ENGR-4201/4202 Engineering Project 1 & 2

Student Success Guide

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1. INTRODUCTION

Welcome to ENGR-4201 and ENGR-4202 Engineering Projects 1 & 2. We affectionately call this two semester sequence: Senior Design.

This capstone course is designed to simulate the typical New Product Development process followed by most engineering organizations in industry. You will begin with team selection. You will be challenged to determine a problem that may be solved using technology. You and your team will develop alternative concepts, select a concept for further development, design system architecture, develop details, build, test and demonstrate a final prototype. The success of your prototype will be based on how well it meets the requirements necessary to address your originally chosen problem.

Like in industry, your Senior Design project will have constraints and opportunities within which you will work. You'll design, analyze, build and test your prototype with fixed funds, time, and other resources and do all of this within a team setting. Thus your personal success will greatly depend on the overall success of your team.

Senior design will be significantly different from most other courses you have taken. Unlike an emphasis on analysis with known single solutions, in this course, you will face open ended design problems which typically have many possible solutions. With this in mind, it is highly recommended to tap into the expertise and experience of any engineering or other faculty members. We are all happy to support you in your endeavor.

Our over arching goal in this course is for you to be well prepared for your next endeavor, whether in graduate school or in industry.

RULES OF SENIOR DESIGN

The below is designed for you to record the ten pithy sayings as revealed throughout the Fall semester:

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

8. ____

9. ____

10. ____

2. PROJECT REQUIREMENTS

As engineers in industry develop new products for the benefit of society, your Senior Design experience will center around developing a new product that provides a solution to a problem. You will develop and construct through the first prototype stage. You, as a team, will decide on the content of your project. You are encouraged to “create your own invention”. Faculty will assist in defining your project scope and even provide some ideas. Often project ideas come from outside Harding and may be accordingly sponsored by another organization. But ultimately, your project is your team’s decision.

The following are some guidelines and requirements for your project.

TECHNICAL CONTENT

All projects must involve the expertise of the students on each of the teams. So, technical content of each prototype must challenge and utilize the learning skills of every team member.

COMPUTER

Teams with one or more computer engineering majors must develop a prototype using a microprocessor and software that controls the device. A microcontroller system must be designed from the board level up. No pre-assembled microprocessors (Arduino, Raspberry Pi, their clones or similar derivatives) are allowed. Basically, students having completed the microprocessor course are required to develop their own microcontroller hardware and software environment.

ELECTRICAL

Teams with one or more electrical engineering majors must develop a prototype containing significant electrial engineering hardware. This could include a microprocessor for controlling the device, or instrumentation for measuring physical parameters, analog or digital signal filters, etc [full power supplies, if needed, are expected to be purchased]. Regardless, a professional quality printed circuit board must be designed, fabricated and included in the prototype. Fabrication methods in our labs will suffice. If microprocessor control is a designed prototype feature, see configuration requirements for computer engineers.

MECHANICAL

Teams with one or more mechanical engineering majors (probably most) must develop a prototype that moves and/or has moving parts, can be analyzed using equations of motion or involves heat and mass transfer (refrigeration or heating). Pre-assembled microprocessors are acceptable, but not necessary if no EE or CE students are on the team.

BIOMEDICAL

Teams with one or more biomedical engineering majors must develop a prototype having a biomedical application. This generally involves a high interaction with the human body and/or is a device targeted for use in the health industry. The project will be approved by Dr. Lance Gibson, the Director of the Biomedical Engineering program. Dr. Gibson is also an excellent source for project ideas. Pre-assembled microprocessors are acceptable, but not necessary if no EE or CE students are on the team.

PROJECT SCOPE

TEAM ACTIVITY

Project selection is a team activity. In selecting your project, it must be a solution to some problem. First select a problem, then consider several possible alternative solutions, before finally selecting a project for designing and building. In thinking of a problem to solve, you are encouraged to think of some pet peeves. What annoys you and makes you wish there was another way to do the task so that it was easier, costs less, or more convenient? What is a significant problem for others in terms of health or safety? What do you think is the type of market needing to purchase your product?

IDEAS

For the last several years, we've encouraged senior design students to work with business students in the Entrepreneurial Management class to compete in the Arkansas Governor's Cup Collegiate Business Plan Competition. Several past teams have performed quite well. You may have heard that the senior design team, called T.I.R.E., placed first. In 2020, TKAA (BioPrecision) team won 2nd place and $15,000. You could brainstorm ideas or talk to some of your friends in that or other business classes for their ideas. Bonus points are available for working with the business class. I'd also encourage you to look at some web sites for ideas. You might want to look at the Source America Design Challenge at https://www.sourceamerica.org/design-challenge/home for a design competition for helping people with disabilities improve their ability to get gainful employment. IEEE and ASME sponsor several design competitions. The Bill and Melinda Gates foundation has several areas identified as major humanitarian needs in the areas of health, economic development, and education. Engineering World Health has a similar focus with more of a bioengineering emphasis in developing countries (www.ewh.org). Want to see what the National Institutes of Health thinks significant problems are? Check out the National Institutes of Health SEED Topic Portfolio. There is also ASME's Engineering for Change project https://www.engineeringforchange.org/home . Likewise, NASA provides financial sponsorships for Senior Design projects http://national.spacegrant.org/index.php?page=senior-design as well as the Arkansas Space Grant Consortium. You might also be able to talk to other professors about needs or wants that they have for devices or equipment. Mainly, the project should be something you and your other team members are interested in and believe in. You're going to be spending A LOT of time working on your project, and it will be a lot easier to motivate yourself to work on it if you find the idea exciting and fun.

TECHNICAL SCOPE

The project should have reasonable technical scope. The project should be challenging, but not overly so, and reasonable for a team of three or four to complete in two semesters.

You should aim to design and build a new device using a new combination of existing technology. Structures need to be analysized for strength, circuits configured for function and circuit protection, and/or control algorithm written.

At one extreme, students might find a design on the internet or a ready-made kit and simply propose to put it together. This would be too easy and wouldn't involve any design work, so this would not be allowed. It might be beneficial to look at other designs and modify them to make your prototype better, cheaper, etc., but full scale copying of a design is not acceptable.

At the other extreme, students may want to design and build a device that requires an overly complex or high risk technical design. This also applies if more precise fabrication techniques (such as nanotechnology) are needed than is readily available or within budget.

Regardless of your choice of project, the end prototype must function and work such that it meets your requirements specification. Details will be covered later, but we will emphasize again and again, that the end goal for the engineer is how well the device works as intended.

BUDGET

The majority of for-profit and non-profit organizations maintain substantial financial monitoring and control for multiple functions. This includes new product development projects. Likewise, you will need to monitor and control all expenses. The total allowable financial spending (budget) for your project will be announced in class. We usually recommend that you select a project that you anticipate will cost no more than 60% to 70% of the total allowable amount. The reason for this is that this gives you some contingency funds to select alternate parts, pay for shipping and sales tax, replace parts you break, etc. It is very rare that teams don't push the budget limit right to the edge. If you budget the entire amount for anticipated costs, you likely won't have enough left to replace a broken item, pay for an item you didn't anticipate needing, but now find you do need, etc. Cost overruns are taken seriously in industry. Likewise, they are scrutinized in Senior Design. If costs to develop your prototype go over budget, then all team member course grades will be reduced based on the graph shown in Figure 1 below:

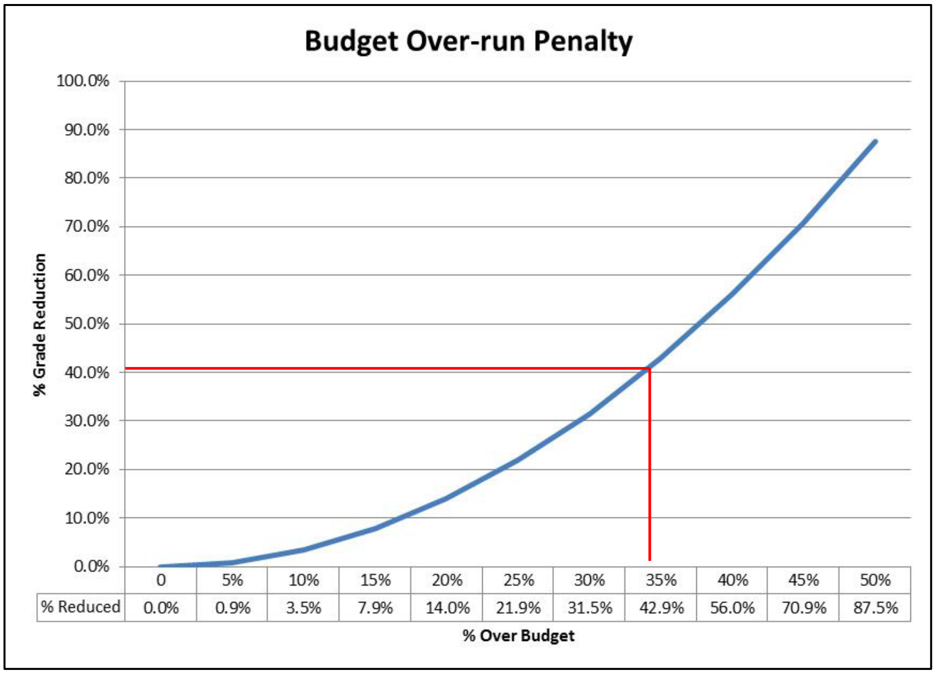


Figure 1: Budget Over-run Penalty

SAFETY

Deuteronomy 22:8 (NIV) 8 When you build a new house, make a parapet around your roof so that you may not bring the guilt of bloodshed on your house if someone falls from the roof.

A parapet is a low protective wall along the edge of a roof, bridge, or balcony designed to prevent people from falling. The above Israelite law reminds us of the importance to keep human safety at the forefront of our engineering endeavors.

It is imperative that you place safety first in all your senior design project work. This means you will:

Design a safe product that does not impose any undue hazard.
Construct your prototype in a safe manner.
Test your prototype in a safe manner.

Design for Safety Guidelines[1]

You should use the following guidelines as you develop and evaluate your prototype:

1. Recognize and identify the actual or potential hazards, and then design the product so they will not affect its functioning.
2. Thoroughly test prototypes of the product to reveal any hazards overlooked in the initial design.
3. Design the product so it is easier to use safely than unsafely.
4. If field experience turns up a safety problem, determine the root cause and redesign to eliminate the hazard.

5. Realize that humans will do foolish things, and allow for it in your design. More product safety problems arise from improper product use than from product defects. A user-friendly product is usually a safe product.
6. There is a close correspondence between good ergonomic design and a safe design. For example:
    a. Arrange the controls so that the operator does not have to move to manipulate them.
    b. Make sure that fingers cannot be pinched by levers or other features.
    c. Avoid sharp edges and corners.
    d. Point-of-operation guards should not interfere with the operator's movement.
    e. Products that require heavy or prolonged use should be designed to avoid cumulative trauma disorders like carpal tunnel syndrome. This means avoiding awkward positions of the hand, wrist, and arm and avoiding repetitive motions and vibration.

7. Minimize the use of flammable materials, including packaging materials.
8. Paint and other surface finishing materials should be chosen to comply with EPA and OSHA regulations for toxicity to the user and for safety when they are burned, recycled, or discarded.
9. Think about the need for repair, service, or maintenance. Provide adequate access without pinch or puncture hazards to the repairer.
10. Electrical products should be properly grounded to prevent shock. Provide electrical interlocks so that high-voltage circuits will not be energized unless a guard is in the proper position.

Some additional safety considerations:
If there are spinning parts, sprockets and chains, etc., these should be reasonably enclosed so that it would be unlikely fingers could get mashed or cut. If there is large heat generation, then it should be safely vented and/or insulated so that burns can't result. Flammable materials or compressed gasses must be safely handled. If the prototype plugs into a wall outlet, appropriate safety precautions need to be taken to prevent electrocution, etc.

