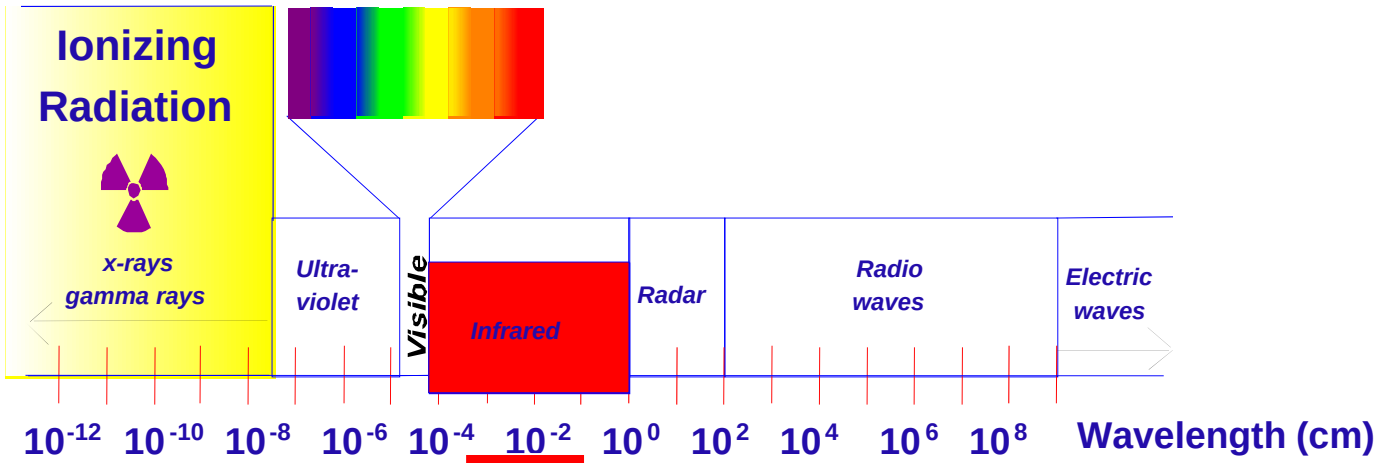
Common Infrared Lasers

Infrared radiation ranges from **760-1,000 nm**.



Common Infrared Lasers								
Near Infrared							Far Infrared	
Ti Sapphire	Helium neon	Nd:YAG	Helium neon	Erbium	Hydrogen fluoride	Helium neon	Carbon dioxide	Carbon dioxide
800 nm	840 nm	1,064 nm	1,150 nm	1,504 nm	2,700 nm	3,390 nm	9,600 nm	10,600 nm

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Common Visible Light Lasers

Violet	Helium cadmium	441 nm
Blue	Krypton	476 nm
	Argon	488 nm
Green	Copper vapor	510 nm
	Argon	514 nm
	Krypton	528 nm
	Frequency doubled Nd YAG	532 nm
	Helium neon	543 nm
Yellow	Krypton	568 nm
	Copper vapor	570 nm
	Rohodamine 6G dye (tunable)	570 nm
	Helium neon	594 nm
Orange	Helium neon	610 nm
Red	Gold vapor	627 nm
	Helium neon	633 nm
	Krypton	647 nm
	Rohodamine 6G dye	650 nm
	Ruby ($CrAlO_3$)	694 nm

The wavelength range for light that is ***visible*** to the eye ranges from **400-760 nm**.

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Laser Hazard Classes

The **ANSI Laser Safety standard** has defined ***Laser Hazard Classes***, which are based on the relative dangers associated with using these lasers.

Least Hazardous

Class 1

Class 2

Class 3a

Class 3b

Class 4

Most Hazardous

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Class 1 Lasers
(Except)

This class **cannot produce a hazardous beam** because it is of extremely low power,

or

because it has been rendered *intrinsically safe* due to the laser having been completely enclosed so that no hazardous radiation can escape and cause injury.

Example: Laser printer, CD-Rom

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Class 2 Lasers
(Low Power)

- These lasers are **visible light (400-760 nm)** continuous wave or pulsed lasers which can emit energy greater than the limit for Class I lasers and radiation power not above 1 mW.

