LABORATORY SAFETY

IESL-FORTH

Petros Samartzis

9/12/2022

http://safety.iesl.forth.gr

COVID-19

- Virus contracts through airborn droplets
  - Droplet source: nose, mouth
- Protection:
  - Vaccinate
    - **Weekly tests for non-vaccinated**
  - Distance: **>1.5m**
  - Masks**:** Recommended if crowded
  - Hygiene:
    - Wash hands (20’’ minimum)
    - Don’t touch nose

https://safety.iesl.forth.gr/index.php/home/covid-19/

LABORATORY SAFETY

- GENERAL LAB SAFETY
- EARTHQUAKE SAFETY
- FIRE SAFETY
- ELECTRICAL SAFETY
- CHEMICALS & WASTE HANDLING
- PRESSURE SAFETY (HIGH & VACUUM)
- LASER & X-RAYs SAFETY
- CRYOGENICS SAFETY

LABORATORY SAFETY

GENERAL LAB SAFETY

RULE NUMBER ONE:

SAFETY

IS OUR FIRST

PRIORITY

GENERAL RULES

- YOU are responsible for your safety
- Safety training mandatory before working in the lab
  - Lab-specific training by PI/Group Safety Officer
- Use of appropriate safety equipment is mandatory in the laboratories: get familiar with them
- Consider SAFETY when designing an experiment
- Avoid working alone in the lab
- Keep labs clean and tidy
- No access of un-authorized personnel in the laboratory (especially kids)
- No food & drinks in the lab
- Use common sense
- If in doubt, ASK!

SAFETY CONTACTS

- Group/Activity Safety Officer
  - Principal Investigator/Safety Officer
- Division Safety Officer
  - Lasers: Petros Samartzis (x1467)
  - Materials: Benoit Loppinet (x1465)
  - Microelectronics: Ilias Aperathitis (x4123)
  - Comp. Center: Vassilis Kirkinis (x1815)
- IESL Safety Officer: Petros Samartzis
  - Office: Γ260 – Phone: x1467
  - Lab: B217 – Phone: x1333
  - Email: sama@iesl.forth.gr

Emergency Phone Numbers

ΤΗΛΕΦΩΝΑ ΑΜΕΣΗΣ ΑΝΑΓΚΗΣ – EMERGENCY PHONES

Πύλη ΙΤΕ (Φύλακας)	-1111	FORTH gate / Security
Υποδοχή	-1168	Reception
Πυροσβεστική	199*	Fire Department
Αστυνομία	100*, 2810-282316*	Police
ΕΚΑΒ	166*	Emergency (Ambulance)
ΠΕΠΑΓΝΗ	2810-392111*	University Hospital
Βενιζέλειο	2813-408000*	Venizelio Hospital
Τεχνική Υπηρεσία	-1094, -1095, -1455 -1574, -1570	Technical Service Department

Γραμμή άμεσης ανάγκης: 112 (κινητό ή σταθερό) - Emergency number: 112 (mobile or fixed* phones)*
**Για εξωτερική γραμμή πρώτα το 9 (Dial 9 to get an outside line)*

Monday to Friday 08.00-15.30 ***Available 24/7***

Lab Phone Numbers

ΕΡΓΑΣΤΗΡΙΟ (LABORATORY) : Β-123 (tel: -1234)

ΥΠΕΥΘΥΝΟΙ ΕΡΓΑΣΤΗΡΙΟΥ : α) Δρ. Α. Υπεύθυνος — *a) Dr. A. Ypeythinos*
LAB SAFETY OFFICERS β) Καθ. Β. Υπεύθυνος — *b) Prof. B. Ypeythinos*
Τηλέφωνο (Tel.) : α) -1234 γρ. *(office)*, 6944123456 κινητό *(mobile)*
β) -1234 γρ. *(office)*, 6944123456 κινητό *(mobile)*

ΥΠΕΥΘΥΝΟΣ ΑΣΦΑΛΕΙΑΣ ΤΟΜΕΑ (ΟΝΟΜΑ_ΤΟΜΕΑ): Δρ. Ο. Επίθετο
DIVISION *SAFETY OFFICER (DIVISION_NAME)* *Dr. N. Lastname*
Τηλέφωνο (Tel.) : -1234 γρ. *(office)*, 6944123456 κινητό *(mobile)*

ΥΠΕΥΘΥΝΟΣ ΑΣΦΑΛΕΙΑΣ ΙΝΣΤΙΤΟΥΤΟΥ (ΙΗΔΛ): Δρ. Π. Σαμαρτζής
INSTITUTE *SAFETY OFFICER (IESL)* *Dr. P. Samartzis*
Τηλέφωνο *(Tel.)* : : -1467 γρ. *(office)*, 6946280983 κινητό *(mobile)*

ΕΠΙΚΙΝΔΥΝΟΤΗΤΑ – HAZARDS:

Λέϊζερ (LASERS)*:* P-UV EXCIMER: 248 nm; 193 nm, CW-VIS HeNe: 632 nm, P-UV Nd-YAG: 355 nm
*P=pulsed, CW=continuous, **all lasers CLASS IV**

ΧΗΜΙΚΑ: οργ. διαλύτες (μεθανόλη, αιθανόλη), χρωστικές λέιζερ, ορυκτέλαια αντλιών
CHEMICALS: *org. solvents (methanol, ethanol), laser dyes, pump oil*
ΑΕΡΙΑ *(GASES)*: He, Xe, N_2, F_2 (4 φιάλες *(4 cylinders)*)
ΑΝΤΛΙΑ ΔΙΑΧΥΣΕΩΣ *(DIFFUSION PUMP)*

