

Mechatronics Safety Study Guide:

Module 1, Unit 1

Introduction: The Engineer's First Responsibility - The Safety Mindset

Welcome to the study of mechatronics. Before exploring the integration of mechanical, electrical, and software systems, it is essential to establish the foundational principle upon which all successful engineering is built: safety. In an academic laboratory, one of the primary objectives is not just to provide hands-on experience with equipment but "to develop the students' ability to work safely in a laboratory environment without risk to themselves or others".¹ This is not a secondary task; it is a core learning outcome, as critical as mastering circuit analysis or programming a microcontroller.

The essence of this responsibility lies in a simple but powerful concept: "thinking ahead about the possible consequences of your actions".¹ Safety is not a static checklist to be memorized; it is an active, cognitive process—a professional mindset that precedes every action. While engineering controls can limit exposure to hazards and personal protective equipment can shield the body, these are only partial solutions. Ultimately, safe practice is rooted in behavior, in the conscious decision to work with purpose and awareness.²

This guide reframes safety as a fundamental design parameter. Just as an engineer considers constraints like cost, material strength, and power consumption, safety must be treated as a non-negotiable requirement in the design of any procedure or experiment. An unsafe practice is, by its very definition, an example of poor engineering. For example, using the wrong tool for a job is not merely a violation of a rule; it is a failure in the "design" of that task, introducing unnecessary and predictable risks.¹

Furthermore, it is critical to understand the danger of normalizing deviance. Small, seemingly harmless deviations from protocol—working while tired, taking a minor shortcut, or neglecting to double-check a connection—can become accepted practice over time.³ This slow erosion of standards creates the hidden preconditions for a major accident. Many catastrophic failures are not the result of a single, dramatic error but the culmination of these overlooked,

normalized deviations.⁴ Therefore, cultivating a safety mindset means committing to rigorous adherence to protocols, not just for your own protection, but for the integrity of the entire engineering process and the well-being of everyone in the laboratory.

Section 1: The Human Factor - Personal Preparedness and Protection

Situational Awareness: The Art of Seeing, Hearing, and Thinking in the Lab

Situational awareness is the continuous process of observing your environment, understanding its meaning, and projecting its future status. In a busy mechatronics lab, where multiple projects with different hazards may be running side-by-side, this skill is paramount.² It begins with the fundamental rule to never work alone. Having another person present provides a second set of eyes that may notice a hazard you have missed and ensures there is immediate support in an emergency.¹

This awareness is built upon sensory input, and the lab rules are designed to protect the most critical of these senses. The repeated prohibitions against using headphones or earbuds are not about musical taste; they are about preserving your hearing as a vital safety tool.² Wearing headphones eliminates one of your five senses, making it impossible to hear the distinct sound of a glass container breaking, a machine beginning to fail, or, most importantly, a verbal warning from a colleague.² In a lab environment, your ability to hear is as crucial as your ability to see.

Communication and focus are the other pillars of situational awareness. When working in a team, you must never assume that others know what you are planning to do; clear and constant communication is essential to prevent accidents.¹ Likewise, distractions must be eliminated. Using a cell phone or other personal electronic device while operating machinery is strictly forbidden because it divides your attention at a moment when full focus is required to manage a hazardous task.² Working with purpose means dedicating your full cognitive capacity to the task at hand.

Dressing for the Task: Your Everyday Armor

Your choice of clothing and personal grooming is your first line of defense against common laboratory hazards. These rules are not arbitrary; each one is a direct response to a known risk of injury.

