

# ***LABORATORY SAFETY***

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## ***ELMO Special Edition***

Petros Samartzis

October 5, 2022



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



# ***LABORATORY SAFETY***

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<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***

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## **GENERAL LAB SAFETY**



# ***RULE NUMBER ONE:***

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**SAFETY**

***IS OUR FIRST***

***PRIORITY***



# GENERAL RULES

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- **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***

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- **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>	<b>-1111</b>	<b>FORTH gate / Security</b>
Υποδοχή	<b>-1168</b>	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	<b>-1094, -1095, -1455</b> <b>-1574, -1570</b>	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, N<sub>2</sub>, F<sub>2</sub> (4 φιάλες (4 cylinders))

**ΑΝΤΛΙΑ ΔΙΑΧΥΣΕΩΣ (DIFFUSION PUMP)**





# ***In Case of an Incident***

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- **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**

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



# A message from Technical Service

**Don't abuse building facilities**



# ***LABORATORY SAFETY***

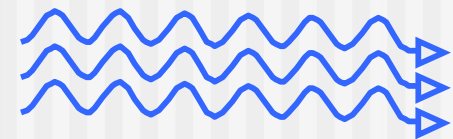
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## **LASER SAFETY**



# ***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)

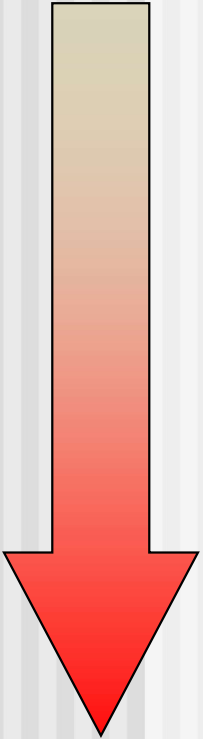


Coherence,  
Monochromaticity,  
Directionality



# LASER CLASSES

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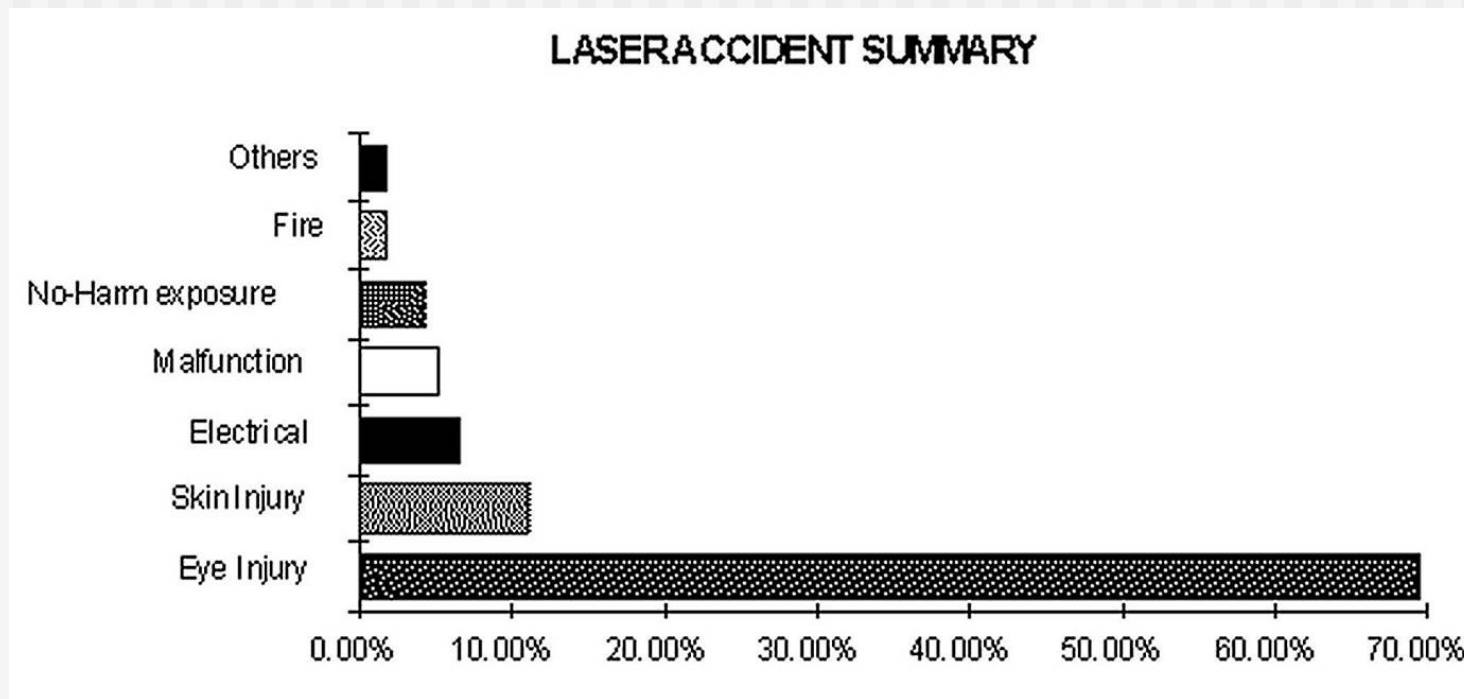
- 
- **CLASS 1**      harmless
  - **CLASS 2**      visible radiation  
momentary exposure (0.25s)
  - **CLASS 3**      3a (1 – 5 mW)  
3b (5- 500 mW)  
no direct exposure
  - **CLASS 4**      Pulse or cw (>500 mW)  
Extremely hazardous