Safety Incident

In Case of an Incident

- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel

- **<u>USE COMMON SENSE</u>**

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A message from Technical Service

Don’t abuse building facilities

LABORATORY SAFETY

EARTHQUAKE SAFETY

Before an Earthquake

- Secure cabinets, shelves, gas cylinders, heavy equipment to the wall or to the ground
  - Special attention to dangerous chemicals
- Designate earthquake "go-to" areas in your workspace:
  - Under a door frame or a desk
  - Away from windows, outer walls, glass surfaces, heavy equipment
- Heavy objects should be on OR close to the ground
- Don't block corridors inside and outside the labs
- Memorize possible escape routes

During an Earthquake

- **Keep calm** & assess the situation
  - Monitor wall structure for cracks/damage and room environment for falling objects
- **Turn off risk-posing equipment**: lasers, ovens, HV power supplies
- Close any open **gas cylinder valves**
- Seek cover under a desk or door frame
  - Do NOT go under laser tables; Legs may give up.
  - Keep away from heavy equipment
  - **DO NOT RUN AWAY**

After an Earthquake

- Attend to wounded people only if you are not in danger
- Check building for structural damage and fallen objects
- If there is structural damage, evacuate building
  - Use stairs (NOT elevators)
  - Go to an open space
- Do not enter buildings that have cracks/structural damage
- Be prepared for aftershocks

LABORATORY SAFETY

FIRE SAFETY

Before the Fire

- Check **fire escape routes**
  - Memorize how to leave the lab in case of emergency
- Locate closest **fire alarm** and **fire extinguisher**
- Check that your fire extinguisher works for the materials you use
- Keep flammable materials as away from heat, fire and electricity as possible
- Don’t block corridors inside and outside the labs
- **No smoking!**

In Case of a Fire

- Keep calm & assess situation
- **Activate fire alarm – Call for help**
- In danger: Leave immediately
  - Intervene ONLY if not in danger
- Intervene only if you know what you are doing
  - Priority 1: Injured people
  - Priority 2: Put out the fire
    - Use the **correct** fire extinguisher
- Do not open windows/doors
- NO WATER ON ELECTRICAL FIRES

LABORATORY SAFETY

ELECTRICAL SAFETY

ELECTRICAL HAZARDS

- Sources
  - Regular/generator electrical lines and outlets
  - UPS electrical lines and outlets (red OR labeled “UPS”)
  - Equipment (e.g lasers, vacuum pumps, computers)
  - High voltage power supplies
- Hazards
  - Electrocution
  - Electrical Fires

ELECTRICAL SAFETY PRACTICE

- **Do NOT use back to back power strips**
- **Keep cables OFF the floor**
- Keep water away from electrical equipment
  - Water low – electricity high
- Beware of BARE cables
- Follow specifications
- Ground appropriately
- **DON'T** try to repair equipment
- Turn OFF power supply before touching "hot" parts
- **If in doubt, ASK!**

In Case of an Electrical Incident

- **Remain calm!**
- **Assess the situation**
- Cut off power supply (panel may be outside the lab)
- **No water** on electrical fires
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

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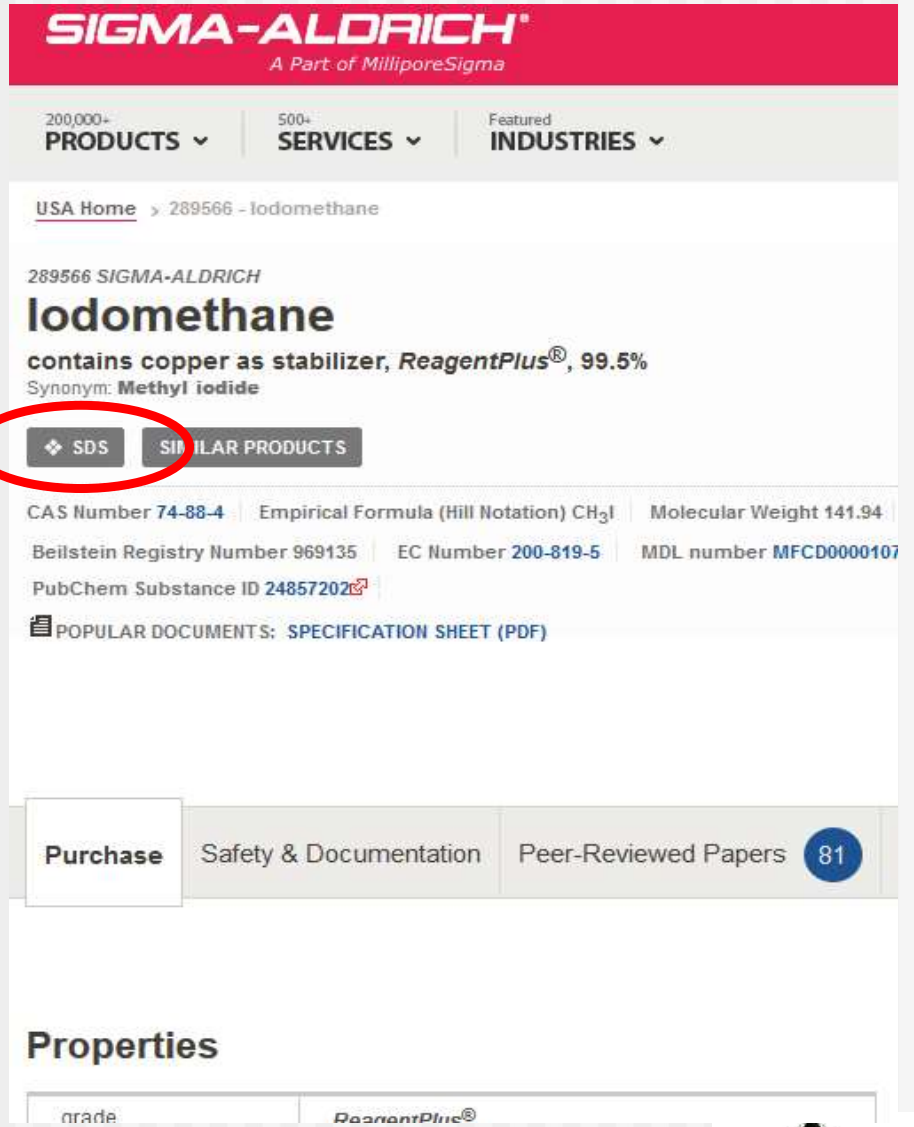
CHEMICAL SAFETY & WASTE HANDLING

