King Faisal University

College of Engineering

Committee of Infrastructure and Laboratories

Safety Guidelines

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Safety Guidelines

I. Introduction

This manual is a safety reference document for laboratory personnel at the College of Engineering in King Faisal University. It provides basic information about hazards that you may encounter in the laboratory and safety precautions to prevent laboratory accidents and minimize exposure to hazardous chemicals. Overall safety in the lab is EVERY LAB USER'S responsibility. The Laboratory Safety Code incorporates both general guidelines as well as more in-depth information about specific laboratory safety practices.

One of the most fundamental aspects of safety is good laboratory housekeeping. This includes the proper storage and handling of chemicals, gas cylinders, and electrical equipment and so on. There are two golden rules in developing a safe and productive environment:

- Whenever you use a lab, it is your responsibility to see that unsafe conditions are corrected immediately
- Always leave a laboratory in better condition than you found it.

It is important for you to know what is expected of you and what your responsibilities are with regards to safety, to yourself, your colleagues and our environment. In addition, there are safety practices and safety equipment with which you must be thoroughly familiar if you are to work safely in the laboratory.

Safety incorporates only a few principles, but each one is essential. These principles are:

I.1. Practice Safety

One problem concerning the practice of safety is that it is a subjective matter. For example, some people consider smoking safe while others do not. In order to have an effective safety program, some common ground rules must be established. This is the main purpose of this safety Code.

I.2. Be Concerned About the Safety of Others

Your concern for safety must include the people around you. Your experiments must be safely maintained so that everyone in the area is protected and warned of inherent dangers. This practice could involve something as simple as reminding a friend to wear safety glasses. Another aspect of this second principle involves alerting those around you of an accident. It is your responsibility to alert personnel in the immediate vicinity of a fire or an emergency!

I.3. Understand the Hazards Associated with Your Particular Experiment

Prevention is the key to safety. Prior to performing any experiment, it is wise to consider the potential hazards and safety precautions involved in the work. Hazards may include toxic substances, electrical circuits, mechanical equipment, and waste chemicals. Safety precautions should include correct materials storage, proper ventilation, proper grounding of equipment, and training sessions when necessary. Whenever possible, information about the unique hazards and precautions necessary for any type of work should be prepared and made available to everyone working in the lab.

Material Safety Data Sheets (MSDS) and manuals are important sources of information.

I.4. Know what to do in an Emergency

You must be prepared to respond quickly and precisely to an emergency. You must familiarize yourself with the laboratory you are working in, its exits, and its associated safety equipment: eyewash stations, showers, sinks, fire blankets, fire extinguishers, and spill kits.

I.5. Report Hazards or Hazardous Conditions

You must report any incidents without delay. A statement of the problem must be made to your supervisor/advisor.

II. OBJECTIVES

The basic purpose of laboratory safety is to protect students, researchers, technicians and teachers from the many hazards encountered during the use of various materials and equipment, so safety in the laboratory must be of vital concern to all those engaged in experimental work. Therefore it is expected that everyone must be familiar with this manual in order to satisfy the following objectives:

- Make the Safety Plan readily available to all employees.
- Provide employee training in safe work practices and laboratory procedures.
- Inform employees of risks involved in materials testing.
- Minimize chemical exposures.
- Ensure that laboratories meet Standard codes
- Provision or maintenance of equipment and systems of work that are safe and cause no risk to health
- Ensuring the safe use, handling, storage and transport of equipment and substances
- Provision of information, instruction, training and supervision necessary to ensure the health and safety of all persons in the Faculty
- Maintaining the places of work under the Faculty's control in a safe condition and provision of safe entries and exits.
- Making available adequate information about relevant tests and research concerning substances used at the place of work.

III. First Aid

Immediately provide the minimum necessary first aid to prevent further injury to the victim. If the injury requires more than a band aid, call **9900** and request assistance. Be prepared to describe accurately the nature of the accident and your location.

Provide first aid within the scope of your training while waiting for professional help to arrive. It is important that you do not attempt any medical treatments with which you are unfamiliar. However, there are certain serious injuries in which time is so important that treatment must be started immediately. The proper aid is outlined below according to the type of injury. Report all injuries to your supervisor/advisor after professional help arrives.

III.1 Wounds

Small cuts and scratches

Direct pressure: place sterile pad over wound and apply pressure evenly with the opposite hand.

Elevation: if direct pressure does not control bleeding, raise the area above the level of the heart.

Cleanse area with soap and water.

III.2 Severe Bleeding

Call Emergency Rescue (9900).

Direct Pressure: Severe bleeding can almost always be controlled by firm and direct pressure, place sterile pad over wound and apply pressure evenly with the opposite hand.

Elevation: Raise the bleeding part higher than the rest of the body and continue to apply direct pressure.

Wrap the injured to avoid shock.

Keep victim lying down.

Never use a tourniquet.

III.3 Stoppage of Breathing

For stoppage of breathing (e.g. from electrical shock or asphyxiation), the mouth-to-mouth method of resuscitation is far superior to any other known. If the victim is found unconscious on the floor and not breathing, rescue breathing must be started at once, seconds count. Do not waste time looking around for help, yell for help while resuscitating victim.

III.4 Thermal Burns

First-degree burns (e.g., sunburn or mild steam burn) are characterized by redness or discoloration of the skin, mild swelling and pain.

First aid procedures for first degree burns are as follows:

- Apply cold water applications and/or immerse in cold water for at least 10 minutes.
- Seek further medical treatment as needed.

Second and third degree burns are characterized by red or mottled skin with blisters (second degree), white or charred skin (third degree).

First aid procedures for second and third degree burns are as follows:

- Call Emergency Rescue (9900).
- Wrap area in clean, dry material.

In case of a clothing fire:

- The victim should drop to the floor and roll. Do NOT run to a safety shower. A fire blanket, if nearby, should be used to smother the flames.

- After flames are extinguished, deluge the injured under a safety shower, removing any clothing contaminated with chemicals.
- Keep the water running on the burn for several minutes to remove heat and wash area.
- Place clean, soaking wet, ice-packed cloths on burned areas, and wrap to avoid shock and exposure.
- Never use a fire extinguisher on a person with burning clothing.

3.5 Chemical Burns

If hazardous chemicals should come into contact with the skin or eyes, follow the first aid procedures below.

- Skin
    - Immediately flush with water.
    - Remove victim's clothes: Apply a stream of water while removing any clothing that may have been saturated with the chemical.
    - Remove victim's shoes: chemicals may also collect here.
    - Rinse the area with large quantities of water for at least 15 minutes (sink, shower, or hose).
    - DO NOT apply burn ointments/spray to affected areas.
    - Call Emergency Rescue (9900) without delay.
- Eyes (acid/alkali, e.g., HCl, NaOH)
    - Call Emergency Rescue (9900) without delay.
    - Flush area of eyes gently for at least fifteen minutes with clean water. Wash in a direction away from the other eye.
    - If safety goggles are worn during a chemical exposure to the face, leave them on until the surrounding area is thoroughly rinsed, they may be the only thing keeping the chemical out of your eyes.

3.6 Traumatic Shock

In cases of traumatic shock, or where the nature of the injury is not clear, keep the victim warm, lying down and quiet. Wait until medical assistance arrives before moving the victim. One should treat all injuries as potential shock situations, as they may turn into one. Some common symptoms of shock are cold and clammy skin, paleness, and deliria.

3.7 First Aid Kit

First aid kits should be standard equipment in every laboratory. Commercial, cabinet-type, or unit type first aid kits are acceptable. A typical first aid kit for laboratories includes a variety of items specially selected to carry out emergency treatment of cuts, burns, eye injuries, or sudden illness. The first aid kit should contain individually sealed packages for each type of item. Contents of the kit should be checked weekly to ensure that expended items are replaced. Laboratory supervisors are responsible for maintaining the contents of the first aid kit.

No oral medication (including aspirin) should be dispensed from the first aid kit

4. Fire safety

4.1 Precaution Procedures

- Everyone working in labs must know how to use emergency equipment such as fire extinguishers, blankets, safety showers, and eye wash apparatus. Know where these items are located in your laboratories. Safety is the responsibility of everyone. (NOTE: Do not block access to fire escape routes).
- Neatness prevents many fires. Fire spreads much faster when it has cluttered waste materials to feed on. Oily rags waste or papers improperly stored are common causes of spontaneous combustion.
- Overloaded electrical circuits are potential fire hazards. Flammable vapors can ignite far away from their source and thus should be vented properly.
- Be aware of ignition sources in the lab area (open flames, heat, and electrical equipment).
- Purchase and store flammable reagents in the smallest quantities available.
- Store flammable liquids in appropriate safety cabinets and/or safety cans.
- Do not store incompatible reagents together (e.g., acids with flammables).
- Make sure that all electrical cords are in good condition. All electrical outlets should be grounded. Never remove the grounding prong or use an adapter to bypass the grounding on an electrical cord.
- Remain out of the area of a fire or personal injury unless it is your responsibility to meet the emergency responders. Meet responders from a safe location.
- Be aware of the condition of fire extinguishers. Report any broken seals, damage, low gauge pressure. If the seal has been broken, assume that the fire extinguisher has been used and must be recharged. (NOTE: Do not use fire extinguishers unless you are trained and feel confident to do so). Report ALL fires by phoning 9900.
- Keep the fire alarm system in the college clear and unblocked to function properly. Be sure that all heat and smoke detectors are clean and functioning well.

4.2 Emergency Procedures

- Call **9900** and report the location of the fire.
- Activate the fire alarm to evacuate the building. These fire alarms sound only within the building, and do not alert fire officials. You must call 9900.
- Confine or control the fire if possible.
    - Immediately turn off gas supplies and electrical power sources.
    - Use an appropriate extinguisher (see item5.4)
- Use common sense. A fire in a beaker may often be extinguished by covering the beaker and depriving the fire of oxygen. Using a fire extinguisher on the same beaker of burning solvent may cause the solvent to splatter, increasing the hazard.
- If you are absolutely certain that you have extinguished the fire, call 9900 to report that the fire is out. The fire truck response will be cancelled, although Fire Safety officials will still come to assess the damage and to complete a report.
- You are expected to use good judgment. Obviously, it may not be necessary to evacuate the building for a small fire in the lab. However, if there is any chance that

the fire may endanger others or may cause serious damage, do not hesitate to pull the alarm. Never feel embarrassed about being over-cautious.

- Immediately after using a fire extinguisher, call Fire Safety (9900) to request that the fire extinguisher be recharged. They will remove the extinguisher, fill and reseal it.

4.3 Evacuation Plan

Evacuation plans in the Faculty of Engineering have been prepared by the Department of Safety in KFU and this evacuation process must be implemented once each semester.

The procedure to be followed is as follows:

- A continuous ringing of the fire bells located in the corridors means everyone is to leave the building.
- Leave the building immediately by the nearest exit; [See the evacuation plan diagrams, Appendix A]
- Shut down and secure any laboratory equipment that is in operation.
- Leave your laboratory. Close but do not lock the door and proceed out the building following the exit signs available in the college.
- Go to the Emergency Evacuation Assembly point [See the evacuation plan diagrams,
- Appendix A]
- Do not re-enter the building until advised it is safe to do so by the building warden or by security staff.
- Do not loiter in the streets. They must be kept clear for access by emergency vehicles. Do not block any area necessary to access other parts of the building.
- Classroom instructors are expected to interrupt class activity and advise students to evacuate the building. Students are obliged to follow emergency procedures in accordance with the training evacuation process.

4.4 Classes of Fire and Methods of Extinguishing

4.4.1 Class A Fire

- Multi-purpose dry chemical Halon
- **Material**: Wood, paper, textiles and other ordinary combustible materials.
- **To extinguish**: Pressurized water

4.4.2. Class B Fire

- Multi-purpose dry chemical Halon
- **Material**: Flammable liquids: oils, solvents, grease, paint, etc.
- **To extinguish**: BC dry chemical, regular Carbon dioxide (if fire is contained in a small area).

4.4.3. Class C Fire

- Multi-purpose dry chemical. Effective, but will destroy electronic gear.
- Electrical Fires
- **To extinguish:** Carbon dioxide Halon BC dry chemical, regular. Effective, but will destroy electronic gear.

4.4.4. Class D Fire

- **Material**: Metals: Magnesium, Aluminum, Sodium, Potassium, Zirconium, Titanium etc.
- **To extinguish**: Special metal extinguishers the ordinary extinguishers found in the building should not be used on metal fires because a violent reaction may result.

Appendix B, shows a poster how to use the fire extinguisher.

5. Safety Rules

The purpose of this guide is to promote safety awareness and encourage safe work practices in the laboratory. These are guidelines; they should serve as a reminder of things you can do to work more safely. Although these guidelines are applicable to all research, teaching and academic laboratories.

5.1. General Personal Safety Instructions

5.1.1. Safety first while in the laboratory

The set of information presented here to safeguard you while in the laboratory. It should be announced clearly inside each lab, and these instructions should be exactly followed.

