

LABORATORY SAFETY

ELMO Special Edition

Petros Samartzis
February 15, 2023



<http://safety.iesl.forth.gr>



LABORATORY SAFETY

<http://safety.iesl.forth.gr>

- GENERAL LAB SAFETY
- LASER SAFETY
- FIRE SAFETY
- EARTHQUAKE SAFETY
- ELECTRICAL SAFETY
- CHEMICALS & WASTE HANDLING
- PRESSURE SAFETY (HIGH & VACUUM)
- 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 a lab
 - **WHO: the PI/Group Safety Officer**
- **Use of appropriate safety equipment is mandatory in the laboratories: get familiar with them**
- **Consider SAFETY when designing an experiment**
- **Don't work alone in the lab**
- **Keep labs clean and tidy**
- **No access to un-authorized people (especially kids)**
- **No food & drinks in the lab**
- **Use common sense**
- **If in doubt, ASK!**



SAFETY CONTACTS

- **Group/Activity Safety Officer**
 - **Principal Investigator**
- **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**



LABORATORY CARDS

ΤΗΛΕΦΩΝΑ ΑΜΕΣΗΣ ΑΝΑΓΚΗΣ – EMERGENCY PHONES

<u>Πύλη ΙΤΕ (Φύλακας)</u>	-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
<u>Βενιζέλειο</u>	2813-408000*	<u>Venizelio Hospital</u>
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



LABORATORY CARDS

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

ΥΠΕΥΘΥΝΟΙ ΕΡΓΑΣΤΗΡΙΟΥ : α) Δρ. Α. Υπεύθυνος
LAB SAFETY OFFICERS β) Καθ. Β. Υπεύθυνος

a) *Dr. A. Ypeythinos*
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):
DIVISION SAFETY OFFICER (DIVISION_NAME)

Δρ. Ο. Επίθετο
Dr. N. Lastname

Τηλέφωνο (Tel.) : -1234 γρ. (office), 6944123456 κινητό (mobile)

ΥΠΕΥΘΥΝΟΣ ΑΣΦΑΛΕΙΑΣ ΙΝΣΤΙΤΟΥΤΟΥ (ΙΗΔΛ):
INSTITUTE SAFETY OFFICER (IESL)

Δρ. Π. Σαμαρτζής
Dr. P. Samartzis

Τηλέφωνο (Tel.) : -1467 γρ. (office), 6946280983 κινητό (mobile)

ΕΠΙΚΙΝΔΥΝΟΤΗΤΑ – HAZARDS:

Λείζερ (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: org. διαλύτες (μεθανόλη, αιθανόλη), χρωστικές λείζερ, ορυκτέλαια αντλιών

CHEMICALS: org. solvents (methanol, ethanol), laser dyes, pump oil

ΑΕΡΙΑ (GASES): He, Xe, N₂, F₂ (4 φιάλες (4 cylinders))

ΑΝΤΛΙΑ ΔΙΑΧΥΣΕΩΣ (DIFFUSION PUMP)



In Case of an Incident

- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel
 - **ASAP** for injuries requiring doctor or hospital treatment
- Complete an incident report
- **USE COMMON SENSE**

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A message from Technical Service

Don't abuse building facilities



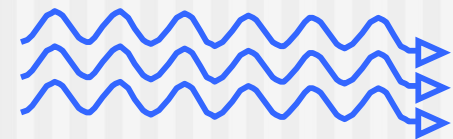
LABORATORY SAFETY

LASER SAFETY



IESL LASER SOURCES

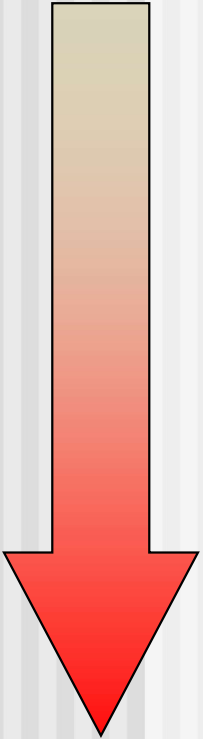
- Solid state (Nd:YAG: 1064/532/355/266 nm, TiSapph: 800 nm)
- Gas lasers (HeNe: 632.8 nm)
- Excimer (KrF:248 nm, ArF:193 nm, XeCl:308 nm)
- Dye lasers (220-800 nm)
- Diode lasers (e.g. femto lasers pump units)