[1] Engineering Design 5th Edition, Dieter, George; Schmidt, Linda, McGraw-Hill 2013

MOVEABILITY

The prototype must be easily moved and stored. This means that there should be some limit on its weight and size. Generally, it is ideal if the unit can be moved by one person (two at most) and it should be able to fit through standard size doors (less than 34.0 inches wide), easily moved from lab to lab (on the elevator) etc. The device should weigh less than 50.0 lbs. Should the nature of the device require it to weigh more, then it must be easily disassembled, without tools, and reassembled in less than 10.0 minutes. In no case may the total prototype weigh more than 75.0 lbs.

This represents the overall class requirement. The potential market for your product will often drive for lower weight and size. This is especially true for any devices meant to be portable or often moved.

Note: we try to keep your prototype intact a full year for demonstration purposes. However, should the device be oversized and thus need to be dismantled per above, it may not be remain on display once the school year has ended.

NEAT AND COMPLETE

The device should look neat and complete. We have traditionally combined with the computer science students in April for the Computer Science and Engineering Showcase. We have many visitors there and even the university president has dropped by at the showcase in the past. Thus, the device should be enclosed in an attractive housing or at least look like it is in a finished state. Structures made from metal, for instance, should be painted. Clear body panels are encouraged. This is a requirement, but it is very much secondary to how well your prototype works.

WHEN INVOLVING HUMAN SUBJECTS IN TESTING

The below comes from the following website: https://www.harding.edu/irb/faq

Harding Institutional Review Board (IRB)

Under federal law and regulations, an IRB is the official group that has been formally designated by an institution to review any research involving human subjects. The fundamental purpose of IRB review is to assure that the rights and welfare of human subjects are protected. A signed informed consent document is evidence that the document has been provided to a prospective subject and that the subject has agreed to participate in the research. IRB review of informed consent documents also ensures that the institution is in compliance with applicable regulations.

Does My Project Require IRB Approval?

Projects that do not require IRB review includes anything that is NOT research. This includes but is not limited to: records reviews, data requests, or classroom surveys conducted by a teacher to inform his or her instruction (and not intended for presentation or research).

In general, a project or a study that involves data gathered from groups or individuals solely for internal, on-going campus use (e.g., coursework, course evaluation, program assessment or internal programming), and **NOT presented or distributed to individuals outside of a classroom or shared with external sources**, does not need to be reviewed by the IRB. If results of a project or a study are publicly disseminated in any way (e.g., conference presentation, publication) or will contribute to generalizable knowledge, then the study probably constitutes research and will require IRB review/approval. [Note: first student to email Prof. Wells with the following code will receive 5 bonus quiz points: “IRB”] If no dissemination is planned at the time the data is gathered but the possibility of future dissemination exists, the researcher is advised to submit the project for IRB review/approval before initiating the (research) project. Typically, an exemption is the form to be filed with the IRB.

If a Harding University student project does not constitute research and is determined by the student and the faculty advisor to be outside of the IRB preview, in the spirit of ethical principles, you are expected to respect the individuals participating, to protect their privacy and to maintain the confidentiality of data by conducting the project with good ethical and responsible practices.

3. PROJECT DELIVERABLES

Often, business managers, project managers and team members will focus on deliverables. Project deliverables are tangible items produced or provided as a result of a process. While producing a product or service in the course of a project there will be due dates for deliverables, as well as specific and measurable key performance indicators, such as quality or quantity. In the case of senior design, deliverables include those items that will be assessed and graded. The major deliverables are described below. See the course syllabus for a list of all graded items.

ENGINEERING NOTEBOOKS (OPTIONAL)

Engineering notebooks provide valuable records to the organization and the individual engineer. It provides an extension of personal memory by documenting everything that was done and when it was done. It records an engineer's work for other engineers who may need to carry on with your work. This gives you more flexibility to move on to new responsibilities rather than be tied down to one subject. The engineering notebook protects patent rights or it can be used to invalidate someone else's patent rights. It could be part of legal proceedings when determining liability for accidents or failures.

We recommend that each of you keep an engineering notebook. As an experiment, these will not be graded this year. The below are recommendations for keeping a quality notebook. Use the format and style that best suits your needs. You will know the quality of your notebook as you develop the written reports. Well done notebooks will contain the reference materials and personal notes for easy transfer into the reports. Should you find yourself looking up references and not recalling work accomplished earlier, you might consider stepping up your notebook entries.

The notebook will be a record of all your contributions to the project. The notebook will be periodically reviewed by your instructors. To get full credit, the engineering notebook content must show that you are substantially contributing to the project and the notebook must follow the proper format and conditions.

CONTENT

The value of the engineering notebook increases as the following are documented within:

a. All original thought – capture it before you lose it or before everyone else knows!
b. All project assumptions as they occur.
c. Key concepts and ideas from your project proposal.
d. Sketches and pictures documenting the design process - annotate!
e. Research findings–reference information for all sources.
f. Diagrams, schematics, or block diagrams for any system or sub-system which is to be tested. There should be an accompanying discussion of the principle design problems and decisions made.
g. Equations and formulae used in the design process, with references. If derived by you, provide enough information so that someone can recreate your work.
h. Documentation of testing and debugging. Indicate what is being tested and include set-up diagrams and all results. Difficulties should be noted with analysis and next steps defined.
i. Analysis of, and proposed solutions for, any problems. Include revisions to documents and test configuration.
j. Documentation of final performance tests and design verification.
k. Outlines for oral and written reports.
l. Interview information (who was contacted, why, when, and what was discussed or learned).
m. Group meeting notes.
n. Rationale for decisions.

Two types of notebooks are typically used in industry. One is a paper bound physical notebook (format instructions below). The other is an electronic notebook. Both types have pros and cons. This class has traditionally used a paper bound notebook. However, we have now transitioned to the more modern electronic notebook. These notebooks should have the same information as that described in the CONTENT section. We will also be expecting that there will be entries into the electronic notebook during "team time". These entries will automatically be time and date stamped to ensure the work was done at the appropriate time. More details regarding the pros and cons and expectations for the electronic notebooks will be provided in class.

FORMAT

All should follow the stated format for your engineering notebook:

a) Must have sewn pages. That is, pages cannot be easily removed or added without it being obvious.
b) Pages must be permanently numbered.
c) All entries must be in ink.
d) No blank pages or pages with significant blank space. Simply draw lines through blank or unused space as entries are made (greater than 2" in size).
e) Each page must be signed and dated by the author.
f) Mistakes are marked through with a single line, or two, so that the mistake is still readable.
g) Corrections should be initialed and dated.
h) All entries should be original entries, not transcribed at a later date from some other paper.
i) All entries should be legible.
j) Should provide evidence of continuous work. For this class, entries are expected daily with no gaps greater than three days. Exceptions such as Thanksgiving, Christmas and Spring break must be noted.
k) Each page should be witnessed and dated by someone who understands the work, but not the author of the notebook. Instructors will sign while grading your notebook.
l) When possible, entries should be read either vertically (portrait) or from the right (landscape).
m) In the first few pages of the notebook, there should be a table of contents page or pages.
n) Supplements should be permanently attached (glued or taped) to a notebook page and signed across all borders.
o) As the notebook becomes full, new notebooks should be consecutively filled out. The Engineering department will supply a second notebook when the first is full.
p) Generally, there should be one notebook per engineer.
q) The notebook may contain a single project or multiple projects.
r) Page headings should indicate task or investigation title.
s) Negative comments concerning the feasibility of the project should be avoided. Don't say, "This won't work." or "Device is worthless." Just state the facts.

TEAM CHARTER

Each team will develop a charter intended to ensure good collaboration and communication. The team charter is divided into four major sections:

- Establishing team procedures
- Identifying expectations
- Timelines and milestones (your team's process for planning a timeline and milestones)
- Specifying the protocol and consequences for failing to follow procedures and fulfill expectations

A3 PROBLEM SOLVING COMMUNICATION

Arguably the two most valued industry skills for all engineers are problem solving and communication. Effective problem solvers recognize and identify important problems. They solve them. They learn from the problem solving process and share their discoveries with others. To facilitate learning these concepts, senior design employs a problem solving communication process developed by Toyota[1]. The process, called 'A3', enables engineering teams to practice good problem solving techniques and communicates learning through a single page format. This section first describes concepts of the A3 process and then provides detailed instructions for implementation in senior design.

PLAN-DO-CHECK-ACT

The PDCA cycle, see Figure 2, is a continuous loop of planning, doing, checking and acting. It provides a simple and effective approach for solving problems and managing change, and it's useful for testing improvement measures on a small scale before updating procedures and working methods[2].

Figure 2: PCDA Cycle

You can use it in all sorts of business processes, from developing new products, such as in senior design, through to managing the product and manufacturing supply chain.

The approach begins with a **Plan** phase in which problems are clearly identified and understood. Root causes are ascertained and goals/targets for improvements are established. Potential solutions are tested on a small scale in the **Do** phase while making the change happen, and the outcome is then evaluated and **Checked**. It's important to learn from what went well as what went wrong.

You can go through the Do and Check stages as many times as necessary before the full, polished solution is implemented in the **Act** phase when the change is adopted, abandoned or recycled. The new solution becomes the baseline for further improvements making this a continuous cycle. As will be shown later, the A3 process works through the PDCA cycle.

OBJECTIVITY and LOGICAL THINKING

Developing A3's encourages one to grasp the facts of the situation as opposed to opinion or wishful thinking. First hand observations are included. "Just the facts" are documented. The team-based nature of A3's in senior design allow and encourage multiple viewpoints which enable more creative problem solving.

Incorporating standard storylines and format promotes and reinforces a logical, thorough approach to product development. Strong emphasis is placed on cause and effect. Validation of proposed solutions ensures issues are truly resolved.

RESULTS AND PROCESS

[1] Shook, John; 2007; "Managing to Learn: Using the A3 management process"

[2] www.mindtools.com

A3’s focus on results and process. Results are important because they test one’s true understanding of multiple success factors. Ultimately, your final prototype results indicate the overall ability to identify and solve problems in complex situations. Likewise, your personal development is critical. The A3 process displays how you approach problems and improves the likelihood you will repeat such skills on future problems following graduation. The entire A3 process enables a mentoring environment amongst faculty and fellow classmates where issue resolution may be openly discussed.

SYNTHESIS, DISTILLATION AND VISUALIZATION

The A3 process includes gathering information from multiple sources such as technical articles, product specifications, design concepts, test results and information from teammates. This information is synthesized (think mashup) and then distilled down to just the most vital points, having the most impact, that fit in the single page format. [Note: first student to email Prof. Wells with the following code will receive 5 bonus quiz points: “goHarding”] Visual and graphical representations often convey said information best. You are encouraged to include conceptual drawings, system body diagrams, mathematical models (such as CAD, Multisim and FEA), photos of construction progress and plots of test results.

ALIGNMENT including 3D COMMUNICATION

A3’s place high value on agreement concerning team decisions. When compiling, each person affected contributes something concrete that can be agreed to or not. Developing and presenting A3’s involves “3D” communication. Information is shared up and down in the organizational hierarchy. In this case, you are sharing with your faculty. Information is shared horizontally across the team and other teams. In senior design, you present to your classmates. Information is shared back and forth in time. You discuss what has happened and your plans for future action.

COHERENCY AND CONSISTENCY

A3’s require coherency from one step to the next providing overall consistent interconnections of thought. Common “storylines” develop tacit understanding of the logic for approaching specific situations. Situations are consistently approached and communicated. This allows the receivers to focus quicker on the issues at hand and thus enables higher quality feedback.

SYSTEMS VIEWPOINT

Before taking action, well developed A3’s require you to understand the purpose of the course of action and how the action plan furthers the organization’s goals, needs, and priorities. You will also focus on how the project fits into the larger picture.

WHY ONE PAGE REPORTS

Single page A3 reports force deeper understanding to express ideas clearly and briefly. They offer greater efficiency. Each report will be written once, but read many times. Short reports are distributed to all affected with the expectations that they will actually read it. And most importantly, one page A3’s facilitate dialog.