**ALL lasers in IESL labs are CLASS 4**



# LASER ACCIDENTS

Laser accidents (USA, 1964-1992)



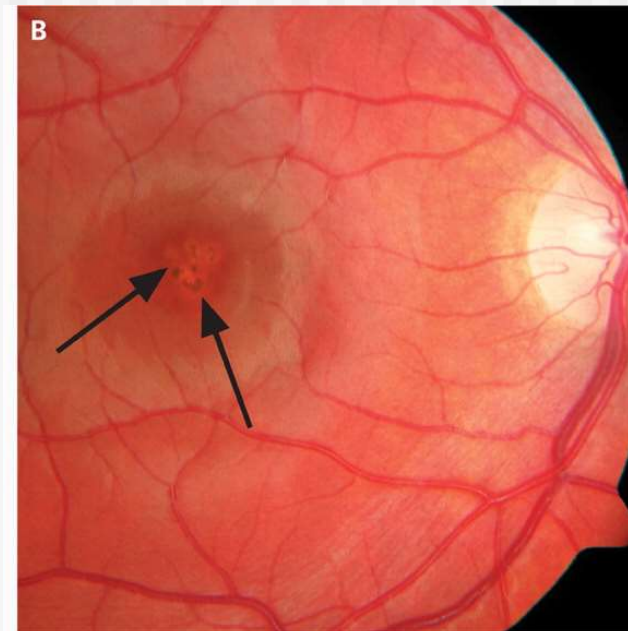
Most accidents involve **eye injuries**



# LASER RADIATION DAMAGE

## ■ EYES

150 mW  
green laser pointer  
(532 nm)