Coherence,
Monochromaticity,
Directionality



LASER CLASSES

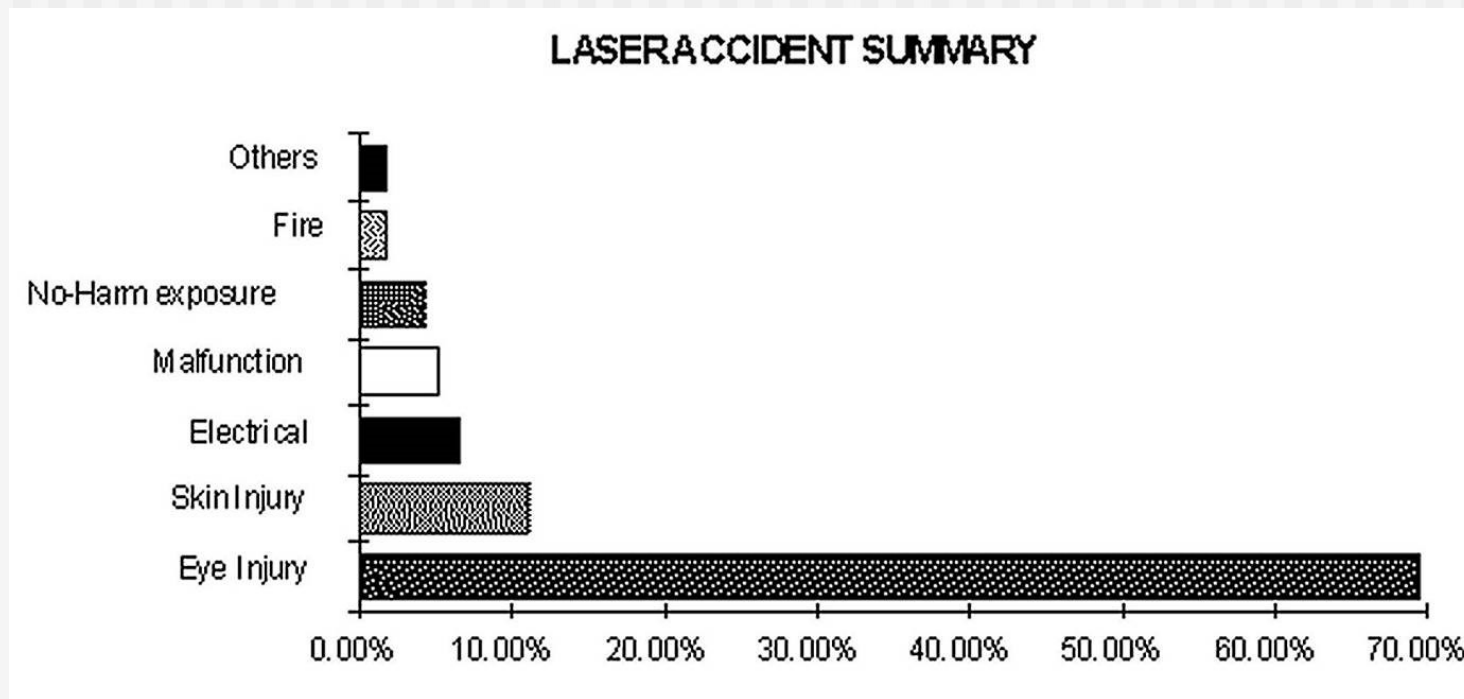
- 
- **CLASS 1** harmless
 - **CLASS 2** visible radiation
momentary exposure (0.25s)
 - **CLASS 3** 3a (1 – 5 mW)
3b (5- 500 mW)
no direct exposure
 - **CLASS 4** Pulse or cw (>500 mW)
Extremely hazardous

ALL lasers in IESL labs are CLASS 4



LASER ACCIDENTS

Laser accidents (USA, 1964-1992)