SENIOR DESIGN IMPLEMENTATION

An A3 template, in PowerPoint, is provided in Canvas for your use and is shown in Figure *3*. This section explains the overall instructions for the A3 document and then breaks down the individual content expected in each of the seven boxes of the template.You may create your own template but it must look the same as that provided. Some prefer MS Word over the provided PowerPoint. The top banner may be removed and/or reduced. Team name, date and team member names must remain. The completed file will be uploaded into Canvas by the designated time before the

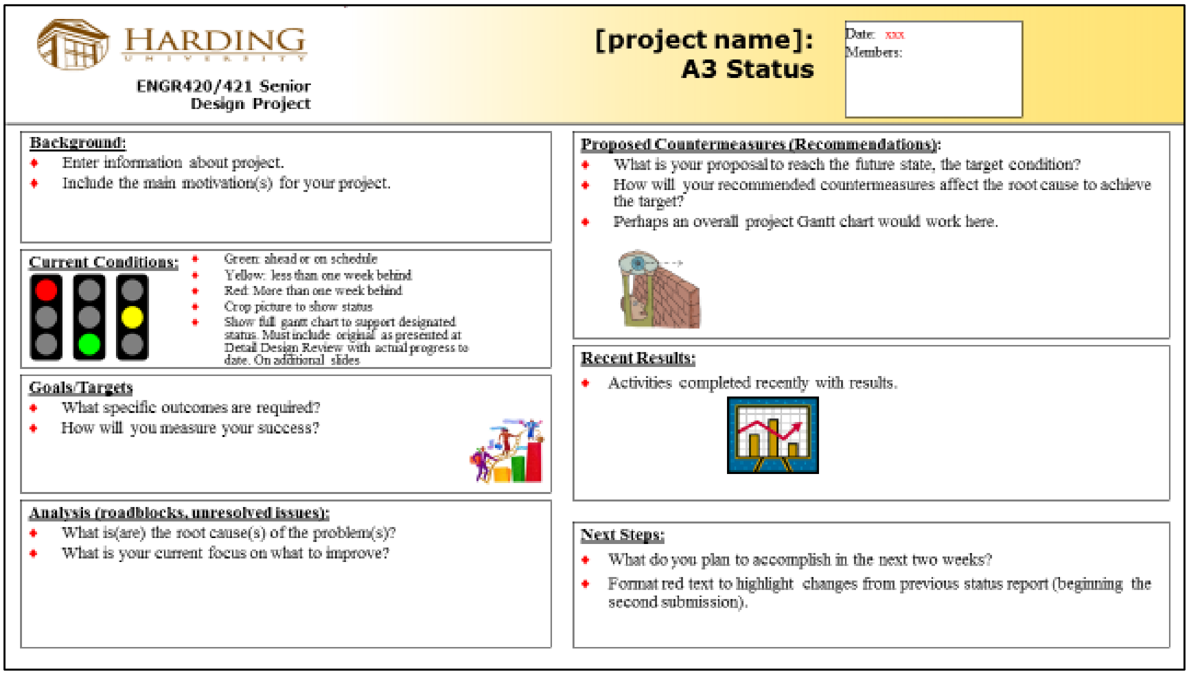


Figure 3 A3 Template

scheduled in-class oral presentation. Three full size handouts will be provided for instructors. The A3 must be the first slide and contain all information

to be presented. Additional slides may magnify content for viewer legibility and/or include videos. At least one illustration is expected on the A3 page. All team members must contribute to the A3

and present to receive credit. Prerecorded video is accepted in cases of team member absence. As a general rule, each team will complete and present an updated A3 every other week. The precise schedule is available in Canvas.

A3 CONTENT

The first three blocks within the A3 may be thought as a road map consisting of the project Background, Current Conditions and Goals/Targets.

The Background represents your starting point. It describes the basic problem statement your project plans to solve. Researched quantitative information indicating the magnitude or severity of the problem is preferred. Describe how your project addresses the problem statement. The combination should answer the question, “What is your inner, altruistic motivation for doing this project?”

Moving on to the Goals/Targets block. It describes your end destination. These quantifiable requirements depict the major functions and features of your planned prototype. For example: suppose you are developing a new automobile with a customer need that it be fast. In that case, two good targets would be: 1) has a top speed of at least 175 mph and 2) can accelerate from 0 to 60 mph in under 4.5 seconds. The Goals/Target block should answer the question, "How will you measure product success?"

The in-between block, titled Current Conditions, presents your project accomplishments to date with respect to your overall plan. It depicts your current location on your road map. That location is described with respect to your project schedule. You will display a traffic light with either a green, yellow or red light. A green light indicates you are on or ahead of schedule. A yellow light indicates you are less than one week behind. Red indicates greater than one week behind. A graphic depiction, such as a Gantt chart, of your whole project provides more detail to support your traffic light color choice. The Current Conditions block should answer the question, "How do your current accomplishments compare to your plan?"

The next two blocks, Analysis and Proposed Countermeasures, distinguish the A3 format from that of typical one-page status reports. These sections take the user on the PDCA problem solving journey.

In the Analysis (roadblocks, unresolved issues) block, list the unforeseen problems or issues you have encountered on your project journey that have the potential to negatively impact either the timing or quality of your end prototype. This requires some trust in your audience. It is imperative we all provide positive support to all teams. Identifying and understanding the root nature of a problem leads one to the most efficient and effective solution(s). This block reminds us that a little confession can be good for the soul. The Analysis (roadblocks, unresolved issues) block should answer the question, "How well do you understand your most important/urgent issues?"

In the Proposed Countermeasures (Recommendations) block, you will include action items that will resolve your previously stated issues. These countermeasures need to be specific, measurable and aligned with the issues. Specific actions should lead to specific solutions to your roadblock/issue. It cannot be over emphasized to be specific in all details. For example, performing a literature search is very generic and reading up on a subject never fully solves a problem. However, learning required timing protocols and tuning software until all signals are synchronized depicts a more specific situation. Communicating in specifics improves organizational confidence in your work. You should plan to quantifiably measure the before and after solution performance of your prototype. This ensures the issue is resolved. One or more countermeasures should clearly align with each and every roadblock stated in the Analysis block. The Proposed Countermeasures block should answer the question, "How do you know your action plans will eliminate your most important/urgent issues?"

The Recent Results block contains the most important completed tasks that moved your project forward since your previously presented A3. These should address your planned actions stated in the Next Steps block of your previous A3. Be as specific and complete as possible. For example, if you completed a test, then show the test data and evidence supporting any conclusions. Include what was learned. The Recent Results block should answer the question, "How well did you do what you said you were going to do?"

The Next Steps block depicts your plans for the most important project actions that will occur prior to the next scheduled A3 presentation. This is usually a two-week time frame. Be specific with the planned actions and include which team member will be responsible for each task. The Next Steps block should answer the question, “How focused are your next steps?”

The A3 Problem Solving Process is growing in popularity throughout industry. After practice, you may include in the skills section on your resume. Several past students indicate such an entry helped them land their first job. As an anecdote, a graduate from a few years ago voluntarily used the A3 format for his routine on-the-job status updates. He indicated an instant increase in management confidence in his work. This will improve your problem-solving thought processing.

PROJECT TOPIC SELECTION

Early in the semester, turn in the following for your selected project on a single page (or at most two):

- **Project Topic:** short phrase that describes your planned prototype
- **Problem**(s) your product will **solve**
- **Project Description:** full single paragraph depicting the overall function(s) of your proposed device and indicates the technological scope of the project.
- **Benefits:** Describe how your device will provide benefit to its intended users.
- **Decision Matrix:** Include for 3 or more project finalists (alternatives) include summary discussion of results.
- **Team Members and designated leader.**
- Submit one [.pdf] document per team to Canvas

STAGE-GATE MILESTONES

More than 80 percent of companies in North America use some type of a Stage-Gate innovation model[3]. The Stage-Gate model divides the total New Product Development process into predetermined timeframes of activities (stages) with each concluded by a major continue-or-stop development decision point (gates).

In Senior Design, the two semesters are divided into five stages with five assessment gates. The assessment gates are opportunities for your instructors to provide graded feedback of submitted reports and department faculty assessment and feedback for your review presentations. Successful reviews will allow teams to continue their prototype development into the next stage. Less complete reviews will require selective redo of requested deliverables. The five stage-gates in Senior Design are: Project Launch, System Design, Detail Design, Build Design and Product Readiness.

PROJECT LAUNCH – EARLY FALL

The Project Launch aims to convince management (faculty) in the feasibility, viability and marketability (usefulness) of your project. You are challenged to motivate your management to

[3] www.stage-gate.com

invest in your project with approval and funding to develop your prototype. The project launch report and review presentation should contain the background, motivation, customer needs, technical requirements and overall development plans for your project. Expectations are all customer needs and aligned technical requirements are complete and the project team is ready to begin system level design. Terminology will be explained in class.

SYSTEM DESIGN – MID FALL
The system design report and review should contain the system and subsystem requirements, system functional interfaces as defined by functional decomposition diagrams, system description with concept design selection criteria and process, system level calculations, and pertinent project management information. Expectations are that all major system concepts have been selected and supported by sound engineering decision making.

DETAIL DESIGN – LATE FALL
The detail design report and review should contain the system and subsystem requirements, system design and subsystem design information based on progress to date of your project. Expectations are all major system and component designs are complete and the project team is ready to procure the necessary parts and materials to finish fabrication.

BUILD DESIGN – MID SPRING
The build design report and review should contain the updated system and subsystem requirements, updated system design, updated detail design, system test plans and subsystem test results based on progress to date of your project. Expectations are all major sub-systems and components are constructed and several subsystem tests are completed. Focus is on issue resolution.

PRODUCT READINESS – LATE SPRING
The Product Readiness report and review should contain an overall description of your prototype design, significant test results and budget/resource performance. Expectations are all major system and component designs are constructed and tested to demonstrate prototype completeness.

REPORT WRITING AND PRESENTATION HELPS
Written and oral communication skills are highly valued in industry. New engineering graduates are often criticized for lack of communication skills. In Senior Design, you will write major reports and orally present your project progress. As stated earlier, the primary objective in Senior Design is for you to be well prepared to enter the workforce. See the chapter on Course Concepts within this success guide for general guidelines and helps on technical report writing and making good presentations. The following provides specific expectations for the reports and reviews in each of the Senior Design stage-gates.

Historically, we have focused principally on the technical content of reports. However, it is more and more widely recognized that to be an effective communicator, written reports should engage the reader rather than just provide the facts. Whereas the information provided below on format can be used as a guide in constructing your reports, they do not necessarily need to be followed verbatim and in the order shown. Instead, you will engage the reader by illustrating what the problem is, why it is important, how solutions have been attempted previously, why those previous attempts have been lacking, and why your solution is innovative, creative, and likely to solve the problem more effectively. We will follow a process of writing iteratively do accomplish these goals. This means that most writing assignments will require drafts that will be used to provide feedback prior to turning in the final copy of a report. More details will follow in class regarding good reading engagement, and in particular "story telling".

PROJECT LAUNCH REPORT GUIDELINES

The project launch and technical requirements report should contain the background, motivation, customer needs, technical requirements and overall development plans for your project. Expectations are all customer needs and aligned technical requirements are complete and the project team is ready to begin system level design.

Contents of the report will likely include the following in a cohesive, logical, orderly, and engaging format:

Title Page

Include team name (product name), report name, team members and submission date.

Table of Contents

List all major report sections with page numbers.

Overview

Provide a 150-200-word paragraph that briefly describes the background of your project including motivation and how the functionality of your product will address the issue(s). This is basically a slightly expanded version of the background entry from your A3 but in narrative form.

Statement of the problem

Provide a more thorough description and analysis of the motivations for your project. Include brief assessments of similar products and how they are not fulfilling the problem at hand. Discuss the function of your product and your vision of how it will fill these voids. Discussion of what is in scope and not in scope is valuable here.