Protection begins from the ground up with proper footwear. Shoes must, at a minimum, cover the entire foot and be securely fastened. This protects you from falling objects, chemical spills, and sharp debris on the floor. For this reason, sandals, clogs, open-toed shoes, and high heels are unacceptable, as they offer no protection and can create an unstable posture.¹

Your clothing must afford protection without creating new hazards. Loose clothing, neckties, scarves, and unbuttoned sleeves are strictly forbidden in any area with machinery. These items can easily become caught in rotating parts, pulling you into the machine before you have time to react.³ Similarly, long hair—including long beards—must be tied back securely so that it cannot come into contact with moving equipment like drill presses or grinders.³

Finally, all jewelry must be removed before beginning work. This rule serves a dual purpose. First, items like rings, watches, bracelets, and necklaces present a significant risk of mechanical entanglement in machinery.³ Second, and just as critically, metal jewelry is an excellent electrical conductor. In the event of accidental contact with an energized circuit, a metal ring or watch can cause a severe localized burn or create a path for a fatal electrical shock.¹

Personal Protective Equipment (PPE): An Extension of Your Senses

Personal Protective Equipment is the final barrier between you and a hazard. It is not optional and must be used correctly for the specific task you are performing. Of all the injuries PPE is designed to prevent, damage to the eyes is often the most catastrophic and irreversible. A simple but profound rule to remember is this: "Skin will heal after minor burns or lacerations but your eyes will not".²

For this reason, approved safety glasses or chemical splash goggles must be worn at all times in designated laboratory areas, even if you are not actively working on an experiment.³ Threats to your eyes are everywhere: flying metal chips from a grinder or drill press, high-velocity particles propelled by compressed air, and accidental splashes of hazardous chemicals.⁵ It is also important to note that standard prescription eyeglasses are not a substitute for safety

glasses. Furthermore, wearing contact lenses in the lab is strongly discouraged. In the event of a chemical splash, a contact lens can trap the substance against the cornea, intensifying the damage and making it difficult to flush the eye effectively.⁷

Hand protection is also critical, but its use requires careful judgment. Gloves should be worn when handling extremely hot materials or hazardous chemicals.³ However, a crucial paradox of PPE is that its misuse can be more dangerous than not using it at all. Gloves must

never be worn when operating machinery with rotating parts, such as a drill press, lathe, or grinder.³ A glove can reduce your dexterity and, more dangerously, can get caught on a spinning component, pulling your entire hand into the machine with devastating consequences. This demonstrates a higher principle of safety: you must understand not only the intended function of your PPE but also its potential failure modes and the contexts in which it can create a hazard.

Other forms of PPE are deployed as needed. Hearing protection, such as ear plugs or muffs, is mandatory when operating loud equipment that generates noise levels in excess of 85 decibels to prevent permanent hearing loss.¹ Lab coats, face shields, and welding jackets provide additional layers of protection for specific tasks involving chemical splash risks or high heat.¹

Section 2: The Environment of Innovation - Mastering the Laboratory Space

A Place for Everything: The Critical Role of Housekeeping and Hygiene

A clean and organized laboratory is a direct reflection of a professional and safe mindset. Clutter is not just an inconvenience; it is a hazard that introduces unnecessary risks and increases the cognitive load on everyone in the space. A cluttered workbench or floor makes it harder to find tools, forces you to process irrelevant information, and reduces your mental capacity to focus on your task and react to unexpected events. Good housekeeping is therefore a form of cognitive engineering, designed to optimize the human operator for safe and efficient work.

The first rule of lab hygiene is a strict "no food or drink" policy.¹ This prevents two distinct dangers: the accidental ingestion of hazardous materials that may have contaminated your hands or the benchtop, and the contamination of sensitive experiments by food particles or spills.² Along with this, basic personal hygiene is essential. Always wash your hands after handling any hazardous materials and before leaving the lab. Keep personal items, like backpacks and coats, separate from your work area to prevent cross-contamination. Finally, do not apply cosmetics in the lab, as this involves bringing your hands to your face and creates a direct route for chemical exposure.²