- No smoking is allowed in the laboratory.
- No food or beverages are allowed in the laboratory.
- Avoid long hair and long sleeved loose clothes and wear lab coat while conducting experiments to minimize the risk of clothing getting caught in the machines.
- Use appropriate personal protective equipment at all time, like Gloves, Safety glasses, Skin
- Protection, Hearing Protection, and Foot Protection (don't wear open sandals) (Appendix D)
- No running, playing, bantering, and kidding in the laboratory.
- Know locations of first aid and all emergency equipment, such as fire alarm, water hoses, fire extinguishers, fire blankets, eyewash stations, and safety showers. Know how to find and use them.
- Use laboratory equipment for its designed purpose.
- Always follow instructions and use only machines and equipment that you are authorized and qualified to operate. If you have any question, consult with your supervisor.
- Know and follow safety rules for specific experiments or tasks.
- Know potential hazards in your work and ways of working safely to prevent such hazards.
- Working alone should be avoided. Someone should always be within call when a laboratory procedure is being performed.
- Avoid exposure to gases, vapors, and particulates by using a properly functioning laboratory fume hood.
- Use ground fault circuit interrupters where there is a risk of an operator coming in contact with water and electrical equipment simultaneously.

- Follow electrical safety rules and make sure your hands are dry before using electrical equipment, grounding portable electrical tools. Make sure electrical wires are connected properly without short circuit before operating. Wear protective clothing, well-insulated gloves and boots, if required.
- Only trained, qualified personnel may repair or modify electrical or any equipment.
- Reduce fire hazard
  - Use shower for fire victims.
  - While fire on clothing, do not run or fan flames.
  - Smother flames by wrapping in fire blankets.
  - Spills of flammable solvents can be a source of fire.
- Upon hearing fire alarm, you should evacuate the area and follow emergency procedure.
- Report all injuries including minor scratches, cuts, and burns for First Aid treatment. Corrective actions should be taken to prevent future injuries.
- Report any damage to equipment or instrument and broken glassware to the laboratory instructor as soon as such damage occurs.
- Wash hands upon completion of laboratory procedures and remove all protective equipment including gloves and lab coats.

5.1.2. Awareness

- Be alert to unsafe conditions and actions, and call attention to them so that corrections can be made as soon as possible.
- Segregate chemicals by compatibility groups for storage.
- Be aware of the potential interactions of lab furniture and equipment with chemicals used or stored in the lab. (e.g., are oxidizers stored directly on wooden shelving?)
- Post warning signs for unusual hazards such as flammable materials, biohazards or other special problems.
- Pour more concentrated solutions into less concentrated solutions to avoid violent reactions (i.e., always add acid to water; not water to acid).
- Avoid distracting any other worker. Practical jokes or horseplay have no place in the laboratory.
- Use equipment only for its designated purpose.
- Position and secure apparatus used for hazardous reactions in order to permit manipulation without moving the apparatus until the entire reaction is complete

5.1.3. Housekeeping

- Eliminate safety hazards by maintaining laboratory work areas in a good state of order.
- Maintain at least two clear passages to laboratory exits.
- Always keep tables, fume hoods, floors, aisles and desks clear of unnecessary material.
- Wipe down bench tops and other laboratory surfaces after each use with an appropriate cleaning or disinfecting agent.
- All equipment should be inspected before use.

- If experiments must be left unattended, place a note next to experimental apparatus indicating the chemicals involved, your name and a number where you can be reached in case of an emergency.
- Keep the laboratory floor dry at all times. Immediately attend to spills of chemicals or water, and notify other lab workers of potential slipping hazards.
- All machinery under repair or adjustment should be properly tagged prior to servicing. All service work should be done by authorized personnel.
- All compressed gas cylinders should be securely chained or clamped to a rack or fixed stationary piece of lab furniture. Mark empty cylinders, but use all safety precautions as if the cylinder were full.
- Access to all emergency equipment (fire extinguishers, first aid kits) is to be kept free from obstruction.
- If last to leave the Lab, make sure all equipment is turned off.
- If contractors are working in your area, make known to them any hazards that may exist in your area, i.e. flammable liquids, dusts, combustible material.

5.1.4. Working alone

Working alone is not a good laboratory practice. An individual is advised to work only under conditions in which appropriate emergency aid is available when needed. Another words, try and work when others are around to provide help if it is needed. If others are working nearby, let them know where you will be working so that they can occasionally check on you and you can check on them.

5.1.5. After Hours Access

- Anyone requiring access Labs outside of normal operating hours is required to have formal approval from the Dean of Engineering College. Students requiring after-hours access for a specific time or a specific purpose must apply to the Dean of Engineering on the appropriate after-hours access form.
- When working after hours, the completed after-hours access form and Student ID, must be available for inspection by faculty staff or security.
- Ensure that the doors of buildings are securely closed and locked after entering and leaving the building.
- Ensure that the doors to internal areas are secured on leaving.
- Ensure that you are familiar with the safety rules and emergency contact numbers.
- Do not give anyone else security codes, or keys.
- Do not provide access to buildings to unauthorized persons.
- Work in groups.

5.2 Safety Equipment

5.2.1 Personal Protective Equipment (Appendix D)

5.2.1.1. Protective Clothing

- Lab Coat: The lab coat is designed to protect the clothing and skin from chemicals that may be spilled or splashed. It should always be properly fitted to the wearer and is best if it is knee length.
- There are several different types of lab coats for different types of protection.
- Cotton protects against flying objects, sharp or rough edges and is usually treated with a fire retardant.
- Wool protects against splashes of molten materials, small quantities of acid, and small flames.
- Synthetic fibers protect against sparks and infrared or ultraviolet radiation. However, synthetic fiber lab coats can increase the severity of some laboratory hazards. (May dissolve in some solvents and melt when contact with flames).
- Aluminized and reflective clothing protect against radiant heat.

5.2.1.2. Eye Protection.

In all laboratories where chemicals are used there is the hazard of splashes or dust particles entering the eyes. Pressurized or vacuum vessels may explode or implode sending shrapnel through the lab. While working with electrical wiring there are hazards from molten solder and debris. When testing samples on tensile test equipment or other equipment, pieces can chip and enter the eye. All of these activities, and many others, require the use of safety glasses, chemical goggles or face shields. Most lab operations simply require the use of safety glasses. However, when any chemicals are being used at least chemical goggles should be used or in some cases a face shield is required.

Use and Maintenance: Eyewear should be as comfortable as possible, fit snugly over the eyes and around the face, and not interfere with the movement of the wearer.

Appropriate eye protection should be worn when using:

- Caustics, corrosives, or irritants
- Cryogenic materials
- Flammable materials
- Radioactive materials
- Explosives
- Lasers (special lens protection required)
- UV light (special lens protection required)
- Biohazards

Eye protection should also be worn when performing these machine shop operations:

- Welding
- Grinding
- Sawing
- Sanding
- Drilling

Eye safety equipment should be capable of being cleaned and disinfected.

Eye protection should always be kept in good condition.

5.2.1.3. Hand Protection

Protective gloves acting as a shield between hands and hazardous materials, some gloves can also absorb perspiration or protect the hands from heat. Because certain glove types can dissolve in contact with solvents, it is important to take extra care in matching the protective glove with the nature of the job.

Gloves should be selected on the basis of the material being handled and the particular hazard involved.

- PVC protects against mild corrosives and irritants.
- Latex provides light protection against irritants and limited protection against infectious agents.
- Natural Rubber protects against mild corrosive material and electric shock.
- Neoprene for working with solvents, oils, or mild corrosive material.
- Cotton absorbs perspiration, keeps objects clean, and provides some limited fire retardant properties.

When working with extremely corrosive material, wear thick gloves. Take extra precaution in checking for holes, punctures, and tears. Laboratory Safety Guide

Care should be taken when removing gloves. Peel the glove off the hand, starting at the wrist and working toward the fingers. Keep the working surface of the glove from contacting skin during removal.

Wash hands as soon as possible after removing protective gloves.

5.2.1.4. Foot Protection

Foot protection is designed to prevent injury from corrosive chemicals, heavy objects, electrical shock, as well as giving traction on wet floors. If a corrosive chemical or heavy object were to fall on the floor, the most vulnerable portion of the body would be the feet. For this reason, shoes that completely cover and protect the foot are recommended.

Fabric shoes, such as tennis shoes, absorb liquids readily. If chemicals happen to spill on fabric shoes, remove footwear immediately.

When selecting footwear for the lab, choose sturdy shoes that cover the foot. These will provide the best protection.

The following shoe types should not be worn in the laboratory:

- Sandals
- Clogs
- High heels
- Shoes that expose the foot IN ANY WAY

The following are recommended types of footwear:

- **Safety Shoes** (steel-toed) protect against crushing injuries caused by impact from any object during work activities (e.g., lifting heavy objects, using power tools, etc.).
- **Treated Shoes**, Rubber Boots or Plastic Shoe Covers protect against corrosive chemicals.
- **Insulated Shoes** protect against electric shock.
- **Rubber Boots with slip resistant outsoles** provide traction in wet conditions where the possibility of slipping exists.

Safety Shoes, Rubber Boots or Plastic Shoe Covers protect against specific types of chemical contamination and like gloves must be selected to match the current hazard.

5.2.1.5. Ear Protection.

The healthy ear can detect sounds ranging from 15 to 20,000 hertz. Temporary exposure to high noise levels will produce a temporary hearing loss. Long term exposure to high noise levels produces permanent hearing loss. There appears to be no hearing hazard (although possible psychological effects) to noise exposure below 80 dB. Exposure above 130 dB is hazardous and should be avoided. Ear muffs offer the highest noise attenuation, and are preferred for levels above 95 dB. Ear plugs are more comfortable and are preferred in the 80-95 dB range.

Types of ear protection include:

- **Ear plugs** provide basic protection to seal the ear against noise.
- **Ear muffs** provide extra protection against noise, and are more comfortable than ear plugs.
- **Cotton inserts** are poor suppressors of noise and should be avoided.

5.2.1.6. Head Protection

Some environments have the potential for falling or flying objects. Appropriate head protection can protect laboratory workers from impacts, penetration by falling or flying objects, electric shock and burns.

5.2.1.7. Respiratory Protection.

Because certain laboratory procedures can produce noxious fumes and contaminants, respiratory protection may be required.

There are many shapes and sizes of respirators and in order to be effective it must be properly fitted. There are also a variety of cartridges available each having a specific application.

5.2.2 Laboratory Safety Equipment

5.2.2.1. Laboratory Chemical Fume Hood

If there are undesirable or hazardous effluents in some laboratory operations, the fume hood offers an extra measure of protection.

- Operation
  - All laboratory workers with access to a laboratory chemical fume hood should be familiar with its use.
  - The hood should always be in good condition and capable of routine use. Any hood or component of ventilation not properly functioning must be taken out of service and clearly tagged.
  - All protective clothing should be worn when working with chemicals in the hood. In addition to gloves, safety glasses, and lab coats, a face shield or explosion shield will provide an extra measure of safety from reactive chemicals.
- Maintenance
  - Keep the inside of the hood clean and uncluttered.
  - The lab worker should not be able to detect strong odors released from materials in the hood. If odors are detected, check to make sure that the ventilation fan is turned on. If the fume hood is malfunctioning, discontinue work and call maintenance.
  - Solid objects or materials should not be allowed to enter the exhaust ducts at the rear of the hood, as they can become lodged in the duct or fan.
  - Fume hoods should not be used for long-term chemical storage.
  - Maintain the fume hood as recommended by the manufacturer.

5.2.2.2. Chemical Storage Cabinets

Storage of flammables and corrosives in the lab should be limited to as small a quantity as possible. Flammable materials should be stored in flammable material storage cabinets which meet standard specifications.

- Use and Maintenance
  - Chemicals should never be stored in alphabetical order without consideration for chemical compatibilities. This system may contribute to the probability of incompatible materials being stored next to one another. Incompatible reagents should not be stored next to each other.
  - Storage outside of the cabinet should be limited to materials used in the current process.
  - The vent cap on chemical storage cabinets should not be removed unless the cabinet is attached to an approved ventilation system.
  - Glass containers should be stored on the bottom shelf of storage cabinets.

- Types of Cabinets
  - Flammable liquid cabinets are designed for storage of flammable or combustible liquids.
  - Acid/corrosive cabinets are designed for corrosion resistance.
  - Bulk storage cabinets can be used for storage of flammable and corrosive liquids outside the laboratory setting.

5.2.2.3. Individual Storage Containers

Selecting the best means of storage for chemical reagents will, to a great extent, depend on that reagent's compatibility with the container.

A safety can is an approved container of no more than five gallons (19 liters) capacity. It has a spring-closing lid and spouts cover, and is designed to safely relieve pressure buildup within the container.

Vent caps may be purchased for original manufacturers' glass containers to help minimize explosion hazards.

5.2.2.4. Eyewash Stations

Eyewash stations provide an effective means of treatment when chemicals come in contact with the eyes. Eyewash stations should be readily available and accessible to all laboratory personnel.

The eyewash facility should be clearly marked. Laboratory workers should be able to locate the eye wash facility with their eyes closed (eye injuries may involve temporary blindness).

An eye injury usually accompanies a skin injury. For this reason, eye wash stations should be located near the safety shower and/or drench hose so that eyes and body can be washed.

- Use and Maintenance
  - Water/eye solutions should not be directly aimed onto the eyeball, but rather, aimed at the base of the nose. This increases the chance of effectively rinsing the eyes free of chemicals (harsh streams of water may drive particles further into the eyes).
  - Eyelids may have to be **forcibly** opened to attempt eye rinse.
  - Flood eyes and eyelids with water/eye solution for a minimum of 15 minutes.
  - Remove contact lenses as soon as possible to rinse eyes of any harmful chemicals.
  - Eye wash stations should be drained and tested weekly by laboratory personnel and inspected every six months.