LAB CHEMICALS

- **Flammable**: e.g. organic solvents, H_2
- **Explosive**: e.g. acetylene, azides
- **Pyrophoric**: e.g. phosphor
- **Toxic**: e.g. chlorine, methyl iodide
- **Corrosive**: e.g. strong acids & bases
- **Carcinogenic**: e.g. benzene

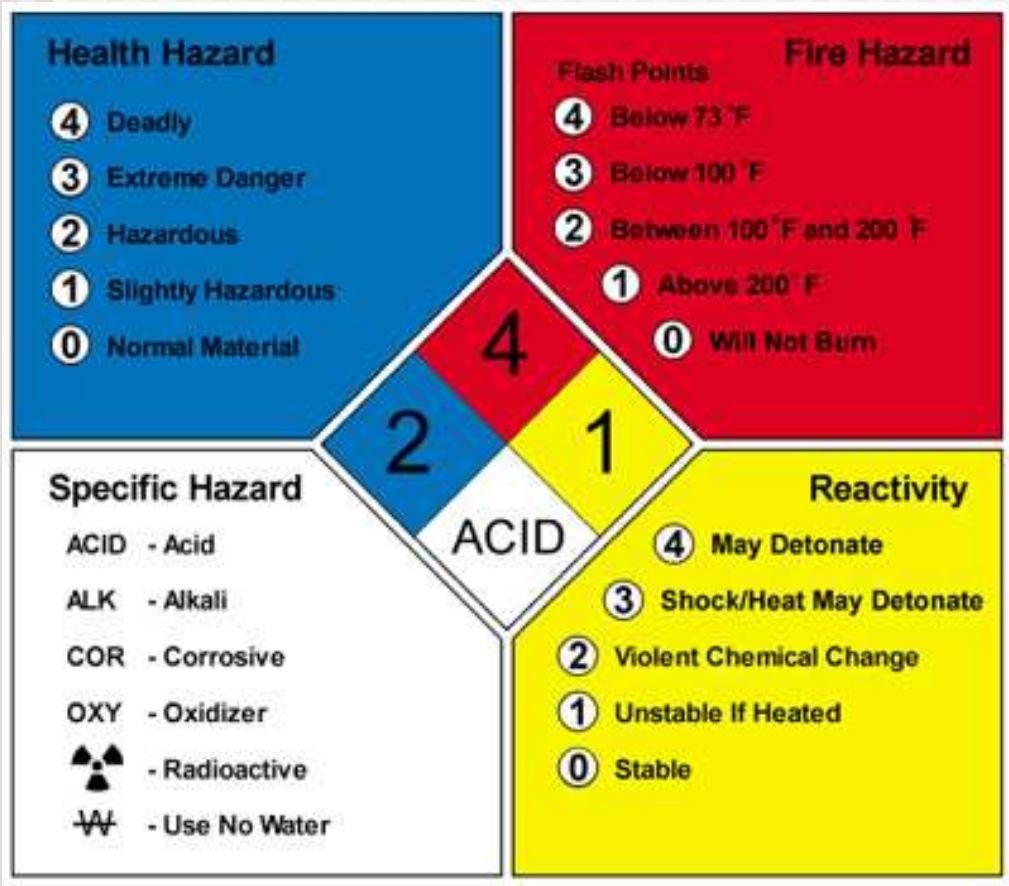
Material Safety Data Sheets (MSDS)