Every person who uses the lab shares the responsibility for its cleanliness. When you finish your work, all tools and equipment must be returned to their proper storage locations.¹ Most importantly, aisles, exits, and the areas around emergency equipment like fire extinguishers and eyewash stations must be kept clear and unobstructed at all times.³ In an emergency, a clear path can be the difference between a minor incident and a tragedy. A common mistake is to use compressed air for cleaning surfaces or clothing. This is an extremely dangerous and forbidden practice. The high-velocity air can propel small particles with enough force to cause serious injury and can even inject air into the skin.³ Always use designated tools like brooms, dustpans, and vacuums for cleanup.³

Reading the Signs: Labels, Warnings, and Emergency Equipment

A well-managed laboratory communicates critical safety information visually. Learning to "read" these signs is a fundamental skill. All chemical containers must be clearly labeled with their contents and any associated hazards.² This simple practice prevents catastrophic mistakes, such as storing a corrosive acid in a metal container or accidentally mixing incompatible chemicals.²

Before you begin any work, you must learn the location and proper use of all emergency equipment. This includes fire extinguishers, fire alarm pull stations, first aid kits, chemical spill kits, and eyewash stations.¹ You must also know the emergency evacuation route from your building.² In the event of a fire alarm, all work must stop immediately. Shut down any equipment you are using and exit the building calmly, closing all doors behind you to help contain the spread of fire and smoke.³

For machinery, the most important piece of emergency equipment is the emergency stop, or E-stop. This is typically a large, red, mushroom-shaped button. The very first action you should take before operating any machine is to locate its E-stop.¹ This should become as reflexive as putting on a seatbelt in a car. In the event of an accident or malfunction, you will not have time to search for it. For personal emergencies, like getting a chemical in your eye,

you must proceed immediately to an eyewash station. Activate the fountain and flush the affected eye for at least 15 continuous minutes, holding the eyelid open to ensure the water reaches the entire surface.⁷ Knowing these procedures and locations by heart ensures that you can act decisively and correctly when seconds count.

Section 3: The Dangers in Motion - Understanding Mechanical Hazards

Respecting Stored Energy and Moving Parts

Mechanical systems are powerful and unforgiving. Their danger often comes from concentrated points of force and motion. It is essential to identify and respect common mechanical hazards, which include cutting heads, sharp blades, rotating drills, and, most insidiously, "pinch-points." A pinch-point is any location where a moving part of the machine meets another part, creating a space where a finger, hand, or piece of clothing can be trapped and crushed.³

The cardinal rule when working with any machine is to never place your hands or any other body part in the immediate vicinity of a moving component.³ Before powering on any piece of equipment, a thorough sweep of the work area must be conducted to remove all hand tools, accessory devices, and other foreign objects.³ An object left on a machine can be thrown at high velocity or can jam the mechanism, causing a catastrophic failure.

Your Lifelines: Safety Guards, Shields, and E-Stops

Modern machinery is designed with integrated safety features that are not obstacles to be bypassed, but critical system components essential for safe operation. These include physical guards that block access to moving parts, transparent shields that stop flying debris, and electronic systems like light curtains that automatically shut down a machine if a person enters a dangerous area.³ Before operating any equipment, you must verify that all such safety mechanisms are securely in place and functioning correctly.³

As mentioned previously, the most critical user-operated safety device is the emergency stop (E-stop). Locating this button must be the first step in your pre-operational check.¹ It is your immediate lifeline, designed to be quickly and easily activated to bring the machine to a halt in an emergency. Treating these safety systems with respect and ensuring their functionality is a core responsibility of any machine operator.

A Practical Guide to Common Machine Tools

General safety principles become clearer when applied to specific machines. The way a machine operates dictates the specific risks involved.