Customer Needs

Provide a complete list of perceived customer needs as described in your text and lectures. Include a description and reason for each.

Technical requirements specification

Provide a complete list of technical requirements along with a description of how they relate to the customer needs. Include a discussion of each along with reasoning for the requirement and justification for target value selection. This includes a customer needs matrix that provides a full relationship map between the needs and resulting specifications. It should include at least one requirement in each of these categories: performance/function, size, sound, environment, movability, and standards/regulations. Several requirements will probably address performance/function.

Operational description (draft user's manual)
Describe the planned environment and steps necessary for the end user to start-up, operate and maintain the device. Keep this high level without getting into technical solutions.

Implementation considerations
Service

Describe how routine actions not required with each use will affect the design of your product. These are items such as oiling or cleaning that may be required periodically but not with every use. Examples: fueling or changing the oil for an automobile.

Maintenance

Describe how non-routine repair needs of your device will affect its design. Explain how your design minimizes the time and ease of replacing failed components.

Manufacturability

Describe how the fabrication capabilities and materials available to you will affect your product design. Include discussion concerning known Harding fabrication capability and make vs. buy decision criteria.

Preliminary system test plan
Provide a brief list of planned physical tests that will validate/verify your product and specifically your technical requirements. Describe each.

Plan to Proceed
List out the planned responsibilities of each member of your team and how those roles match with that member's personal interests and skills. Include a timing plan for major tasks which includes the entire fall semester.

Appendix

Lab reports
Patent or literature searches
Marketing studies, etc.
Relevant codes and standards
Other References

Note that as you include most or all of these sections, there could be additional sections that are relevant to your report that are not relevant to other reports. All sections may not be required or may have a very small emphasis. Regardless of the overall structure and actual contents of your report, it is important to write in such a way that the information is engaging and tells a complete and logical compelling story throughout. Writing that is engaging is very important to have reader investment in your ideas, whether that investment be actual funding, consideration of you being promoted, getting a raise, or having your project purchased by a customer.

PROJECT LAUNCH REVIEW GUIDELINES

Content for the short review (presentation) includes: An agenda, the Problem Statement of your project, your list of perceived Customer Needs with supported reasoning, your developed Technical Requirements based on customer needs, any Preliminary Concepts of your potential prototype developed to date and your Plan to Proceed which addresses team member roles and proposed development timing plan.

ASSESSMENT

The entire engineering department faculty are invited to your presentation. Likewise, the Harding Engineering Industry Advisory Board (see below) is invited as this is scheduled during the IAB's annual meeting. Each member of the audience is requested to provide quantified feedback. The requested length of your presentation (usually under 15 minutes) will be discussed in class. Bring 15 sets of printed handouts – 2 slides per page.

Name of Company________________ Name of Evaluator________________

Date________________ Title of Project________________

ENGR420 Project Launch

	Possible	Given
Presentation Content (40%)		
Thorough coverage of the topic (breadth)	10	____
Sufficient details supplied (depth)	10	____
Relevance of all material presented	5	____
Technical aspects adequately explained	5	____
Obvious structure and organization	5	____
Transitions and connections between topics	5	____
Oral Presentation Mechanics (20%)		
Voice audibly projected	4	____
Pace neither too slow nor too fast	4	____
Length close to 15 minutes		
Deduct if too long or too short	4	____
Proper grammar, pronunciation, and enunciation	4	____
Smooth and natural flow, enthusiasm and confidence	4	____
Visual Presentation Mechanics (20%)		
Appropriate number of electronic slides	4	____
Relevant, succinct and concise text on slides	4	____
Appropriate font, background, and layout	4	____
Correct grammar and spelling	4	____
Relevant and enlightening graphics	4	____
Level of Project Analysis (20%)		
Sufficient analysis of customer needs	8	____
Sufficient analysis of technical requirements	8	____
Sufficient analysis of schedule	4	____
	Total 100	____
Deductions:		
Inappropriate appearance or dress	-10	____
Inability to answer reasonable questions	-10	____
Lack of handout	-10	____
	Final Score	____

Comments:

Figure 4: Project Launch Assessment

The assessment tool for your Project Launch presentation is shown in Figure 4 and provided in full size in Appendix A. It is highly recommended for you to review and understand each of the assessment items and develop a strategy to score highly in each. Your team grade will be the average score from all audience participants. Also, additional evaluator-written comments will be provided anonymously.

INDUSTRY ADVISORY BOARD

The Industry Advisory Board (IAB) is a group of engineers whose purpose is to support the mission of the Department of Engineering and Physics at Harding University. The group is comprised of approximately a dozen well-respected, Christian engineers who work in various firms and capacities across the United States. The IAB offers insight and guidance to ensure that the department's curricula within the biomedical, civil, computer, electrical, and mechanical engineering programs meet the educational needs of future graduates by providing meaningful feedback for the Department's programs regarding academic and other goals and by assisting the Department in developing medium and long–range strategic plans. Also, part of the role of the IAB is to serve as the employer constituency in the ABET accreditation plan by identifying the needs of employers who hire biomedical, civil, computer, electrical and mechanical engineers.

SYSTEM DESIGN REPORT GUIDELINES

The system design report should contain the system and subsystem requirements, system functional interfaces as defined by functional decomposition diagrams, system description with concept design selection criteria and process, system level calculations, and pertinent project management information. Expectations are that all major system concepts have been selected and supported by sound engineering decision making. The project group is ready to begin detailed design.

The following contains suggested content for the System Design Report guidelines. Similar to the Project Launch Report Guidelines, this report should also engage the reader using the information provided in the Project Launch Report section, and as discussed in class.

Title Page

Include team name (product name), report name, team members and submission date.

Table of Contents

List all major report sections with page numbers.

Project Specifications

Any and all updates to the requirements specifications should be included and finalized. If necessary, elaborate on your project constraints (goals), procurement availability, resources available including your individual group member skills, construction/build considerations and other resources. Include fully updated problem statement, customer needs and technical requirements.

Functional Decomposition Diagrams

Describe the input energy, signal and materials with output energy, signals and materials of your system. Breakdown into as many levels as required to assign individual responsibility for each subsystem.

Functional description of the blocks in each level.

Describe the function and interfaces for each subsystem in each level depicted. Include values, tolerances and units. Discuss the reasoning for all of your decisions. This may be combined with the previous FDD section.

System description

Describe the physical characteristics of your proposed system. Include discussion concerning any final list of original concepts developed. Show engineering decisions for your concept selections. Decision matrices and decision trees are good tools to use here.

Systems analysis – mathematical analysis and computer simulations

Discuss any and all numerical solutions obtained that helped drive your decision making. Include trends and not just “single answer” types of analyses. Show how the physical (spatial and material) implementation meets requirements and is consistent with the System Block Diagram. Include how major functions are met including, space, motion and energy usage. Note: major calculation tools such as Solidworks, Matlab, Multisim, Schematics and Flowcharts are very welcomed.

Expectations for inclusion in the System Design Stage:

Full mechanical assembly showing overall configuration using Solidworks
Overall control strategy
Electrical schematic

Organization and Plan

Include a full discussion of the following:

Budget: itemize each major component. Include projected project, reuse/donation and total costs.

Timing for long lead items known: identify those items requiring the longest time to procure and/or fabricate.

Provide Gantt Charts with much detail for this fall and overview for the spring. Discuss the major decision points that characterize the relationships between tasks.

Include critical Path (Pert Charts) for the complete fall semester.

List your group members' general skills and how they will be utilized successfully throughout the project.

Overall project R.A.S.I.C. chart that is consistent with all descriptions of the system and work such as FDD's, Gantt charts and budget.

List of References

Provide external sources for information.

Appendix

The appendix should contain the following items:

Project Demonstration Rubric: Reduce each technical specification to a phrase with measurable metric and include in the supplied rubric. Assign a weight to each specification leading to a total of 100%. Include within the appendix.

Report level R.A.S.I.C. chart for the roles and responsibilities in creating and contributing to this report. Use R and S only.

Any other pertinent information generated for the project that supports information in the body of the report. Examples may include: software code, MATLAB program code, additional Solidworks models, etc.

SYSTEM DESIGN REVIEW GUIDELINES

Your system design review will depict the progress of your overall prototype design. It will highlight the most important information from the associated report. Emphasis is on engineering thought processes employed. During this and all following Stage-Gate Reviews, you have 30 minutes to present followed by a 20-minute question and answer session. Attending faculty will complete two assessment tools.

The first assessment focuses on presentation quality (available in Appendix A). It follows closely with the presentation evaluation form for the Project Launch. The length of presentation is updated along with minor changes in the Level of Project Analysis section. This form is used for all remaining Stage-Gate reviews through the spring. As in the Project Launch, your grade is based on the average evaluator score. Individual feedback comments will be provided anonymously.

The second assessment, System Design Review Technical Rubric, focuses on the engineering thought processes employed during your prototype development. This rubric is also available in Appendix A. Your team must receive an average rating of 3.0 or higher in all categories to successfully complete the Stage-Gate Review. Otherwise, your team must “redo” and re-present the work necessary to complete the deficient category. Details for such with project-specific expectations will be discussed should you find your team in this situation. As discussed earlier, a “redo” negatively affects the team’s overall grade. The results for all teams are also reported aggregately in the Harding Engineering ABET accreditation self-studies.

Submit your PowerPoint file to Canvas. Bring 2 sets of printed handouts – 1 slide per page. To the review. These aid the audience in following your presentation.

During the presentation your team should cover the following although not necessarily in this order:

- Agenda
- Performance Requirements Specification
- Identification of Specifications Based on Other Realistic Constraints
- Idea Generation
- Feasibility Evaluation and Selection
- Functional Decomposition Diagrams
    - Including System Block Diagram
- Calculations/Simulations
- Design Illustrations
- Budget
- Resources
- Plan to proceed

PROTOTYPE REQUIREMENTS SPECIFICATION

Provide the background, customer needs and technical requirements. These may have been updated from the Project Launch Review but perhaps should be condensed for time purposes. Be sure to convey your passionate motivation for your project. This updates your audience on the purposes and goals for your work making it easier to follow the technical details.

INDENTIFICATION OF SPECIFICATIONS BASED ON OTHER REALISTIC CONSTRAINTS

Every endeavor or project meets external realistic constraints or limitations. Some typical limitations experienced in Senior Design include: timing and technology availability, procurement processes, resources and skills within the team and from others, construction and build technologies, and other resources.

IDEA GENERATION

Your text states good design ideas and concepts precipitate equally from group discussions, such as in brainstorming sessions, and in individual reflection and thought moments. Categorize and discuss the best of these generated ideas by major device functions.

FEASIBILITY EVALUATION AND SELECTION

You should have narrowed your overall design to one mainstream system design concept. Your decisions should be based on how well the concept meets the stated technical specifications as compared to alternative designs. Decision Trees and Decision Matrices work well for decision making and communication. Focus on your thought processes.

FUNCTIONAL DECOMPOSITION DIAGRAMS INCLUDING SYSTEM BLOCK DIAGRAM

Functional Decomposition Diagrams – FDD's focus on the technical interfaces between major subsystems and between components. They include focus on energy transfer, material handling and control signals. All other pertinent project information should synchronize and be consistent with the FDD's. Details will be discussed in class.

CALCULATIONS/SIMULATIONS

Show pertinent numerical solutions that helped drive your design decisions. Use trend line plots when applicable. They show the relationship between dependent and independent variables and help describe the observed phenomenon. Connect all these relationships to your technical requirements.

DESIGN ILLUSTRATIONS

Show how the physical (spatial and material) implementation meets requirements and is consistent with the FDD's. Explain how major functions are being met: space, motion and energy usage. Engineering toolsets such as Solidworks, MATLAB, Multisim, Schematics and Flowcharts may help.

BUDGET

Itemize the estimated cost by all major components. Compare with your maximum budget. Discuss project risks based on planned margins and potential timing and final decision point for potential long lead items.

