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A Structured Approach to Improving Safety in Capstone Courses

Dr. Robert Hart, University of Texas at Dallas

Robert Hart is a Professor of Practice in the Mechanical Engineering Department at the University of Texas at Dallas (UTD). He teaches the capstone design course sequence and serves as a Director for the UTDesign program, which facilitates corporate sponsorship of capstone projects and promotes resource sharing and cross-disciplinary collaboration among engineering departments. Upon joining UTD in 2012, he developed the capstone design course sequence in the newly formed mechanical engineering department and has been responsible for teaching it since. He is a recipient of a University of Texas System Regents' Outstanding Teaching Award. His professional interests are in the areas of engineering education, fluid mechanics, and thermal science. Robert is an active member of ASEE and the Capstone Design Conference Organizing Committee and has held leadership positions in both organizations. Before joining UTD, he worked as an engineer at Southwest Research Institute. Robert is a licensed professional engineer in Texas and holds a B.S. and M.S. degree in mechanical engineering from the University of Houston and a Ph.D. degree in Mechanical Engineering from the University of Texas at Austin.

Dr. Todd W Polk, University of Texas at Dallas

Dr. Todd Polk is an Associate Professor of Practice in the Bioengineering Department at the University of Texas at Dallas. He has a Bachelor of Science degree in Electrical Engineering from Texas A&M University. He received his Master of Science and Doc

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Abstract

Students working on design and build engineering capstone design projects can encounter safety hazards of various types and severities. In our program, students receive classroom instruction on how to design prototypes that operate safely. To ensure that students understand how to work safely in the capstone studio, all students are required to complete a series of online training modules. However, we recognized that this training does not address all the hazards that students might encounter as they work on their capstone project. The hazards present during the design phase or during prototype construction and testing are often temporary and are not associated with the operation of the prototype itself. It can also be difficult for instructors to have a thorough understanding of what safety hazards are present in all projects, especially in a large program with many teams working on a diverse range of projects.

This paper describes the capstone design project safety process that we developed at our university to address these challenges. This process supplements our existing training with two new deliverables focused on safety. The first is a checklist that is introduced early in the capstone course to make students aware of potential hazards and what types of work are prohibited without prior instructor approval. Later, after teams have finalized their designs on paper, they are required to complete a written Project Hazard Assessment (PHA). We explain how these processes are implemented and share lessons learned from their use in recent years. This process has helped to identify many safety hazards and we have been able to ensure that teams have plans in place to manage these hazards. Since implementation, we have not experienced a safety-related incident.

1. Introduction

At our university (University of Texas at Dallas), students are required to complete a team-based, two-semester engineering capstone course sequence. Capstone projects are provided through sponsor partnerships with companies and organizations like our local academic medical center [1]. The benefits of providing students with a multidisciplinary experience [2], [3] and the natural overlap in required project skill sets led us to combine students from the Biomedical and Mechanical Engineering Departments into a single capstone course. The course is co-taught by the respective department instructors (known as the Engineering Directors). In this joint capstone course, we typically have 50-60 teams per year, consisting of 5-6 students each. Project work is done in an on-campus capstone design studio that is overseen by dedicated staff. Each team has an assigned workspace in the studio and students can access the studio at any time by using their university identification card.

Our project teams follow a waterfall engineering design process. During the first semester of the capstone course, project teams are expected to gain an understanding of their Sponsor’s problem and proceed through conceptual and detailed design phases to produce a complete engineering design of a device or system to solve their given problem. This semester also includes a classroom component that covers topics such as professional skills (communication, teamwork, etc.), engineering design, safety, and project management. The second semester consists of prototype fabrication and testing. Teams are required to meet separately each week with the Sponsor point-of-contact (known as the Client) and an experienced advisor not affiliated with the Sponsor (known as the Team Mentor).

Because of the real-world nature of capstone projects, students encounter safety hazards of various types, some of which can pose serious dangers. There is a limited amount of literature focusing on safety in experiential learning courses. An extensive search found only three papers addressing safety in capstone or related design/build courses [4] – [6], with the most recent being seven years old. As our program grew, we recognized that the safety procedures we had in place did not fully address the types of hazards students could encounter as they worked on their capstone projects. As student safety is our top priority, we recognized that the existing process needed to be enhanced. These considerations motivated us to create the structured approach described here and to share the work we have done to improve safety in our capstone course.