- **This class is hazardous** only if you stare directly into the beam for a long time, which would be similar to staring directly at the sun.

- Because class 2 lasers include only visible wavelengths, the ***aversion reaction*** will usually prevent us from permanently damaging our eyes. The ***aversion reaction*** refers to our tendency to look away from bright light.

Example: Barcode Scanner

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Class 3a Lasers
(Low Power)

- This class of intermediate power lasers includes any wavelength.
- Only hazardous for **intrabeam viewing**.
- This class will not cause thermal skin burn or cause fires.

Example: Laser Pointer

Class 3b Lasers
(Medium Power)

- **Visible and near-IR lasers** are very dangerous to the eye.
- **Pulsed lasers** may be included in this class.
- This class will not cause thermal skin burn or cause fires.
- Requires a Laser Safety Officer and written Standard Operating Procedures.

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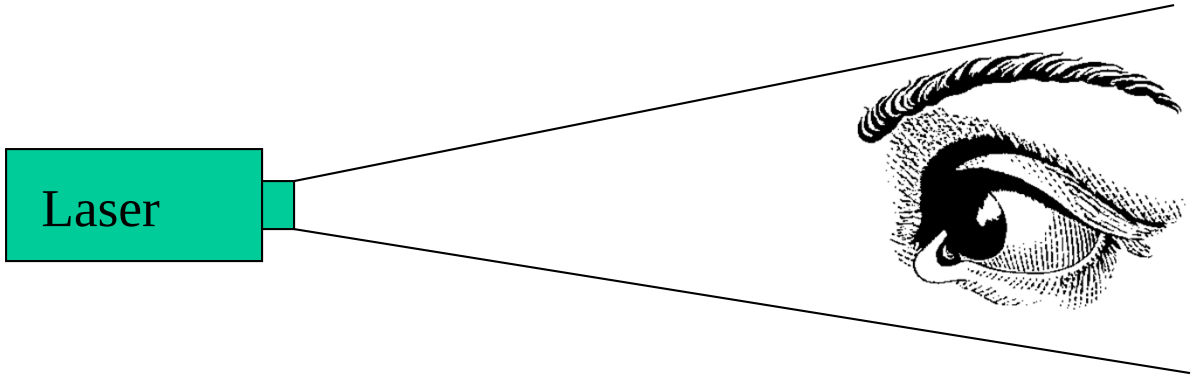
Class 4 Lasers (High Power)

- These high-powered lasers are the most hazardous of all classes.
- Even a **diffuse reflection** can cause injury.
- Visible and near-IR lasers will cause *severe* retinal injury and burn the skin. Even diffuse reflections can cause retinal injuries.
- UV and far-IR lasers of this class can cause injury to the surface of the eye and the skin from the direct beam and specular reflections.
- This class of laser can cause fires.
- Requires a Laser Safety Officer and written Standard Operating Procedures.

Direct Intrabeam Viewing



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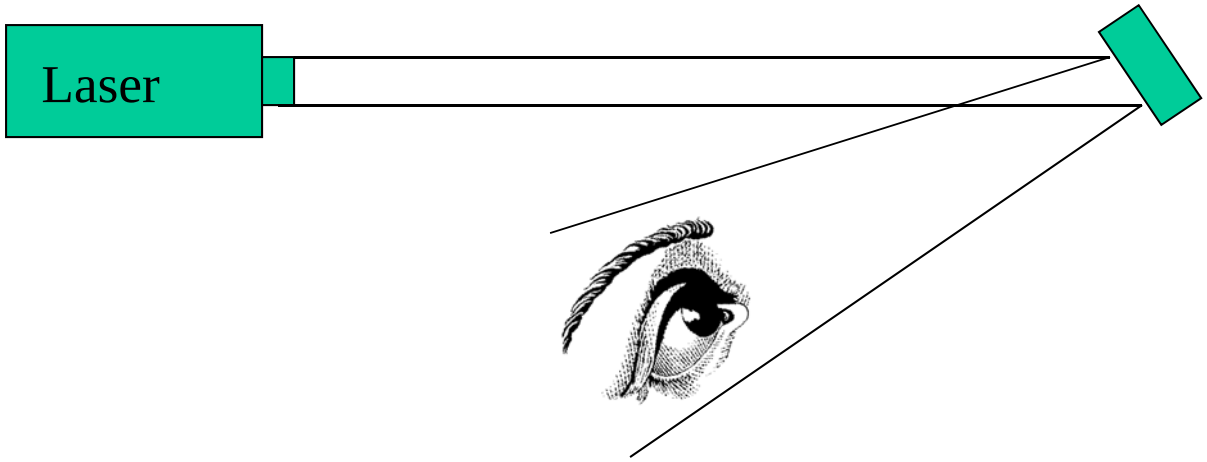
Specular Intrabeam Viewing