On a **drill press**, the primary danger comes from the rotational force of the drill bit. Any material being drilled must be securely fastened to the machine's table using a drill vise or clamps. Never attempt to hold the workpiece by hand.⁵ If the drill bit "grabs" or binds in the material, especially when breaking through the other side of a thin piece of metal, the workpiece will be instantly and violently spun. This effectively turns the material into an exposed, high-speed blade, which can cause severe lacerations to the hand that was trying to hold it.⁵

When using a **band saw**, the blade guide must always be adjusted so it is just slightly above the top of your workpiece. This provides maximum support for the blade, keeping it aligned and preventing it from flexing or coming off its rollers. Be particularly cautious when cutting thin sheet metal, as it has a tendency to catch in the blade's teeth, which can damage the blade and potentially injure the operator.⁵

A **grinder** presents multiple hazards. First and foremost, always wear safety goggles, as the high-speed abrasive wheel can throw sparks and particles.⁵ Never stand directly in the plane of the wheel's rotation. If the workpiece is caught or the wheel fails, fragments will be ejected with tremendous force in this direction.⁵ A critical and often overlooked danger relates to the material being ground. Never grind soft materials like aluminum, wood, or plastic. Particles of these materials will become clogged and embedded in the pores of the grinding wheel. This clogging not only ruins the wheel's effectiveness but, more importantly, can unbalance it. At high rotational speeds, this imbalance can cause the wheel to vibrate violently and even shatter or "explode," sending shrapnel toward the operator. For the same reason, never grind on the side of the wheel; it is designed only for peripheral grinding and the sideways stress can cause it to fracture.⁵ These examples illustrate how machines have a "language" of failure. An unbalanced grinder wheel will vibrate differently, and a binding drill bit will sound different. Rules that demand focus and prohibit distractions like headphones are designed to ensure you can perceive these sensory cues and react before a failure becomes catastrophic.²

Section 4: The Invisible Threat - A Deep Dive into Electrical Safety

Deconstructing Danger: Why "Low Voltage" Doesn't Mean "Low Hazard"

One of the most dangerous misconceptions in a laboratory environment is that low voltage is not a significant threat. The truth is that the primary factor determining the severity of an electrical shock is not voltage, but *current*, which is measured in amperes.¹¹ An electrical shock occurs when the human body becomes an unwilling part of a closed electrical circuit, allowing current to flow through it.¹¹

Even the seemingly benign voltages found in a standard wall outlet, typically 120 volts, can be lethal.¹² The severity of the injury is determined by three key factors: the amount of current flowing through the body, the path that current takes, and, critically, the length of time the body remains in the circuit.¹¹ To put this in perspective, a standard circuit breaker in a building is designed to trip at 15 amperes, or 15,000 milliamperes, to prevent wires from overheating and causing a fire. However, a current of just 100 milliamperes can be fatal to a human.⁶ This vast difference illustrates a crucial point: circuit breakers and fuses are designed to protect equipment and buildings from fire, not to protect people from electric shock.¹³

The Body Electric: The Path and Effects of Electrical Shock

To understand the danger, it helps to visualize the physiological effects of electricity as the current increases.

At just **1 milliampere**, you would feel a faint tingle. This is the perception level.⁶

At **5 milliamperes**, you would feel a slight shock. While not painful, it can be startling. Critically, at this level, an average person can still overcome the muscle stimulation and let go of the source.¹¹

Between **6 and 30 milliamperes**, the shock becomes painful, and a dangerous phenomenon occurs: you lose voluntary muscle control. This is known as the "can't let go" or "freezing" current range.⁶ The electrical current itself causes the muscles in your hand and arm to contract powerfully, forcing you to grip the energized source even tighter. This creates a terrifying positive feedback loop: the shock prevents you from letting go, which prolongs your exposure to the current. Since the severity of injury is proportional to the duration of the shock, this feedback loop is what makes seemingly small currents so deadly.¹¹

From **50 to 150 milliamperes**, the victim experiences extreme pain, respiratory arrest, and severe muscular contractions. Death is now a distinct possibility.¹¹