- Types of Eye Wash Stations
  - **Gravity Feed** - Self Contained provides the laboratory worker with emergency eye wash treatment in areas inaccessible to plumbing.
  - **Faucet-mounted** (pin or push plate activators) provides continuous water flow while freeing hands to open eyelids. It turns a standard faucet into a practical emergency eye wash station.
  - **Laboratory Bench sprays** with squeeze handles can be installed through the bench top for instant availability.
  - **Swivel Eye Wash mounts** on lab bench or counter top adjacent to a sink. It swivels 90< over the sink for use, or out of the way for storage.
  - **Bowl-mounted** (pin, push plate or foot pedal activators) provides continuous water flow through a free-standing plumbed unit. The bowl may be directed to a floor drain or connected directly to a sewer connection for easy testing and use.

5.2.2.5. Safety Showers

Safety showers provide an effective means of treatment in the event that chemicals are spilled or splashed onto the skin or clothing. Safety shower facilities should be installed wherever corrosive chemicals are used (e.g. acids or alkalis) and must be readily available to all personnel.

- Use and Maintenance
  - Safety showers should be in a clearly marked location. The facility should be no more than 100 feet, or 10 seconds, away from every lab work bench.
  - Laboratory workers should be able to locate the shower(s) with their eyes closed (emergency situations may leave victims temporarily blind).
  - Safety showers are operated by grasping a ring chain or triangular rod.
  - The pull mechanism is designed for people of most heights but may require a modification for wheelchair access. It should always be accessible and hang freely.
  - Safety showers should supply a continuous stream of water to cover the entire body.
  - Individuals should remove contaminated clothing, including shoes and jewelry, while under an operating shower.
  - Safety showers should be located away from electrical panels or outlets.
  - If at all possible, safety shower facilities should be installed near appropriate drainage systems.
- Types of Safety Showers
  - Ceiling/Wall Emergency Shower provides a continuous water flow and mounts directly to overhead vertical pipes or horizontal wall pipes.
  - Floor-Mounted Emergency Combination eye wash/face and body wash mounts directly to horizontal pipes.
  - Deck-Mounted Drench Hose is a hand operated unit intended to augment a safety shower for quick spot-washing of injuries.

5.2.2.6. Fire Safety Equipment

- Fire Alarms
  - Designed so that all laboratory personnel and building occupants are alerted by an audible warning. Fire alarm activations must be reported to Emergency Assistance (9900) from a safe location.
  - All employees/students should become familiar with the exact location of the fire alarm stations nearest to their laboratory.
  - Smoke detectors and heat detectors may automatically activate the fire alarm. (This should not be considered a substitute for manual fire alarm activation.)
- Fire Extinguishers:
  - Spaced and located as required by current fire codes and standards.
  - Multipurpose fire extinguishers can be found in hallways and near exits in most laboratories.
  - Additional or redundant extinguishers will only be provided at a charge to the requestor (Note: Special purpose fire extinguishers are provided where necessary).

- Only use a fire extinguisher if the fire is very small and you know how to use the extinguisher safely. If you can't put out the fire, leave immediately. Make sure the safety department is called even if you think the fire is out.
- In laboratories, fire extinguishers should be securely located on the wall near an exit. The lab occupant should be aware of the condition of the fire extinguishers by observing them for broken seals, damages, low gauge pressure, or improper mounting, any fault should be reported to the safety department.

5.3. Chemical Safety

Care should be taken to see that chemicals are not only stored, transported and handled safely, but also that they are disposed of in a way that harms neither equipment and plumbing, nor other people.

5.3.1 Transporting Chemicals

When chemicals are carried by hand, they should be placed in a carrying container or acid carrying bucket to protect against breakage and spillage. When chemicals are transported on a wheeled cart, the cart should be stable under the load and have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly. Provisions for the safe transport of small quantities of flammable liquids include:

- The use of rugged pressure-resistant, non-venting containers
- Storage during transport in a well-ventilated vehicle
- Elimination of potential ignition sources.
- Chemicals should not be carried in open containers in hallways or elevators where they may be spilled.

5.3.2 Storage & Handling of Chemicals

Every chemical should have a specific storage space.

They should not be stored on countertops where they can be knocked over or in hoods where they interfere with proper air flow. Flammable liquids should be stored in ventilated storage cabinets. They should not be stored near ignition sources or in areas where accidental contact with strong oxidizing agents is possible. Oxidizing agents include; chromic acid, permanganates, chlorates, perchlorates, and peroxides.

All containers must be labeled (including such harmless items as distilled water). The label should contain the proper name of the chemical and, if appropriate, a statement of hazards (with the most severe first), precautions, date of purchase or synthesis, and the name of the user.

Do not use chemicals from unlabeled containers. The need for adequate labeling extends far beyond the immediate requirements of the individual users, since they may not be present in case of fire or explosion, or when containers are broken or spilled. Proper labeling is extremely important as it is impossible to dispose of unlabeled chemicals.

Do not pipet by mouth. Never taste or smell any chemical.

Clean spills immediately, Small spills may be safely handled by lab personnel familiar with handling precautions for that material. If in doubt of your ability to handle the situation, evacuate the lab, close the door, and call 9900 and explain the nature of the emergency.

Avoid direct contact with any chemical, what might be considered safe today may eventually be found to be unsafe. The first step in using any chemical should be a review of the Material Safety Data Sheet (MSDS) supplied by the manufacturer. If you happen not to have an MSDS for a particular chemical, the local supplier of the chemical or the manufacturer should be able to provide you with an MSDS, or you can search the internet. Pay specific attention to the potential hazards and safety equipment required for working with the material. Be familiar with the proper emergency procedures recommended for the chemical in case of accidental exposure.

The following are specific examples of potentially hazardous conditions and how to prevent them.

5.3.2.1. Unattended chemical reactions

Take great care in setting up chemical reactions that are to be left unattended for any period of time. Note that unattended operation should be avoided if at all possible. The possible hazards that might arise from failure of a heating mantle (overheating), failure of a water cooling system (hose becoming disconnected or bursting), and failure of an exhaust (if flammable solvents or toxic gases are involved), are obvious points to check before leaving a reaction unattended. Any reaction that is left unattended should be clearly labeled as to the nature of the reaction and its components, the possible hazards (i.e., poisonous vapors), and the name and phone number of the experimenter. A notice describing the nature of the unattended experiment, emergency procedures, and who to contact in case of emergencies should be posted on the outside of the door to the laboratory in which the experiment is being conducted.

Before beginning a chemical reaction the experimenter should have an idea of how it will proceed. Thus, ice baths can be ready if it is exothermic; a vent is available if gases are generated, automatic shutdown incorporated in the event of loss of electrical power, cooling water, etc. The experimenter should also notify his advisor that the experiment will be running overnight. If your work presents a hazard of chemicals being splashed into your face, locate the nearest eyebath for emergency use.

5.3.2.2. Toxic hazards.

Researchers should be aware of the toxic hazards of the materials they are using, and those being used by others in their vicinity. Toxic materials may enter the body through the skin, inhalation, and/or ingestion. Care should be taken to prevent these means of entrance when handling toxic materials. A large number of common substances are acute respiratory hazards and should not be used in a confined area in large amounts. They should be used only in a hood. Some of these include; ammonium hydroxide, carbon monoxide, chlorine, fluorine, hydrochloric acid, hydrogen sulfide, and sulfur dioxide. These may form as by-products of certain reactions. Control of these by-products should be part of the experimental procedure.

5.3.2.3. Acids and Bases

Acids and bases are found in most laboratories since there are a variety of applications for them. Three important hazards are associated with acids and bases: chemical burns suffered from spills, inhalation of caustic vapors, and fires or explosions caused by strongly exothermic reactions occurring when strong acids are diluted rapidly. Strong bases may often cause more severe burns than acids as they don't often provide a warning, such as a burning sensation until damage to the skin has already occurred.

Always dilute acids by adding them to water and not vice versa.

Use diluted acids and bases whenever possible.

Keep bottles of strong acids and bases closed when not in use since they can react with moisture in the air to form caustic fumes.

If acids or bases are accidentally splashed in the eye or on the skin, flush with water immediately, continue flushing for 15 minutes, and call for help.

5.3.2.4. Organic Solvents

Many organic solvents possess harmful vapors or pose health hazards because they can be easily absorbed through the skin. Most solvents are quite volatile and the vapors are flammable. Always refer to the MSDS of a solvent before using it to become aware of the hazards, safety precautions, and emergency procedures associated with that specific solvent. Always store them according to the guidelines for storage of flammable liquids.

A few examples of the hazards of some common solvents are provided below, but this list is by no means complete.

- **Acetone**: Possesses toxic and flammable vapors. Use proper ventilation, safety glasses, and gloves. Store in a flammable liquids storage area.
- **Methanol**: Possesses harmful vapors that can cause dizziness, central nervous system depression, and shortness of breath. Severe exposure can lead to coma and eventually death. Less severe exposure can cause blurring of vision, conjunctivitis, headaches, gastrointestinal disturbances, and definite eye lesions. Methanol should be used in a ventilation hood and neoprene gloves should be worn.
- **Benzene**: Carcinogenic. Chronic poisoning can occur by inhalation of relatively small amounts over a long time. Can also be absorbed through the skin. Vapors are flammable and it should be stored in a flammable liquids storage area.
- **Ethers**: Ethyl ether, isopropyl ether, dioxane, tetrahydrofuranand and many other ethers tend to absorb and react with oxygen from the air to form unstable peroxides, which may detonate with extreme violence when they become concentrated by evaporation or distillation, when combined with other compounds that give a mixture that can be detonated, or when disturbed by unusual heat, shock or friction (sometimes as little as unscrewing the bottle cap). This class of compounds should be avoided if there is a safer alternative. It is generally recommended that ethers which will form

peroxides should be stored in full, airtight, amber glass bottles, preferably in the dark, or in metal containers.

5.3.2.5. High Energy Oxidizers

Very small amounts of strong oxidizers (0.25g) can result in severe explosions and must be handled with the proper protective equipment, such as: protective clothing, leather gloves and face shields. Larger amounts require special procedures involving explosion barriers. Specific procedures are included in the MSDS for the chemical.

5.3.2.6. Powders

Most ceramic materials are considered inert with the human body however submicron particles in the lungs may cause respiratory irritation. Whenever working with fine powders correct respiratory protection is recommended. Cloth dust masks available in the stockroom are not appropriate for work with extremely fine powders. Some powders such as SiO2, cause lung diseases such as silicosis. BeO and PbO are considered extremely toxic and must be handled with great care. If possible use powders in a hood so as to not contaminate the laboratory. The specific requirements for each powder are generally listed on the MSDS. Some fine powders are pyrophoric and may explode when dispersed in air.

5.3.2.7. Whiskers and Fibers

Since the cancer causing nature of asbestos was discovered, other mineral and ceramic fibers are under suspicion for their health hazards. It is not well known whether this health risk involves a chemical or physical reaction in the body. Fibers and whiskers must be handled with care so that they may not be inhaled or brought into contact with the skin.

Note:

Many other compounds have serious hazards associated with them. You should make it a point to learn about the proper handling of the compounds that you use.

5.3.3 Disposal of Chemicals

5.3.3.1. Organic Solvents

Contaminated organic solvents such as acetone, alcohol, methyl ethyl ketone (MEK) should never be poured into the sink.

These solvents should be put into metal safety cans.

Every time you add a compound to the safety cans, you must do the following:

- List the compound name and quantity each time. Estimate quantity in millimeters.(We suggest transferring the waste in a graduated beaker).
- Initial your disposal.
- Write legibly.

DO NOT PUT ACIDS IN SOLVENT WASTE CANS. THIS INCLUDES ELECTROPOLISHING ELECTROLYTES AND ETCHANTS.

5.3.3.2. Non-Organic Waste

To dispose of non-organic wastes:

- Place in a 'Primary ' container (or original glass container). Label this with the amount and identity of the contents.
- Place all primary containers in a secondary (cardboard box) filled with packing material. Label this box with the contents of primary containers, your room number and the building number.
- Fill out a chemical disposal sheet and mail it to the responsible office. They will come and pick it up.

This procedure is to be followed for all inorganic waste including acids and toxic substances. Always label all waste material. Never mix two chemicals that are to be disposed: they might form explosive or otherwise harmful mixtures.

5.3.4 Chemical Spills

If a hazardous spill occurs: follow the following Safety Procedures

- Assess the severity of the hazard to yourself before attempting to clean it up.
- If you are unable to SAFELY remove the spill,
  - ❏ Alert everyone in the area.
  - ❏ Post a warning
  - ❏ Contact the lab supervisor or call 9900

5.3.4.1. Acid Spills

Anyone using acids for etching, electroplating or other experimental work should have available in the immediate work area a five pound bottle of sodium bicarbonate. In case of an acid spill, put sodium bicarbonate on the acid to neutralize it. It is recommended that 1 to 1 ratio of sodium bicarbonate to spilled acid. There will be a foaming reaction and sodium bicarbonate should be added until the foaming subsides. This mixture can then be put in a sink and diluted with copious amounts of running water.

5.3.4.2. Mercury Spills

Extreme caution should be used in handling mercury as a spill contaminates a whole area. It is recommended that procedures using mercury be confined to high-sided plastic trays to prevent the escape of mercury droplets. All spills must be reported to Safety department to clean up the spill and test for toxic levels of mercury in the area.