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

## ■ SKIN

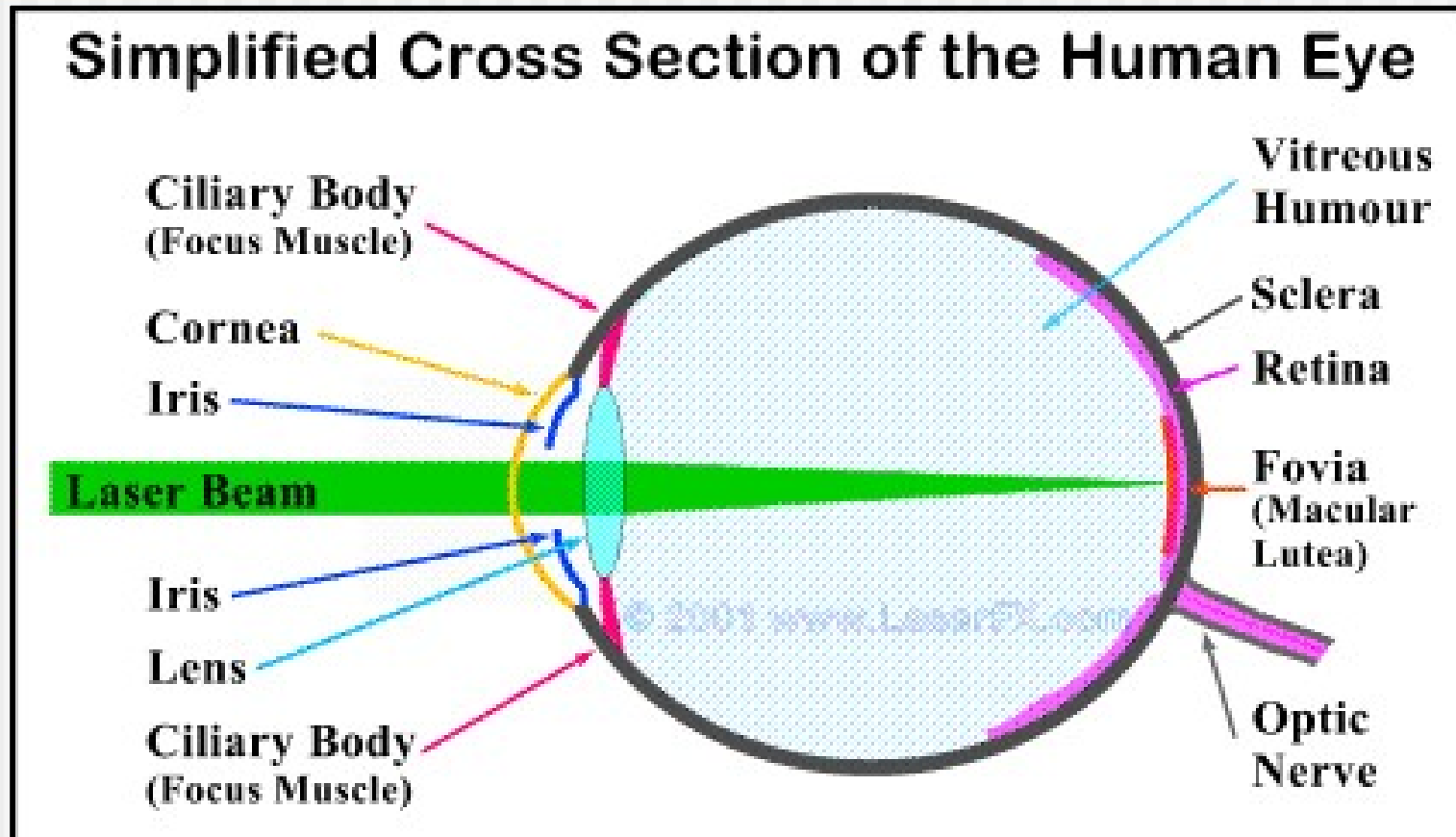
5W/cm<sup>2</sup> for 1 sec  
CO<sub>2</sub> laser  
(10,6 μm)



<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.)

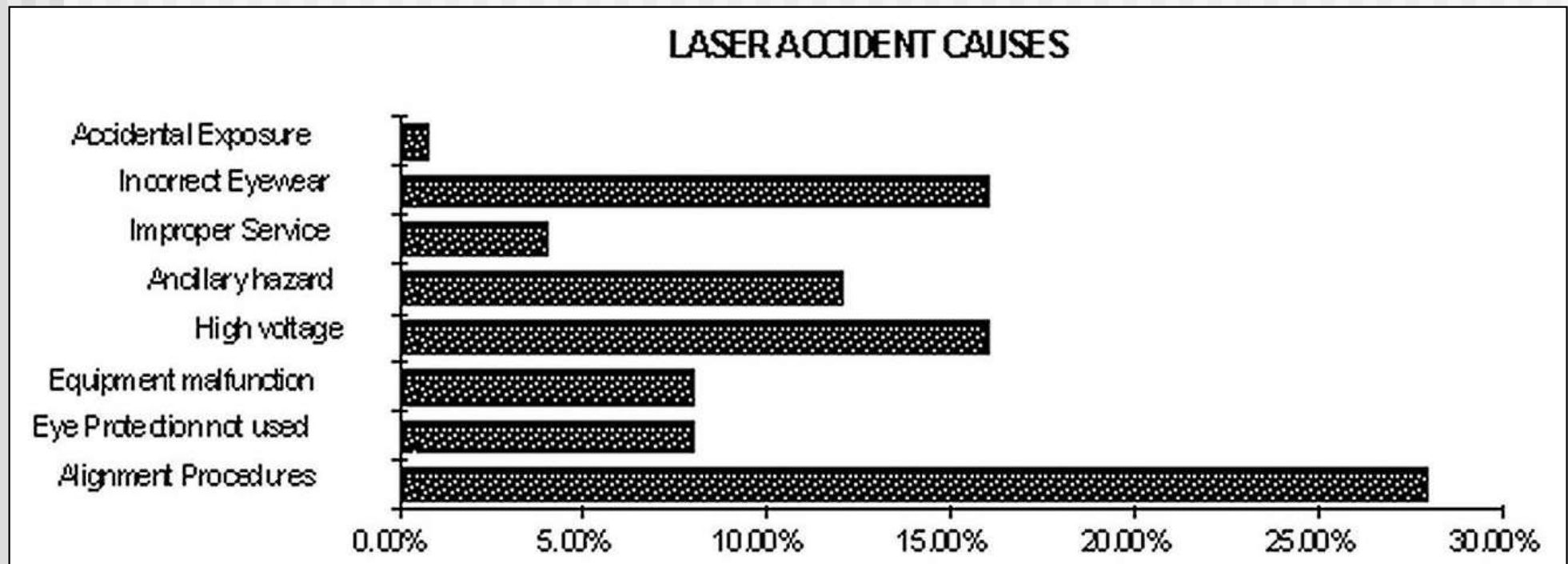
**Retina (αμφιβληστροειδής):** 400 nm – 1400 nm





