Airbag Automaton (BR14)

Maintain communication between all members and sub teams
It is important for all members of the team to maintain some cognizance of what is happening with the other team members. All aspects of the project are coupled by time, if not anything else also. Knowing what the other sub teams are working on and planning to do help align priority for the tasks at hand. This way, teams can work continuously, minimizing down time caused by waiting for other members of the team.

It is also important to clearly assign tasks with due dates and hold to those due dates as best as possible. These tasks should be assigned with reasonable lead time and leaders should routinely check up on team members to be sure everything is going smoothly. Team members should repeat assigned tasks back to the leader to confirm understanding and should also expect to be responsible for something at all times. If a team member does not have a task, communicate this. Volunteer to take on a task or think of something to help the team out and let the rest of the team know.

Regularly hold design reviews
Design reviews do not have to be a formal meeting that involves the entire team, sponsors and supervisors. All it takes to hold a design review are a couple of team members who sit down and evaluate the positive and negative aspects of a design. It is often a good idea to bring in someone outside to team that can bring in some new ideas. Listen to everything, be honest and take compliments and critiques seriously. These design reviews will help avoid road blocks in the end of the design process like over-complicated designs, missing design requirements, impractical features and components that are impossible to manufacture.

Make a good schedule and stick to the schedule
Due to inexperience, estimating the time it will take to complete tasks is difficult. This makes it easy to overextend the commitment of the team. Therefore, take some time and develop a schedule with "reasonable" goals. Then, post the schedule somewhere visible. If the schedule is never seen, it never exists. Constantly seeing the schedule will help team members get stuff tasks completed on time. If, for some reason the team falls behind, try to determine what needs to be done to get back on schedule. This may take putting in longer days, redistributing the work load or at worst, narrowing the scope of the project.

Get the functional requirements down hard
Designing is much more successful when the goals and requirements of the design are laid out clearly and in detail. Once this is done, the components can be designed quickly and accurately. Knowing all the requirements at the beginning of the design process also reduces the amount of redesigning that may have to occur if something is forgotten.
Dumpster Divers: Hybrid Hydraulic System for Garbage Trucks (P32)

Lessons Learned:

If after every project you are given the opportunity to do it over again, there are always items that the team would want to approach or do differently. Listed below are items that we as a team agreed would have made the project a little easier from the beginning:

- Understand Scope of Project, set "solid" Phase dates
- Set and Keep Rules in your meetings so they are more time effective and less likely to "wander off."
- Have each member of the group take turns facilitating the meeting, and another taking minutes.
- Make deadlines for Tasks clear and reasonable at your meetings and then follow up.
- Keep an organized Notebook
- Report Progress on a weekly basis to someone that cares about success of project, ask for advice.
- Plan on a task taking longer than you expect, plan ahead.
- Have occasional brainstorming sessions at a local restaurant or bar.
- Get to know your group well, find out their likes and dislikes, get together with the group for other than business purposes, invite family and significant others.
- Look for the strengths and weakness of team members, work with the strengths.
- Try not to save anything for the end; there is always something you can get started on.
Electrolife: Lifetest Apparatus for Surgical Electrodes (BR16)

The Lessons Learned by our group

Student #1:

1. Practical circuitry. I learned how to solder much better, connect wires and for the power on the box. The proper way to connect switches.

2. Learned about working with a team, the dynamics involved. It was essential that as a team we effectively communicated the expected roles and assignments as well as outlining the overall project goals so that we were on the right track.

3. Improved my organization skill in regards to project overview. This involved identifying and prioritizing the action items to move ahead in the project as well as keeping correct pace to finish in time.

4. How to select and assemble selected components, much of this involved a considerable amount of obtaining documentation and examining/interpreting the documentation.

5. I now have a more full understanding of the benefits of creating diagrams and flowcharts to describe the system. I was able to use the flowcharts to design reliable code from. It helped us as a team and other people to have system diagrams that described the flow of data.

6. Overall I learned how the design process works as a whole, obtaining customer specs, giving back solution concepts, iterating that process. Then taking the design and implementing it by buying parts that met specification learning how to use and connecting them and verifying the final product that it met specifications.

Student #2:

Overall, I feel that the Senior Capstone class was the most valuable learning experience in my college career. I learned many practical and professional skills that will indeed help in my career. Specifically, communicating effectively with your customer is one of the most important roles of any design project. It is sometimes difficult to fully comprehend what your customer is looking for and being able to communicate with him/her on a professional level can save your team a lot of time in the end. In addition, set realistic goals and try not to get hung up early on in the process with other tasks.