5.4 Electrical Safety

While electricity is in constant use by the researcher, both within and outside the laboratory, significant physical harm or death may result from its misuse. With direct current, a man can detect a "tingling" feeling at 1 mA and the median "let-go" threshold (the current at which he cannot release the conductor) is 76 mA. For 60 Hertz alternating current, the values are 0.4 mA and 16 mA, respectively. Higher currents produce respiratory inhibition, then ventricular fibrillation, and ultimately cardiac arrest. If an electrical hazard is suspected, the device in question should be disconnected immediately and the cause must be ascertained by the person competent to do it. Work on electrical devices should be done only after the power has been shut off in such a manner that it cannot be turned on accidentally. Since malfunctioning equipment may contain shorts, merely turning off the equipment is not sufficient to prevent accidents. Equipment should be unplugged before being inspected or the circuit with which equipment is wired must be deactivated by putting the circuit breaker in the off position, or by removing the fuse. Equipment wired to a safety switch should be turned off at the safety switch. Internal energy storage devices such as capacitors must be discharged.

All electrical wiring and construction must conform to standard safety practice. High voltage equipment must be labeled: "Danger. High Voltage.” Switches to turn-off all electrical power to the equipment in case of emergency should be prominently labeled.

The following are a list of rules for working with electrical equipment:

- Turn off the power to equipment before inspecting it. Turn off circuit breakers or unplug the equipment. To turn off a safety switch wear insulating gloves made of leather or heavy cotton or rubber, turn your face away from the box, and pull the handle down. Circuits may discharge violently when being turned on or off and the cover to the junction box may be blown open.
- Use only tools and equipment with non-conducting handles when working with electrical devices.
- All current transmitting parts of any electrical devices must be enclosed.
- When checking operating circuits, keep one hand either in a pocket or behind your back to avoid making a closed circuit through the body.
- Maintain a work space clear of extraneous material such as books, papers, and clothes.
- Never change wiring with a circuit plugged into a power source.
- Never plug leads into a power source unless they are connected to an established circuit.
- Avoid contacting circuits with wet hands or wet materials.
- Wet cells should be placed on a piece of non-conducting material.
- Check circuits for proper grounding with respect to the power source.
- Do not insert another fuse of larger capacity if an instrument keeps blowing fuses; this is a symptom requiring expert repairs. If a fuse blows, find the cause of the problem before putting another.
- Extension cords must be connected to a power strip equipped with a fuse.
- Do not use or store highly flammable solvents near electrical equipment.
- Multi-strip outlets (cube taps) should not be used in place of permanently installed receptacles. If additional outlets are required have them installed by an electrician.
- Keep access to electrical panels and disconnect switches clear and unobstructed.

Static Electricity and Spark Hazards: Sparks may result in explosions in areas where flammable liquids are being used and therefore proper grounding of equipment and containers is necessary. Some common potential sources of sparks are:

- The making and breaking of an electrical circuit when the circuit is energized.
- Metal tanks and containers.
- Plastic lab aprons.

- Metal clamps, nipples, or wire used with no conducting hoses.
- High pressure gas cylinders upon discharge.

5.5. Mechanical Safety

5.5.1. Equipment

Before using an instrument or machine, be sure you have been instructed and authorized by the person responsible for the equipment. Become familiar with potential hazards associated with the equipment, emergency shutdown procedures, as well as the operating procedures.

Check all electrical connections and mounting bolts before each use.

Check that all rotating parts are free to turn, and that there are no mechanical obstructions before starting.

Attach an "emergency shutdown card" to any piece of equipment left operating unattended outside normal working hours. This card should contain your phone number and all information that would be required by anyone who might find a reason to shut down the equipment.

Laboratory equipment is not to be placed in corridors.

5.5.2. Refrigerators

While domestic refrigeration units are appropriate for keeping foods cold, they are not designed to meet the special hazards presented by flammable materials. Therefore, laboratory refrigerators should be carefully selected for specific chemical storage needs. To prevent potential safety hazards, the length of storage of any material should be kept to a minimum. In addition, refrigerators should be periodically inspected and undergo maintenance when required.

Each refrigerator, freezer or other cooling unit should be prominently labeled with appropriate hazard signs to indicate whether it is suitable for storing hazardous chemicals. Label chemical hazard refrigerators with the sign "For Chemical Storage Only. No Food or Drink Allowed."

If radioactive materials are to be stored, a refrigerator must be clearly labeled "Caution,

Radioactive Material. No Food or Beverages May Be Stored in This Unit."

The containers placed in the refrigerator should be completely sealed or capped, securely placed and labeled. Avoid covering materials with aluminum foil, para film, corks, and glass stoppers.

Refrigerators should be frost free to prevent water drainage.

Because ignitable vapors can build up in refrigerators, it is important to store flammable and combustible materials in specially-designed units. These refrigerators will have self-contained electrical safety elements to avoid spark induced explosions.

Explosion-proof or intrinsically safe refrigerators are specifically designed for hazardous environments, featuring enclosed motors to eliminate sparking.

Highly volatile flammable and combustible substances that require refrigeration may be stored only in explosion-proof refrigerators especially designed for such use. Such refrigerators must meet the requirements for Class 1 Division 1 Electrical Safety Code (NPFA 70 and NFPA 45) and require direct wiring to the power source via a metal conduit. The same storage requirements apply to any solution or specimen that may release flammable fumes.

5.5.3. Centrifuges: Use and Maintenance

- Do not attempt to operate a centrifuge until you have received instruction in its specific operation. Read the operation manual, if available, and ask an experienced colleague to demonstrate procedures.
- Individual users are responsible for the condition of the centrifuge machine and rotors during and at the end of procedures. This responsibility includes proper loading, controlling speed to safe levels, safe stopping, removal of materials, and cleanup.
- Ultracentrifuge rotors require special cleaning procedures to prevent scratching of surfaces, which can lead to stress points and possible rotor failure during operation.
- In selecting a centrifuge, carefully consider:
    - Location, type, and use
    - Balance capability each time the centrifuge is used
    - Adequate shielding against accidental "flyaway"
    - Suction cups or heel brakes to prevent "walking"
    - Accessibility of parts, particularly for rotor removal
    - Lid equipped with disconnect switch, which shuts off rotor if the lid is opened
    - Safeguard for handling flammables and pathogens. (This may include positive exhaust ventilation, a safe location or sealed cups.)
    - Positive locking of head
    - Electrical grounding
    - Locations where vibration will not cause bottles or equipment to fall off shelves

POTENTIAL PROBLEMS TO WATCH FOR:

PROBLEM	EFFECT	PRECAUTION AGAINST
Unbalanced load	Damage to seals or other parts	Keep lid closed during operation and shut down and stop the rotor if you observe anything abnormal, such as: noise vibration
Broken tubes	Centrifuge contamination and personal injury	When loading the rotor: examine tubes for signs of stress discard tubes that look damaged or defected

5.5.4. Heating Devices : Use and Maintenance

Electrical devices that supply heat are commonly used in laboratories. Electrically heated devices include:

- Hotplates
- hot-tube furnaces
- Heating mantles
- hot-air guns
- Oil baths
- ovens
- Air baths

Improper use could result in fire or burns to the user.

If baths are required to be activated when not attended, they should be equipped with timers to turn them on and off at suitable hours and, if possible, a thermostat to turn off power if the unit overheats.

Flammable or combustible solvents should never be used in a heated bath unless housed in a chemical fume hood.

Before using any heating device:

- Check to see if the unit has ability to automatically shut-off in case of overheating;
- Note the condition of electrical cords and have them replaced as required;
- Make sure the apparatus has been maintained as required by the manufacturer;
- Make sure the device maintains a Underwriters' Laboratories (UL®) or Factory Mutual Engineering Division of Associated Factory Mutual Fire Insurance Companies (FM®) listing;
- Check to see that all heating units in use without automatic shut-off have been turned off before leaving the area for any extended period of time.

5.5.5. Ovens and Furnaces

Electric ovens are often used in laboratories for removing solvents or water from samples and to dry laboratory glassware. These ovens if not properly vented or used in a hood, discharge the volatile substances into the laboratory atmosphere which can accumulate in toxic concentrations. Small amounts of vapor can accumulate inside the oven and mix with the air to form explosive mixtures. Ovens should not be used to dry any chemical known to possess toxic vapors or that might volatilize and pose an explosion hazard or acute chemical hazard unless special precautions have been taken to ensure continuous venting to a hood. Organic compounds should not be dried in ovens whose heating elements or temperature controls (which may produce sparks) are exposed to the interior atmospheres. It is recommended to have blown out panels in the rear of drying ovens so that an explosion will not blow the door and contents into the lab. Bimetallic strip or alcohol thermometers rather than mercury thermometers should be used in ovens.

Exhaust fans in the hood must always be on when furnaces are being heated. Goggles, safety masks and heat-resistant gloves must be used at all times. Tongs of proper length must be used with proper care. Any cyanide pot used for carburizing must be used with special care. If contact is made, immediately wash off the salt with copious quantities of water. Students must be authorized by the instructor and faculty advisor to operate furnaces. Otherwise only instructors are permitted to ignite the furnaces. For casting, instructors only are permitted to remove molten material from the furnace. For students, pouring and casting must be supervised. No one can be forced to pour - the act must be voluntary. Water should not be present in the working area. It produces a violent explosion in contact with molten metal.

Removal of Organics in Furnaces: When removing binders or other organic substances from ceramic powders prior to sintering, one must observe similar precautions to those discussed for drying ovens. During decomposition, binders break down into shorter chain molecules and volatilize from the sample. These decomposition products often contain carbon monoxide as well as other toxic gases. If not properly vented, these gases may pose acute or chronic toxicity hazards to people in the lab and they can also form explosive mixtures when combined with the furnace atmosphere. Prior to burning out any organic material in a furnace one should estimate the chemical composition of possible decomposition products and ensure the heating cycle and furnace atmosphere are properly controlled so that the explosive limits of the by-products are not reached.

5.5.6. Vacuum Systems

Mechanical vacuum pumps used in laboratories pose common hazards. These are the mechanical hazards associated with any moving parts and the chemical hazards of contaminating the pump oil with volatile substances and subsequently releasing them into the lab. A few guidelines will help in the safe use of these devices. Distillation or concentration operations requiring large concentrations of volatile substances should be performed using a water aspirator. If a vacuum pump is required for lower pressures, the pump must be fitted with a cold trap to condense the volatiles. The output of the pumps should be vented to a hood or alternate exhaust system. The pump oil should also be replaced when it becomes contaminated.

5.5.6.1. Use and Maintenance

- Every laboratory vacuum pump must have a belt guard in place when it is in operation.
- The service cord and switch, if any, must be free of observable defects.
- Use a trap on the suction line to prevent liquids from being drawn into the pump.
- If vapors are being drawn through the pump, a cold trap (which is a tube that will condense vapors passing through it) should be inserted in the suction line to prevent contamination of the pump oil.
- Place a pan under the pump to catch any oil drips.
- Use only containers that can withstand evacuation. When possible, tape containers must be evacuated and use a standing shield to guard against implosion.
- Always close the valve between the vacuum vessel and the pump before shutting off the pump to avoid sucking vacuum oil into the system.

Explosion Prevention: In order to prevent explosions:

IF THE PUMP IS USED	YOU MUST

for vacuum distillation or filtration of organic liquids	Direct the discharge to an operating hood or other exhaust system. Discharge into an enclosed space such as a cabinet can cause an explosion.
in an area where flammable gas, vapor, or dust are present	Ensure that the motor, cord, plug, and all electrical parts are explosion-proof.

5.5.6.2. Glassware

- Glassware used for vacuum distillations or other uses at reduced pressure must be properly chosen for its ability to withstand the external pressure of the atmosphere.
- Only round-bottom vessels may be subjected to vacuum.
- Each vessel must be carefully inspected for defects such as scratches or cracks.

5.5.7. Gas Cylinders

- All cylinders must be stood upright and placed behind chain or wire restraints. Never lay cylinders on the floor.
- Secure gas cylinders with a strap or chain to a stable object (preferentially a wall or heavy lab bench), whether or not they are in use. Always leave the cap on when the tank is not being used.
- Transport gas cylinders with cap on, and use a proper cart.
- Do not use an open flame near gas cylinders.
- Never use grease or other lubricants on gauges or connections (This may form explosive mixtures with oxidizing gases).
- Before using gas in an experiment, be sure there are no leaks in the system.
- Learn directions for closing and opening valves. (All main valves close clockwise).
- Before connecting a non-toxic gas cylinder to a system, remove the valve cap and open the valve for an instant to clear the opening of particles or dirt. To turn on a system, open the main cylinder valve completely and open remaining valves successively further from the main cylinder. To shut down a system, close the main cylinder first and close remaining valves in the order in which they were opened to avoid storing high pressure in the system.
- Do not use adaptors to connect regulators. Use only regulators specified for the particular gas. Have all regulators inspected and serviced regularly. Regulators open by turning the handle clockwise; this increases the pressure in the system.
- Only use regulators, pipes, and fittings specified for the type of gas you will be using.
- Do not locate gas cylinders near heat sources, like furnaces, where they may heat up and explode.
- Familiarize yourself with the toxic properties and safety hazards of each gas you work with. Post any safety information that may pertain to others working in the lab.
- Store oxygen cylinders and combustible gases separately.

5.5.8. Waterlines

All waterlines connecting apparatus to water outlets must be copper tubing with proper metal fittings or high pressure water hoses fitted with proper clamps, even if the water flows at a low-pressure and low rate since an obstruction in the hose can subject it to line pressure. The bursting pressure of the hose must safely exceed the highest pressure attainable in the water mains.