# 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***

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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 :

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

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

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

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



# ***LASER SAFETY RULES***

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- **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***

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- 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***

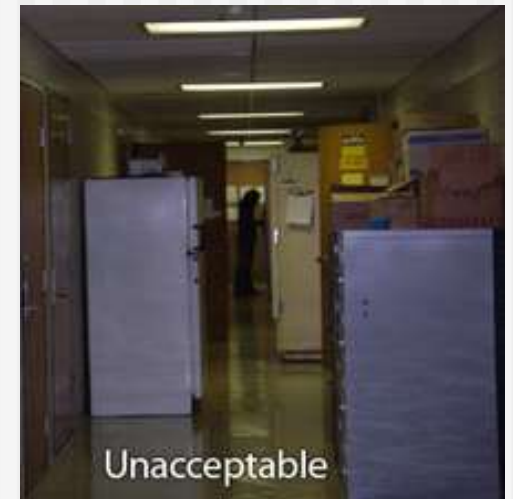
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## **FIRE SAFETY**



# 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

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- 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***

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## **EARTHQUAKE SAFETY**





# Before an Earthquake

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- 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

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- **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

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- 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***

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## **ELECTRICAL SAFETY**



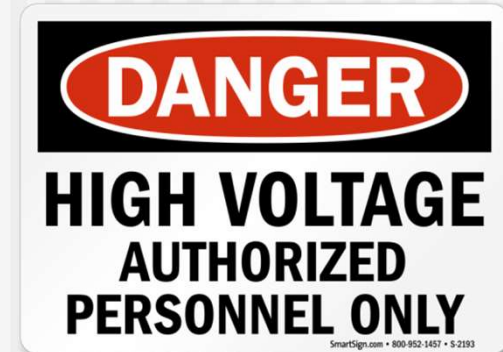
# ELECTRICAL HAZARDS

## ■ 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

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- 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***

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- **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**

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



# ***LABORATORY SAFETY***

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## **CHEMICAL SAFETY & WASTE HANDLING**





# LAB CHEMICALS

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- **Flammable:** e.g. organic solvents, H<sub>2</sub>
- **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)