In this paper, we explain some of the special safety concerns encountered in capstone projects and present two new processes that we have developed to address these issues. Our previous safety practices, combined with these new processes, provide a structured approach that improves safety for capstone students. The approach is multi-layered and addresses safety at multiple points from the beginning to the end of the project cycle. We will also discuss some lessons learned and give examples to demonstrate the effectiveness of this approach. This work will hopefully provide a basis to help others implement similar procedures to further improve student safety in capstone courses.

2. Background

To ensure that students understand how to work safely in our capstone studio, all students are required to complete a series of online training modules on topics such as lab and tool safety. This training is a prerequisite for being granted access to the studio. In addition, the Office of Institutional Risk & Safety works closely with studio staff to ensure that the studio space meets all university requirements.

Safety is also addressed by the Engineering Directors, Team Mentors, and the students themselves. Since the size of our program makes it difficult for the Engineering Directors to closely monitor the progress of each team, we hold a series of internal design reviews to gauge team status and offer feedback at important checkpoints during the project [7]. These design reviews take the form of individual meetings between each team and the Engineering Directors at important checkpoints during the project. We always make it a point to cover safety in these reviews. Team Mentors also help teams identify and address safety issues. Finally, in our program, students receive classroom instruction on how to design prototypes that operate safely. Teams are tasked with analyzing the safety of their designs using the approach they have learned in class.

For many years, safety was primarily addressed through the measures just discussed. As our program grew, we recognized that there were limitations and gaps in our process. One issue was that the internal design reviews did not permit us to consider safety in sufficient detail and early enough in the course. Although Team Mentors [8] play an important role in helping teams address safety issues, we did not feel it was appropriate to rely on their intervention since they come from varying backgrounds and may have limited experience in a project topic area. There is also no way to ensure how consistently or thoroughly they cover safety with their teams. We also observed that the ability of students to identify and manage potential safety hazards is limited by their lack of practical experience. Furthermore, we felt that the basic online safety training required by the university did not help students understand the specific hazards they might face as they work on a capstone project. The size of our program presents another challenge. The large number of teams makes it difficult for the Directors and studio staff to be familiar with the details of what each team is doing at all times.

Another important realization was that while it is natural to pay the most attention to the safe operation of the prototype itself, there can be significant safety hazards present *before* and *during* prototype construction and testing. We encourage teams to purchase and try potential components and to do experiments during the first semester as one way to build confidence in their final design choices. However, we lacked a process outside of the general lab safety procedures to ensure that this work was being done safely. For example, we had instances of teams acquiring hazardous chemicals and unsafe equipment on their own and bringing these items into the capstone studio. We also recognized that there can be hazards present during the construction and testing of a device (e.g., lifting a heavy object into place during assembly or electrical troubleshooting). Because these hazards are temporary and not associated with the operation of the prototype itself, they are easy to overlook.

3. A New Structured Approach to Safety

To address these shortcomings, we supplemented the measures discussed above with two new project deliverables (i.e., assignments) focused on safety. The first of these, the Studio Safety Hazards Checklist, helps to make students aware of potentially hazardous materials and processes. The second deliverable, the Project Hazard Assessment (PHA), requires teams to perform a detailed analysis of the safety hazards present in their project work and present a safety plan for each hazard. Together, these two new deliverables recognize the responsibilities that students have in the safety process while providing more detailed information to allow the Engineering Directors to know what teams are doing (or plan to do) so that we can ensure students work safely.

3.1 Studio Safety Hazards Checklist

Appendix A contains the guidelines provided to students for the Studio Safety Hazards Checklist deliverable. This checklist contains 21 common types of hazards that might be encountered in a capstone project. The list was created based on experience and is updated as necessary. It is made clear to students that any use of the checklist items or processes in the studio is not allowed without Engineering Director approval.

The document shown in Appendix A is made available to students as an individual assignment early in the first semester. Students must confirm that they have read and understood the content of the checklist. They are also asked to list any of the 21 hazard items that they might encounter during the first semester of the project while building small portions of the design to confirm their design choices.

The checklist approach is an easy way to make students aware of potential hazards and it reduces the reliance on students identifying hazards themselves. It simplifies the process of identifying hazards that may be outside of an individual team's discipline and expertise. The process also provides a way to increase the Directors' awareness of the work being done by teams. The Engineering Directors review the responses from each student to get an indication of any potential safety issues the team may encounter. We then reach out to the team to discuss any issues that may need an additional safety plan before the team starts working. Depending on the circumstances, we may discourage (or prohibit) the use of the item/process, help the team find an alternative, or permit use after ensuring that appropriate safety measures are in place. When necessary, university safety staff are involved in this decision-making process.