5.5.9. Distillations and Condensers

Superheating and sudden boiling frequently occur when distilling under vacuum. Therefore, it is important that the assembly be secure and the heat be distributed evenly (i.e. with heating mantle or liquid bath). A standing shield should be in place to guard against implosion. An additional thermometer should be inserted near the bottom of the distilling flask to warn of a dangerous exothermic reaction. After finishing a vacuum distillation, cool the system before slowly bleeding in air, since air may induce an explosion in a hot system. Be sure that hoses carrying cooling water are securely attached with hose clamps to prevent accidental floods. Glass joints should be secured with clips available from the stockroom to prevent accidental disconnection or disconnection caused by vapor build up.

5.5.10. Glassware: Use and Maintenance

Accidents involving glassware are a leading cause of laboratory injuries. These can be avoided by following a few simple procedures. In general, be certain that you have received proper instructions before you use glass equipment designed for specialized tasks that involve unusual risks or potential injury. Listed below are some safety rules.

- Handle and store glassware carefully so as not to damage it or yourself.
- Properly discard or repair damaged items.
- When inserting glass tubing into rubber stoppers, corks or when placing rubber tubing on glass hose connections:
    - ❏ Protect hands with a heavy glove or towel
    - ❏ Lubricate tubing or stopper with water or glycerol and be sure that the ends of the glass tubing are fire-polished
    - ❏ Hold hands close together to limit movement of glass should fracture occur
- Substitute plastic or metal connections for glass ones whenever possible to decrease the risk of injury
- Use glassware designed for vacuum work for that purpose
- When dealing with broken glass
    - ❏ Wear hand protection when picking up the pieces
    - ❏ Use a broom to sweep small pieces into a dustpan
    - ❏ Package it in a rigid container (i.e. corrugated cardboard box) and seal to protect personnel from injury.
    - ❏ Broken glass thermometers containing mercury should be treated in the same way as a mercury spill. These should never be thrown in a broken glass container or trash receptacle.

5.6. Cryogenic Safety

- Generally, only liquid nitrogen, acetone and dry-ice mixtures, and liquid helium should be used for trapping and cooling.
- When using a liquid nitrogen cold trap, charge the trap only after the system is pumped down. Since the boiling point of liquid nitrogen is -196°C and the boiling point of liquid

oxygen is -183°C, liquid oxygen as well as volatile organic substances could condense in the cold traps. These mixtures may explode. When shutting down a system, charge the lines with nitrogen gas to prevent oxygen from entering the system.

- Do not mix any organic material with liquid nitrogen for the reasons explained above.
- Handle any liquefied gas carefully.
- At extremely low temperatures it can produce an effect on the skin similar to a burn caused by a hot object.
- Eyes should be protected with face shielded safety glasses.
- Gloves should be worn.
- Stand clear of the boiling and splashing liquid and its issuing gas.
- when any liquefied gas contacts the skin or eyes, immediately flood that area of the body with large quantities of unheated water and then apply cold compresses.
- Large quantities of liquid nitrogen can condense oxygen and thus remove it from the air. Use liquid nitrogen only in a well-ventilated area so that the ambient oxygen concentration does not drop lower than 16% (the same applied to liquid helium).
- High pressure gas hazards are always present when cryogenic fluids are used as they are usually stored at their boiling point. Never obstruct the vent valve on cryogenic containers.
- Glass dewars used for holding and transferring small quantities of liquid gases must either be surrounded by a protective metal shield or wrapped with tape to prevent injury from flying glass resulting from implosion. Large containers for liquid gases must be all-metal dewars.
- Safety goggles must be worn at all times around glass apparatus subject to possible implosion or explosion.

5.7 Radiation Safety

A number of acute and long term effects on humans have been related to exposure from various types of ionizing radiation. Radiation hazards arise when using radio-isotopes, lasers, x-ray generators and plasma torches. Each is hazardous in a unique way. A thorough knowledge of the device or the isotope which is to be used is mandatory. The precautions vary widely. However, several precautionary procedures should always be followed:

- Radioactive Materials
    - All work with radioactive material or radiation producing equipment must be registered and reported. All persons using radioactive material and x-ray machines must be instructed in the potential hazards and the necessary safety precautions.
    - All persons working with radioactive materials or equipment must complete a training session before beginning their work.
    - Do not wear another person's badge or allow another person to wear yours.
    - Report any potential exposures to non-ionizing radiation such as ultraviolet, visible, infrared and microwave radiation.
    - Clearly mark areas in which lasers, ultraviolet, or high intensity light sources are in use.
    - Wear eye protection appropriate to the type of radiation being used when working with these sources.

- X-ray Equipment:
    - Persons using the X-Ray Diffraction equipment must have permission and must have received adequate instruction as to the safe use of the equipment. Any experimental set-up deviating from standard practice must be checked out. The door to the laboratory must be locked when it is not being used by authorized personnel.
    - Under no circumstances should any part of the body be placed directly in primary x-ray beams.
    - Whenever possible turn the x-ray beam off before working on the machine. If this cannot be done, double check to be sure that the shutter on the port involved is closed.
    - Never align samples with the eye in such a position that it might be exposed to the primary beam.
    - Do not defeat any interlock devices, e.g. wiring shutters in the open position.
    - Do not use any x-ray machine that is not working properly.
    - Wear any required personnel monitoring devices at all times while using the x-ray machine.
    - Report any suspected overexposures immediately.
    - Do not depend upon lead foil or sheets for permanent shielding. Shields should be constructed of more durable materials. If lead is to be used it should be as a liner inside brass or some other material.
    - Remember the additional high voltage hazard associated with x-ray machines.
- Lasers
    - There are many types/intensities of lasers and therefore only general guidelines are given.
    - Never look directly at the beam or pump source.
    - Never view the beam pattern directly; use an image converter or other safe, indirect means. To decrease reflection hazard, do not aim by looking along the beam.
    - Do not allow any object which could cause specular reflections in or along the beam, such as spherical buttons, screw heads, or jewelry.
    - Keep a high general illumination level where lasers are in operation to cause contraction of pupils and reduced hazard.
    - Always wear goggles that offer protection against specific wavelengths of the laser in use.
    - Post warning signs outside and inside the laboratory to warn of potential hazards.
    - Clearly mark any areas where laser beams are in use.
- Ultraviolet Lamps:
    - All radiation of wavelengths shorter than 3500 Å should be considered dangerous.
    - Protective safety glasses with UV absorbing lenses should be worn when the eyes may be accidentally exposed.
    - Skin exposed to UV radiation can receive painful burns, analogous to sunburns and should be protected.

Appendix A: Evacuation Plan of College of Engineering


لوحة مخارج الطوارئ
FIRE ESCAPE LAYOUT
ادارة السلامة
تعليمات
LEGENDS
خرطوم حريق
FIRE HOSE
جرس الانذار
FIRE ALARM
طفاية حريق
FIRE EXTINGUISHER
اتجاه المخارج
ESCAPE DIRECTION
انت هنا
YOU ARE HERE
المخارج
EXITS
في حالة الطوارئ التزم الهدوء
IN THE EVENT OF EMERGENCY
المغادرة عبر اقرب مخرج
LEAVE THE NEARST EXIT
المشي بخطى سريعة و عدم التدافع والتوجه الى اقرب نقطة تجمع
ASSEMBLE SAFLEY TO THE ASSEMBLY POINT
عدم استخدام المصاعد
DON'T USE LIFTS
للطوارئ الاتصال على
REQUEST THE EMERGENCY
9900
0135899900
مفتاح الخريطة
KEY PLAN


لوحة مخارج الطوارئ
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تعليمات
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ASSEMBLE SAFLEY TO THE
ASSEMBLY POINT
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مفتاح الخريطة
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للطوارئ الاتصال على
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9900
0135899900
مفتاح الخريطة
KEY PLAN
PUMP SHAFT
MECHANICAL SHAFT
ELECTRICAL SHAFT

لوحة مخارج الطوارئ
FIRE ESCAPE LAYOUT
ادارة السلامة
تعليمات
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0135899900
مفتاح الخريطة
KEY PLAN

Appendix B: Emergency Contact Number

Appendix C: How to use the Fire Extinguisher

كيفية إستخدام الطفاية اليدوية

How To Use Manual Fire Extinguishers

1

توجه إلى مكان الحريق حاملا معك الطفاية اليدوية

Take the Fire Extinguisher to the Fire Area

2

إسحب مسمار الأمان الموجود بأعلى جسم الطفاية

Pull out the safety pin

3

قف مع إتجاه الريح و ليس معاكسا لها

Stand in the wind direction, not against it

4

إضغط على المقبض في نهاية الخرطوم مع توجيهه على قاعدة اللهب

Press the handle at the end of the hose and point it to the base of the flame

5

قف على بعد مناسب من الحريق لتتمكن من مكافحته بحرية

Keep a safety distance from the fire

Appendix D: Safety in Labs Check List

College الكلية	Department القسم	Lab Name إسم المختبر	Lab supervisor مشرف المختبر

ITEM	YES	NO	Note
1. Safety code for lab is available. يتوفر كود سلامة في المعمل			
2. Hazard signs and emergency numbers are clearly displayed in appropriate locations. الاشارات التحذيرية من المخاطر وارقام الطوارئ معلنة بوضوح وفي مكان مناسب			
3. General safety instructions are clearly displayed and announced in appropriate location inside the lab. تعليمات السلامة العامة معلنة في مكان مناسب داخل المعمل			
4. Appropriate personal safety equipment (lab coat, safety goggles, gloves, shoes,…) are available توفر أدوات السلامة الشخصية المناسبة (مريول مختبر، نظارات، قفازات. ...) ،			
5. Safety devices(safety showers, eye washes, laboratory hoods, etc.) are available and functional اجهزة السلامة(دشات، مغاسل، خزائن شفط الابخرة) متوفرة وصالحة			
6. First aid kits - available & stocked properly. خزانة اسعافات اولية متوفرة ومخزنة بشكل صحيح			
7. No food or drink is within designated lab areas. لا توجد مأكولات ومشروبات داخل المعمل			
8. Worktables or counters are clean and free of debris. طاولات العمل والبنشات نظيفة وخالية من الحطام			
9. Floor space is clear of hazardous objects. ارضية المعمل نظيفة وخالية من الاشياء الخطرة			
10. Fire alarm present and working. يتوفر نظام انذار حريق يعمل بشكل جيد			
11. Appropriate fire extinguishers are present, updated, and accessible يتوفر طفايات حريق مناسبة وصالحة حتى تاريخه ويمكن الوصول اليها بسهولة			
12. Electrical plugs and connections are in good condition. مخارج التغذية بالكهرباء والوصلات الكهربائية بحالة جيدة			
13. Heavy objects stored below shoulder level. الأشياء الثقيلة لا يتم خزنها في اماكن مرتفعة			
14. Compressed gas cylinders are properly stored and secured. يتم تأمين اسطوانات الغاز وخزنها بشكل صحيح			

15. All containers are properly labeled and labeling is correct. يتم تسمية جميع الخزائن والحاويات بشكل صحيح			
16. All chemicals and fuels are labeled and stored in proper location. يتم تسمية الكيماويات والوقود وتخزن بشكل صحيح وفي مكان مناسب			
17. Material Safety Data Sheets (MSDSs) for all chemicals are posted and up to date. ورقة بيانات السلامة لجميع المواد الكيميائية معلنة ومحدثة			
18. Flammable liquids are stored in flame proof cabinets and marked with "FLAMMABLE". المواد القابلة للاشتعال تخزن في كبائن مقاومة للحريق ويكتب عليها قابل للاشتعال			
19. Oxidizing and reducing agents are separated. يتم فصل المواد المؤكسدة والمختزلة			
20. Emergency exit signs are available and clear. علامات مخارج الطوارئ متوفرة وواضحة			
21. Doors are not closed from inside. الابواب لا تغلق من الداخل			
22. Accident reports filed and reviewed. تقارير الحوادث يتم حفظها في ملفات وتراجع			
23. Waste properly stored and labeled. يتم تسمية النفايات وتخزن بشكل جيد			
24. Radioactive material storing and handling according to standard specifications. يتم التعامل مع المواد المشعة وتخزينها حسب المواصفات العالمية			

Appendix E: Safety Tools

No.	Name Items	Pictures	No.	Name Items	Pictures	No.	Name Items	Pictures
1	Lab Coat		5	Eye protection		9	Latex gloves	
2	Helmets		6	Safety Face Shield Mask		10	Hearing protection (ear protection)	
3	Hand protection (Gloves)		7	Electrical safety Gloves		11	Leather gloves	

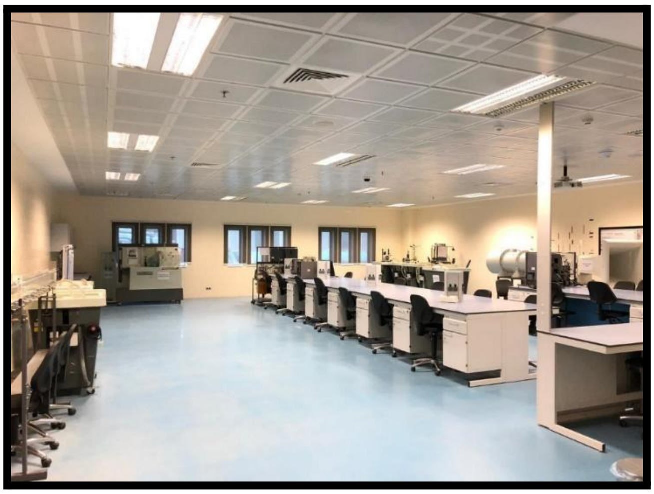
4	**Ear Plugs**		8	**Dust Masks**		12	**Breathing protection**	

Appendix F: Lab Descriptions

I. Mechanical labs

I.1. Fluids Mechanics Laboratory

In this laboratory many concepts related to fluid properties, fluid static and fluid dynamics will be studied experimentally. Also energy principle, momentum principle, hydraulics and aerodynamics will be investigated.