At currents from **1,000 to 4,300 milliamperes**, or 1 to 4.3 amperes, the electricity is likely to induce ventricular fibrillation. This is a chaotic quivering of the heart muscle that stops it from pumping blood effectively. At this stage, death is the most likely outcome.⁶

Above **10,000 milliamperes**, or 10 amperes, the result is immediate cardiac arrest, severe burns, and probable death.¹¹

The path the current takes through the body is also a critical factor. A current that passes across the chest, for example from one hand to the other or from a hand to a foot, is far more likely to pass through the heart and cause a fatal arrhythmia.¹⁴

Best Practices for a Spark-Free Lab

Given the profound dangers of even small currents, rigorous adherence to electrical safety practices is non-negotiable.

First, always treat circuits as if they are live. Before performing any maintenance or making adjustments, equipment should be unplugged and de-energized whenever possible.⁶ Only personnel who are qualified and trained for the task should ever work on energized electrical equipment.⁵ Never experiment with circuits you do not fully understand.⁵

Second, practice diligent equipment inspection. Before plugging in any device, visually inspect its cord and plug. Never use equipment with frayed, cracked, or damaged cords.⁵ The ground prong on a three-prong plug is a critical safety feature that provides a path for fault current to travel to the earth. Never break off this prong or use a 3-to-2 prong adapter to defeat it.⁶

Third, manage your workspace to minimize electrical hazards. Near any source of water, such as a sink, electrical outlets must be protected by a Ground Fault Circuit Interrupter, or GFCI. This device rapidly shuts off power if it detects a small amount of current leaking to ground,

which can happen if a device falls into water.¹³ Never link power strips together in a series, a practice known as "daisy-chaining," as this can overload the circuit and create a fire hazard.⁶ Always keep the area in front of electrical breaker panels clear and unobstructed for at least three feet to ensure access in an emergency.⁶

Finally, remember that electrical hazards are systemic and can propagate through the environment in unexpected ways. Avoid placing electrical cords on the floor, where they can become a trip hazard or, in the event of a water leak, energize the entire flooded area.⁶ This illustrates that electrical safety requires thinking about the entire laboratory system, not just the single wire you are about to touch.

Section 5: The Power of Air - Navigating Pneumatic System Hazards

More Than Just Air: The Physics of High-Pressure Gases

Compressed air is one of the most common power sources in a mechatronics lab, but its familiarity can breed complacency. It is crucial to understand that compressed air is not merely air; it is a medium for storing and transmitting a significant amount of energy. When that energy is released in an uncontrolled manner, it can be incredibly destructive.

A stream of compressed air is focused and moves at an extremely high velocity.¹⁰ Even a relatively low pressure of 20 pounds per square inch (

psi) can produce a flow of air that is supersonic—faster than the speed of sound.⁸ This high-velocity stream can easily pick up small particles like metal chips, dust, or even small components and turn them into dangerous projectiles that can strike with the force of shrapnel.⁸ The energy is also stored in the pressure itself. A compressed gas cylinder contains immense potential energy. If the cylinder is damaged or its valve is broken off, it can become a literal rocket or a fragmentation bomb, releasing its contents with explosive force.¹⁰ This stored energy is often invisible and silent, making it a particularly insidious hazard. Unlike a spinning flywheel or a sparking wire, a pressurized line often gives no sensory cue of the danger it contains. Safety, therefore, cannot rely on your senses; it must rely on rigorous, procedural verification of the system's state.

The Anatomy of an Injury: From Eye Damage to Air Embolism

The misuse of compressed air presents three primary categories of risk, ranging from common to lethally severe.