To help remind students of the items on the checklist, a version of the list is presented on a large poster that is located near the entrance to the studio. We have intentionally not combined this deliverable with the online safety training modules required by the university so that we can present it separately to emphasize its importance.

3.2 Project Hazard Assessment

Appendix B contains the guidelines provided to students for the Project Hazard Assessment deliverable. The PHA is built around the same hazard categories used in the Studio Safety Hazards Checklist. In this deliverable, the goal is for teams to focus on the hazards they will encounter during the building and testing of their device in the second semester of the project. The distinguishing feature of these hazards is that they are temporary and typically will not be present when the device is assembled and operating in its final form. This deliverable is team-based and each team is required to use the checklist to identify and explain relevant hazards and describe their safety plan for managing each hazard. This process shares some similarities with the approach described in [6]. In addition, this deliverable requires teams to list any hazards that might not be on the checklist and provide details of any off-site work. We have found that teams take a more casual approach to safety when "working in their garage" as opposed to working in the capstone studio. It is important to understand any work the team will do off campus.

The Project Hazard Assessment process is summarized in Figure 1. After submission, the Directors meet to review each team's PHA. The Directors discuss the information provided and the safety plans presented by the team. If these are found to be sufficient, the team is notified via email. If the plan needs revision or if additional clarification is required, a request is sent to the team. In cases where there are unusual safety hazards or if the Directors do not feel qualified to evaluate the submission, then the team is instructed to schedule an appointment with a member of the university safety staff. In either of the latter two cases, a team is expected to submit a revised PHA for re-review by the Directors.

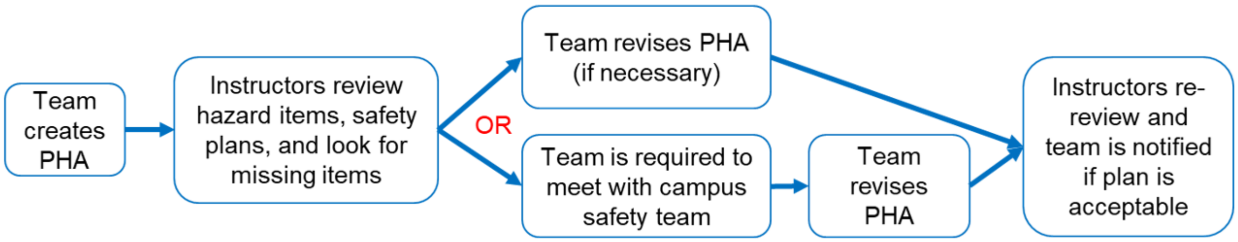

Figure 1: Flowchart of the Project Hazard Assessment process.

The actions that result from the PHA can range from simple to complex. In some cases, the safety concerns are minimal, the team has an acceptable plan, and the equipment needed to safely complete a task is available. In more complex cases, we have involved staff from other university offices such as the electrical shop, fire & life safety, and moving services. We have always found these individuals to be helpful and willing to lend their expertise to help students work safely on their projects. Other common outcomes of the PHA include finding suitable locations on campus for a team to do a particular type of task (e.g., in a wet lab or a paint booth) or working with the staff member responsible for chemical hygiene to make sure that a team has plans to safely store and dispose of any chemicals purchased for a project. One special circumstance that happens occasionally is a team doing work at their Sponsor's facility. In these cases, the Directors work with the Sponsor to make sure that liability, training, and safety issues are satisfactorily addressed. In a few instances, we have had to prohibit activities and, in these cases, we work with the team to help them find an alternative that allows them to complete their project. Often the solution involves getting the Sponsor to do work for the team in their specialized facilities.

A major benefit of preparing the PHA is requiring the students to think carefully about the hazards they will face as they build and test their projects and how to do their work safely. Completing this deliverable is a good learning experience for the students and it focuses their attention on safety issues that they might not otherwise have considered. Additionally, it gives the Directors insight into what the teams are doing and is an opportunity to make sure that every team has appropriate safety measures in place.

4. Results and Discussion

4.1 Studio Safety Hazards Checklist

The Studio Safety Hazards Checklist was a new addition in the Fall 2024 semester. Although we have limited experience with this process, we have had no further instances of teams using materials or processes that were not pre-approved. We plan to continue implementing this deliverable in future cohorts.