The objective of this laboratory is to enhance the student knowledge in the area fluid mechanics, and to support the student information of fluid mechanics principles and concepts. Also to link the practical side with the theoretical one.

Equipment:

1.Hydrostatics and Properties of Fluids
2.Flow Measurement
3.Reynolds Number and Transitional Flow
4.Orifice and free jet flow
5.Impact of a Jet
6.Losses in Piping Systems

I.2. Strength of Materials Laboratory

The purpose of the Strength of Materials (SoM) Lab. is the education of the undergraduate students by demonstrating the fundamental principles in the fields of mechanics of materials and strength of structural components throughout conducting fundamental and technological state-of the art series of experiments. Students are also introduced to the data acquisition systems used in experimental study. Moreover, this Lab. provides students with the conceptual ethics of strength evaluation and design of structural components and structures, as well as the analysis of structural failures.

Equipment:

1.Universal Testing Machine
2.Torsion Testing Machine
3.Hardness Testing Machine
4.Fatigue Testing Machine
5- Impact Testing Machine

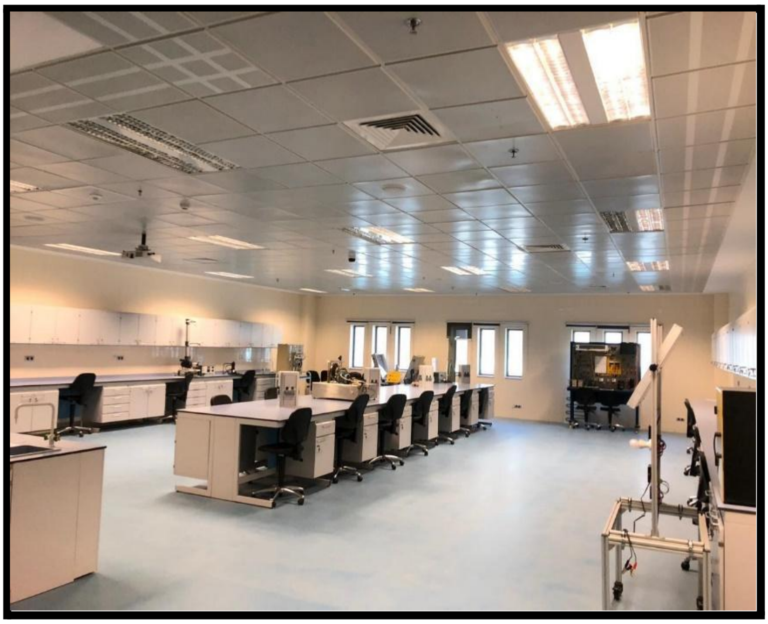
5.Deflection of Beams
6.Buckling Tester
7.Thin Wall Pressure Vessel Apparatus
8.Creep Measurement Apparatus
9.Unsymmetrical Bending /Shear Center Apparatus

I.3. Mechanical Systems Laboratory

This laboratory covers experiments to understand some basic concepts of heat transfer, refrigeration systems, special humidity sensor and vibration systems. Also internal Combustion Engines, Solar Energy principle, can be investigated. The lab make students familiar as much as possible with the devices by getting readings, analyzing the results then comparing with the theoretical calculations for each experiment, and then trying to find the basic technical reasons of these differences.

Equipment:

1.Linear Heat Conduction
2.Combined Convention And Radiation
3.Boiling Heat Transfer Module
4.Heat Exchanger Service Unit
5.Cross Flow Heat Exchanger
6.Compressible Flow Range
7. Diesel Engine Auto Trainer
8. Petrol Engine Auto Trainer
9. Heat Pump Trainer
10.Air Conditioning Unit
11. Hot Water Instrument and Control Panel
12.Solar Energy Demonstrator
13. Vibration Modules



I.4. Measurement and Instrumentations Laboratory

The primary purpose of this lab is to provide fundamental knowledge in the theory and practical experience in the application of mechanical engineering measurements. Experiments in related to pressure measurement, temperature measurement, calibration, strain gauges, and different sensors can be conducted in the lab.

Equipment:

1.Pressure Measurement and calibration

2.Temperature Measurement and Calibration

3.Strain Gauge Trainer

4.Starin Gauge Kit

5.Sensors and Instrumentations system

I.5. Control and Vibration Laboratory

This lab contains many equipment related to Process control like level control, pressure control, and temperature control. In addition, two setups related to Servo and Stepper motor control. Fully basic and advanced hydraulic rigs are also available. On the other hand complete setup vibration equipment that capable to perform many of basic vibration experiments.

Equipment:

Level Workstation

Flow temperature workstation

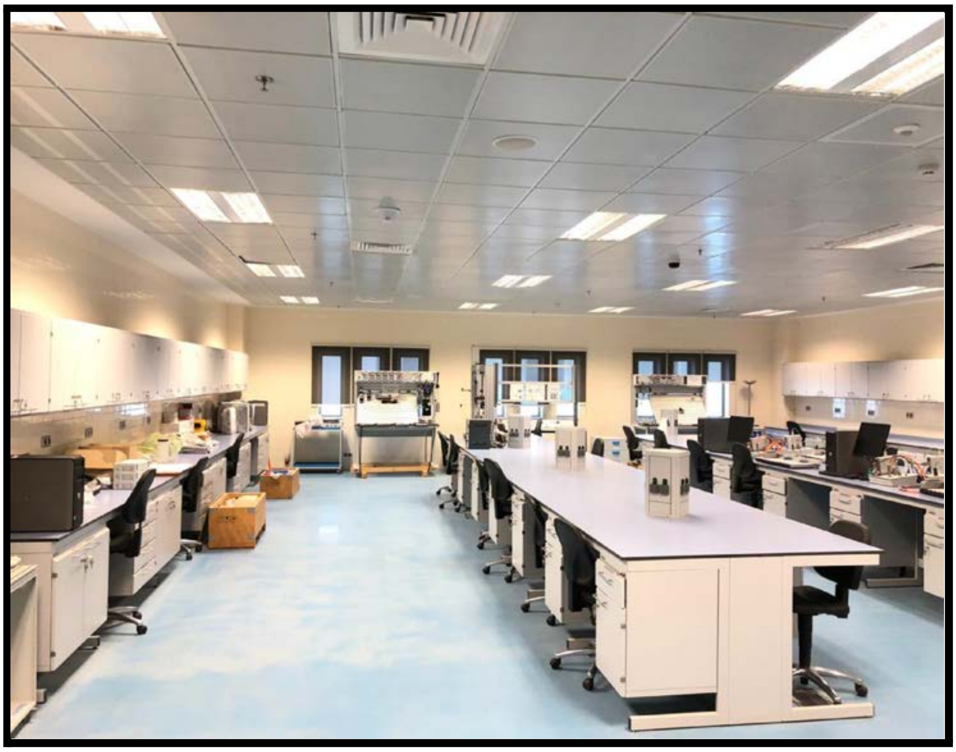
Pressure Workstation

Proportional hydraulics basic level

Hydraulics and electro-hydraulics basic and advanced level

Servo-control system and stepper-control system

Universal vibrations apparatus



II. Electrical labs

II.1. Power Electronics and Drives Laboratory

The hardware laboratory can support several experiments on Thyristor Commutation Techniques, Controlled Rectifiers, AC Voltage Controllers, Closed-loop control of DC drives, DC Choppers, etc. In addition, PSIM software is available in this laboratory to explore the theory, development and analysis of Power Electronics systems, and their applications in various domains.

Equipment:

II.2. Electric Energy & Machines Laboratory

This laboratory provides the students different experiments on DC and AC machines on both no load and loaded conditions. The data obtained from these experiments are used to find main performance parameters of the machines and are the same time to draw characteristic curves between measured parameters during no load-loaded tests. In addition, this lab provides the student's three-phase circuit's connections, single phase, and three phase transformer efficiency and regulation calculation tests.

Equipment:

II.3. Power Systems Laboratory

Power Systems teaching Laboratory provides students hands-on learning tools that teach the many properties of electric generation and use. The three workstations in the lab include test benches to teach power system components, transformers, protection, control. Beside the student experiment sets, the laboratory also has Power world simulation program provides students learn modeling and simulations of the different structure of power systems to understand the load flow, fault and stability analysis.

Equipment:

II.4. Microprocessor Lab

This laboratory focuses on the programming side of hardware; it has training kits that are used for programming microprocessors and microcontrollers through a PC that is connected to these kits. Student work with the MDA8086 kit to program the microprocessors and the Y0037 kit to program PIC microcontrollers. The microprocessor experiments focus on the assembly language and controlling the microprocessor features (stack, interruptions, addressing modes etc), students will also learn how to optimize the code to get a program working with fewer lines of code, they learn also how to control different electronic components (LED, 7 segment display, Digital to Analog Converter, LCD display). The mechatronics experiment focus on the PIC programming in assembly and C language using MPLAB and PIC compiler, student will practice how to control different electronic components and how to apply clean code concepts in their program.

Equipment:

1. Mechatronics Training Set (Y-0037 Experiment Set)
2. MDA training kit

II.5. Mechatronics and Control Laboratory:

The Mechatronics and control part let students practice the analogue systems control through experimentation. By using RYC units, they can study the behavior of 1st and 2nd order system and learn how to change its parameters. Student will also practice the implementation of PID controllers and adjust its settings to find the system's best compromise between stability, speed and steady state error. In addition to the available equipment, students can simulate their system using MATLAB Simulink to find the optimal results before implementing them on real equipment. Students will work also with Programmable Logic Controller PLC to learn how to create ladder programs to control industrial production chains.

Equipment:

1. RYC control unit
2. PLC unit
3. PLC base station

II.6. Digital Logic Design Laboratory

This laboratory is equipped with several educational training kits along with their PCs in order to reinforce classroom lectures and provide hands-on-training in digital design techniques and procedures. Students are exposed to a wide range of laboratory experiments that cover the physical and engineering properties of different digital logic design issues. Such experiments mainly utilize the two digital hardware training sets of Y0100/Y0200 and the Multisim software simulator for digital logic design. Students conduct experiments for digital design on: Analyzing and Verifying the Behavior of Logic Gates, 7-Segment Display and Hexadecimal Driver/Decoder, Tri-State Buffer & 4066 Analog Switching IC, K-Maps and Boolean Algebra, Combinational logic Design and Analysis, and Sequential logic Design and Analysis.

Equipment:

2. Digital Logic Training Set (Y-0010 Experiment Set)
3. Digital Logic Training Set (Y-0020 Experiment Set)
4. Bread Boards with wires for connections with full set of digital logic chips

II.7. Electronic and Electrical Circuits Laboratory:

The purpose of the electric circuits part of this laboratory is to practice essential laboratory measurement and report preparation skills, to reinforce the concepts and circuit analysis techniques, and to gain an increased understanding of some of the practical issues of electrical engineering circuit analysis and design. It is equipped with various types of resistors, variable rheostats, inductor banks, capacitor banks, dc and ac power supplies, switches, lamp boards, ammeters, voltmeters, analog and digital wattmeters, function generators, oscilloscopes, etc. In the laboratory classes, students are taught how to build electric circuits, safety rules of electric circuits, installation of common household appliances and how to write technical reports. The students also verify different electric circuit and network theorems e.g., KCL, KVL, mesh, node, Y-D and D-Y transformation, Thevenin's, Norton's, maximum power transfer and superposition theorems, etc. They also construct phasor diagram of the circuits from the experimental data, determine mutual inductance for the coupled circuits, find the series and parallel resonance frequency of ac circuits, types of filters and quality factors of the inductance coil, measure the ac power in the single phase and three phase circuits, etc.

As for the electronic circuits part of this laboratory, its main purpose is to study electronics through experimentation. Students will be able to use standard laboratory equipment to analyze the behavior of basic electronic devices and to design and construct simple circuits containing these devices, Such as Diode Characteristics, Half wave and full wave Rectification, BJT Transistors, MOSFET Transistors, etc. In addition, they will have the ability to use electronic test & measurement instruments and software, such as oscilloscopes, function generators, etc. Beside the student experiment sets, the laboratory also has simulation programs such as (MULTISIM simulation) to help students measure exact results and error.

Equipment:

1. Digital Multimeter
2. Power meter
3. Digital Multimeter
4. magnetic powder brake
5. DC voltage source
8. Oscilloscope
9. Measurement Device with Middle Indicator
10. Multimeter
11. Variable Resistor
12. Variable Capacitor

6. AC Power supply
7. Function generator
13. Function generator
14. MOSFET panel

II.8. Communication Systems Fundamentals Laboratory

The Communication Systems Fundamentals Laboratory is one of the major laboratories of the EE department, King Faisal University. The goal of this laboratory is to study communication systems through experimentation. Upon completion of this lab, students should be able to use standard laboratory equipment to analyze the behavior of basic communication systems and to design and construct simple communication experiments such as AM Modulation and Demodulation, FM Modulation and Demodulation, PAM, PCM …etc. In addition, the ability to use communication test & measurement instruments such as oscilloscopes, CASSY, etc. We guide our students on the path of becoming experts in the area of Communication Systems. Some of the Equipment used in the Lab are PC (Matlab and Cassy must be installed), Function Generator, Oscilloscope, Coaxial Cables, AM modulator and AM demodulator, FM modulator and FM demodulator, PAM modulator and PAM demodulator, PCM Modulator and PCM Demodulator.