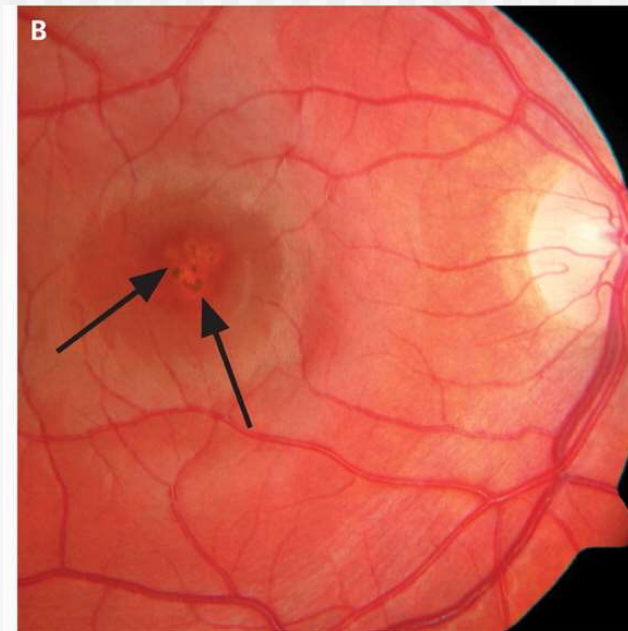
Most accidents involve **eye injuries**



LASER RADIATION DAMAGE

■ EYES

150 mW
green laser pointer
(532 nm)



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

■ SKIN

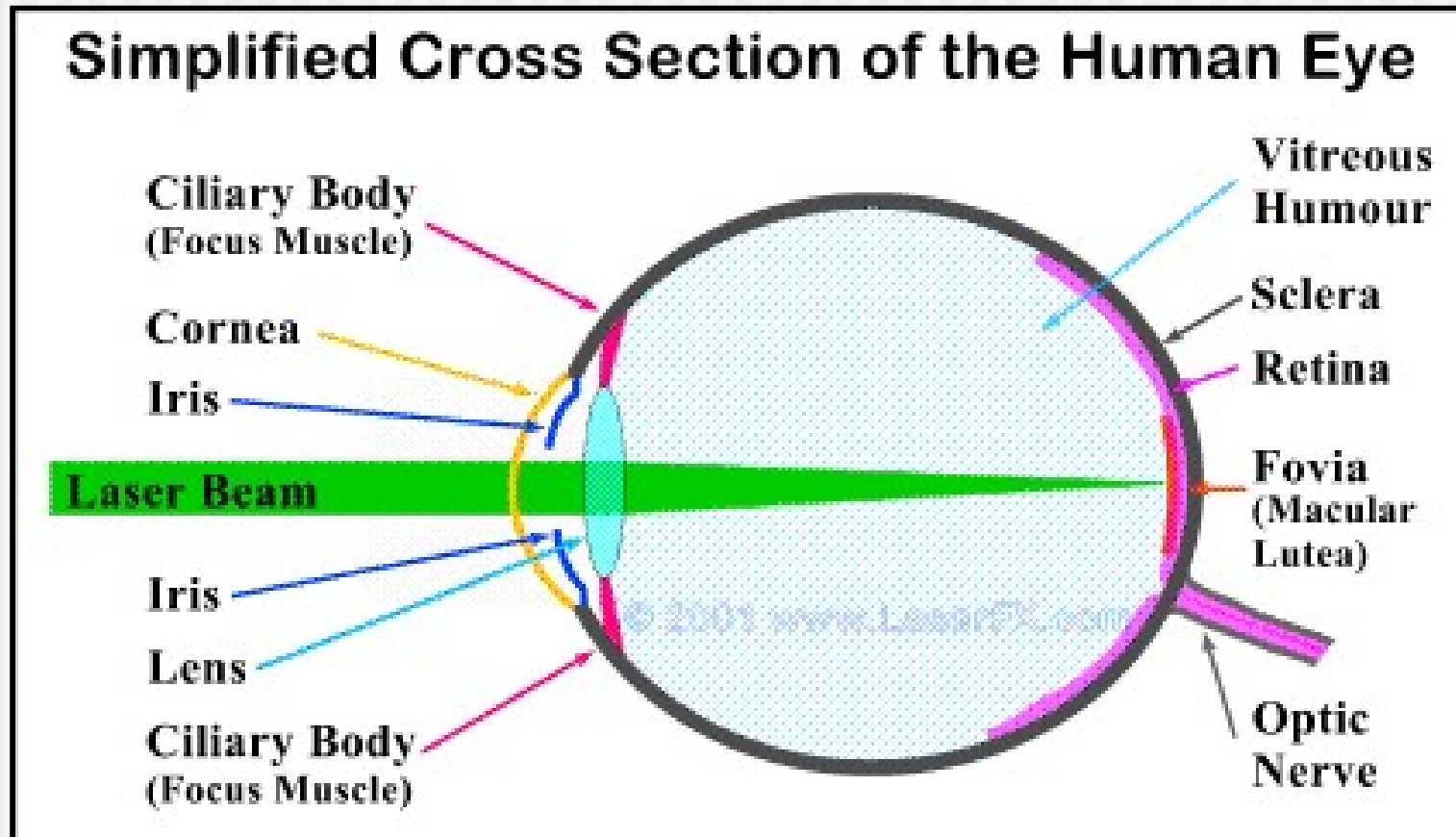
5W/cm² for 1 sec
CO₂ laser
(10,6 μm)