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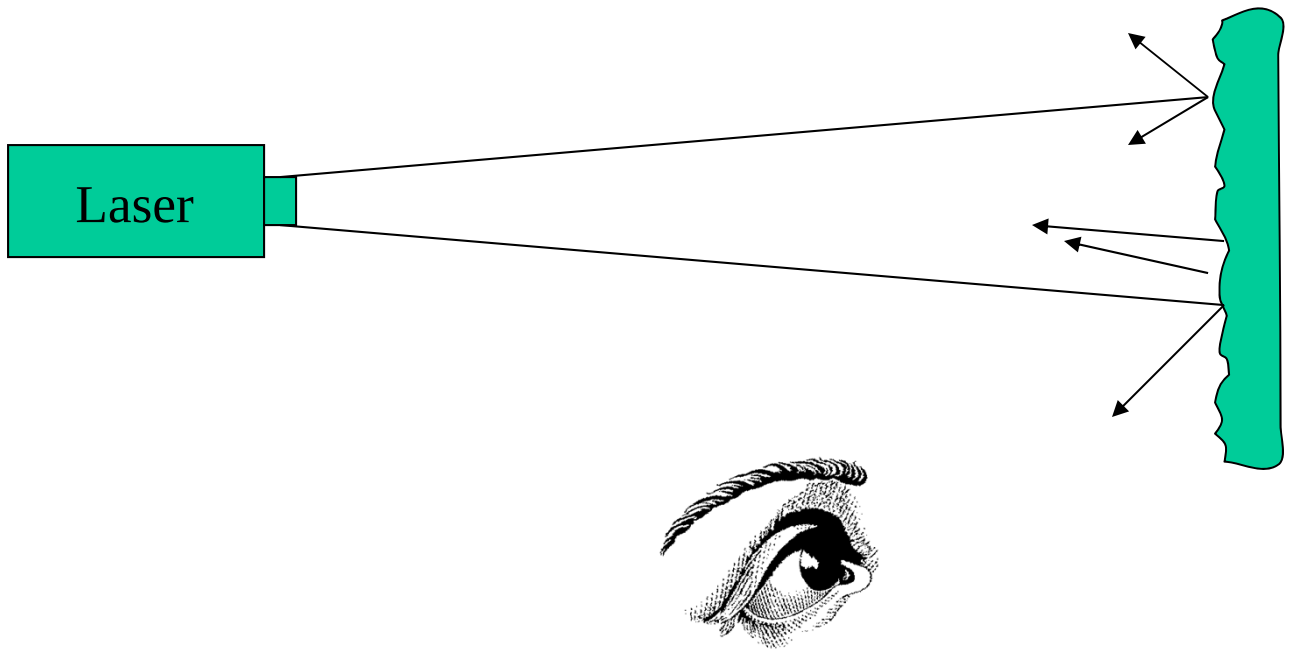
Diffuse Reflected Viewing



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PERSONAL PROTECTIVE EQUIPMENT for Skin

Personnel Protective Equipment (PPE) **for Skin** exposed to **Class 3b or 4 lasers**:

- **Ultraviolet lasers and laser welding/cutting operations** may require that **tightly woven fabrics** be worn to protect arms and hands. **Sun screen** may also be used to provide some additional protection.

- For lasers with wavelengths **> 1400 nm**, large area exposures to the skin can result in dryness and even heat stress.