Equipment:

1. Educational laboratory Virtual instrumentation
2. PCM transmitter
3. Plug-in communications board
4. PCM demodulator
5. Plug-in board
6. Oscilloscope
7. magnetic powder brake
8. Digital multimeter
9. DC voltage source
10. data acquisition system
11. AC Power supply
12. Fiber Optic transmitter
13. Function generator
14. Fiber Optic receiver
15. dc power supply
16. Set of FSMA optical fibers
17. function generator
18. optical waveguide
19. AM transmitter
20. optical power meter
21. AM receiver
22. Fiber Micro-positioner
23. FM/PM Modulator
24. plug-in panel
25. FM/PM Demodulator
26. wireless transmitter
27. ASK/FSK/PSK transmitter
28. wireless receiver
29. ASK receiver
30. DSP kit
31. FSK/PSK receiver
32. Spectrum Analayzer
33. PAM modulator
34. Network Analayzer
35. PAM demodulator

III. Civil and Environmental labs

III. Environmental Engineering Lab

Introduce the student to the principles of environmental engineering, including topics like environmental chemistry, materials and energy balances, water quality management, water treatment, and wastewater treatment. The objective of this lab for the students is to be able to apply mass balance, chemical kinetics, and other empirical concepts and techniques in developing basic treatment schemes. Understand the relevance of concepts in general and physical chemistry in determining the quality and treatment options for water supplies, and wastewater. Identify, recognize, analyze and comprehend wastewater problems, and the engineering principles behind the major unit operations employed for wastewater treatment.

Equipment

1. Drying Oven
2. Refrigerator
3. Water Baths
4. Microscope
5. UV-Vis Spectrophotometer
6. Analytical Balance
7. Atomic absorption spectrometer (AAS)
8. Gas Chromatograph
9. High Performance Liquid Chromatograph (HPLC)
10. Total Organic Carbon Analyzer (TOC)
11. Incubator – Upright
12. Water Still
13. Nessler Tube System
14. Turbidity Meter
15. Muffle Furnace
16. Filter Photometer/Colorimeter
17. Flame Photometer
18. Autoclave - Bench Top
19. Colony Counter - Darkfield Quebec type
20. Membrane Filter Apparatus, filter holders
21. Deionizer
22. Flocculation test unit (JAR TEST)
23. Kjeldhal Distillation
24. BOD Refrigerator/Incubator
25. Centrifuge
26. Air Compressor Supply
27. COD Reactor
28. CO Analyzer

III.2. Geotechnical Engineering Lab

The Geotechnical Engineering lab teaches the use of natural material such as soil and rock in combination with engineered material such as concrete, steel and geosynthetics, in the design of dams, tunnels, on-shore and off-shore reclamation for airports, landfills, deep excavations, and foundations for structures of all kinds. The students perform tests for soil samples following properties Index and classification of soil, soil stresses, soil compaction, consolidation and consolidation settlement, shear strength of soils.

Equipment

1. Slake durability device
2. Bench-mounting mixer
3. Soil Hydrometer ASTM (151 H)
4. Mechanical analysis stirrer
5. Proctor Compaction Rammer, 5.5 Ib
6. ASTM Compaction Mould
7. Sand cone density test
8. Vibrating Table
9. Dynamic cone penetrometer
10. Automatic Compactor
11. Consolidation Apparatus
12. Constant Head Permeability Apparatus
13. Sample Extruder
14. Triaxial Test Device
15. Direct shear device
16. Plate bearing test equipment
17. Core drill
18. Core Trimmer and cutting machine
19. Masonry Saw
20. Digital point load test device
21. Falling head permeability Apparatus
22. Unconfined compression machine
23. Portable rock shear box device
24. Sieve shakers
25. Vernier Callipers
26. De-airng Pump

III.3. Highway Engineering Lab

Introduction to Performance Grade (PG) specifications and SuperPave mix design, hands-on testing on SuperPave equipment, determination of the rheological properties of Bitumen using SuperPave equipment, Evaluation of Hot Mix Asphalt (HMA) using SuperPave equipment. The objective of this lab is for the students to understand Performance Grade (PG) specification of asphalt and the SUPERPAVE mix design process.

Equipment

1. Servopac Superpave Gyratory Compactors with extra molds
2. Asphalt Pavement Analyzer – APA
3. Brookfield Rotational Viscometer (RV)
4. Dynamic Shear Rheometer (DSR) Spindles 25mm and 8mm
5. Asphalt Pressure Aging Vessel (PAV)
6. Bending Beam Rheometer (BBR)
7. Direct Tension Tester (DTT)
8. Bench Mounting Mixers (5 liter nominal Capacity)
9. Vaccum Pyknometer (6000 g)
10. Rice Test Vibrator
11. CoreLok Density Measurement Device
12. Asphalt Material Performance Tester (SPT)
13. NCAT Binder Ignition Oven
14. Friction Tester
15. Digital Laboratory CBR Test Machine
16. Large Capacity Oven (>425 liters)
17. Buoyancy Balance (15kgx0.1g)
18. Automated Core Trimmer/Cut-off Machine (Wet Saw)
19. Cleveland Flash Cup Apparatus
20. Rolling Thin Film Oven (RTFO)
21. Servo Hydraulic UTM-130

III.4. GPS & Surveying Lab

An introduction to surveying, which includes surveying terminology, distance and area measurement, coordinate systems, surveying techniques, equipment use, and theory of errors, tape measurements, leveling, theodolite, traverse surveying, topographic surveys, highway curves, control survey and land survey. Introduction to reference systems; types of GPS observable; basic principles of GPS operations; GPS error analysis; field procedures; data collection, processing; applications. Emphasis placed on use of the hand compass and GPS receivers. Designing and conducting experiments as well as to analyze and interpret data through conducting several field experiments ranging from distance measurements to topographic mapping.

Equipment

1. Total Station
2. Digital Theodolite
3. Digital Level Sprinter
4. Digital Planometer
5. Laser distance measuring device
6. Measuring Wheel
7. Laser Level
8. GPS




III.5. Construction Materials Lab

Civil engineers are often responsible for specifying, designing and manufacturing the materials with which they build their structures. Studies in construction materials are intended to make structural, transportation and foundation engineers aware of the fundamental properties of the materials they use. This lab provides civil engineering students fundamental principles of the behavior, physical and engineering properties of various common civil engineering materials, including, sands, aggregates, cement, and concrete. Selection and design of materials based on their intended use in design and construction are emphasized. The laboratory is designed to provide students a hand-on experience on concrete mix design, which includes proportioning, mixing, casting, and concrete testing concepts and procedures.

Equipment

1. Air Entrainment Meter, 5 Liters
2. Table Vibrator, 600 ✕ 400 mm
3. Specific Gravity Frame
4. High Performance Ultrasonic Tester
5. VICAT Apparatus
6. Vebe Consistometer
7. Compacting Fracture Apparatus
8. Motorized Sieve Shaker
9. LA Abrasion Machine
10. Concrete Mixer
11. Poker Vibrator
12. Flexural / Tensile Testing Machine
13. Compression Machine
14. Flexural Beam Frame
15. Concrete Test Hammer
16. Drying Oven
17. Digital Platform Scale 60 Kg
18. Digital Balance 6 Kg
19. Digital Balance 30 Kg

IV. Chemical Engineering labs

IV.1. PROCESS FLUID MECHANICS LABORATORY

The process fluid Mechanics laboratory in the chemical engineering department is engaged to enhance understanding of the basics of fluid engineering principles. The experiments are designed to apply various measurements of fluid properties and flow characteristics. The lab is equipped with different units related to fluid mechanics such as flow measurement unit, fluid friction in pipes and fittings test unit, viscometers, pumps and others.

Equipment:

1. Hydrostatics and Properties of Fluids
2. Flow Measurement unit
3. Losses in Piping Systems
4. Series and Parallel Pump Test Set
5. fixed and fluidized bed

IV.2. SEPARATION PROCESS I LABORATORY

The separation processes 1 Laboratory is equipped for the study of the various mechanical operations associated with solids particles. Experiments mainly deal with size reduction, size separation, clarification, solid fluid separation etc. All basic experiments for fluid particle mechanics like Jaw Crusher, Plate and Frame Filter press, Froth Flotation, Batch Sedimentation, and Sieve Shaker are available in this laboratory.

Equipment:

1. Plate and frame Filter Press
2. Jaw Crusher
3. Sieve shaker
4. Sedimentation unit
5. Aeration tank
6. floatation unit

IV.3. HEAT TRANSFER LABORATORY

Heat Transfer Laboratory helps the students to understand the basic concepts of heat transfer: Conduction, Convection and Radiation, which are the three basic modes for heat transfer to take place. To enhance the practical knowledge of industrial equipment, students perform experiments on some common heat transfer equipment such as linear heat conduction, free and forced convection, Double Pipe Heat Exchanger, Shell & Tube Heat Exchanger and Single Effect Evaporator.

Equipment:

1. Linear/Radial heat conduction unit.
2. Free and forced convection unit.
3. Radiation heat transfer unit.
4. Boiling heat transfer unit.
5. Shell and tube heat exchanger.
6. Parallel tube heat exchanger.
7. Thermal conductivity measurement unit.

IV.4. THERMODYNAMICS LABORATORY

The purpose of Thermodynamics Laboratory is to help the undergraduate students to understand the basic thermodynamic principles by practical applications. The lab includes Bomb calorimeter, Stirling cycle, Work to heat apparatus Temperature and pressure measurement apparatus.

Equipment:

1- Mechanical Equivalent of heat.

2- Bomb Calorimeter.

3- Sterling Engine.

4-Temperature measurement kit.

5- Pressure measurement kit.

IV.5. REACTION ENGINEERING LABORATORY

Reaction engineering laboratory provides undergraduate students with hands-on acquaintance on chemical reactor operations involved in industrial operations. The reaction laboratory inculcates students' skills to correlate theoretical concepts and practical reactor operations.

The experiments performed by the students in the laboratory are related to chemical kinetics, operation of reactors such as batch reactor, Continuous Stirred Tank Reactor (CSTR), tubular reactor. Experiments related to chemical reactor dynamics are also conducted. Reactors are either operated in manual mode or automatic mode and the data collected is processed and analyzed using soft skills.

Equipment:

1. Batch reactors.
2. Tubular reactor
3. Continuous Stirred Tank Reactor

IV.6. UNIT OPERATIONS LABORATORY

Unit operations lab is part of Chemical Engineering Lab III – ChE406; it is designed to introduce students to larger scale industrial processes commonly encountered by chemical engineers in industry. In each experiment, students work in teams to collect experimental data followed by thorough analysis using the theoretical principles they learned in previous courses.

The laboratory is equipped with top quality learning equipment that cover a wide range of industrial processes ranging from traditional separation processes such as distillation, evaporation, extraction, drying, adsorption and gas absorption, to nontraditional separation processes such as ion exchange and reverse osmosis.

Equipment:

1. Distillation column
2. Packed Tower Gas Absorption
3. Single effect evaporator
4. Liquid-liquid Extraction column
5. Tray drier
6. Ion exchange unit
7. Reverse osmosis
8. Cooling tower
9. Adsorption unit

IV.7. PROCESS CONTROL LABORATORY

Process control lab is part of Chemical Engineering Lab III – ChE406; it is designed to introduce students to larger scale industrial processes commonly encountered by chemical engineers in industry. In each experiment, students work in teams to collect experimental data followed by thorough analysis using the theoretical principles they learned in previous courses.

The laboratory is equipped with top quality learning equipment that cover a wide range of industrial processes control such as pressure control, temperature control, flow control and level control. In addition, students perform simulation experiments that mimic real industrial processes using specialized software.

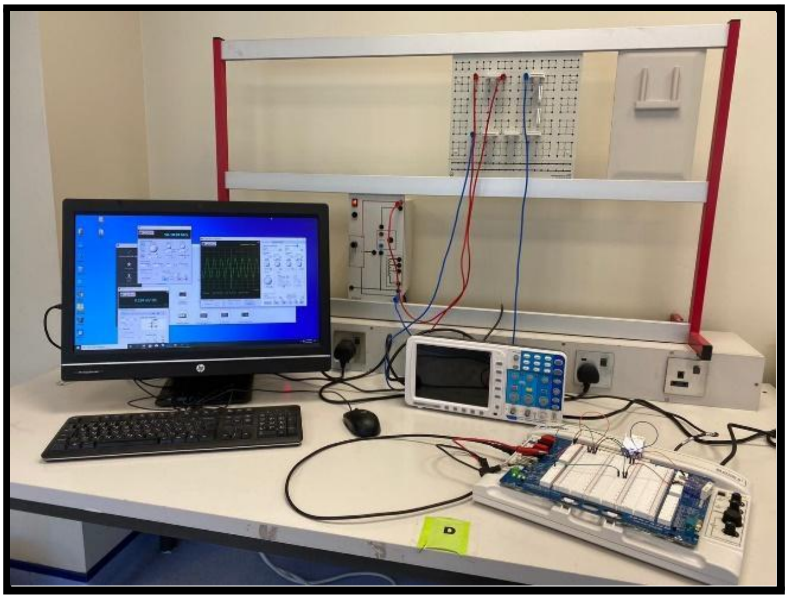
V. Biomedical Engineering labs

V.1. Biomedical Electronics Lab:

This lab is intended to supplement, in a practical way, the material the students learn in Electronics. In each lab the student will perform three different kinds of experiments commonly used by professional engineers: (1) Basic exploration of electronic devices and circuits using predefined experiments, (2) Construction of experiments to determine the behavior of devices and circuits, and (3) Design of electronic circuits using performance specifications. Successful completion of this lab will help to improve these critical engineering skills. Students will be able to use standard laboratory equipment to analyze the behavior of basic electronic devices and to design and construct simple circuits containing these devices, Such as Diode Characteristics, Half wave and full wave Rectification, BJT Transistors, MOSFET Transistors, etc. In addition, they will have the ability to use electronic test & measurement instruments and software, such as oscilloscopes, function generators, etc. Beside the student experiment sets, the laboratory also has simulation programs such as (MULTISIM simulation) to help students measure exact results and error.