Based on our experience, we have found it best to introduce this deliverable early in the first semester. This timing is important to ensure that students are aware of what is and is not allowed from the very beginning of the course. As mentioned earlier, we expect students to be doing preliminary work in the studio during the design phase.

4.2 Project Hazard Assessment

The Project Hazard Assessment process described above was first implemented in the Spring semester of 2023 and has been used in four cohorts to date. The only significant change to the process thus far has been the refinement of the hazard list. As we gained experience, we added some items (e.g., ladders and sharps) and clarified others that were confusing to students.

To date, the PHA process has been used by a total of 88 project teams. Among these, 40% of the teams provided an initial submission with an acceptable listing of hazards and safety plans. In 48% of the cases, we had to ask for clarifying information and/or work with the team to revise their safety plan. For the remaining 12%, we found it necessary to refer the team to a university safety staff member. Our experience has been that teams do a thorough job of preparing the PHA, with many erring on the side of providing extra information. While many of the hazards are minor and the safety plans are adequate, the PHA process has worked to identify significant potential safety issues before students engaged in hazardous activities.

The PHA process has contributed to an improved safety culture for our teams. While significant Engineering Director time and effort are required to conduct the Project Hazard Assessment, it is evident that the process is working as intended. Since implementing this process, we have not had a serious safety incident.

The following are some examples of serious safety issues uncovered during the PHA process and how they were handled:

- There are significant hazards present when working with elevated pressures. In one project, a team was automating a pneumatic press. Although the team had implemented all the necessary safety features in their prototype design (such as two-handed operation), the PHA revealed the need for a lock-out/tag-out procedure. In this case, the PHA process called attention to the special hazards that could occur during testing and troubleshooting.
- Another project involved a team using CO_2 cartridges. We met with this team to ensure that appropriate safety measures were in place for handling and using the cartridges.

- The PHA process often reveals issues with lifting and moving heavy objects. For example, a team was planning to install a 150 lb. gearbox on top of a 5 ft. stand. The team identified this activity in their PHA and their safety plan was to have several people lift the gearbox into place by hand. Besides the hazards of lifting such a heavy object by hand, the team did not consider what would happen if the gearbox was dropped. In this case, we identified this issue when we reviewed the PHA and we worked with our facilities staff who provided a forklift and helped the team complete the task safely.
- The PHA process can indicate the need to bring in additional expertise. For example, we had a team that was creating a demonstration system with a large battery and some household wiring. After reviewing the PHA, we got fire & life safety involved due to the size of the battery. Additionally, we had a university electrician inspect the wiring to ensure that it was done correctly and would operate safely. We have also involved our university safety staff when there are projects that include drones.
- Chemical hazards are often identified through the PHA process. We have had numerous instances in which teams planned to use hazardous chemicals either during the construction or testing of their prototypes. Due to the students' lack of experience, they did not recognize the level of hazards and their safety plans were inadequate. For example, one team was planning to do testing with compressed oxygen. We referred all these teams to the university safety staff. In all these cases, we were able to find alternatives that avoided the need for the teams to use the chemicals.
- In other instances, the PHA process has identified the need for additional personal protective equipment (PPE), chemical disposal plans, ladder training, and sharps disposal.

Some key recommendations and lessons learned from the implementation of the Project Hazard Assessment process over several cohorts include the following:

1. We have found that it works best to require submission of this deliverable immediately following the Critical Design Review (CDR), which occurs early in the second semester. The CDR is a meeting between the team and their Sponsor to present the final design that the team plans to build and for the Sponsor to give their approval of the design. At this point, the detailed design is finalized and teams are beginning to procure parts and materials in preparation for fabrication. If done earlier, teams often do not have a complete and accurate plan for what will be involved in the building and testing of their prototype. If done too late, there is not sufficient time available to review the submissions and plan interventions.
2. It is important to remind teams to be specific in the descriptions of their expected hazards and in their safety plans. It requires significant time to follow up with teams to gather critical information.
3. This deliverable is not graded to encourage teams to be open in disclosing any safety concerns. Teams are reminded in class and in the deliverable instructions that this process depends on them being careful and thorough in their analyses. In addition, we make it

clear to students that identifying safety issues or stating that they are unsure about an issue will not reflect negatively on their team or their project.