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PPE for Eyes

- PPE is **not required for class 2 or 3a lasers** unless intentional direct viewing > 0.25 seconds is necessary.
- PPE **for eyes exposed to Class 3b or 4 lasers** is **mandatory**. Eyewear with side protection is best. Consider these factors when selecting eyewear:
  - Optical Density (OD) of the eyewear
  - Laser Power and/or pulse energy
  - Laser Wavelength(s)
  - Exposure time criteria
  - Maximum Permissible Exposure (MPE)
  - Filter characteristics, such as transient bleaching

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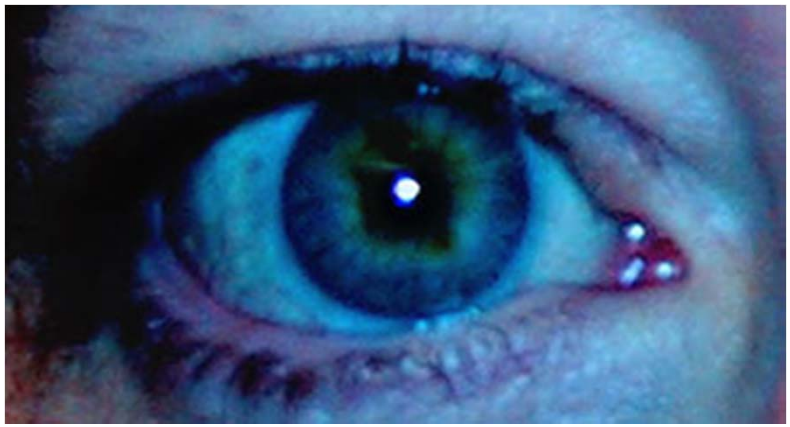
Protect Your Eyes!!!



In a fraction of a second, your vision can go dark.

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Warning Labels

Only Class 1 lasers require **no labels**. All other lasers must be labeled at the beam's point of origin.

Class 2:
"Laser Radiation – Do Not Stare into Beam."

Class 3a:
"Laser Radiation – Do not Stare into Beam or View Directly with Optical Instruments."

Class 3b:
"Laser Radiation – Avoid Direct Eye Exposure."

Class 4:
"Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation."