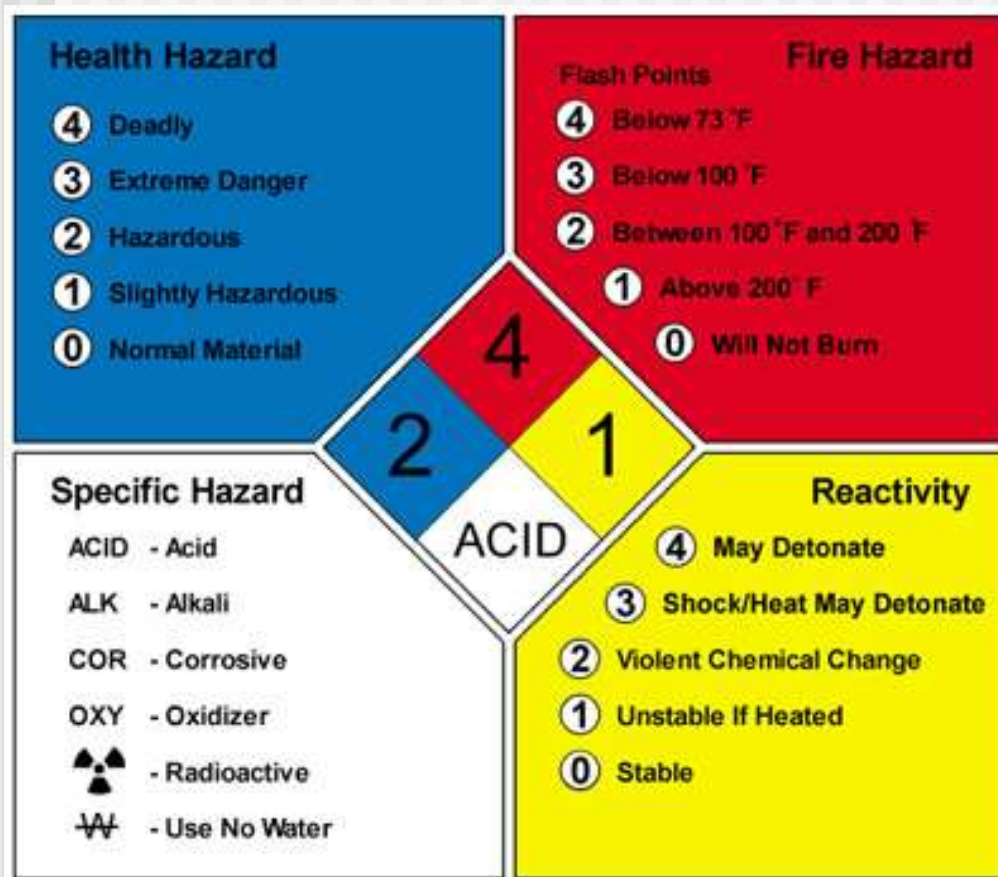
**All you need to know about safety of a chemical**  
**Keep MSDS in the lab for all chemicals used**

The screenshot shows the Sigma-Aldrich website interface. At the top, the logo 'SIGMA-ALDRICH' is displayed as 'A Part of MilliporeSigma'. A search bar is present. Below the navigation bar, there are links for '200,000+ PRODUCTS', '500+ SERVICES', and 'Featured INDUSTRIES'. On the right, there are links for 'Hello, Sign in. ACCOUNT', '24/7 SUPPORT', and '0 Items ORDER'. The main content area shows the product page for 'Iodomethane' (CAS Number 74-88-4). The chemical formula  $\text{ICH}_3$  is prominently displayed in a large box. Below the product name, there is a description: 'contains copper as stabilizer, ReagentPlus<sup>®</sup>, 99.5%' and a synonym: 'Methyl iodide'. A red circle highlights the 'SDS' button in the navigation area. Other buttons include 'SIMILAR PRODUCTS'. Below the product information, there are links for 'POPULAR DOCUMENTS: SPECIFICATION SHEET (PDF)'. A small image of the chemical container is shown at the bottom right of the product page.

**All manufacturers are required to provide MSDS**



# Different labeling systems



[www.nfpa.org](http://www.nfpa.org)