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



LASER vs HUMAN EYE



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

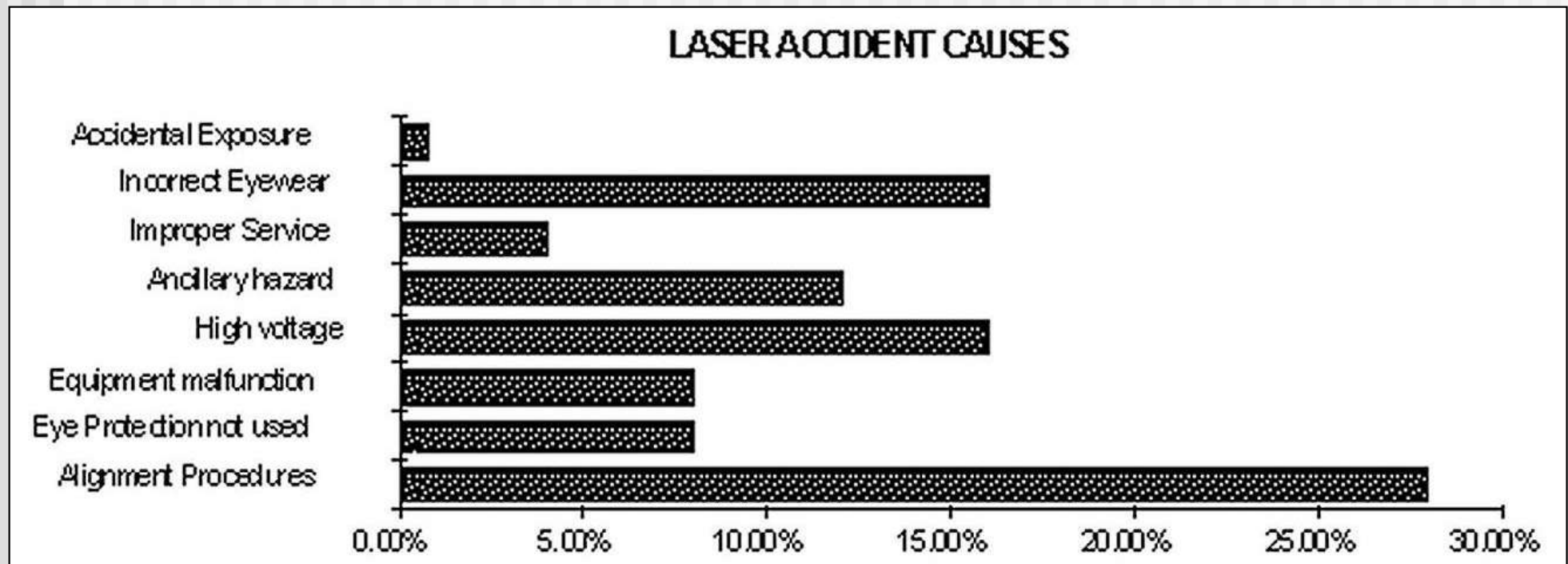
Lens (Φακός): 315 nm – 390 nm & 700 nm – 3000 nm (sel.)