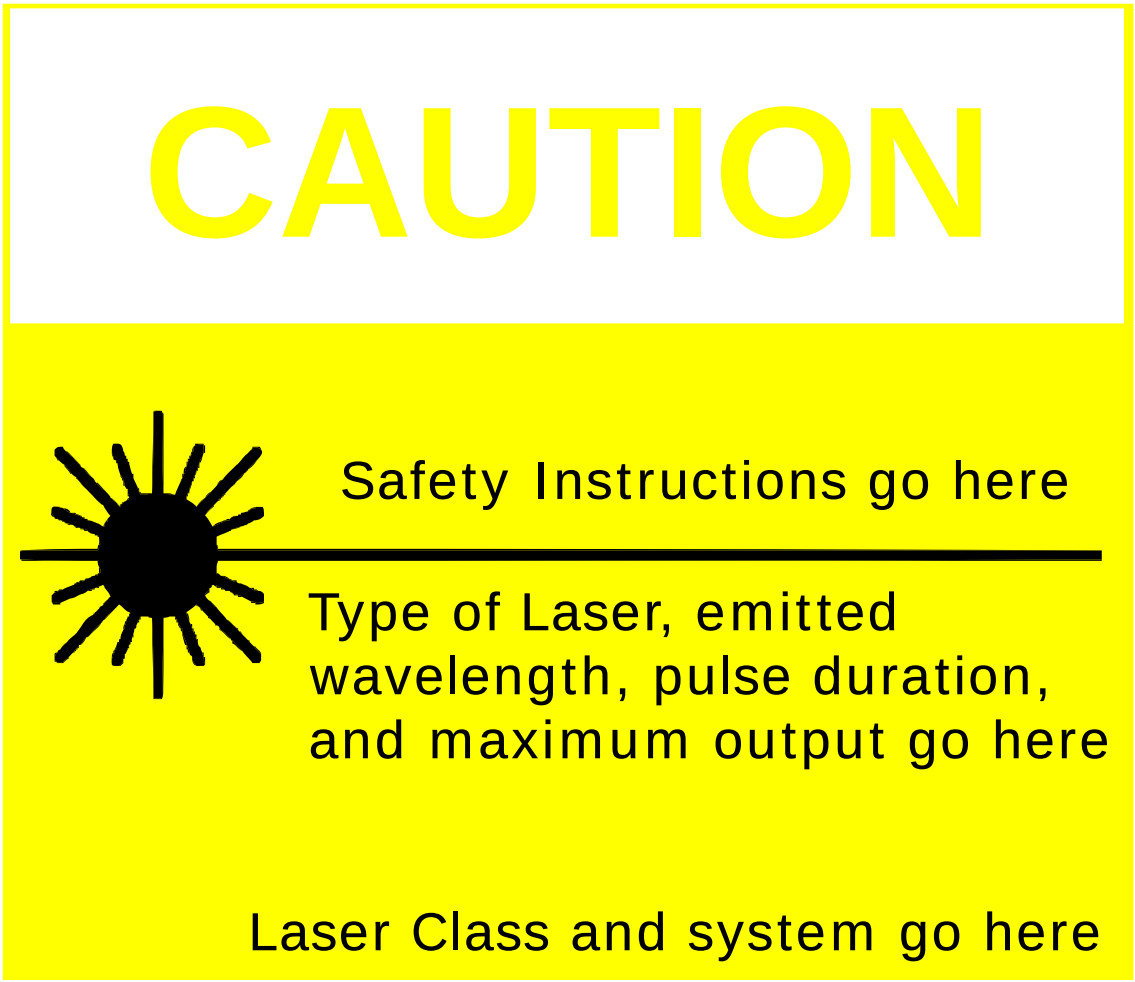
Laser Warning Signs

- "**DANGER**" indicates a very dangerous situation that could result in serious injury or death. This sign should be used **for Class 3b and 4 lasers.**

- "**CAUTION**" indicates a potentially hazardous situation which could cause a less serious injury. This sign should be used **for Class 2 and 3a lasers.**

- "**NOTICE**" does *not* indicate a hazardous situation. This sign should only be used to make people aware of facility policies regarding laser safety and/or to indicate that a repair operation is in progress.

"CAUTION" Warning Sign



Safety Instructions may include:

- Eyewear Required
- Invisible laser radiation
- Knock Before Entering
- Do Not Enter When Light is On
- Restricted Area

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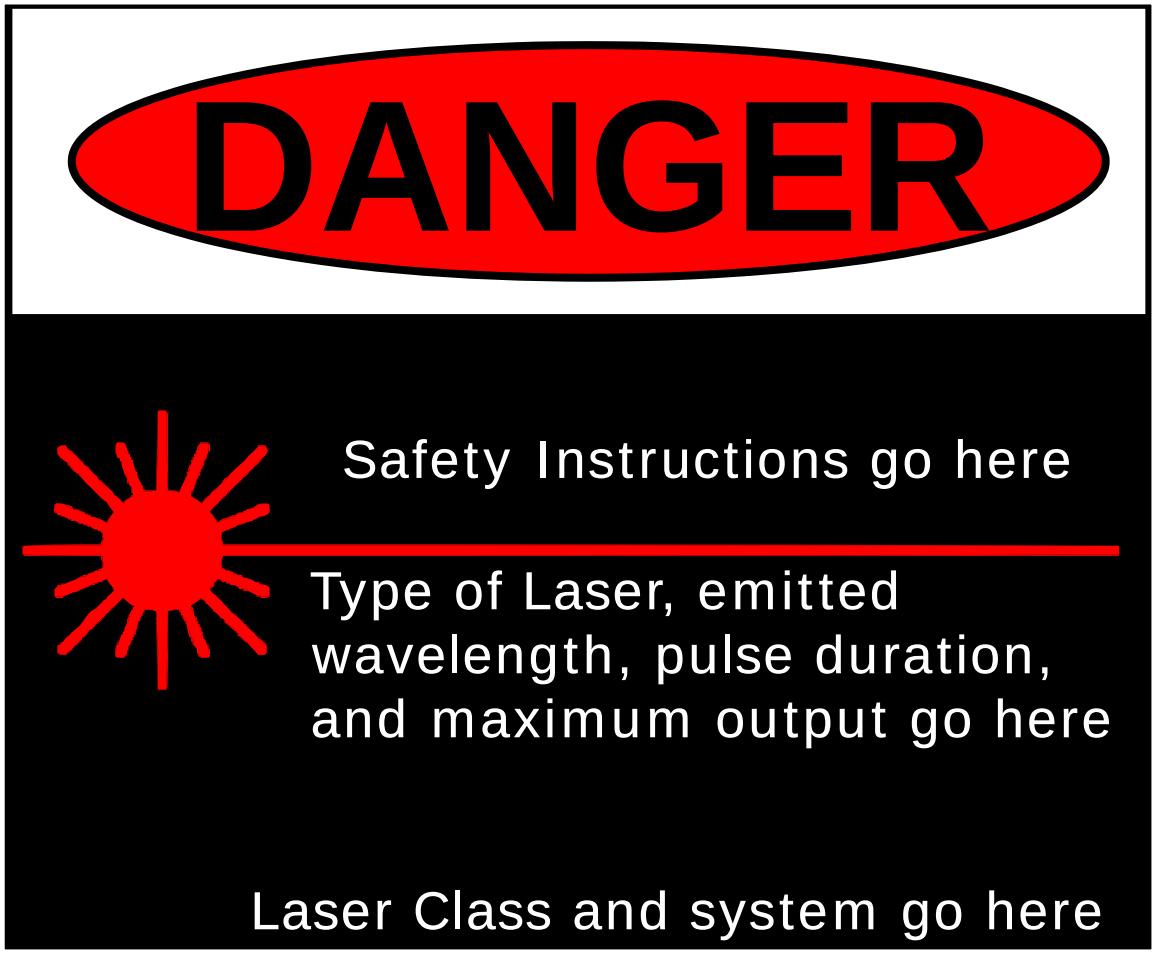
“DANGER” Warning Sign