RESOURCES

Discuss the skills of you team members and how they align with project roles and responsibilities. Include any potential issues with other resources needed for successful project completion.

PLAN TO PROCEED

Provide a detailed Gantt chart for the remainder of the Fall semester and all of the Spring. Discuss critical path and strategies to stay on schedule.

FOR YOUR CONSIDERATION

If there are any questions concerning priorities in the development of any of your presentations, the faculty wants you to demonstrate the following:

- Your depth of understanding for the societal need of your project.
- Your creativity.
- Your use of math and science as it influences your decision making.
- Your work ethic.
    - Thoroughness
    - Attention to detail
- Your management of the other success factors.
- Your presentation skills.

DETAIL DESIGN REPORT GUIDELINES

The detail design report should contain the system and subsystem requirements, system design and subsystem design information based on progress to date of your project. Expectations are all major system and component designs are complete and the project team is ready to procure the necessary parts and materials to begin fabrication.

The following contains suggested content for the Detail Design Report guidelines. Similar to the Project Launch Report Guidelines, this report should also engage the reader using the information provided in the Project Launch Report section, and as discussed in class.

<u>Title Page</u>

Include team name (product name), report name, team members and submission date.

<u>Table of Contents</u>

List all major report sections with page numbers.

<u>Introduction and Requirements Specifications</u>

Any and all updates to your problem statement, customer needs and technical requirements should be updated and finalized. Reference and include your demonstration rubric within the appendix.

Include an overall introduction to this report stating its purpose and content.

<u>System Design</u>

Update the system design including functional decomposition diagrams with appropriate explanations. Emphasize how it meets the overall technical specifications. Use computer aided design and engineering to demonstrate the overall system operation and function.

<u>Subsystem Design</u>

Describe each item/box within each FDD Level 2 Subsystem. Begin with fully defined operation and requirements for that item. Include calculations, simulations and any other pertinent technical information used to make decisions and finalize the design. Focus on **WHY** you made your design decisions based on sound engineering calculations and judgment.

Within each subsystem section, include discussion of the following:

Discuss your evaluation of alternative design ideas. Include the final design decision criteria as tied to your technical requirements and other constraints such as ascetics, manufacturability, team member skills, etc. Consider all subsystem interrelationships. Verify that subsystems and components have been completely designed for form, fit and function. Show clear evidence the components will work together properly. Leverage mathematical models to support your design decisions. Show relationships between dependent and independent design variables via trend lines. Show the iterations necessary to harmonize system, subsystem and component interfaces.

Design Failure Mode and Effects Analysis (DFMEA)

Complete a Design Failure Mode and Effects Analysis for your system. Use the provided FMEA spreadsheet template provided in Canvas (under “TEMPLATES and FORMS”). Additional information on the process is available in the Information tab. You only need to drill down to the inputs and outputs of your level 2 FDD’s. In other words, include the failure modes for each input and output for both Level 1 and Level 2 and the subsystems/components within Level 2. Demonstrate how your design improved based on following this process. In other words, show before and after RPN results. Describe the resultant design changes and how they improve the operation of the device.

If your product is targeted for an industry that prefers a different design risk assessment technique, such may be used with prior instructor consent.

Project Management

Fully update and describe your budget, project schedule and work breakdown structure. Include discussion of your decisions in each category. Your budget should include project costs, donation/reuse costs and total costs. Discuss your timing progress with respect to your original plans. Any Gantt chart or other timing illustration should include actual progress as compared to the original plan for the Fall semester and full plan for the Spring. Include full system and subsystems. Describe the delays and early completions your team experienced. Update the overall R.A.S.I.C. plan.

List of References

Provide external sources for information.

Appendix:

The appendix should contain the following minimum items:

Detailed FMEA analysis

Project Demonstration Rubric

Any other pertinent information generated for the project that supports information in the body of the report. Examples may include: software code, MATLAB program code, additional Solidworks models, etc.

One of the better past examples of the Detailed Design report is that done by the BEAST group during the 2010-2011 academic year. Observe the use of calculations and component test results and analysis using trend lines to drive design decisions. An electronic version is available for download from Canvas in the “Senior Design Knowledge Base” course. Be aware that course requirements for functional decomposition diagrams have changed since this report was written. Also, the title of the report has changed (was called Final Design, now called Detail Design).

ADDITIONAL HELPS

The following points are for your consideration when writing your Detailed Design Reports. Many also apply to all reports. It is not the rubric. Points are not assigned to each item. These items are merely meant to be helpful tips to keep in mind as you write the reports. Some ideas may be relevant to your report. Other points may be totally irrelevant and can be ignored. The overall theme of the report is to give an update on the status of your project (which should include subsystem designs) and to convince the reader that your design is well thought out, complete, and will be successful when built in the spring semester. This should all be presented in a logical, clear, and consistent manner.

Be sure to engage the reader. Use story telling principles. Ensure the reader knows why they should spend their time reading your report.

1. You may use a previous year report as a starting point. However, it is very important to write in a cohesive and engaging fashion. All the technical information in the world is irrelevant if it won't be read because it is written in a dry and boring style.

2. Update all schedules and budgets. Point out major changes to schedules and budgets and tell why those changes have taken place. Note if any items are significantly over budget or under budget and why. Also note if any task is significantly ahead or behind schedule and why. Answer the question of what is being done to bring the project back on schedule or budget.

3. All electrical circuits should be designed, showing schematics and simulation results in Multisim.

4. Mechanical components should have all parts professionally modeled in Solidworks and should show how these parts fit within the whole. Exploded views work nicely for this. Mechanical parts should also be appropriately analyzed for function and strength. Complex motion should be shown by animation.

5. All flow charts should be completed for code and some code should be written and working on the microprocessor chosen for your project. If very brief, code can be included in the main report. However, it is preferable to insert lengthy code into an appendix. A short description of the various sections of code, the code’s completion status, etc., can be included in the main report.

6. If it is impossible to simulate a component, then you should know the datasheet information for that part very well, and/or have the part built or in a partially built stage to show that it does or will work as you intend. You may have to treat the component as a black box using the datasheet information to incorporate it into your simulation results.

7. Simulations and design analyses should show results for subsystems that are within the ranges as specified in the functional decomposition diagrams of the Preliminary Design Report. If they are not within the previously determined ranges, the system and subsystem block diagrams should be updated and the changes should be pointed out.

8. All parts of the project should be designed and should include some description in your report. However, this doesn't mean that all parts are equal and get equal page lengths. You are free to write more or less about subsystems as you see fit in order to convince the reader your subsystem/prototype will be successful.

9. Include your selected parts' datasheets in an external appendix. If a datasheet is very long, only include a maximum of the 10 most relevant pages and a citation to where the rest of the datasheet can be found.

10. Carefully proof your work for spelling and grammatical errors and awkward wording. Sloppy writing tends to make the reader think the design is also sloppy. This will tend to annoy the reader and cause more scrutiny of design flaws and a reason to reject the design as flawed.

11. Don't include shoddy designs just to get a grade with the idea that something is better than nothing. It is much better to admit that a section isn't complete than to have the reader carefully look at your design and form the conclusion you are incompetent. You may include components of an incomplete design, or sketch out verbally how it will come together, but don't indicate it's complete if it isn't complete.

12. Having parts partially built and in working order goes a long way in convincing the reader the design will work. Show photos or test results of items already working. This isn't necessarily required for the fall semester, but it is more convincing to show a working part than a simulation that indicates it will probably work.

13. Background information and problem statements should be included as before. You should keep in mind that the reader could be someone who doesn't have any knowledge of your project and is looking at it for the first time. Each subsystem update should give a brief description of its status prior to launching into the work.

14. Make sure all formatting of figures and tables are well done. Graphs should have axes marked with appropriate units. Legends should be clear. Figures and Tables should be appropriately numbered with captions.

15. Make sure the reader can clearly understand why each item is included and how it relates to the fundamental thesis of your project. That is, the reader should readily understand how each section relates back to solving a problem that is actually worth solving.

DETAIL DESIGN REVIEW GUIDELINES

Your Detail Design Review will depict the progress of your overall prototype design. It will highlight the most important system and completed detailed design information from the associated report. Discussions will focus on design selection, synthesis, analysis and physical mockups.

Emphasis is on engineering thought processes employed. During this and all following Stage-Gate Reviews, you have 30 minutes to present followed by a 20-minute question and answer session. Attending faculty will complete two assessment tools. The Presentation Evaluation and Detail Design Review Technical Rubric are available in Appendix A.

Submit your PowerPoint file for the team to Canvas. Bring 2 sets of printed handouts – 1 slide per page to the review.

During the presentation your team should cover the following although not necessarily in this order:

- Agenda
- Performance Requirements Specification
- System Design Overview
- Design Selection
- Detailed Synthesis
- Engineering Analysis/ Evaluation
- Physical Mockups
- Budget and other resources (update)
- Plan to proceed

PERFORMANCE REQUIREMENTS SPECIFICATION

Provide the background, customer needs and technical requirements. These may have been updated from the System Design Review but perhaps should be condensed for time purposes. Be sure to convey your passionate motivation for your project. This updates your audience on the purposes and goals for your work and brings possible new audience members up to date.

SYSTEM DESIGN OVERVIEW

Using CAD and other illustrations, walk through the overall prototype design and how it will operate. Tie key features and design considerations to your overall technical requirements. This will position your audience to understand your big picture engineering decisions making the subsequent discussions on detailed subsystem and component design easily grasped.

DESIGN SELECTION

Discuss full evaluation of alternative and competing designs. Specify final design decision criteria. Tie decisions to technical requirements and constraints. Decision matrices help communicate these thought processes.

DETAILED SYNTHESIS

Synthesis is the process of combining a composition of individual parts or elements to make a new whole system. Discuss your subsystems and components for form, fit and function. Consider all subsystem interrelationships. Show clear evidence the components will work together properly.

ENGINEERING ANALYSIS/EVALUATION

Leverage mathematical models for design decisions of all major components. Demonstrate connectivity(interface) between components. Show relationships between dependent and independent variables via trend lines. Discuss these relationships in mathematical terms such as linear, asymptotic, exponential, etc. Connect these relationships to your prototype requirements. Show your iteration steps to harmonize system and component interfaces.

DIGITAL MOCKUPS

Demonstrate full working computerized model (mockups) of mechanical, electrical and control systems for spatial requirements and function. Show mechanical aspects via a complete Solidworks system model. Demonstrate FEA of major structures. Employ Solidworks-Motion for moving mechanisms. You may also use MATLAB or equivalent modeling software where applicable. Show full electrical schematic including Multisim models of major power and control circuits. Show control algorithm schemes via flow charts, hierarchical structure chart, data flow chart, state chart and/or pseudocode.

PHYSICAL MOCKUPS

Display form and fit of major mechanical systems utilizing inexpensive materials readily available. The most valuable mockups indicate size, shape and mechanical connections. Bring this mockup to your review. Demonstrate electrical controls showing actual microprocessor control of similar motor and/or sensor types as planned in the final prototype. Videos of these working control systems are acceptable.

BUDGET

Itemize the estimated cost of all major components. Breakdown these costs in three categories. Project Costs are the monies spent on the project against your budget. Donation/Reuse Costs are the market value of items you reuse from previous senior design projects or have obtained free from a third party. Total Costs are the sum of Project and Reuse Costs. Your performance with respect to your budget is measured based on the sum of your Project Costs. Discuss project risks based on planned margins and potential timing for long lead items.

RESOURCES

Discuss your Gantt chart from the System Design Review with included actual timing of tasks overlaid on the original plan. Discuss what changed and why. Include lessons learned for future planning. Present the R.A.S.I.C. chart showing the detailed roles and responsibilities of your team members. Include any potential issues with other resources needed for successful project completion. Definitions will be discussed in class.

PLAN TO PROCEED

Provide a detailed Gantt chart for the Spring semester. Discuss critical path and strategies to stay on schedule.