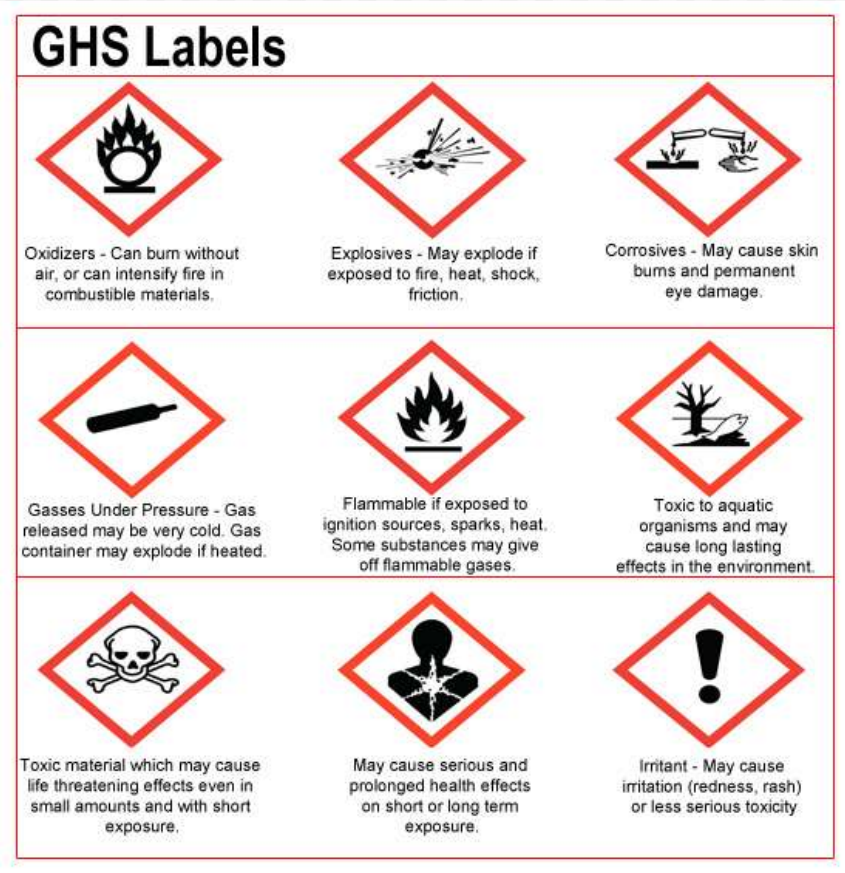
- **Physical & Chemical properties**
- **Hazards**: Physical, Heath, environmental
- **First Aid & symptoms**
- **Fire fighting info**
- **Accidental release measures**
- **Safe handling and storage**
- **Disposal & transport info**
- **Exposure control & prevention**
- **Reactivity & stability**
- **Toxicological and ecological info**



All manufacturers are required to provide MSDS

Different labeling systems





www.nfpa.org

https://www.osha.gov/dsg/hazcom/pictograms/index.html

CHEMICAL SAFETY RULES I

- Design your experiment carefully
  - Use smallest quantities allowed
- **Study Material Safety Data Sheets**
  - Where/how to store: Fridge? Cabinet?
  - Where/how to use: Hood? Air sensitive?
  - How to transport: Shock sensitive?
  - How to dispose: Compatible? Sensitive?
- Use **APPROPRIATE** protective equipment
  - Gloves, lab coats, masks, goggles, hoods, glove box, inert environment,…
  - Lab coats: no wash if you use dangerous chemicals

CHEMICAL SAFETY RULES II

- Use **APPROPRIATE** protective equipment
  - Gloves, lab coats, masks, goggles, hoods, glove box, inert environment,…
  - Lab coats: no wash if you use dangerous chemicals
- **Store appropriately (MSDS)** if not in use
- Use appropriate **transport protection equipment & practices**
  - Rubber buckets, cardboard boxes, containers
  - Do not hold containers from lids

CHEMICALS TRANSPORT

LABEL APPROPRIATELY

- Chemical name or formula
- Owner/lab
- Phone
- Date

If not properly labeled, your containers will be treated as waste

BASIC WASTE HANDLING

- Follow **MSDS** instructions for disposal
- Follow/establish **lab rules** related to waste
- Sink: only for some salts, acids & bases if NEUTRALIZED and DILUTED with plenty of water
  - Sink if you can drink
- Liquid: organic (halogenated/non-halogenated), water solutions, inorganic salts, pump oil, …
- Sharps/solid waste go to "**Solid Waste**", NOT "normal" trash
- Storage Space: Lab/Group → Facility → Pickup
- Label your waste containers when first drop is in
- **If in doubt, ASK!!!**

In Case of a Chemical Incident

- **Remain calm!**
- **Assess the situation**
  - Spill, glassware breaking, explosion, fire,…
- Call for help
- Seek medical attention
- Contact safety personnel