In relation to saving time, it is wise to develop a year long schedule by working backwards from Expo. Essentially, the team needs about 3-4 weeks for
testing the design, as there are always unforeseen problems once it is put together. This means you want to have it built by the beginning of April – at the latest. Give your team about a month to manufacture/build all of the components, which means that all of the material needs to be ordered and a detailed drawing package needs to be complete by the beginning of March/end of February. You may spend up to about two weeks revising your drawings, so submit an initial drawing package by mid February. HAVE A DETAILED DESIGN BY THE BEGINNING OF SECOND SEMESTER!!

Keep up the pressure throughout the entire year and try to stick to your schedule as much as possible. Be sure to continually get feedback from your customer/advisors as they can provide a great deal of help and input. When scheduling design reviews, talk with Russ Porter and have him include his opinion on the design; it may turn out that some components in the design are not possible/too difficult to machine. Overall, have fun and use this class to your advantage.

Student #3:

I think the most important thing I'll take from senior design is positive acceptance to criticisms. When someone challenges design ideas it can be helpful in pointing out overlooked critical items and requires the designer to really understand the fundamentals behind their design to be able to defend it. If you are open to feedback from the beginning when the design is still conceptual, you can learn a lot from more experienced people (i.e. Steve, Russ, and Odom) and you can make changes easily on the drawing board. This is ultimately better than the inevitable criticism you’ll receive at Design Expo if you are stubborn and block out other’s suggestions. Just remember when the product is built, there is little you can change. So really engineer the design and get it right on the chalk board first. That way Dr. Odom will be patting you on the back the day of Expo, and not sending juniors to point and laugh at you… DON’T BE THAT TEAM!!!
End Effect: End Effector for Hot Cell (BR4)

Lessons Learned

1. Start Early- The Design process takes a lot longer than you expect. Your design will change many times before you are completed. Each stage of Senior Design takes a lot of time and sometimes you can't move to the next stage without completing the previous step.

2. Don't be Afraid to ask- When you begin the design process ask people what they think of your design. People that have experience with senior design projects before are the best people to talk to. These people will give you advice on how to change your design so that it will work. Asking people is how we were able to get our final design to work without major modifications.

3. Leave plenty of time for fabrication- This might be the step that most people forget, for fabrication leave plenty of time. The last weeks before expo every team is trying to make parts and if you are done early it will make this time less stressful.

4. Commit to a design- When we first decided that we were going to use a design we tried to design it so that it would always work and never have any problems. In the words of our customers the engineers try to design to 100% but the last one percent is the hardest to get. 99% is usually where the corporate world builds stuff because of time and money constraints. When you get a design that will work for your project commit to it and begin to build.

5. If a design doesn't work scrap it- You will have many different ideas but don't be so locked in on one idea that you won't just give it up for something better? We had many ideas that we never even used. This can be very frustrating you might spend 2 weeks on an idea but they once you get it finalized you realize that it will never work and will probably fail. It is really hard not to try to redesign it to work but sometimes you just have to let it go and find something that will work.
Filthy Filters (P37)

Lessons Learned

1. Designing

We learned a tremendous amount about how to design a machine so that it is simple and functional. All of our designs started from hand sketches which detailed the basic concept of our design. From the conceptual design we were able to develop a more detailed system design using Solidworks. Once we started machining we realized that some of our parts were overly complicated to machine. So we went back to the drawing board to redesign our parts so that they were easier to machine. This saved us a ton of time and by making this realization we became better engineers.

2. Time Management

This was the biggest engineering project any of us had taken part in and this required us to do things a little differently then we have in previous classes. We learned very quickly that if we wanted to finish on time we would have to consistently work on our project throughout the year. Occasionally that meant that we had to sacrifice some time during our breaks to get everything done. If we had not realized that the project would require this much time and effort we could have easily not made our deadline.

3. Making Decisions

There are a lot of teams who were not able to make tough decisions when the time came and that ended up wasting their time. We were not one of those teams. We ran into many problems through the course of our project and in many cases the problems caused us to totally rethink our design. We knew that we couldn’t waste time each time there was a disagreement over a design detail. In order to make quick decisions on our design we would write down the pros and cons of each idea have a quick discussion and then vote on the idea that we thought was best. The idea with the most votes was what we stuck with.