The most common injuries are **eye injuries**.⁹ These typically occur during cleaning operations, when an operator uses an air gun to blow away debris. The high-velocity air strikes the surface and causes particles to bounce back directly toward the operator's face. The eyes are extremely sensitive, and even a tiny particle traveling at high speed can cause significant damage, leading to impaired vision or permanent blindness.¹⁵ Statistics show that up to 90 percent of these injuries are preventable with the proper use of safety glasses, particularly those with side shields that protect against particles coming from an angle.¹⁵ The severity of such an injury cannot be overstated. In one documented case, a man was struck in the eye by a blast from a compressor air gun. The sudden increase in intraorbital pressure was so great that it caused a near-complete transection of his optic nerve, resulting in permanent vision loss.¹⁶

The second major risk is **hearing damage**. The noise generated by a compressed air nozzle can easily exceed 120 decibels (dB), which is far above the permissible occupational exposure limit of 90 dB.⁹ Both short, intense blasts and repeated exposure can cause gradual but irreversible hearing loss and tinnitus, a persistent ringing in the ears.⁹

The third and most deadly risk is **air embolism**. This can occur if a stream of compressed air is directed at the body. Air at a pressure of just a few tens of psi has enough force to penetrate the skin, especially through an existing cut or abrasion, or through a body opening.⁸ If the air enters a blood vessel, it forms bubbles in the bloodstream. These bubbles, called an air embolism, can travel to the brain or heart, where they can block a narrow blood vessel. This blockage can trigger a catastrophic medical event, such as a stroke or a heart attack, which is often fatal.⁸ This is the explicit reason why you must

never point an air nozzle at another person or use compressed air to clean your clothing or skin.⁷

When Systems Fail: The Violent Reality of Hose Whip and Tank Ruptures

While individual misuse of compressed air is dangerous, systemic failures can be catastrophic. The danger of invisible, stored energy was tragically illustrated in an incident at the National High Magnetic Field Laboratory.⁴ The event unfolded through a chain of seemingly small errors. The system involved a high-pressure water cooling line that was controlled by a large, pneumatically actuated butterfly valve. A latent error existed in the system: a small, manual compressed air valve that supplied the actuator was in the closed position. As a result, the main butterfly valve failed to seat properly, allowing water at 325

psi to leak slowly into a section of pipe that was believed to be isolated and depressurized. This leak compressed the air trapped in the pipe, creating a massive, un-instrumented, and invisible pocket of stored energy, later estimated to be equivalent to nearly a pound of TNT. Two technicians, believing the system was safe and at zero pressure, began to loosen the bolts on a flange in that section of pipe. The stored pressure was released in a violent explosion, killing one technician and injuring the other.

A more common type of system failure is **hose whip**. This occurs when a pneumatic hose either bursts or becomes disconnected from its fitting while still under pressure.¹⁷ The sudden, uncontrolled release of high-pressure air causes the hose to thrash about violently and unpredictably. A whipping hose can cause serious impact injuries, and the escaping air can propel debris across the room.¹⁷ To prevent this, several safety measures are employed. Safety check valves can be installed at the air source; these devices sense the sudden surge in airflow from a broken hose and automatically shut off or restrict the flow.¹⁸ Additionally, physical restraints like whip check cables should be used at every connection point. These steel cables link the hose to its connection point, ensuring that if the fitting fails, the hose is physically restrained and cannot whip around.¹⁸

Section 6: Building with Air - Safe Assembly and Maintenance of Pneumatic Circuits

The Push-to-Connect Fitting: A Guide to Its Form and Function

In laboratory and industrial settings, the most common type of pneumatic connector is the push-to-connect, or push-in, fitting. Its design allows for the rapid, tool-free, and leak-proof connection of pneumatic tubing, making it ideal for building and modifying circuits.¹⁹ These fittings are available in a variety of materials, including plastic, brass, and stainless steel, with

the choice depending on the application's pressure, temperature, and chemical environment.²⁰

The genius of the push-in fitting lies in its simple yet effective internal mechanism. When a tube is inserted, it first passes through a plastic release ring, or collar. Inside the fitting, there is a circular metal collet with a series of sharp teeth or claws pointing inward. As the tube is pushed past these teeth, they grip its outer surface, creating a strong mechanical lock that prevents the tube from being pulled out.²⁰ Deeper inside the fitting, an O-ring is seated in a groove. When the tube is fully inserted, this O-ring compresses against the tube's outer diameter, forming a perfect, airtight seal.²⁰ It is this combination of the collet's mechanical grip and the O-ring's pneumatic seal that makes the connection so reliable.