- **USE COMMON SENSE**

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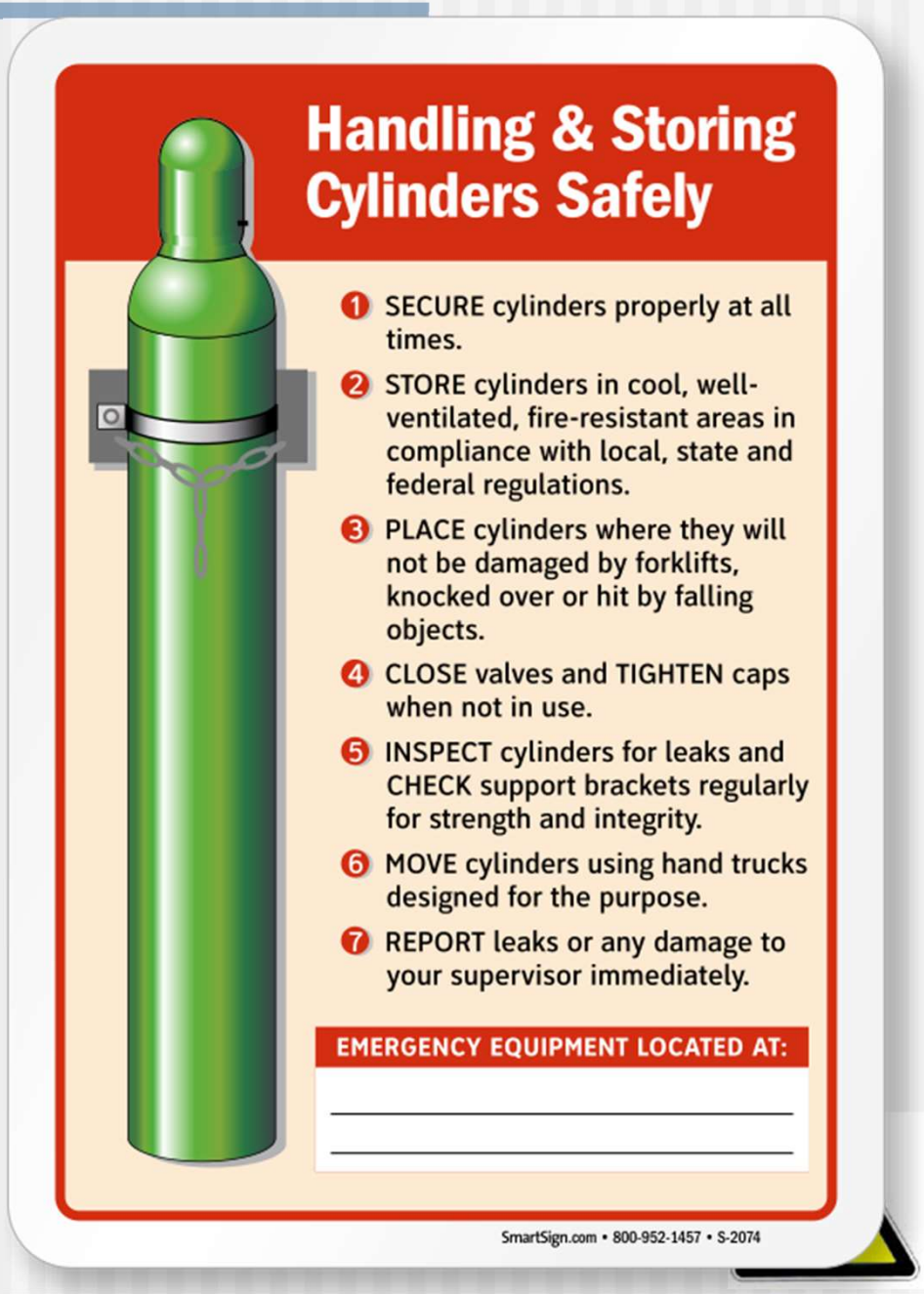
HIGH PRESSURE & VACUUM SAFETY

PRESSURE SAFETY PRACTICE

- **Secure gas cylinders** on **wall/heavy** tables **correctly**
- **Always** use appropriate regulator
- Move gas cylinders safely
  - Do **NOT** hold it by the valve or regulator
  - Leak-check gas/vacuum lines/chambers safely
- Beware of vacuum implosions
- Beware of pressurized cooling water network
  - Water low – electricity high
- Report any problems
- **If in doubt, ASK!**



IESL cylinder 2019

In Case of a Pressure Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

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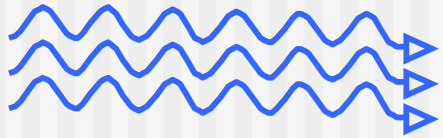
LABORATORY SAFETY

LASER SAFETY

IESL LASER SOURCES

- Solid state (Nd:YAG: 1064/532/355/266 nm, TiSapph: 800 nm)
- Gas lasers (HeNe: 632.8 nm)
- Excimer (KrF:248 nm, ArF:193 nm, XeCl:308 nm)
- Dye lasers (220-800 nm)
- Diode lasers (e.g. femto lasers pump units)