4. Pleasing the Customer

The main goal of the senior design project is for the student to produce a useful product for the customer. If the customer isn’t happy we didn’t do our job right. We made sure to keep in constant contact with our customer to keep him updated with our progress. This way he could give us feedback on our progress and make sure that we don’t get off task. We were able to keep in contact with him through phone conversations and emails and through our website. This line of communication helped us to figure out what the customer wanted and to produce desirable results.
5. Being Resourceful

Obtaining hardware for a prototype or determining if you can buy something instead of making it can sometimes be a daunting task. We knew we couldn’t finish everything in our project if we made everything so the McMaster-Carr catalog became our best friend. We also utilized the experience of Russ and our mentor Sam whenever we had tough design questions. They were both incredibly helpful whenever we had questions and without them our design might not have turned out the way it did.
Inflators: Airbag Testing Platform (BR15)

Lessons Learned

- Get started on designing and refining the final design as soon as possible after research and the proposed design are completed. There are always set backs with the final design and it is better to confront them earlier than later.

- Leave time for testing. This is the most important part of the design process. If the design does not perform as design, then the design needs to be redesigned.

- Before machining, make sure you have a plan and all the tools that are needed before going into the machine shop. Shop time can be difficult to obtain, so it is best not to waste the time setting up.

- Machining time can be difficult to obtain, so it is a good idea to get in and finish machining before the big rush of other teams working at the last minute.
MekElektroniks: Lithium Ion Battery Charger for Meter Reader (BR3)

Lessons Learned

Clear communication between electrical and mechanical groups is essential to the success of an interdisciplinary project.

Our team had a hard time communicating at first because of our different technical backgrounds. It was also very difficult to relate to each other portion of the project. At first it seemed as if we only were taking ownership of our portion of the project and not the project as a whole. It took time for us to understand that with out either of the systems the product would not function. Once we as a team reached this milestone we were able to work together and be more productive.

Creating and adhering to a well defined schedule is essential to the timely production of a product.

In the beginning of the project we laid out a well defined schedule which was driven by the customers needs. We stuck to the schedule for the first part of the semester but we began to realize that many things were dependent others being done first. These dependencies lead to a breakdown of the schedule. Adjusting the schedule to the dynamic nature of our project allowed us to set more attainable goals. It is very hard to see every hurdle you will encounter and thus hard to plan for these bottlenecks.

Iteration and continuous improvement are key factors in coupling mechanical and electrical systems.

Iteration was key the development of our project. The mechanical group was responsible for the mechanical portion of the project along with providing the electrical group with their design space. The mechanical design was built around continuous improvement making it a very dynamic process. The electrical design being very dependant on the mechanical design also became an iterative process. The electrical group provided feedback on how much space was set aside for electrical components, and the mechanical group in turn made room for those components, altering the overall design.
Maintaining a “Team” mentality throughout the project is extremely important to the success of the project.

As a group working together effectively is very important. There situations in all design projects that call for individual work, but when on a team one should not work entirely as an individual. There should always be team feedback and any individual effort them become a work of the group. Many aspects of the project should be worked on together to ensure that many perspectives are attained. These multiple perspectives help to diversify the concepts and ideas generated by the group.

It is very important to keep the line of communication open with your customer to give and receive feedback.

During the front end of our project we had very good communication with our customer and as time went on and our customer got busy our communication fell off. Our team put a lot of effort in to communication with the customer and this was not reciprocated. Looking back on this there may have been a way that our team could have avoided this. Our project was put on hold and we heard virtually nothing from our customer, so rather that dwell on this we moved forward with the project and continued to develop our product. In the end we had a product both we and our customer could learn from and be proud of.
Music Machine: Reed Gouging Apparatus (BR20)

Student #1
- Always believe in the possibility of success.
- Prioritize tasks inside and outside the project.
- Consult with other people as much and as soon as possible about design ideas and solutions paths.
- Don’t be afraid of an idea or concept.
- Learn about the project as much as possible and as soon as possible.
- Don’t be intimidated if a solution path requires development of new skills and abilities.