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 eyewear was used**

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



REFLECTIONS ARE DANGEROUS

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 :

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

This exceeds the damage threshold of the cornea ($\sim 10^{-7}$ J/cm²) by a factor of $3.2 \cdot 10^4$.

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

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



LASER SAFETY RULES

- **USE APPROPRIATE LASER PROTECTION EQUIPMENT**
 - **GOGGLES** for the wavelength and power used
 - **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 source off to protect others
- Seek medical attention
- Contact safety personnel
 - ASAP for eye/skin injuries
- File an accident report

- **USE COMMON SENSE**



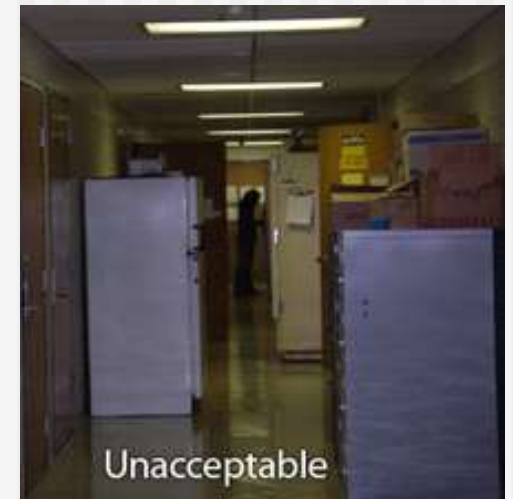
LABORATORY SAFETY

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**
- Injured people?
 - Attempt rescue ONLY if not in danger
- Extinguish? Only if:
 - You are not in danger
 - You know what you are doing
- Otherwise: Leave immediately
- Use the correct fire extinguisher
- Do not open windows/doors
- NO WATER ON ELECTRICAL FIRES



LABORATORY SAFETY

EARTHQUAKE SAFETY



Before an Earthquake

- Secure cabinets, shelves, gas cylinders, heavy equipment to the wall or to the ground
- Secure (dangerous) chemicals to avoid spills
- 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

ELECTRICAL SAFETY



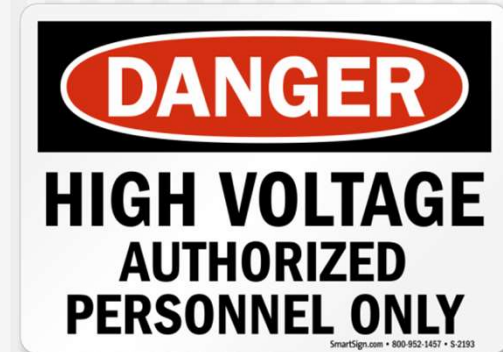
ELECTRICAL HAZARDS

■ Sources

- Regular 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 RULES

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



In Case of an Electrical Incident

- **Remain calm!**
- **Assess the situation**
- Cut off power supply
- **No water** on electrical fires
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel
 - ASAP in case of injury
- **USE COMMON SENSE**

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LABORATORY SAFETY

CHEMICAL SAFETY & WASTE HANDLING



LAB CHEMICALS

- **Flammable:** e.g. organic solvents, H₂
- **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)