Coherence,
Monochromaticity,
Directionality

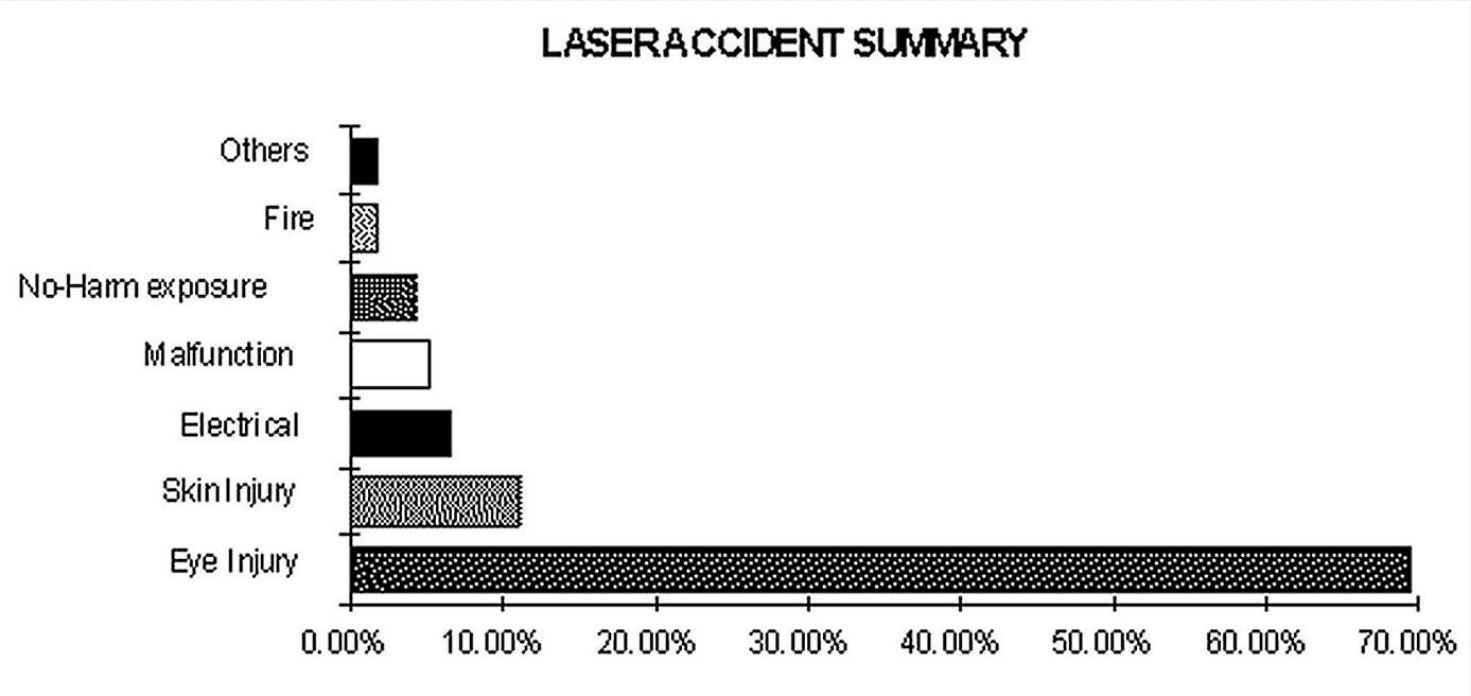
LASER CLASSES

- **CLASS 1** harmless
- **CLASS 2** visible radiation
  momentary exposure (0.25s)
- **CLASS 3** 3a (1 – 5 mW)
  3b (5- 500 mW)
  no direct exposure
- **CLASS 4** Pulse or cw (>500 mW)
  Extremely hazardous

ALL lasers in IESL labs are CLASS 4

LASER ACCIDENT STATISTICS

Laser accidents (USA, 1964-1992)



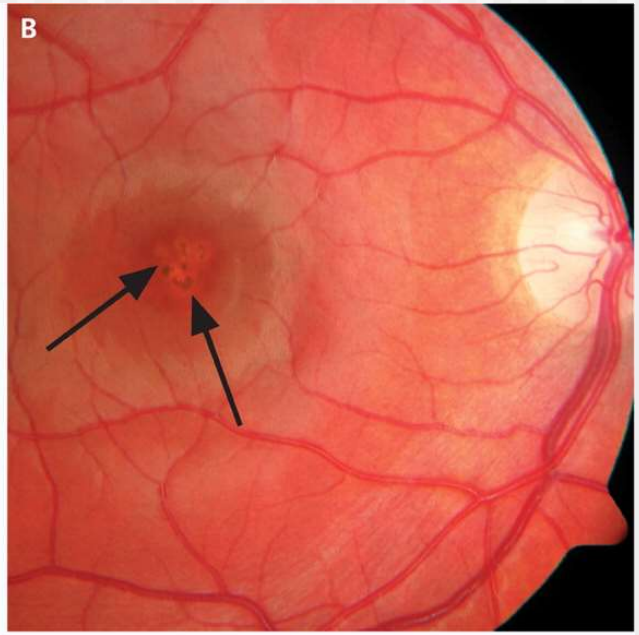
Most accidents involve eye injuries

http://www.adm.uwaterloo.ca/infohs/lasermanual/documents/section11.html

LASER RADIATION DAMAGE

- **EYES**

150 mW
green laser pointer
(532 nm)



http://www.nejm.org/doi/full/10.1056/NEJMc1005818#t=article

- **SKIN**

5W/cm^2 for 1 sec
CO_2 laser
(10,6 μm)