Student #2
- Always be thinking of the next step and about when you need to move ahead. It helps to keep (and regularly refer to) a checklist.
- Make good use of your mentor as an advisor.
- Keep your teammate updated so you both know what’s going on and who’s working on what.
- Update your customer regularly so you can address issues of concern.
- Don’t hesitate to brainstorm, sketch, and solid model, then get feedback.
- Don’t ignore small details or observations. Little things can make a difference and mess things up if not addressed.
- Define parameters, as well as possible, during problem definition, and keep thinking about how you will fulfill them.
Shot in the Dark: Vision System for Inspecting Ammunition (BR22)

Problem Definition

It was evident from our first meeting with ATK the needs of the customer. They where currently using a human visual inspection for their cartridges, which was doubling the cost of the production. They where in need of a automated visual system to improve the inspection and reduce costs. However pinning down the actual scope of the project was difficult because there was a lot to do. Towards the end of the first semester we realized that we needed to redefine the scope because it was too much.

Conceptual Design

Our customer introduced us to a few of the current automated inspection systems and we actually view Schweitzer Engineering inspection system, however there could have been a lot more research in this area. Knowing that our design would need a lot of testing and debugging we started prototyping early and choosing a couple different ideas to start testing. Throughout the year the testing that was done improved in that we started making a more detailed record of the tests so that we could go back and compare.

Detail Design

For the detailed design we had most of the pieces drawn early and started manufacturing in March. However it seems that we should have started this process a little bit earlier. When working on a interdisciplinary team one must consider that the computer and electrical components have to be integrated on the system afterwards. Not having the mechanical engineers finish their part earlier put the electrical and computer engineers in a bind. For instance our rejection mechanism was finally finished the day before expo. This was because the programming had to be done before the rejection mechanism could be tested and approved for the design.

Implementation

For the budget we where doing pretty well up until the end of the semester when there was a last minute purchase to contol the timing of all the components. To add on top of that this piece had to be overnighted, costing us much more. Again this could have been avoided by having the mechanical engineers machine all the parts earlier so there was more time for the system control. The actual inspection was very accurate however the rejection mechanism did not always work. If there was more time to debug the software then the rejection mechanism could have worked properly.
**Communication**

The communication between the team members was for the most part was well. We always seemed to know what each part of the project the other was working on. We had consistent meetings and even had a BBQ now and then. Communication with our customer proved to be a really big assets. ATK was able to supply a lot of the parts needed for the project along with ideas and suggestions. The only problem with communication was with the professors. For assignments like the design review and the final paper it seemed that we where not given much direction and we never knew the criteria until it was too late.

**Teamwork**

All of our teammates got a long most of the time. Towards the end of the semester there was some tension at times, but we all understood the pressure that we under. Having three different majors working on this project made it difficult to understand what each other was doing and the reasons for it. However our team seemed to be interested in knowing the basics of how the all the parts worked. This helped tremendously so that no one thought their part was more important then the others.
X-Stream Team: Small Scale Hydropower Optimization (BR9)

Lessons Learned

**Identifying Functional Requirements**

Working with the customer to establish a solid understanding of the functional requirements is an essential part of engineering. Many headaches can be avoided down the road if both the customer and engineers understand the agreed upon requirements early into the project. Not setting well understood functional requirements can lead to an unhappy customer and an engineer having to redesign the project.

**Engineering Analysis**

Engineering analysis is an important step to the design process. Knowing the problem is not the final answer. After the problem is identified, analysis of many different ways of solving the problem need to be addressed. Ultimately, the best solution is used. But without analyzing every option, you may finish and realize that another option would have been better. You can't put enough emphasis on analyzing the situation and project scope.

**Making Part and Assembly Drawings**

If you create a model of a part that you are modifying or building, it is important that you build it as accurate as possible. This will decrease the amount of errors that you may have in manufacture. It will also save time from not having to review everything on it prior to machining. It is also important to build the solid model in the same way that you intend to build the actual part. This decreases the errors that are encountered in manufacture and assembly.

**Design Evaluation**

Design evaluation is important to do continuously during the project. The reason it is done is to make sure there isn't a better alternative that hasn't been considered or that the alternative chosen is a dead end. It saves time from having to do intense troubleshooting when the project is completed. It also lets you, the customer, and the advisors to be confident that your decisions are correct and accurate.
Technical Writing

While it's important to make technical progress in any project, it's also necessary for others to understand what you've done. To that end, proper technical writing is essential in communicating both a team's progress and their procedure. A poorly written document will detract from its contents, and professors will take this into consideration when assigning grades. So, make sure that any report or other document representing your project portrays the necessary information in a professional, clear, and concise fashion. For instance, this paragraph is a bad example, as it uses both contractions and personal pronouns directed at the reader (both of which are unprofessional).