FOR YOUR CONSIDERATION

If there are any questions concerning priorities in the development of any of your presentations, the faculty wants you to demonstrate the following:

- Your depth of understanding for the societal need of your project.
- Your creativity.
- Your use of math and science as it influences your decision making.
- Your work ethic.
  - Thoroughness
  - Attention to detail
- Your management of the other success factors.
- Your presentation skills.

BUILD DESIGN REPORT GUIDELINES

The build design report should contain the updated system and subsystem requirements, updated system design, updated detail design, system test plans and subsystem test results based on progress to date of your project. Expectations are all major sub-systems and components are constructed and several subsystem tests are completed. Focus is on issue resolution.

The following contains suggested content for the Build Design Report guidelines. Similar to the Project Launch Report Guidelines, this report should also engage the reader using the information provided in the Project Launch Report section, and as discussed in class.

<u>Overall System Progress</u>

Any and all updates to the system design should be updated and finalized. Describe design changes and why you chose to make those changes. Include issues you experienced during the build process and the reasons for the solutions you chose.

<u>System Test Plan</u>

Develop a one to two paragraph description of the test procedure that relates to each technical specification. Include the Test Plan Matrix that relates the planned test procedures with the technical specifications. Include a description of each planned validation test including:

- Purpose of the Test
- Specific Technical Requirement(s) intended to verify
- Test Method

- Equipment and environment used
- Measurement system and accuracy
    - Error must be less than 10% of unit required
    - Example: For a requirement of 20 psi the measurement device senses to 0.1 psi.
        - Error range: 19.9 to 20.1 psi.

Subsystem Design and Test Results

Describe each item/box within each FDD Level 2 Subsystem. Discussion any design changes from what was previously reported. Begin with fully defined operation and requirements for that item. Include calculations, simulations, verification tests and any other pertinent technical information used to verify changes in the design. Focus on why you changed your design using sound engineering calculations and judgment. Present any verification testing accomplished to date. Compare with system requirements.

Subsystem Test Results

Describe the purpose, procedure and results of each test conducted on your subsystem. Emphasize the tests that demonstrate how well your subsystem meets its requirements. Follow this outline:

Technical Specification including its purpose.
Test Procedure (include methods, equipment and environment of the test).
Test Results (be quantitative)
Summarize the strengths and weaknesses of the subsystem as they pertain to the test results.

Schedule Analysis

Fully update and describe your project schedule. Include work completed with emphasis on the remaining tasks to be completed during the semester. Discuss what is on-time, ahead and behind schedule. Include actions items necessary to complete your project on time.

Budget Analysis

Fully update and describe your budget, including all expenses to date and necessary to complete your project. Discuss differences and similarities between projected and experienced expenses. Your budget should include both project and reuse/donation costs.

List of References

Provide external sources for information.

Appendix:

The appendix should contain the following items:

Any other pertinent information generated for the project that supports information in the body of the report. Examples may include: software code, MATLAB program code, additional Solidworks models, etc.

Updated project RASIC and report RASIC

Some Thoughts and other Helps

The readers of your report (we professors) are looking for three overarching concepts. The first is the accumulation of engineering principles and skills you have learned from working on your project. The second is the solid evidence of your progress to date and the related confidence it instills in the successful demonstration of your completed prototype later in the semester. And third, we are also assessing your ability to write engagingly and persuasively. Our expectation is that you will write your technical progress reports in a way that readers will judge that it is worth their time to read your reports in full.

What you have learned

The documenting of any design changes since the Detail Design Report certainly improves the archive for your design. We want you to not only say what has changed but also discuss the reasons for the changes. These “whys” should reveal your engineering thought processes. Design changes usually fall within a few categories.

<u>Finalized Design</u>
Sometimes unanswered questions from the fall semester are addressed now. Design elements are now decided. This does happen. These need to be documented but, in reality, don’t win many positive thoughts since the goal was to complete all design in the Fall.

<u>Discovered Unknowns</u>
Through experimentation and testing, additional variables are discovered that lead to a need for a better design. Good. You have moved some of your “We don’t know what we don’t know” into known problems. This happens very frequently within new product development. We are looking for your ability to assess these situations and develop an improved design that does perform properly.

<u>Other Subsystem Changes</u>
Sometimes changes in other subsystems will directly impact and require change in your design. The assessment of such situations will tell us your knowledge level of your design and your engineering skills in making the changes. One very important item to remember, your subsystem can only be considered working successfully when it is demonstrated in the complete prototype system. Regardless of subsystem test results, there will always be some doubt as to proper subsystem design if the prototype does not operate fully. Often, the interface of the subsystem within the full system is the most critical design feature and is not properly demonstrated without a fully operational complete product. In other words, do what you need to do to help the complete system to work even if that means adjusting your subsystem.

<u>Overcoming Obstacles</u>
Plans may change due to technical and/or logistic issues beyond your control. Components may not perform to published specifications. Often, the designated usage of the component does not match the narrowly controlled test conditions upon which the specifications are based. Also, sometimes, the parts just don’t arrive on time and you must improvise to get a working prototype

anyway. In either case, your perseverance, fortitude, technical capabilities and creativity may shine in such situations.

Progress to Date

We professors are simply looking for how well you have completed what you said you would do. The build, construction and testing progress should match or be ahead of the schedule you turned in previously in the semester. This is usually the most challenging for teams at this stage in the project. Evidence of construction through pictures, with explanations, and test results, with interpretations, of components and subsystems are most beneficial. The more complete the positive subsystem testing the more confidence we will have that you will demonstrate a successful working prototype later in the semester.

BUILD DESIGN REVIEW GUIDELINES

Your Build Design Review will highlight the progress of your prototype and most important information contained in your report. Discussions will focus on construction build progress, issue resolution and product testing plans.

Emphasis is on engineering thought processes employed. You have 30 minutes to present followed by a 20-minute question and answer session. Attending faculty will complete two assessment tools. The Presentation Evaluation and Build Design Review Technical Rubric are available in Appendix A.

Submit your PowerPoint file in Canvas. Bring 2 sets of printed handouts – 1 slide per page to your review.

During the presentation your team should cover the following although not necessarily in this order:

- Construction Build Progress
- Issue Resolution
- Product Testing Plan
- Budget and other resources (update)
- Plan to proceed

CONSTRUCTION BUILD PROGRESS

Discuss the actual status of construction for all subsystems and components of your prototype. Compare actual to that planned in you Gantt chart as presented at the Detail Design Review. Include photos of said fabrication and/or bring key components and subsystems to the review. Include all subsystem test results to date and compare with expectations. Past experience has shown this the most challenging of assessment tasks for senior design teams in terms of completing and preventing a “Redo”.

ISSUE RESOLUTION

Problems and other unforeseen issues arise in all projects. Discuss your major technical problems and how they were solved. Demonstrate your engineering prowess.

PRODUCT TESTING PLAN

Present your final prototype test plan including the following for each test:

- Purpose of the Test
- Specific Technical Requirement(s) intended to verify
- Test Method
- Equipment and environment used
- Measurement system and accuracy

BUDGET

Update the estimated cost by all major components. Breakdown these costs in three categories. Project Costs are the monies spent on the project against your budget. Donation/Reuse Costs are the market value of items you reuse from previous senior design projects or have obtained free from a third party. Total Costs are the sum of Project and Reuse Costs. Your budget is based on your total Project Costs. Compare with your maximum budget. Discuss project risks based on planned margins and potential timing and final decision point for potential replacement items.

RESOURCES

Discuss your Gantt chart from the Detail Design Review with included actual timing of tasks overlaid on the original plan. Discuss what changed and why along with lessons learned for future planning. Include any potential issues with resources needed for successful project completion.

PLAN TO PROCEED

Provide a detailed Gantt chart for the remainder of the Spring semester. Discuss critical path and strategies to stay on schedule.

FOR YOUR CONSIDERATION

If there are any questions concerning priorities in the development of any of your presentations, the faculty wants you to demonstrate the following:

- Your depth of understanding for the societal need of your project.
- Your creativity.
- Your use of math and science as it influences your decision making.
- Your work ethic.
    - Thoroughness
    - Attention to detail
- Your management of the other success factors.
- Your presentation skills.

PRODUCT READINESS REPORT GUIDELINES

The Product Readiness report should contain an overall description of your prototype design, significant test results and budget/resource performance. Expectations are all major system and component designs are constructed and tested to demonstrate concept completeness.

The following contains suggested content for the Product Readiness Report guidelines. Similar to the Project Launch Report Guidelines, this report should also engage the reader using the information provided in the Project Launch Report section, and as discussed in class.

As-Tested Design

Describe the overall design configuration and all major subsystems of your prototype as it was tested. Photos should be well annotated showing key design/build features.

Prototype Test Results

Describe the purpose, procedure and results of each test conducted on your prototype. Emphasize the tests that demonstrate how well your prototype meets the original technical specifications. Follow this outline:

- Technical Specification including its purpose.
- Test Procedure (include methods, equipment and environment of the test).
- Test Results (be quantitative)
- Summarize the strengths and weaknesses of the prototype as they pertain to the test results.

Budget

Include an itemized list of all expenditures during the development of your prototype. This should include two cost numbers.

Project – This includes all expenditures incurred during the year for your project. This may be for parts purchased and not used as well as those used. Itemize and subtract expenditures on items purchased for testing only purposes in the fall. Any items purchased in the fall and used on your final prototype must remain in the budget totals. Any unused items that are returned or sold (with funds returned to Harding) may receive credit. Your final project budget tally is based on this amount.

With donations/reuse - This includes the non-discounted price of all parts on your prototype. List each part (including fasteners) and its normal cost. Include items like the microprocessor (and other normally free samples) and any and all 3D printed part costs ($6.00 per cubic inch of material).

List of References

Provide external sources for information.

Appendix:

The appendix should contain the following items:

Any other pertinent information generated for the project that supports information in the body of the report. Examples may include: software code, MATLAB program code, additional Solidworks models, etc.

PRODUCT READINESS REVIEW GUIDELINES

Your Product Readiness Review will highlight the completeness of your prototype and most important information contained in the related report. Discussions will focus on your final design and prototype test results.

Emphasis is on engineering thought processes employed. You have 30 minutes to present followed by a 20-minute question and answer session. This is an open invitation presentation where family, friends and future senior design students are all welcome. Attending faculty will complete the Presentation Evaluation. The Product Readiness Technical Rubric will be completed separately by your class instructors based on your prototype tests and resultant performance with respect to your Technical Requirements. These assessment tools are available in Appendix A.

During the presentation your team should cover the following although not necessarily in this order:

- Agenda
- Background and Purpose of your Project
- Overall Final Design
- System Test Results
- Budget Performance
- Biggest Lessons Learned

BACKGROUND AND PURPOSE OF YOUR PROJECT

Open your presentation with the background, customer needs and technical requirements. These may have been updated from the Build Design Review. Be sure to convey your passionate motivation for your project. This becomes crucial since it may be a first introduction to your project for many in the audience.

OVERALL FINAL DESIGN

Provide an overview of the major features and characteristics of the final prototype design. Provide a brief demonstration of your device if feasible. Selected videos of your functioning prototype are appreciated.

SYSTEM TEST RESULTS

Include the following for each test:

- Technical Specification including its purpose.
- Test Procedure (include methods, equipment and environment of the test).
- Test Results (be quantitative)
- Summarize the strengths and weaknesses of the prototype as they pertain to the test results.
- Identify which *three* requirements at were satisfied at the *Ideal* level

BUDGET

Update the estimated cost by all major components. Breakdown these costs in three categories. Project Costs are the monies spent on the project against your budget. Donation/Reuse Costs are the market value of items you reuse from previous senior design projects or have obtained free from a third party. Total Costs are the sum of Project and Reuse Costs. Your actual spend budget is based on the summation of your Project Costs. Compare with your maximum allowed budget. Discuss items that cost more and cost less than originally planned. This reflection builds your understanding and helps with future cost estimating endeavors.

LESSONS LEARNED

Briefly review the biggest lessons learned during the year. Focus on those that will guide future decision and problem-solving opportunities.