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Nanoparticle Safety

Exposure to Nanoparticles

- The primary routes of exposure for nanoparticles are inhalation, dermal absorption, and ingestion.
- 3 forms of nano particles or materials: a powder, in suspension, or in a solid matrix.
- The form of the nanoparticles or nanomaterials plays a large role in the exposure potential. For example, a nanoparticle in powdered form will present a larger inhalation hazard potential than a nanoparticle in suspension.

Common tasks for potential exposure to nanoparticles

- Working with nanoparticles in suspension without gloves
- Working with nanoparticles in suspension during pouring or mixing where agitation is involved
- Generating nanoparticles in the gas-phase
- Handling nanoparticle powders
- Maintenance on equipment used to produce nanoparticles
- Cleaning up spills or waste material
- Cleaning dust collection systems
- Machining, sanding, grinding, or mechanically disturbing nanomaterial which can generate an aerosol.

Exposure Control Methods of Nanoparticles

Control Methods	Process, Equipment, or Job Task
Elimination	Change of Experimental Design to Eliminate the Hazard
Substitution	Substitution of a High Hazard with a Lower Hazard (chemical)
Engineering	Isolation/enclosure, Ventilation (Fume Hood)
Administrative	Work Practice Procedures, Chemical Hygiene Plan Policies
Personal Protective Equipment (PPE)	Gloves, Goggles, Clothing, Respirators

Table adopted from NIOSH document entitled, "Approaches to Safe Nanotechnology"

The ideal control method involves the **elimination** of the hazard, or the **substitution** of a less hazardous material. **If** the hazards associated with a specific nanoparticle research project **cannot be controlled with elimination or substitution**, the following control (**next slide**) options should be considered.

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Additional Controls During a Lab Scale Nanoparticle Research Project

Engineering Controls

- Additional factors that will influence the exposure risk include the quantity of material used or generated and the frequency and duration of exposure.
- Engineering controls that should be considered for use in laboratory scale nanoparticle research projects include source enclosure/isolation and local exhaust ventilation systems.
- Projects or processes involving the generation of nanoparticle aerosols and nanoparticles in suspension should be performed in a chemical fume hood, externally ducted biological safety cabinet, or glove box to limit the inhalation exposure potential.