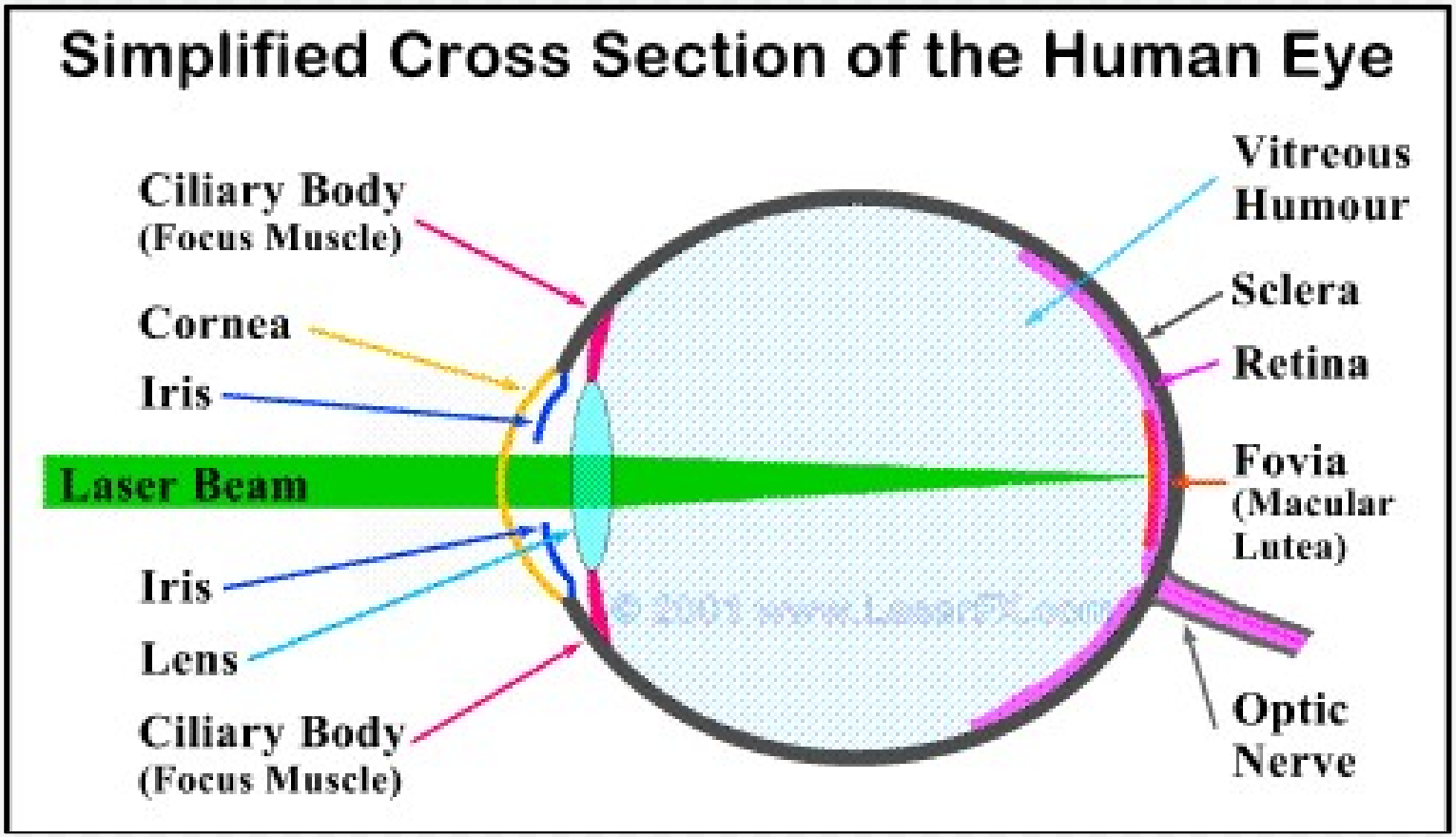
http://www2.lbl.gov/ehs/safety/lasers/bioeffects.shtml

LASER PARAMETERS I

- Emission wavelength (UV, Visible, IR)
- Output power/energy (mW-W, nJ-kJ)
- Pulse duration (cw, ns, ps, fs)

Band		Wavelength
Ultraviolet (UV)	**UV-C**	**200 – 280 nm**
	UV-B	**280 – 315 nm**
	UV-A	**315 – 400 nm**
Visible (VIS)		**400 – 700 nm**
Infrared (IR)	**IR-A**	**700 – 1400 nm**
	IR-B	**1400 – 3000 nm**
	IR-C	**3000 – 1 mm**

LASER vs HUMAN EYE



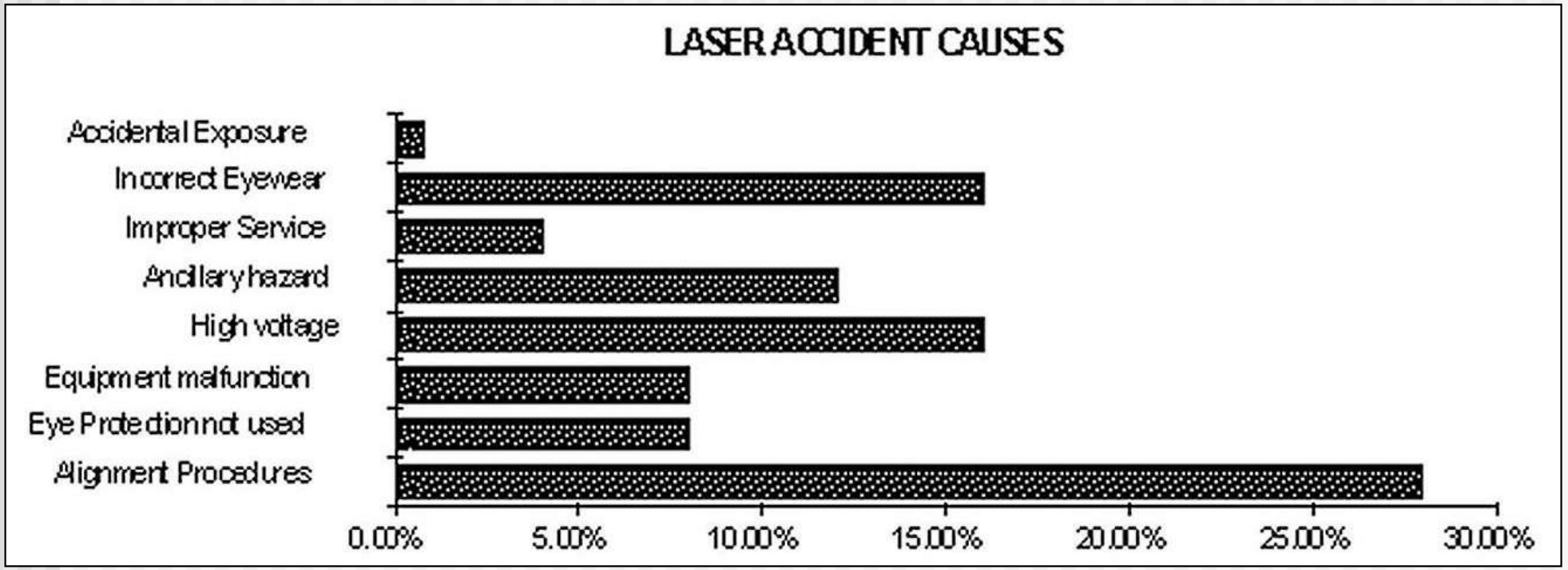
Cornea (κερατοειδής) : 1400 nm – 1mm & 180 nm – 315 nm