The Art of Connection and Disconnection: A Step-by-Step Guide

Properly using push-in fittings is a simple process, but it requires attention to detail to ensure safety and prevent leaks.

To make a connection, first ensure the end of the pneumatic tube has a clean, square cut. An angled or rough cut can damage the O-ring and cause a leak. Insert the tube into the fitting and push it firmly and steadily until it comes to a complete stop. You will feel it bottom out inside the fitting. It is crucial that the tube is fully inserted; an incomplete insertion is one of the most common causes of leaks, as the tube may not be properly seated against the O-ring.²³ After insertion, give the tube a gentle tug to confirm that the locking claws have engaged and the connection is secure.

The process of disconnection is where the most critical safety step must be observed. **First, and without exception, you must verify that the pneumatic line is completely depressurized.** Attempting to disconnect a fitting that is still under pressure is extremely dangerous. It can cause the tube to be ejected from the fitting like a projectile or trigger a violent hose whip incident.¹⁷

Once you have confirmed the line is at zero pressure, the disconnection process is simple. Use your fingers to press the plastic release collar or ring inward, toward the body of the fitting. This action mechanically retracts the locking claws, disengaging them from the tube. While holding the collar in this position, you can then easily pull the tube out of the fitting.¹⁹ The very simplicity of this component can create a psychological "simplicity trap." Because the connection feels so easy to make and break, it is tempting to forget about the invisible hazard of the stored energy within the line. This is why the training on the non-obvious step of depressurization must be so rigorous. The easier a component is to use, the more disciplined

the operator must be about the safety procedures that surround it.

Conclusion: Safety as a Professional Habit

Throughout this guide, a central theme has emerged: safety is not a set of rules to be memorized for an exam, but a professional practice to be cultivated into a lifelong habit. It is an active state of mind that combines situational awareness, procedural discipline, and a deep respect for the energy—whether mechanical, electrical, or pneumatic—that you seek to control.

The goal is to integrate these practices so thoroughly that they become second nature.¹ Checking for the E-stop before starting a machine, putting on safety glasses upon entering the lab, and verifying a pneumatic line is depressurized before disconnecting a tube should become as automatic as checking for traffic before crossing a street. This level of ingrained caution is the hallmark of a competent and responsible engineer.

Finally, remember that the single most important safety tool you possess is the courage to admit when you do not know something. If you are ever unsure about a procedure, unfamiliar with a piece of equipment, or uncertain about a potential hazard, the safest and most professional course of action is always the same: **stop and ask for assistance**.¹ Ignoring a potentially unsafe condition or proceeding with incomplete knowledge endangers not only yourself but everyone around you.¹ In engineering, asking for help is not a sign of weakness; it is a sign of strength, responsibility, and a commitment to the highest standards of the profession.

Works cited

1. Laboratory Safety | Mechanical and Manufacturing Engineering ..., accessed September 6, 2025, <https://miamioh.edu/cec/departments/mechanical-manufacturing-engineering/lab-safety.html>
2. Safe Lab Practices - Environmental Health & Safety - UC Santa Cruz, accessed September 6, 2025, <https://ehs.ucsc.edu/programs/research-safety/safe-lab-practices.html>
3. Lab Safety Guidelines | Mechanical, Industrial, and Manufacturing Engineering, accessed September 6, 2025, <https://engineering.oregonstate.edu/MIME/mymime/lab-safety-guidelines>
4. COMPILATION OF PRESSURE-RELATED INCIDENT SUMMARIES, accessed September 6, 2025, <https://indico.fnal.gov/event/13755/sessions/1912/attachments/14044/17881/Accid>