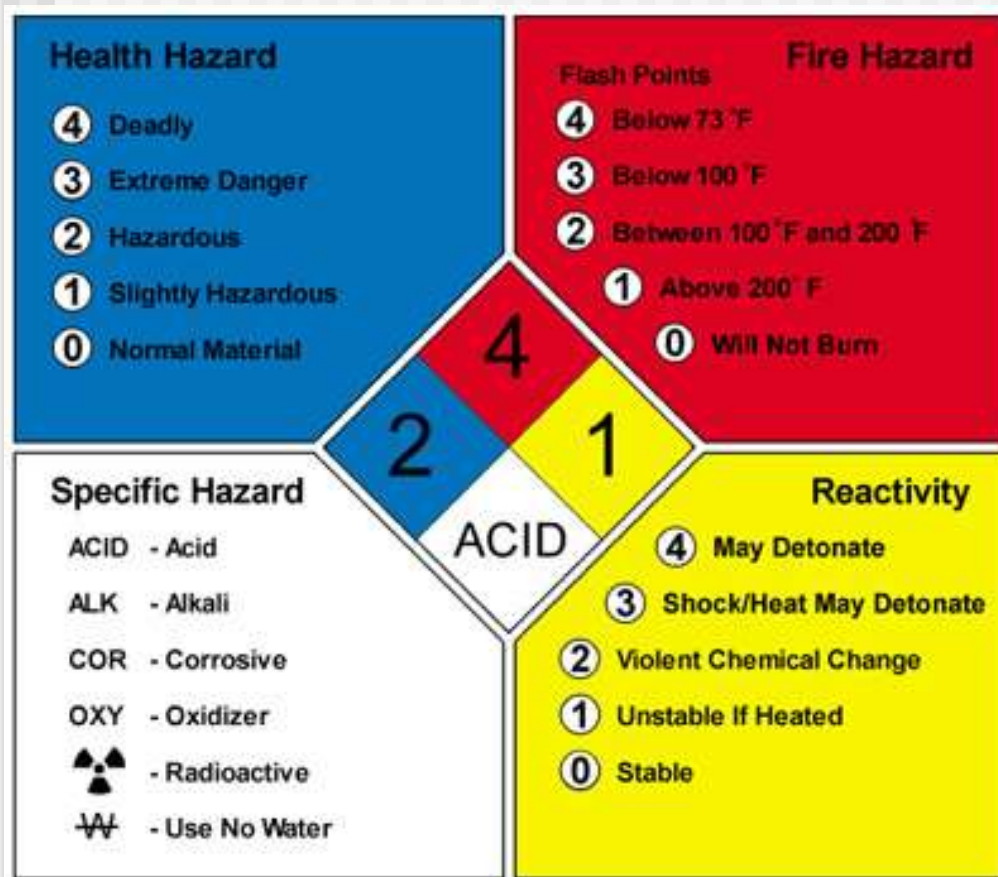
All you need to know about safety of a chemical
Keep MSDS in the lab for all chemicals used

The screenshot shows the Sigma-Aldrich website interface for the product Iodomethane. The header includes the Sigma-Aldrich logo and navigation links for PRODUCTS, SERVICES, and INDUSTRIES. The main content area displays the product name 'Iodomethane' and its chemical formula ICH_3 . A red circle highlights the 'SDS' button in the product information section. Below the product name, there are fields for CAS Number (74-88-4), Empirical Formula (Hill Notation) (CH_3I), Molecular Weight (141.94), Beilstein Registry Number (969135), EC Number (200-819-5), MDL number (MFCD00001073), and PubChem Substance ID (24857202). A 'POPULAR DOCUMENTS' section lists 'SPECIFICATION SHEET (PDF)'. A large image of the chemical formula ICH_3 is displayed on the right side of the page.

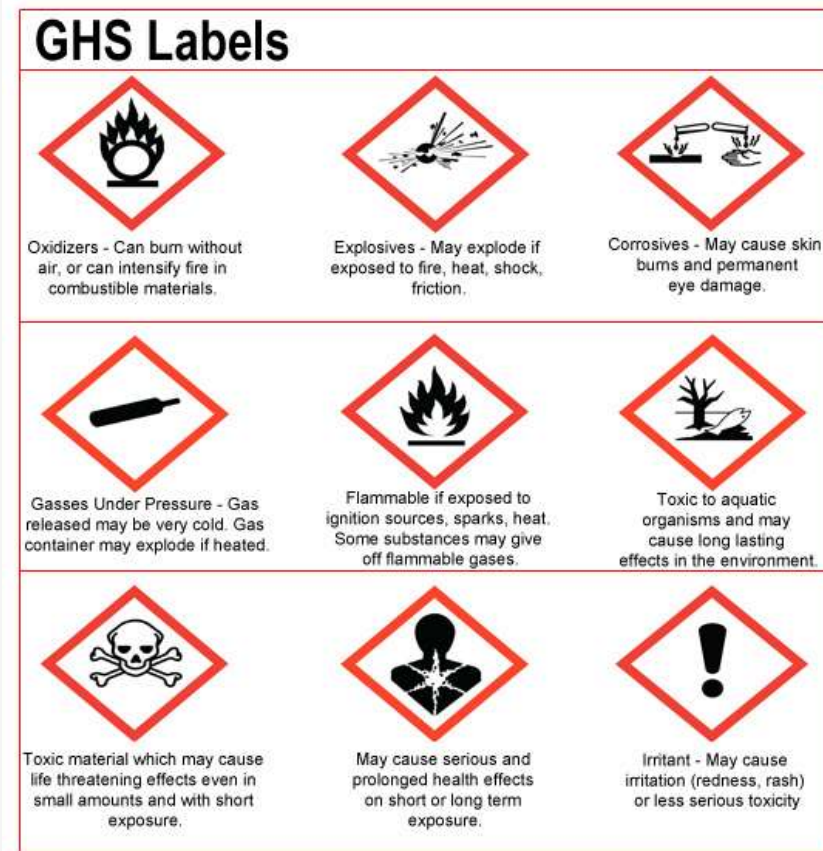
All manufacturers are required to provide MSDS