Administrative Controls

- Providing known information to workers and students on the hazardous properties of the nanomaterial precursors or products
- Education of workers and students on the safe handling of nanomaterials
- Restricting access to areas by using signs or placards to identify areas of nanoparticle research
- Transport dry nanomaterials in closed containers
- Handle nanoparticles in suspension on disposable bench covers
- Always perform nanoparticle aerosol generating activities in a fume hood, externally ducted biological safety cabinet, or glove box
- Clean the nanomaterial work area daily at a minimum with a HEPA-vacuum or wet wiping method

PPE and Laboratory Protection

- Wear latex or nitrile gloves when handling nanoparticle powders and nanoparticles in suspension (glove changes should be performed frequently)
- Wear chemical splash goggles when working with nanomaterials in suspension or dry powdered form
- Wear lab coats. Lab coats should be laundered on a periodic basis. Do not take lab coats home for laundering
- Wear commercially available arm sleeves in situations where dermal contact with nanoparticles in powder or in suspension are expected
- Wear closed-toe shoes (if necessary cover shoes with commercially available booties)
- Consult with NJIT Health and Safety Department (NJIT-HSD: x3086 or x3059) regarding the use of respiratory protection if an inhalation exposure hazard exists. The need for and selection of an appropriate respirator should be determined by the NJIT-HSD

Decontamination and Spill Cleanup Procedures

- All spills involving nanoparticles should be treated like a hazardous material spill and cleaned up immediately.
- If the spill presents an emergency situation, evacuate the area and **dial 3111**.
- If the spill does not present an emergency situation but assistance is needed with cleanup, **contact NJIT-HSD** (x3086 or x3059) .
- Refer to the Handling and Disposal of Chemicals Guidelines for more information regarding spill cleanup procedures.

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Cryogenics Safety

What is a cryogen?

A cryogenic liquid is defined as any liquid with a normal boiling point below – 150° C (123°K). Most commonly used cryogens are nitrogen and helium.

Gas (abbreviation)	Boiling Point (K)	Expansion Ratio
Nitrogen (LN2)	77.4	694
Helium (LHe)	4.22	748

The expansion tells us that when a cryogen boils, its volume increases by a factor of about 700. This can result in high pressures that may cause explosions. Thus it is crucial to learn proper handling techniques.

Cryogen Hazards

Typical use of cryogens at the NCNR creates **three lethal hazards:**

1. The cold can cause **cold burns** – even frostbite – and hypothermia.
2. The boil-off can displace oxygen in the room, leading to **asphyxiation**.
3. The boil-off can build up pressure in a sealer container, leading to an **explosion**.

Cryogen Hazards:

Ways to expose yourself to frostbite or hypothermia

1. Directly by touching the liquid with your skin. (The low viscosity of cryogenic liquids means that they will penetrate woven or other porous clothing materials much faster than, for example, water.)
2. Indirectly by touching something cooled by the cryogenic liquid like a metal transfer line.

3. Indirectly by exposure of skin or eyes to the cold gas coming out of the pressure relief valve at the end of the transfer line.

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Cryogen Hazards: Frostbite

Symptoms:

- Frostbite changes color of the skin to gray or white, possibly followed by blistering
- Deep tissue freezing generally indicated by a waxy and possi bly a yellow appearance to the skin.

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Cryogen Hazards: Explosions

Ways to cause an explosion:

- By sealing any pressure relief valves on a cryogenic sys tem or dewar.
- By leaving a LHE or LN2 dewar transfer valve open such that as the initial boil-off decreases, air can get into the dewar and freeze solid, resulting in a plug inside the dewar.
- This prevents the pressure relief valves from working, resulting in a slow build-up of pressure!

Cryogen Hazards: Explosions

More on Ice Blockage:

- You must take all precautions to prevent air having any chance to get inside a cryostat or Dewar.
- Water in the air can freeze and form a block inside the neck at a point where the temperature is 0°C, trapping liquified air below it.
- When this liquified air boils, pressure builds (remember our expansion ratio of ~700?)

  it can cause the stick to be forcefully ejected, or in extreme cases can cause the dewar or cryostat to explode.

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Cryogen Safety:

Control Measures to Mitigate Hazards Associated with Cryogens

Engineering Control:

- ✓ Pressure Relief Valves
- ✓ Insulation
- ✓ Ventilation

Administrative Control:

- ✓ Training
- ✓ PPE (safety glasses, closed-toe shoes)

Note on PPE:

Insulated gloves are optional, but it is highly recommended that you have them within easy grabbing distance.