4. It is preferable to have more than one person review the PHA submissions. Ideally, the reviewers should have a range of expertise and perspectives.
5. We worked closely with the Office of Institutional Risk & Safety to develop the PHA process. Having a single point of contact within this office who has been involved from the beginning has proven very beneficial. This individual is also the one who meets with teams. Because of her involvement, she understands the capstone program and the PHA process and is therefore able to provide consistent direction to teams.
6. Providing students with a checklist gives them a starting point that makes it possible for them to do a more thorough job than they would likely be able to do on their own if given a more open-ended prompt.

5. Conclusions

Physically building and testing engineering capstone projects can uncover a myriad of safety-related issues that have nothing to do with the actual design itself, but with the process of building and testing the prototype. We hold safety as the number one concern for our teams. For years we have trained our students to produce designs that are safe to operate but neglected to thoroughly instruct them on the hazards that can occur while building and testing the device, beyond the basic lab safety training that the university requires. We also did not give enough attention to the hazards students can encounter as they do preliminary experiments and tests during the design phase of the project.

We have improved our existing process by adding two new project deliverables focused on safety. The result has been the creation of a structured process to identify, define, and plan for safety-related issues that can occur anytime from the start to the finish of the project. This has allowed us to improve the overall safety of our capstone program. The two-phase process has students use a Studio Safety Hazards Checklist to identify potential safety issues related to their initial building and testing of concepts done in the first semester to justify their design choices. In the second semester, a Project Hazard Assessment is completed by teams to more formally identify potential safety hazards associated with building and testing the final prototype. Together, these two items have helped to create a more safety-conscious culture for our students.

By rigorously reviewing these two items, the Engineering Directors for the program have been able to obtain a much better understanding of the potential safety issues faced by their teams. This has been particularly beneficial given the large number of teams that we oversee. The authors have many years of industry experience, and this combined with bringing in outside experts from various university departments has allowed us to reduce safety-related incidents to zero since the implementation of this process.

We have found this process to be efficient and effective and we highly recommend it to any university capstone or experiential learning program that builds actual prototypes. The hazard list can be modified as needed to fit a university’s requirements, and it gives instructors a better understanding of the safety issues their teams may face throughout the project.

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Appendix A

Studio Safety Hazards Checklist

The Studio has the equipment and tools that you need to successfully complete your project. However, there are certain items and classes of items that cannot be brought into the Studio or that require Engineering Director approval for use in the Studio. Also, work involving some types of materials and processes requires approval.

Because of the nature of the work done on some projects, there can be significant safety hazards present during the building and testing phases of the project. This document presents a list of potential safety hazards that you may encounter during the design, building, and testing of your prototype. This list will help you to: (i) Identify potential safety hazards that may apply to your project work, and (ii) Know when Engineering Director approval is required.

The goal of providing this list to you now is to make you aware of these potential hazards as you begin to work in the Studio and do experiments, tests, and pretotyping to support your design work.

In Senior Design II, you will create a Project Hazard Assessment (PHA) to fully understand the items on this list that apply to your project, and to develop a safety plan for working with them as you progress through the building and testing phases of the project. To clarify, the items and processes listed here can be used in your project as needed, but they require approval and appropriate safety measures.

Each of you individually plays a critical role in ensuring that work gets done safely so that you, your teammates, and others are protected. This list is not comprehensive, and you should always feel free to raise concerns or ask questions about safety. The Engineering Directors, Studio staff, and other campus staff are available to assist your team. If you are unsure if any of the hazards listed apply to your project, it is your responsibility to contact your Director for clarification.

Note: A version of the list below is also in the Studio near the main entrance. It is past the first hallway and the two offices on your right. The list is on a large poster on the wall.

You are prohibited from bringing any materials into the Studio or doing any work involving the safety hazards listed below until you have written approval from your Engineering Director.