Lens (Φακός): 315 nm – 390 nm & 700 nm – 3000 nm (sel.)

Retina (αμφιβληστροειδής): 400 nm – 1400 nm

LASER ACCIDENT CAUSES

Cause of Laser accidents (НПА, 1964-1992)



Most accidents take place during beam alignment or/and because no proper eyeware was used

http://www.adm.uwaterloo.ca/infohs/lasermanual/documents/section11.html

REFLECT ON THIS

Small fraction (4%) of pulsed laser beam, diameter 2 mm, with energy of 2.5 mJ/pulse, reflected from a piece of optic has energy density of :

$$(0.04 \times 2.5\ \text{mJ})/(\pi \times (0.1)^2\ \text{cm}^2) = 3.2\ 10^{-3}\ \text{J}/\text{cm}^2$$

This exceeds the damage threshold of the cornea ($\sim 10^{-7}$ J/cm^2) by a factor of $3.2\ 10^4$.

Protection for this level of exposure requires the use of appropriate laser eye-ware with optical density at the laser wavelength :

$$(\text{OD}) = \log(3.2\ 10^4) = 4.5$$

LASER SAFETY PRACTICE

- **USE APPROPRIATE LASER PROTECTION EQUIPMENT**
  - **GOGGLES**
  - **LAB COATS**
- **NEVER look directly at the laser beam**
- **Beware of & minimize/block REFLECTIONS**
- **Always know where your beam (and reflection) is**
- **Keep experiment WAY BELOW eye level**
- **Protect others around you**
  - **Laser light ON**
  - **Use protective panels**
- **If in doubt, ASK!**

In Case of a Laser Incident

- **Remain calm!**
- **Assess the situation**
- Call for help
  - Turn laser off if you can
- Seek medical attention
- Contact safety personnel
- File an accident report

- **USE COMMON SENSE**

X-rays: XRD special rules

- Main X-ray source: XRD
- Training in using XRD safely
- Use of dosimeter is **MANDATORY**
  - **No dosimeter – No XRD**
- Keep your dosimeters near the XRD – not at the office or in the pocket
- Wear it on the way in, leave it on the way out
- New dosimeter each month
- If dosimeter not needed notify IESL secretariat (Lia)

CRYOGENICS SAFETY

CRYO HAZARDS

- Explosion
- Frostbites
- Asphyxiation
- Burns
- Fire (liquid O_2)

http://ehs.ucsf.edu/cryogenic-liquids

CRYO SAFETY PRACTICE

- **Use appropriate handling equipment**
  - Gloves, apron, mask
- **DO NOT TOUCH** cold containers with bare hands
- Vent containers appropriately
- Do not play with cryo-liquids
- L. O_2: no flame/heat/fuel
- Learn how to use cryo-equipment (valves, dewars, hoses) safely
- **If in doubt, ASK!**

In Case of a Cryogenics Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel

- **USE COMMON SENSE**

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Location of First Aid Kits

- **Policy: One in every floor**
- **FORTH Main Building (B)**
  - Basement: **Near gas storage room**
  - Ground Floor: **Near main entrance**
  - 1st floor: **Meeting room**
- **STEP C: Basement, Ground floor**
- **Microelectronics: Kitchen**
- **FORTH Building C:**
  - Main Secretariat
  - Magda's Office
  - Comp. Center

LABORATORY SAFETY

ANY QUESTIONS?

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LABORATORY SAFETY quiz 1

- **Who is responsible for Safety Training in a lab?**
  - **A. IESL Safety Officer**
  - ✓ **B. PI or Lab Safety Officer**
  - **C. A designated student**
  - **D. A designated technician**

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LABORATORY SAFETY quiz 2

- **What is the number to call for emergencies at FORTH, 24/7?**
  - **A. PI's cell number**
  - **B. 100**
  - ✓ **C. 1111 – FORTH Gate/Security**
  - **D. 112**

http://safety.iesl.forth.gr

LABORATORY SAFETY quiz 3

- When working with lasers:
  - A. Goggles are not mandatory
  - B. Any goggle will protect you
  - C. Only plastic goggles will protect you
  - ✓ D. Only appropriate (right wavelength & OD) goggles will protect you

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LABORATORY SAFETY quiz 4

- For water and electricity/cables the rule of thumb is:
  - A. Water low, cables low
  - ✓ B. Water low, cables high
  - C. Water high, cables high
  - D. Water high, cables low

LABORATORY SAFETY quiz 5

- You enter a lab and see a red liquid spilled on the ground. You:
  - A. Mop the floor
  - B. Call cleaning personnel
  - ✓ C. Call Safety Personnel or a PI
  - D. Leave it for someone else to discover