When finished, feel free to take a deep breath and let it out. Job well done!

4. PROCUREMENT PROCEDURES

Senior Design students have two options in obtaining purchased parts and services. The preferred, and generally easier, method involves requesting Harding University to order and pay for the product or service. This is initiated via a Purchase Request. The second involves students purchasing the product or service themselves and then request Harding for reimbursement. This is initiated via a Check Request.

PURCHASE REQUEST

The Senior Design purchase request process flow is depicted in Figure 5. It begins with a student completing a Purchase Requisition Form which is shown in Figure 6 and available full size in Appendix B. A completed example purchase request is also available in Appendix B. The form template is available in a MS Excel file format in Canvas.

Purchase orders will all be conducted electronically..

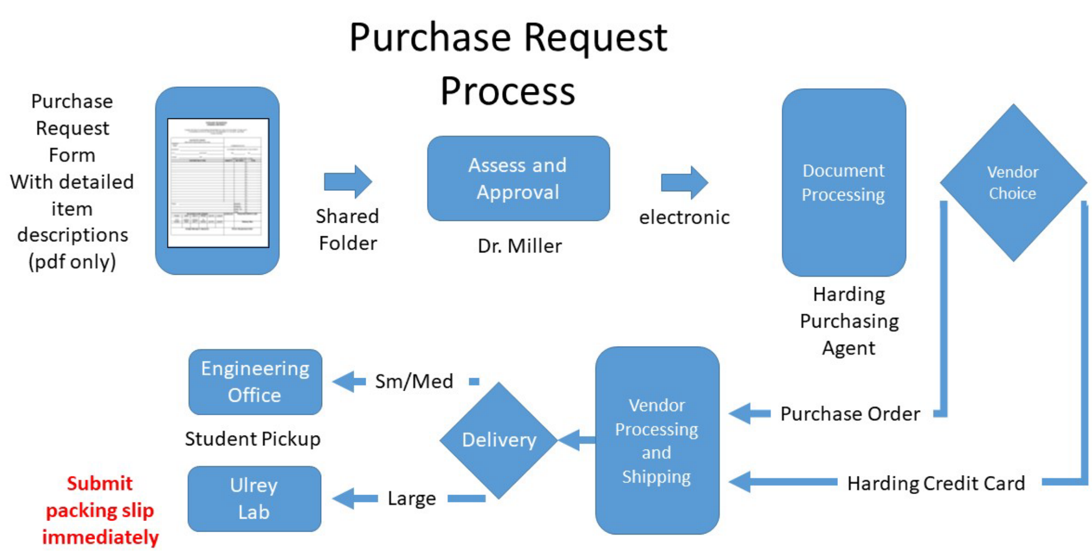
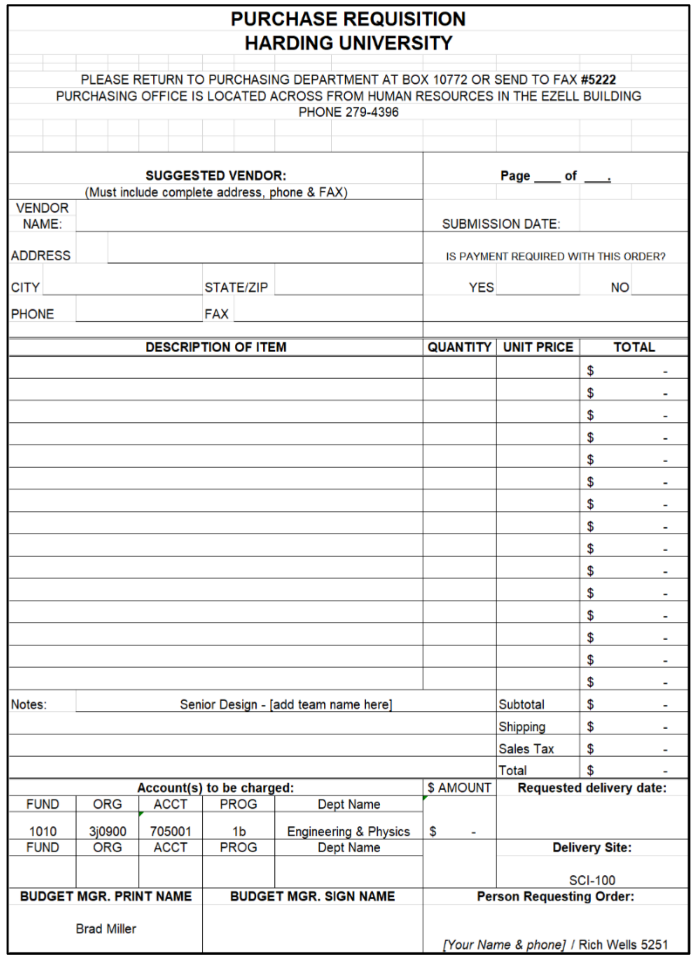


Figure 5: Purchase Request Process

Follow the below instructions to complete the Purchase Request (see Figure *6*).

- Complete all items
- If ordering from a website the vendor name is the URL and remaining lines can be empty except for the phone number.
- Usually payment is required with the order.
- When describing the item be as descriptive as possible.
    - Provide part numbers
    - Color (if important)
    - Proper name of the item
    - When available online, Include url (link directly to item) under each description.
- Include back-up with every requisition issued. (example: quote, website printout, etc.) This is very important to ensure that the correct items are ordered. Record the purchase amount in the $amount space
- Include sales tax (9.75%) on every requisition.
- Provide date for delivery


PURCHASE REQUISITION
HARDING UNIVERSITY

PLEASE RETURN TO PURCHASING DEPARTMENT AT BOX 10772 OR SEND TO FAX **#5222**
PURCHASING OFFICE IS LOCATED ACROSS FROM HUMAN RESOURCES IN THE EZELL BUILDING
PHONE 279-4396

SUGGESTED VENDOR:
(Must include complete address, phone & FAX)

Page ___ of ___.

VENDOR NAME:
SUBMISSION DATE:
ADDRESS
IS PAYMENT REQUIRED WITH THIS ORDER?
CITY
STATE/ZIP
YES
NO
PHONE
FAX

DESCRIPTION OF ITEM	QUANTITY	UNIT PRICE	TOTAL
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
Notes: Senior Design - [add team name here]		Subtotal	$ -
		Shipping	$ -
		Sales Tax	$ -
		Total	$ -

Account(s) to be charged:					$ AMOUNT	Requested delivery date:
FUND	ORG	ACCT	PROG	Dept Name		
1010	3j0900	705001	1b	Engineering & Physics	$ -	
FUND	ORG	ACCT	PROG	Dept Name		Delivery Site:
						SCI-100

BUDGET MGR. PRINT NAME	BUDGET MGR. SIGN NAME	Person Requesting Order:
Brad Miller		*[Your Name & phone]* / Rich Wells 5251

Figure 6: Purchase Request Form (latest version available in Canvas)

- Include your name - phone and “Rich Wells 5251” in “Person Requesting Order”
- The form and any attached items are to be saved into a single pdf file per PR using the following file naming convention: PR_vendorname_yourlastname_firstname_date.pdf
- Save the pdf file to the designated shared folder. Details to be provided in class.
- Dr. Miller’s approval is required on all Purchase Requests.
- Make copies for your records.
- Complete a separate purchase requisition for each vendor/purchase.
- See Wes Plybon for methods should the need arise to return an item.

CHECK REQUEST

Similar to the purchase order requests, the check reimbursement request will take place electronically. The Senior Design check request process flow is depicted in Figure 7. It begins with a student completing a Check Request form which is shown in Figure 8 and available full size in Appendix B. The form template is available in a MS Excel file format in Canvas.

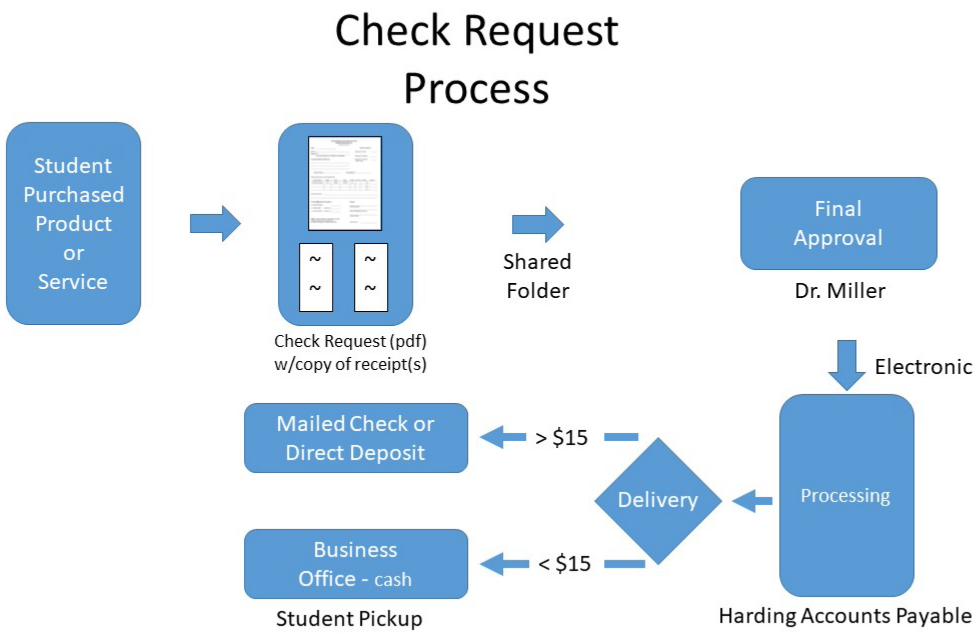


Figure 7: Check Request Process

Follow the below instructions to complete the Check Request:

- Complete all items
- Request a check if the amount is over $15.00
- If the amount is $15.00 or under the business office will only reimburse in cash
- Provide a date needed
- Record the amount in the two places on the form
- Most will select campus mail as method of delivery or direct deposit.
- Direct deposit may be setup within Pipeline. Go to: Personal>Pay info>Direct Deposit. Enter Bank ABA Routing Number, Bank Account # -Select Checking or Savings Accounts Payable -Mark the Box. Save
- Dr. Miller must approve the form.
- Scan all receipts and attach. Receipts must include: description of item(s) purchased, payment method including last 4 digits of card if applicable and zero balance. Keep all originals for your records.
- If you lose the receipt there is nothing we can do to help.
- The form and any attached items are to be saved into a single pdf file per CR using the following filename convention: CR_yourlastname_firstname_date.pdf
- Save the pdf file to the designated shared folder. Details to be provided in class.
- Multiple purchases (and vendors) may be included in a single Check Request.
- Must turn in within 30 days of date on receipt.
- See Wes Plybon should the need arise to return an item after you have submited the check request.

Check Request/Cash Advance Form
Harding University, Inc.
(return to Box 10772)

Date: ____________ **Mark a selection:**

Pay to: ____________ Request for Check ____

Banner H # ____________

(put Social Security # if no Banner # is available) Request for Advance ____

Complete Address (Required): Request for Paid Out ($25 or less) ____

Check Amount: ____________ **Date Needed:** ____________

Please charge the accounts listed below:

Account Name	FUND	ORG	ACCT	PRG	ACTIV	LOCAT	Amount
Engineering Supplies	1010	3j0900	705000	1b			$
							$
							$

Purpose of check: ____________

Choose ONE method of delivery:

A. Mail to Recipient ____________

B. Campus Mail (put box #) ____________

C. Call for Pick-Up (put ext. #) ____________

Signed:

Budget Manager

Other as Required (see note)

Finance Officer

NOTE: Check requests for expenses incurred by budget manager must be approved by the budget managers' immediate supervisor.

Check Number: ____________

Figure 8: Check Request Form (latest version available in Canvas)

5. COURSE CONCEPTS

TECHNICAL WRITING

WRITING CLEARLY AND SUCCINCTLY

Writing in an engaging and persuasive style will be covered in class and through feedback from your draft reports

The best outline, figures and data can be undone by poor writing. Publications are available that discuss this topic in depth. Listed below are seven basic techniques for creating effective technical prose.