[entsCompilation_June16.pdf](#)

5. Lab Safety - Penn State Mechanical Engineering, accessed September 6, 2025, <https://www.me.psu.edu/students/resources/safety.aspx>
6. Electrical Safety in the Research Laboratory, accessed September 6, 2025, <https://drs.illinois.edu/Page/SafetyLibrary/ElectricalSafetyInTheResearchLaboratory>
7. Lab Safety for Students – CCRI, accessed September 6, 2025, https://www.ccri.edu/safety/lab_safety_for_students.html
8. A JHU Safety Note - COMPRESSED AIR MISUSE, accessed September 6, 2025, <https://labsafety.jhu.edu/wp-content/uploads/2019/06/CompressedAirMisuse.pdf>
9. Dangers of blowing with air blow guns for compressed air, accessed September 6, 2025, <https://knowledge.silvent.com/us/dangers-of-blowing-with-compressed-air>
10. section 14: compressed air and gas safety, accessed September 6, 2025, https://www.ucop.edu/safety-and-loss-prevention/_files/shop-safety/sec-14-compressed-air-and-gas-safety.pdf
11. 16.1 Electrical Safety - Cornell EHS - Cornell University, accessed September 6, 2025, <https://ehs.cornell.edu/book/export/html/1441>
12. Electrical Safety for Principal Investigators (PIs), Laboratory & Shop Supervisors, and Students, accessed September 6, 2025, <https://safety.engr.wisc.edu/wp-content/uploads/sites/706/2018/07/CoE-Electrical-Hazards-FAQ.pdf>
13. Avoiding Electrical Hazards in the Lab | NSTA, accessed September 6, 2025, <https://www.nsta.org/blog/avoiding-electrical-hazards-lab>
14. Electrical Injuries - StatPearls - NCBI Bookshelf, accessed September 6, 2025, <https://www.ncbi.nlm.nih.gov/books/NBK448087/>
15. Risk of eye injuries, when blowing with an air blow gun - Compressed Air Knowledge, accessed September 6, 2025, <https://knowledge.silvent.com/us/eye-injuries-one-of-the-most-common-risks-when-blowing-with-compressed-air>
16. Near-complete optic nerve transection by high-pressure air - :: Clinical and Experimental Emergency Medicine, accessed September 6, 2025, <https://www.ceemjournal.org/m/journal/view.php?doi=10.15441/ceem.15.052>
17. Beware of the Hose Whip | Infinity Pipe Systems, accessed September 6, 2025, <https://infinitypipesystems.com.au/news/beware-of-the-hose-whip/>
18. Air Hose Safety - Capital Rubber Corp, accessed September 6, 2025, <https://capitalrubber.com/air-hose-safety/>
19. The fundamentals of Push-in Fitting and how it functions? - EC Pneumatic & Hardware, accessed September 6, 2025, <https://www.ecpneumatic.com.my/the-fundamentals-of-push-in-fitting-and-how-it-functions/>
20. How Do Pneumatic Push-In Fittings Work? - Ideal-bell, accessed September 6, 2025, <https://idealbelltechnology.com/how-do-pneumatic-push-in-fittings-work/>
21. The Ultimate Guide to Pneumatic Fittings -, accessed September 6, 2025, <https://topoautomation.com/the-ultimate-guide-to-pneumatic-fittings/>

22. How Do Pneumatic Air Fittings Work? - MasterMac2000, accessed September 6, 2025, <https://mastermac2000.com.au/how-do-pneumatic-air-fittings-work/>
23. Pneumatic Push-in Fittings Overview | Tameson.com, accessed September 6, 2025, <https://tameson.com/pages/push-in-fittings>
24. Applications and Benefits of Push to Connect Fittings - Brennan Industries, accessed September 6, 2025, <https://brennaninc.com/applications-and-benefits-of-push-to-connect-fittings/>