When you do discover that you need gloves, you need them NOW.

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Cryogen Safety: Transferring

Nitrogen:

Do:

- use a metal line
- wear safety glasses

Don't:

- use a latex line
- Wear open-toe shoes

Helium:

Do:

- open relief valve when finished, close other valves.
- wear safety glasses and proper shoes.
- Vent dewar and cryostat before transferring
- Pressurize with dry He gas.

Don't:

- forget to tighten fill port on cryostat when done
- mistreat delicate transfer lines
- Pressurize more than 8 psi
- Stand in vapor cloud.

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Cryogen Safety:

Warning signs of a damaged dewar or cryostat:

- Continuous venting from a vent valve is not normal. It could mean there is dirt in the vent valve or it is damaged.
- Sweat or Frost at the bottom or sides of a dewar or cryostat is an indication of a faulty or damaged vacuum jack et.

If you discover a dewar or cryostat in this state, contact the NJIT-Police (3111) immediately as an emergency situation.

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Cryogen Safety:

What to do in the event of Suspected Asphyxiation:

Symptoms:

The effect of oxygen deficiency resulting from simple asphyxiant (e.g. nitrogen or helium gas) may include:

- ✓ rapid or gasping breathing,
- ✓ fatigue,
- ✓ diminished mental alertness,
- ✓ impaired muscular coordination,
- ✓ faulty judgment,
- ✓ and depression of all sensations.

As asphyxiation progresses, symptoms include:

- ✓ nausea,
- ✓ vomiting,
- ✓ prostration,
- ✓ loss of consciousness may result, eventually leading to:
- ✓ convulsions,
- ✓ coma,
- ✓ and death.

Cryogen Safety:

What to do in the event of Suspected Asphyxiation:

Asphyxiation: (generally caused by rapid evaporation of liquid)

1. Rescue:
   - If possible (oxygen monitors register >19.5% O2 content in room), remove worker to air with known oxygen content of 20.9%, but do NOT enter the area alone!
   - If oxygen monitors register <19.5% O2 content, contact emergency services to initiate rescue with self-contained breathing apparatus.
2. Contact emergency services for immediate medical attention.
3. If not breathing, give CPR (if qualified).
4. A physician should see the patient promptly as supplemental oxygen may be required (especially if breathing is difficult).

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Cryogen Safety:

What to do in the event of Frostbite:

Frostbite to EYEs:

(generally caused by rapidly evaporating liquid)

1. Remove worker from the source.
2. Contact emergency services and seek immediate medical tr eatment.
3. Open eyelids wide to allow the liquid to evaporate.
4. Flush affected area with copious quantities of cold/lukewar m (unheated!) water for 15 minutes.

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Cryogen Safety:

What to do in the event of Frostbite:

Frostbite to SKIN:

(generally caused by contact with liquid or metal refrigerated by LHe or LN2. In the latter case, the skin can stick to the metal and can tear when pulled away.)

1. Contact emergency services for immediate medical attention if contact with the fluid has resulted in blistering or deep tissue freezing or a reduction in body temperature.
2. Remove contaminated clothing. (This must be done carefully to prevent salvageable skin from being pulled off.)
3. Remove clothing that may interfere with circulation of blood to affected area.
4. Flush affected area with copious quantities of lukewarm (unheated!) water for 15 minutes.
5. DO NOT USE HOT WATER!
6. DO NOT USE DRY HEAT!
7. DO NOT RUB (to prevent further damage to skin)!
8. DO NOT APPLY ANY OINTMENTS!
9. Once area has thawed, cover with dry sterile bandages and a large bulky protective covering until paramedics arrive. (This will help prevent further damage to area and infection.)
10. If a large area has been exposed (such that the body temperature is reduced), then wrap worker in blankets and wait for paramedics arrive.

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Cryogen Safety:

What to do in the event of **Ice blockage**:

Do Not try to fix it and contact the **NJIT-Campus Police** as an emergency situation.

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Cryogen Safety:

What to do in the event of **Explosion**:

If you are still alive, **vacate** the building
and **call** the NJIT-Police (**3111**).

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Cryogen Hazards:

In Conclusion,

- they can freeze you
- they can suffocate you
- they can cause explosions

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