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



# CHEMICAL SAFETY RULES

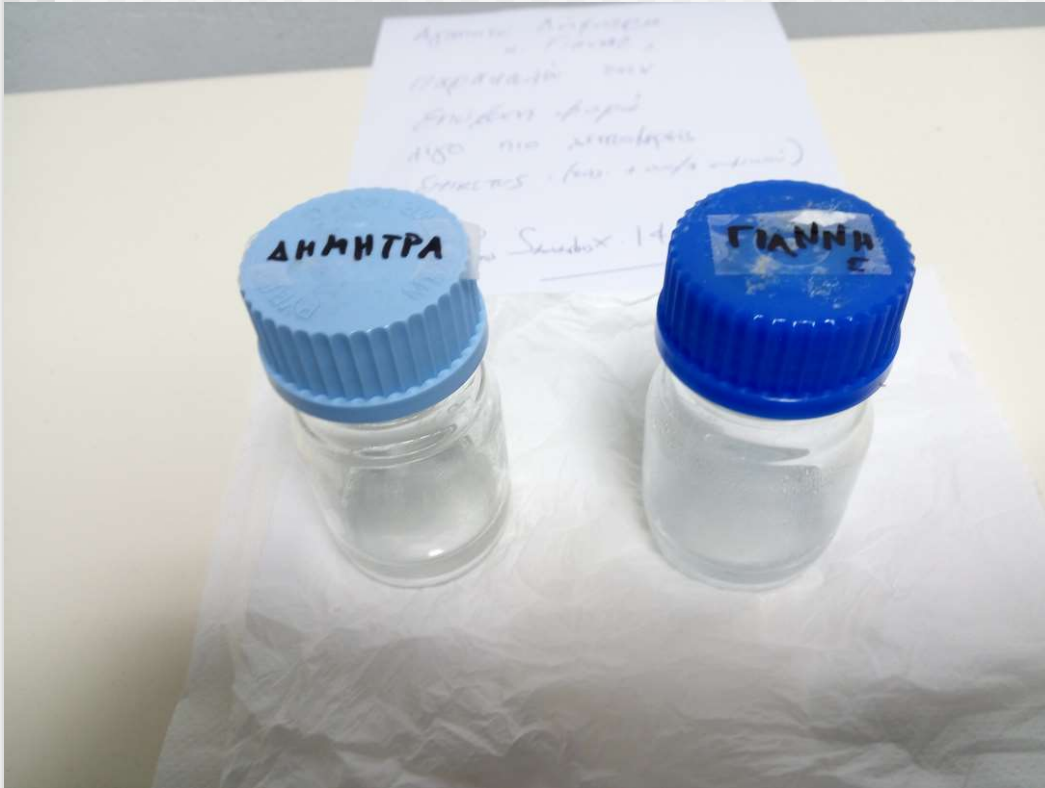
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- Design your experiment carefully
- **Study Material Safety Data Sheets**
- Use smallest quantities allowed
- Use **APPROPRIATE** protective equipment
  - Gloves, lab coats, masks, goggles, hoods, glove box, inert environment,...
- **Store appropriately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



# LABEL APPROPRIATELY

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

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



# BASIC WASTE HANDLING

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- 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***

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- **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***

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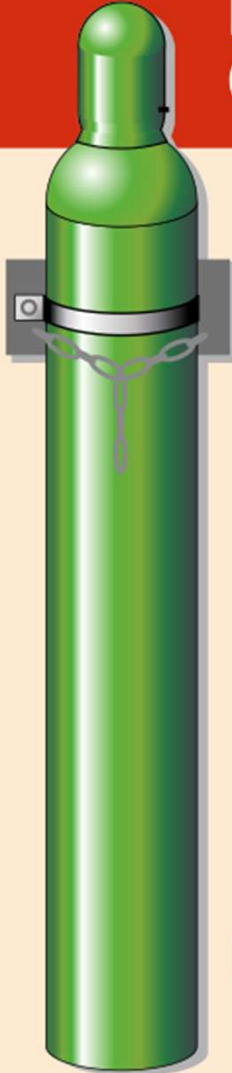
## **HIGH PRESSURE & VACUUM SAFETY**





# 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 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***

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- **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***

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## **CRYOGENICS SAFETY**



# CRYO HAZARDS

- Explosion
- Frostbites
- Asphyxiation
- Burns



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



# CRYO SAFETY PRACTICE

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- 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***

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- **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**

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



# *Location of First Aid Kits*

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- **FORTH Main Building B**
  - Basement: **Outside gas storage room**
  - Ground Floor: **Near main entrance**
  - **1<sup>st</sup> floor: Meeting room**
- **FORTH Building C:**
  - **Main Secretariat**
  - Magda's Office
  - Comp. Center
- **STEP C: Basement, Ground floor**
- **Microelectronics: Kitchen**



# ***LABORATORY SAFETY***

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**ANY QUESTIONS?**

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





# ***LABORATORY SAFETY quiz 1***

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- **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***

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- **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***

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- **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**

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



# ***LABORATORY SAFETY quiz 4***

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- **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***

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- **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**