Equipment:

1. NI ELVIS Electronics device
2. DC and AC power supplies
3. function generators
4. "Computers with Multisim"
5. Multimeters
6. oscilloscopes
7. Breadboards stands
8. Lab kits

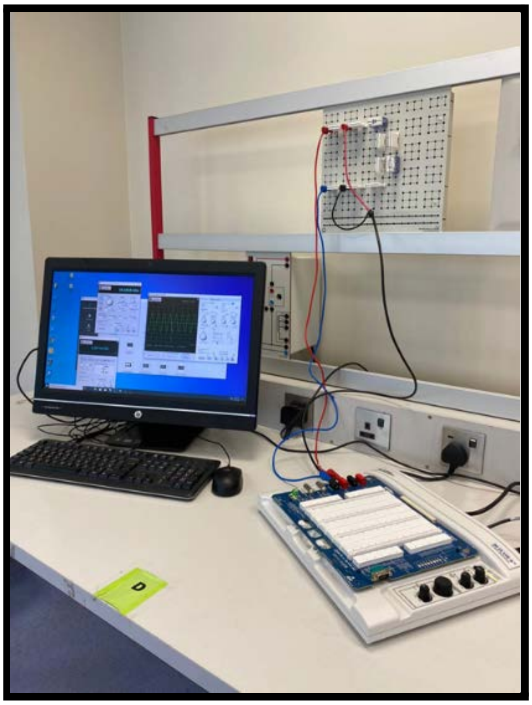


V.2. Electric circuit lab:

In the Electrical Circuit Lab students can create their own electrical circuits and do measurements on it. In the circuits the students can use resistors, light bulbs, switches, capacitors and coils. The circuits can be powered by AC/DC power supply or batteries. There is an ammeter, voltmeter, wattmeter and an ohmmeter. There is also a version of the Electrical Circuit Lab in which data can be collected. Students can analyze the collected data by creating graphs of the data and use the graphs in the conclusion tool. The purpose of the electric circuits part of this laboratory is to practice essential laboratory measurement and report preparation skills, to reinforce the concepts and circuit analysis techniques, and to gain an increased understanding of some of the practical issues of electrical engineering circuit analysis and design. It is equipped with various types of resistors, variable rheostats, inductor banks, capacitor banks, dc and ac power supplies, switches, lamp boards, ammeters, voltmeters, analog and digital watt meters, function generators, oscilloscopes, etc. In the laboratory classes, students are taught how to build electric circuits, safety rules of electric circuits, installation of common household appliances and how to write technical reports.

Equipment:

1. NI ELVIS Electronics device
2. DC and AC power supplies
3. function generators
4. "Computers with Multisim"
5. Multimeters
6. oscilloscopes
7. Breadboards stands
8. Lab kits

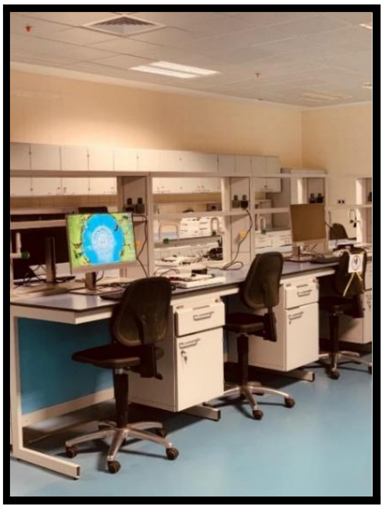


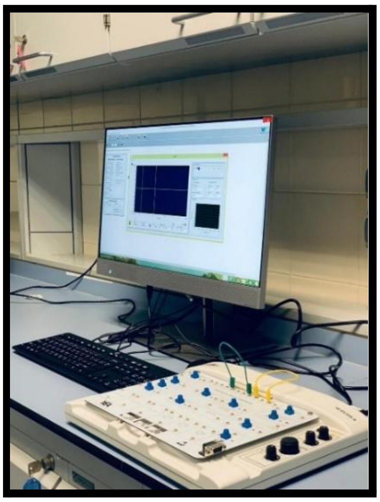
V.3. Biomedical instrumentation lab:

Biomedical Instrumentation Laboratory is equipped with The exercises discussed are intended to introduce students to fundamental concepts of biomedical experimentation, from the instrumentation and data acquisition requirements to subsequent data analysis techniques. The fields of study currently being emphasized include topics such as electro neurology, cardiac electrophysiology, and cardiovascular hemodynamic. Each project consists of a set of experiments exemplifying the types of studies that are typical in each field. and other pertinent issues. Our lab exercises are all designed as PC-based experiments. They are controlled via original virtual instruments (VIs) developed with the LabVIEW programming environment or by using BioBench software. (LabVIEW and BioBench are both products of National Instruments, Austin, TX.)

Equipment:

1. NI ELVIS II Hardware
2. P-2 Probe Set
3. NI SP200B 10:1 AND 1:1 Switchable Passive Oscilloscopes Probe 60V
4. iWorx Bioinstrumentation Senser Package for ELVIS
5. iWorx Bioinstrumentation Senser Addon Package for ELVIS
6. c-iso-256 and c-iso -5c3 from iworx
7. Biomedical Devices Engineering Lab Armenia
8. NI My DAQ Breakout for Biomedical Sensors
9. NI Academic Site License- LabVIEW Teaching Only (Small) - 3years SSP
10. Integrator Operational Ampilifiers Bord For NI ELVIS II/II+
11. NI ELVIS II ADAPTORS
12. Computers
13. Power Cord , AC, UK
14. Starter Kit
15. NI My DAQ Student
16. Mechatronics Kit
17. NI MYRIO -1900



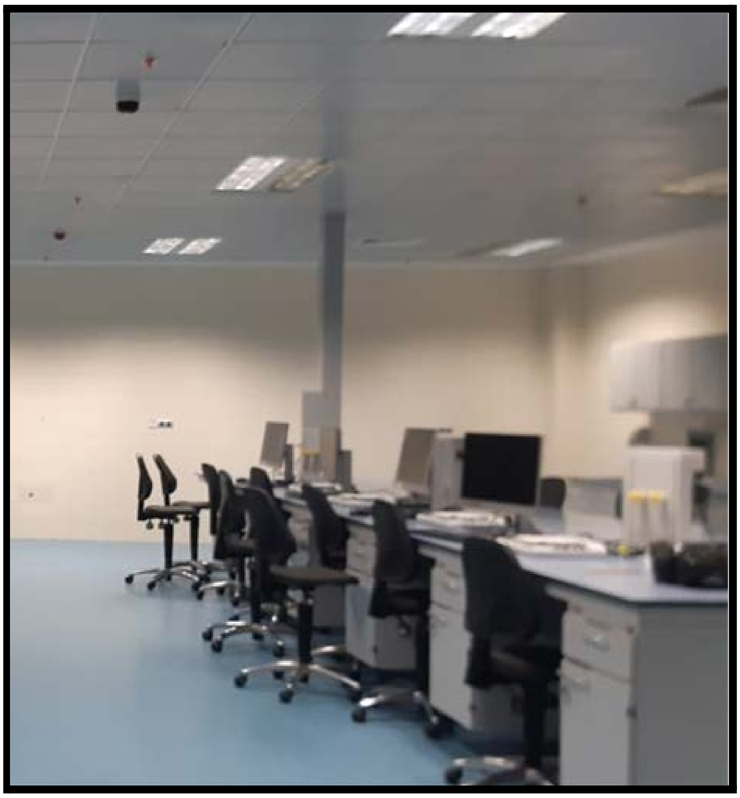


V.4. Biomedical Imaging Lab:

In this laboratory, the students use various image processing tools available in MATLAB software to analyze simulated and/or real medical imaging data obtained from different imaging modalities including Ultrasound, MRI and CT. This lab has 10 PCs with MATLAB and a projector.

Equipment:

1. PC's with MATLAB

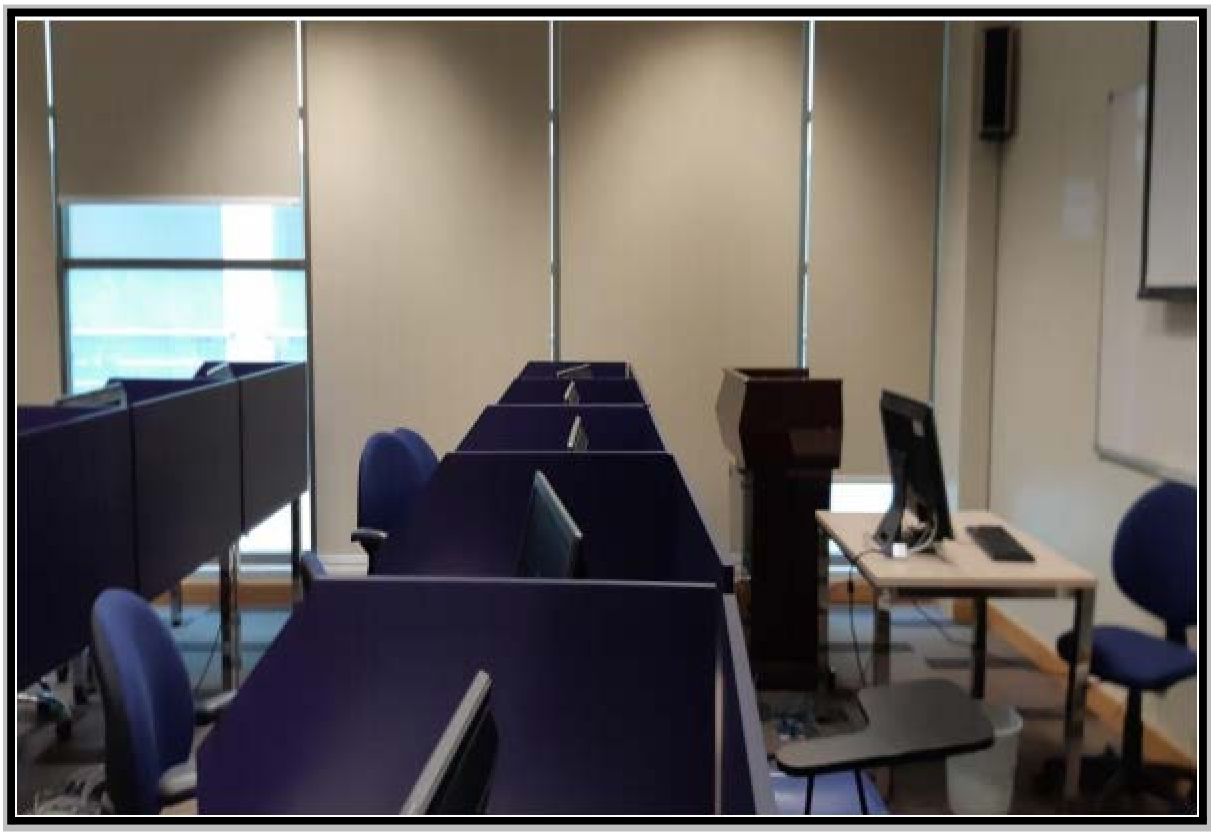


V.5. Engineering design Lab:

This laboratory focuses on different programming languages like MATLAB and C++. MATLAB is a programming language developed by MathWorks. It started out as a matrix programming language where linear algebra programming was simple. It can be run both under interactive sessions and as a batch job. This lab gives an aggressively a gentle introduction of MATLAB programming language. It is designed to give students fluency in MATLAB programming language. Problem-based MATLAB examples have been given in simple and easy way to make the learning fast and effective. In C++, student learn about the C++ programming language, header files, C++ pointers, the general-purpose programming language, C++ reference types, C++ standards, and more. In this course, you will also create applications that will run a wide variety of platforms and operating systems.

Equipment:

1. Computers with Matlab, LabVIEW and Turbo C



V.6. Engineering Programming lab:

This laboratory focuses on the AUTOCAD programming. Students are taught on to know how is of Basic geometric constructions. Technical drawing. Computer Aided Design, CAD. Components description and methods of using CAD systems. CAD system tasks. Basics of construction and making documentation using computers. Basics of AutoCAD 2020, description of user interface, configuration of work parameters. Basics of coordinate systems, commands to create 2D drawings. Drawing of orthogonal projection, setting dimension styles. Plotting techniques. Introduction to 3D modelling, user coordinate system (UCS) and Z-axis, commands for 3D modelling, 3D model views. AutoCAD Electrical to create diagrams, draw symbols and work with symbol libraries, draw electrical and control schemes, and generate documentation.

Equipment:

1. Computers with AutoCAD and Matlab