Different labeling systems



www.nfpa.org



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

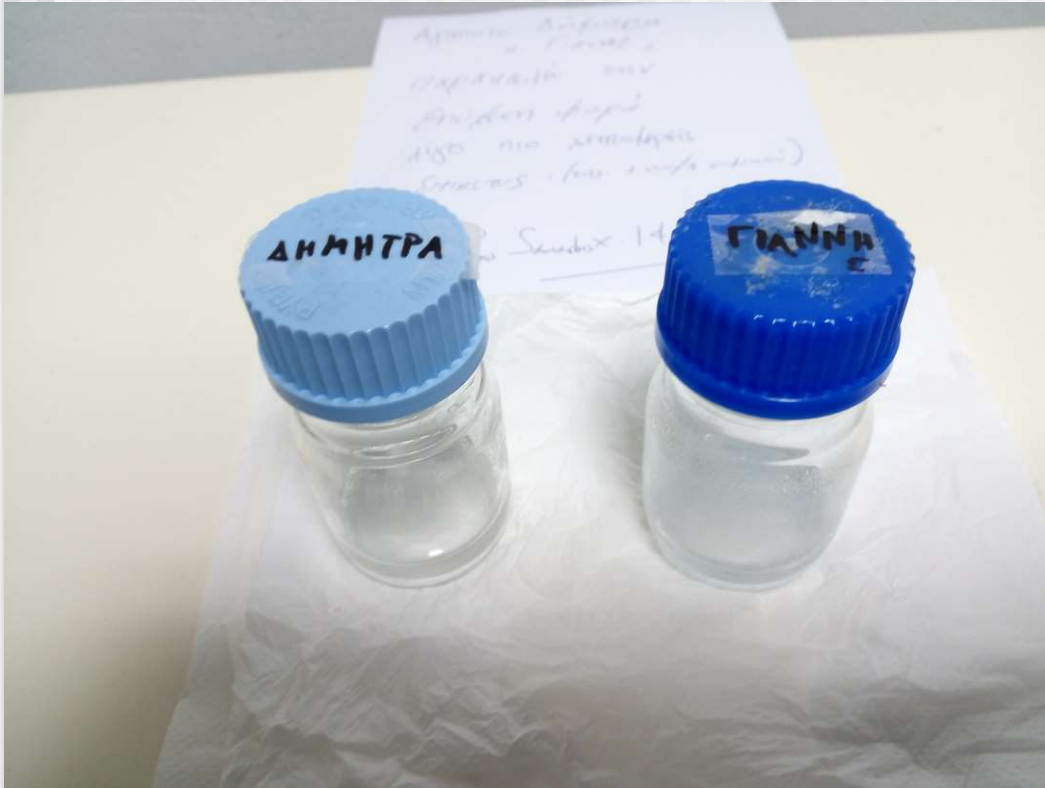


CHEMICAL SAFETY RULES

- Design your experiment carefully
- **Study Material Safety Data Sheets**
- Use smallest quantities allowed
- Use **APPROPRIATE** protective equipment
 - Gloves, lab coats, masks, goggles, hoods, glove box, inert environment,...
- **Store appropriately (MSDS)** if not in use
- Use appropriate **transport protection equipment & practices**
 - Rubber buckets, cardboard boxes, containers
 - Do not hold containers from lids