Potential Safety Hazards

1. Chemicals of any type other than those provided in the Studio. You are required to review the SDS (Safety Data Sheet) to understand the safety measures that need to be taken while using the chemical. Pay special attention to Sections 7 and 8 of the SDS.
    a. In many cases, this work cannot be done in the Studio and will need to be done in the Paint Booth or in another location with a fume hood. Instructions will be provided to you if this is needed.
2. Any work involving any a potential biological hazard (animals/animal tissues, pathogens, bodily fluids, etc.)
3. Operational temperatures less than 0°F (-18°C) or greater than 120°F (49°C), excluding soldering
4. Compressed liquids and gasses at any elevated pressure, including the use of the building-provided compressed air supply
5. Vacuum of any level
6. DC voltages greater than 50V
7. Any use of AC voltage other than the use of purchased equipment like computers, lights, etc. that are simply plugged in and used without modification. This includes manual connection of AC wires to power supplies, motors, etc.
8. Electrical current greater than 1A
9. Power greater than 50W
10. Any device that is intended to store and release significant amounts of energy (large capacitors, large springs, etc.)
11. Lithium Polymer (LiPo) batteries
12. Lifting or movement of objects greater than 50 lbs.
13. Lasers rated Class II and above
14. Devices producing noise/sound in excess of 85 decibels
15. Infrared/ultraviolet light sources other than a single LED
16. Radio frequency (RF) emitting equipment. Purchased devices that use wireless digital communication (Wi-Fi or Bluetooth) and wireless remote controls do not need prior approval.
17. Ionizing radiation, X-rays, radioactive sources, etc.
18. Work that requires the use of a ladder or elevated platform
19. Needles, scalpels, or other similar objects with sharp points or edges that can puncture or cut skin
20. Exposure to moving parts (such as pulleys, gears, belts, etc.) in the system when safety guards are not in place (typically done during construction and/or troubleshooting)
21. Firearms or any item that looks like a firearm

Appendix B

Project Hazard Assessment

As you work on your project, you need to consider two categories of safety hazards. The first category contains safety hazards that are inherent in the normal operation of the device. In training, we talked about methods to identify and mitigate these hazards. You should have already incorporated these considerations in your design. For example, you might have added a guard to prevent a user's hands from getting near a pinch point.

The second category of safety hazards consists of those that you encounter during the building and testing of the device. These hazards are present only during these phases of the project and may be associated with processes you are doing such as lifting a heavy object during assembly or removing a safety cover to troubleshoot an electrical problem. The distinguishing feature is that these hazards will not be present when the device is assembled and operating in its final form. Because of the nature of the work done on some projects, there can be significant safety hazards present during the building and testing phases of the project. The scope of this deliverable is to assess hazards that fall in this second category.

The purpose of this deliverable is for your team to do the following: (i) Identify safety hazards that you may encounter during the building and testing of the device, and (ii) Develop a plan for how to manage these hazards and safely complete your building and testing. Now that your team is past the CDR milestone, you should be in a good position to determine what hazards you may face during building and testing.

For this deliverable, you will prepare a document using the list below to identify hazards that may be present in your project work. The Directors will review your submission and follow up if additional action is required. If necessary, staff from the Research, Campus, and Environmental Safety team will be consulted to help your team develop safety procedures.

You are expected to be careful and thorough in completing this deliverable. Nothing is gained by hastily rushing to complete it. Identifying potential safety hazards does not mean there is a problem with your project. It simply means there are potential issues that need to be properly addressed to keep everyone safe. The Engineering Directors cannot know every detail about what each team is doing at all times. Therefore, it is your ethical responsibility to provide the critical information in this deliverable that will help us and your team develop a plan to work safely. You are also encouraged to seek advice from your Team Mentor as you work on this deliverable.

Each of you individually plays a critical role in ensuring that work gets done safely so that you, your teammates, and others are protected. As you go about the work of building and testing your prototype, you should always feel free to raise concerns or ask questions about safety. The Engineering Directors, Studio staff, and other campus staff are available to assist your team. If you are unsure if any of the hazards listed apply to your project, it is your responsibility to contact your Director for clarification.

Note: You are prohibited from bringing any materials into the Studio or doing any work involving the hazards listed below until you have written approval from your Engineering Director.

Requirements

Each team should prepare and submit a Project Hazard Assessment for their project. Some examples are shown on the final page of these guidelines. This deliverable must contain the following sections in this order:

1. **Cover Page.**
2. **Hazard Identification and Safety Plan.** The list below contains safety hazards that are commonly encountered during the building and testing phases of projects. These items apply to all work done in connection with your project regardless of location on or off campus. If you are unsure about the meaning or how any of the hazards listed apply to your project, you should contact your Director for clarification. In your document, list each of the Potential Hazard items, and do the following:
    - If the item refers to a hazard that you are certain will not be present at any point in your project building and testing, mark it as "Not Applicable".
    - If the item refers to a hazard that is present in your project building and testing (or you think it might be), provide a brief explanation of the hazard. In addition, you must provide an approximate magnitude for quantifiable hazards (e.g., weight of 75 lbs., temperature of 230°F, etc.). Then, for each item, describe your safety plan. The safety plan should explain how the team will mitigate or eliminate the potential hazard while building and testing your device. If you are unsure or need assistance with developing a safety plan, indicate what type of help you need.
3. **Other Hazards.** The list below is not all-inclusive. There may be other special hazards that are present in a project. If you believe that your project involves a hazard that is not listed here, you should describe it in this section, and include your safety plan for each additional hazard listed here. If there are no additional items to list, mark this section as "Not Applicable".