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
- **No sharps/chemicals in “normal” waste**
- Label your waste containers when the first drop is in and add what you put in after that (name, approx. quantity)
- Throw in the sink?
 - **“Sink it if you can drink it”**
- Organic chemicals go to **“Organic Waste”**
- Water solutions go to **“Water solutions waste”**
- Pump oil to **“Mechanical pump oil”**
- Sharps/solid waste go to **“Solid Waste”**
- **If in doubt, ASK!!!**



In Case of a Chemical Incident

- **Accident examples**
 - Spill, glassware breaking, explosion, fire,...
- **Remain calm!**
- **Assess the situation**
- Call for help
- Seek medical attention
- Contact safety personnel
 - ASAP if there is an injury
- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



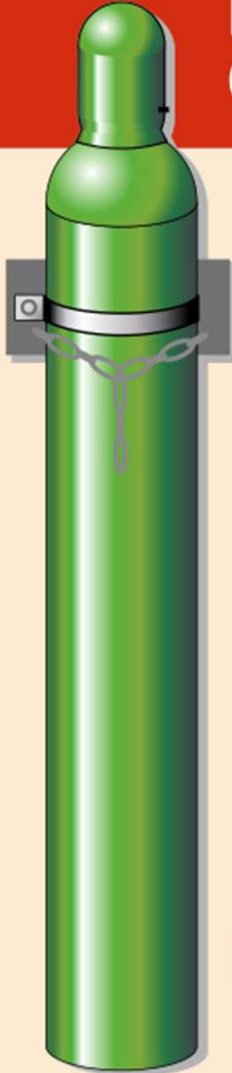
LABORATORY SAFETY

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 pressurized cooling water network
 - Water low – electricity high
- Report any problems you see
- **If in doubt, ASK!**



Handling & Storing Cylinders Safely

- 1 SECURE cylinders properly at all times.
- 2 STORE cylinders in cool, well-ventilated, fire-resistant areas in compliance with local, state and federal regulations.
- 3 PLACE cylinders where they will not be damaged by forklifts, knocked over or hit by falling objects.
- 4 CLOSE valves and TIGHTEN caps when not in use.
- 5 INSPECT cylinders for leaks and CHECK support brackets regularly for strength and integrity.
- 6 MOVE cylinders using hand trucks designed for the purpose.
- 7 REPORT leaks or any damage to your supervisor immediately.

EMERGENCY EQUIPMENT LOCATED AT:

SmartSign.com • 800-952-1457 • S-2074

In Case of a Pressure Incident

- **Remain calm!**
- **Assess the situation**
- Seek help
- Seek medical attention in case of injury
- Contact safety personnel
 - **ASAP** if there is an injury
- **USE COMMON SENSE**

<http://safety.iesl.forth.gr>



LABORATORY SAFETY

CRYOGENICS SAFETY

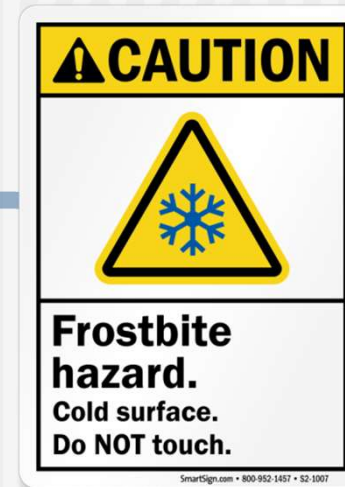


CRYO HAZARDS

- Explosion
- Frostbites
- Asphyxiation
- Burns



<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
- 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
 - **ASAP** in case of injury
- **USE COMMON SENSE**

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Location of First Aid Kits

- **FORTH Main Building B**
 - Basement: **Outside gas storage room**
 - Ground Floor: **Near main entrance**
 - 1st floor: **Meeting room**
- **FORTH Building C:**
 - **Main Secretariat**



LABORATORY SAFETY

ANY QUESTIONS?

<http://safety.iesl.forth.gr>



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**

<http://safety.iesl.forth.gr>



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**



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**

<http://safety.iesl.forth.gr>



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