4. **Off-site Work.** List any work that your team will personally perform on the project that will occur outside of the Studio (Machine Shop, customer site, residence, research lab, etc.). Also indicate the location where the work will be performed. You do not need to list software development. In addition, work done by the Machine Shop staff does not need to be listed here; however, work that a team member will do personally in the Machine Shop should be listed here. The purpose of this section is to understand what work your team plans to do outside of the Studio regardless of whether it involves a safety hazard or not. It is also not necessary to explain what hazards are associated with the off-site work and your safety plans for each item since that information should have already been presented above in Item 2. If there are no items to list, mark this section as "Not Applicable".

List of Potential Hazards

1. Chemicals of any type other than those provided in the Studio. You are required to review the SDS (Safety Data Sheet) for the chemical and list any safety measures that need to be taken while using the chemical. Pay special attention to Sections 7 and 8 of the SDS.
2. Work involving any potential biological hazard (animals/animal tissues, pathogens, bodily fluids, etc.)
3. Operational temperatures less than 0°F (-18°C) or greater than 120°F (49°C), excluding soldering
4. Compressed liquids and gasses at any elevated pressure, including the use of the building-provided compressed air supply
5. Vacuum of any level
6. DC voltages greater than 50V
7. Any use of AC voltage other than the use of purchased equipment like computers, lights, etc. that are simply plugged in and used without modification. This includes manual connection of AC wires to power supplies, motors, etc.
8. Electrical current great than 1A
9. Power greater than 50W
10. Any device that is intended to store and release significant amounts of energy (large capacitors, large springs, etc.)
11. Lithium Polymer (LiPo) batteries
12. Lifting or movement of objects greater than 50 lbs. You should estimate the weight of the object.
13. Lasers rated Class II and above
14. Devices producing noise/sound in excess of 85 decibels
15. Infrared/ultraviolet light sources other than a single LED
16. Radio frequency (RF) emitting equipment. Purchased devices that use wireless digital communication (Wi-Fi or Bluetooth) and wireless remote controls are not included in this category.
17. Ionizing radiation, X-rays, radioactive sources, etc.
18. Work that requires the use of a ladder or elevated platform

19. Needles, scalpels, or other similar objects with sharp points or edges that can puncture or cut skin
20. Exposure to moving parts (such as pulleys, gears, belts, etc.) in the system when safety guards are not in place (typically done during construction and/or troubleshooting)
21. Firearms or any item that looks like a firearm

Example Hazard Identification and Safety Plan

Here are some individual item examples to help you understand the level of detail we are looking for in your initial submission:

Item 1: We need to use IPA as a cleaning solvent for the components under test in our device
Item 1 Safety Plan:

- We are unsure what steps need to be taken to use this chemical safely and require assistance from the Directors

Item 4: We will need to use the building compressed air supply and regulate it down to 50 psi.
Item 4 Safety Plan:

- We will use hoses and connectors rated for 150 psi or greater
- We will use a regulator rated for an input pressure of 150 psi or greater to allow us to regulate the output pressure down to the 50 psi needed for the project
- Air supply will be disconnected from our system and the system will be depressurized before any troubleshooting is performed

Item 7: We will need to connect AC voltage to the terminal strip of our AC-DC power supply.
Item 7 Safety Plan:

- Research proper connection methods
- Power cord will remain unplugged will connection to the power supply terminal block is completed
- Have Team Mentor or Engineering Director review the connections
- Connections covered by a hard cover or electrical tape to prevent anyone touching them
- Power cord unplugged during any troubleshooting

Item 12: We have a 75 pound motor that needs to be lifted and connected to the top of our device.
Item 12 Safety Plan:

- Team will use an engine hoist to lift and hold the motor in place while it is secured
- Team will remain at a safe distance during the lifting process and as the engine hoist is disconnected