Eliminate Unnecessary Words – Casual conversation uses many introductory phrases and colloquialisms. Using these extra words in a technical document, however, dilutes the meaning of a sentence. In a page limited document, these words also reduce the space available for additional or larger figures, or another sentence. Examples of unnecessary words:

now that from the start to go about this

simply the next step from this

A before/after example illustrates how many words can be eliminated without removing content – unnecessary words are highlighted:

Now that *the type of wing* ***that was going to be built*** *was selected,* ***the next step*** *was to select the airfoil* ***that would be used****.* ***To go about this****, research was conducted on* ***different types*** *of airfoils through* ***various*** *airfoil databases.* ***During the search*** *a program called* <u>*Profili*</u> *was discovered.*

After – edited to contain only necessary words:

With the wing configuration selected, airfoil options were evaluated. The team researched airfoil databases and found a program called <u>*Profili.*</u>

Eliminate phrase duplication. In the before/after example below, the original sentence has two sets of duplications, one underlined and the other in boldface:

<u>*Additionally*</u>*, fuel burn* ***has little effect on*** *the center of gravity* <u>*as well*</u> ***(less than a quarter of an inch shift).***

After - with duplications removed:

Fuel burn shifted the center of gravity less than 0.25-in.

<u>**Talk Technical**</u> – Do not use adjectives to quantify a topic, use data. Here are examples of expressions that should not be used in a technical report:

large amount/quantity/effect several

significant increase/decrease some

extensive range a few

low/high level of many

excellent agreement/levels

State a value or range of values, an order of magnitude, or a percentage. This provides the reader with a clear understanding of the magnitude of the data comparison.

Explain Symbols – Introduce symbols and acronyms in the text to spare the reader from constantly referring to the List of Symbols and Acronyms. The first time a symbol is used, provide the definition (in parentheses is adequate). For an acronym, spell out the words of the acronym then follow with the acronym in parentheses.

Cite References in Text – A list of references at the end of the report does not help the reader understand how the references were used in the design process. Where appropriate in the report, cite the reference. If the references are numbered in the list of references, the citing can be worded in parentheses - (*see Reference X*).

Use *due to* Correctly – Since technical reports often describe cause-effect relationships the phrase *due to* is often (over)used. The following guideline will mitigate overuse:

Due to is a substitute for *caused by*. It is **not** a substitute for *because of*.

Test all uses of *due to* with the guideline. Replace with *because of* where appropriate, and also mix in *caused by* to add variety

Keep Tenses Simple - A technical report usually combines a history of work performed with a description of the result. Confusing tense structure can be avoided by using the following guidelines:

- When describing the design development process, write in the past tense. The work was done in the past. The obvious exception is description of follow-on work or work being performed as the report is written. For these cases, use the future or present tense respectively.
- When describing the features of the design, or results of the design process, use present tense (e.g. *the data show*, not *the data showed*). The features, once established, are independent of time. An exception is when describing a feature that was subsequently changed, past tense is appropriate.

Limit using past perfect, present perfect, and conditional tenses, as they add words. Examples:

Instead of - Use -

has been, have been was

would be is

Before/after examples of effective use of tense follows with the verbs highlighted:

Example 1 – present, past, present perfect, and future tenses used:

*The fuselage **is** a simple cylindrical structure constructed from the EPP foam. It **is** permanently attached to the tail boom and will house the payload. This cylindrical structure **was chosen** for its aerodynamics and ease of construction. It **has been** positioned below the wing and centered on the center of gravity so that the addition of the payload weights **doesn't** disturb the center of gravity (CG) positioning. The payload itself **will** consist of lead bars cut to the length of the fuselage.*

After – present and past tenses used:

*A cylindrical fuselage constructed from EPP foam **is** permanently attached to the tail boom. The cylindrical structure **was** selected for its desirable aerodynamics and ease of construction. The fuselage, which carries the payload, **is** positioned below the wing on the projected center of gravity (CG) to minimize CG shift with payload addition. The payload **consists** of lead bars cut to the length of the fuselage.*

Example 2 – past and conditional tenses used:

*A choice **needed to be** made whether to put the hatch on the top or bottom of the wing, each **had** its pros and cons. Putting the hatch on the bottom of the wing **had** the benefit that if the hatch **was** not installed perfectly it **would have** less effect on the lift the wing created, but **would mean** the plane **would have** to be turned upside down to load and additional support **would be** required to keep the weight from falling out. A hatch on the top of the wing **would be** easy to load and the supports already built into the wing **could be** used to carry the weight, but if the hatch was not perfect it **would greatly reduce** the lift of the wing.*

After – present and past tenses used:

*We **traded** two options for the location of the payload hatch: (1) on the top of the wing, and (2) on the bottom of the wing. The figures of merit **evaluated** were lift impact, weight, and ease of loading. The bottom location **is** less sensitive than the top location to lift loss caused by hatch misalignment. The top location **is** lighter because the hatch does not need to support payload weight. The bottom location **requires** turning the aircraft over to load payload.*

FORMAT
Use Chicago formatted footnotes and references within all Senior Design reports.

GOOD PRESENTATIONS

The following is a list of requirements and tips covering specific expectations for your Stage-Gate Reviews in Senior Design. For more generic, but extremely useful, recommendations for public speaking, see the resource in Canvas[4]. Also, you might consider observing some TED Talks available online[5]. We expect more technical details in your presentations because you are engineers

[4] S10-delivering-a-speech.pdf
[5] www.ted.com

presenting to other engineers. However, the techniques used in TED Talks to engage the audience with well-formed sentences synchronized with visuals are well received.

REQUIREMENTS

- Stay within the allotted time (usually 30 minutes).
- Provide handouts as specified.
- Everyone on the team must present technical information.
- Dress professionally. For men: dress shirts with tie and dress pants. Dress coats are preferred but not required until the Spring. You will need a good job interview suit by then if not sooner. [Note: first student to email Prof. Wells with the following code will receive 5 bonus quiz points: “ireadit”] We understand you may prefer a more relaxed time, such as Christmas break, to shop if you currently don’t have a suit. It is best for the entire team to dress similarly. In other words, either all men wear dress coats or not. No mixed. For women: wear what you would wear if you were at an event where the men are wearing such professional clothes. You have more options.
- Number each slide.

TIPS

- Try to anticipate questions. It is recommended to have a backup slide section at the end which contains slides that were cut from the presentation or detailed information for an anticipated question. This always impresses if you do receive the planned question(s). Also, if you don’t know the answer, say you don’t know. Don’t bluff but do follow-up.
- Avoid nervous habits such as: fidgeting, saying filler sounds like “um” and rattling papers. Keep hands out of pockets.
- Mostly look at the speaker. This keeps the audience attention toward the speaker as well.
- Use clear fonts with high contrast. Light colored fonts on dark backgrounds or dark fonts on light backgrounds. Sans serif is easier to read on projected surfaces.
- Make eye contact. Project confidence.
- Rehearse and practice. Smooth and coherent transitions between speakers portrays good team work.
- Let a mistake made by a fellow teammate go unless it drastically changes technical issues. Do not argue with each other or an audience member during the presentation.

- Start bold! Use an attention getter that connects with your project. Tie closely with the motive for your project.
- Check your slides, and especially video, on the equipment you will be using.
- Have one main point or message for each slide. It is best for each slide to make a strong visual impact as well as contain good information.
- Use a minimum font size of 24pt. Or be sure it is easily read from the back of the room. This includes any illustrations or graphs.
- Remember your audience is rooting for you!

STAGES OF GROUP DEVELOPMENT

FORMING, STORMING, NORMING, PERFORMING AND ADJOURNING

American organizational psychologist Bruce Tuckman presented a robust model in 1965 that is still widely used today. Based on his observations of group behavior in a variety of settings, he proposed a four-stage map of group evolution, also known as the forming-storming-norming-performing model. Tuckman, B. (1965). Developmental sequence in small groups. Psychological Bulletin, 63, 384–399. Later he enhanced the model by adding a fifth and final stage, the adjourning phase. Interestingly enough, just as an individual moves through developmental stages such as childhood, adolescence, and adulthood, so does a group, although in a much shorter period of time. According to this theory, in order to successfully facilitate a group, the leader needs to move through various leadership styles over time. Generally, this is accomplished by first being more directive, eventually serving as a coach, and later, once the group is able to assume more power and responsibility for itself, shifting to a delegator. While research has not confirmed that this is descriptive of how groups progress, knowing and following these steps can help groups be more effective. For example, groups that do not go through the storming phase early on will often return to this stage toward the end of the group process to address unresolved issues. Another example of the validity of the group development model involves groups that take the time to get to know each other socially in the forming stage. When this occurs, groups tend to handle future challenges better because the individuals have an understanding of each other's needs.

Figure 9 Stages of the Group Development Model

FORMING

In the forming stage, the group comes together for the first time. The members may already know each other or they may be total strangers. In either case, there is a level of formality, some anxiety, and a degree of guardedness as group members are not sure what is going to happen next. "Will I be accepted? What will my role be? Who has the power here?" These are some of the questions participants think about during this stage of group formation. Because of the large amount of uncertainty, members tend to be polite, conflict avoidant, and observant. They are trying to figure out the "rules of the game" without being too vulnerable. At this point, they may also be quite excited and optimistic about the task at hand, perhaps experiencing a level of pride at being chosen to join a particular group. Group members are trying to achieve several goals at this stage, although this may not necessarily be done consciously. First, they are trying to get to know each other. Often this can be accomplished by finding some common ground. Members also begin to explore group boundaries to determine what will be considered acceptable behavior. "Can I interrupt? Can I leave when I feel like it?" This trial phase may also involve testing the appointed leader or seeing if a leader emerges from the group. At this point, group members are also discovering how the group will work in terms of what needs to be done and who will be responsible for each task. This stage is often characterized by abstract discussions about issues to be addressed by the group; those who like to get moving can become impatient with this part of the process. This phase is usually short in duration, perhaps a meeting or two.

STORMING

Once group members feel sufficiently safe and included, they tend to enter the storming phase. Participants focus less on keeping their guard up as they shed social facades, becoming more authentic and more argumentative. Group members begin to explore their power and influence, and they often stake out their territory by differentiating themselves from the other group members rather than seeking common ground. Discussions can become heated as participants raise contending points of view and values, or argue over how tasks should be done and who is assigned to them. It is not unusual for group members to become defensive, competitive, or jealous. They may even take sides or begin to form cliques within the group. Questioning and resisting direction from the leader is also quite common. "Why should I have to do this? Who designed this project in the first place? Why do I have to listen to you?" Although little seems to get accomplished at this stage, group members are becoming more authentic as they express their deeper thoughts and feelings. What they are really exploring is "Can I truly be me, have power, and be accepted?" During this chaotic stage, a great deal of creative energy that was previously buried is released and available for use, but it takes skill to move the group from storming to norming. In many cases, the group gets stuck in the storming phase.

OB Toolbox: Avoid Getting Stuck in the Storming Phase!

There are several steps you can take to avoid getting stuck in the storming phase of group development. Try the following if you feel the group process you are involved in is not progressing:

Normalize conflict. Let members know this is a natural phase in the group-formation process.

Be inclusive. Continue to make all members feel included and invite all views into the room. Mention how diverse ideas and opinions help foster creativity and innovation.
Make sure everyone is heard. Facilitate heated discussions and help participants understand each other.
Support all group members. This is especially important for those who feel more insecure.
Remain positive. This is a key point to remember about the group's ability to accomplish its goal.
Don't rush the group's development. Remember that working through the storming stage can take several meetings.

Once group members discover that they can be authentic and that the group is capable of handling differences without dissolving, they are ready to enter the next stage, norming.

NORMING

"We survived!" is the common sentiment at the norming stage. Group members often feel elated at this point, and they are much more committed to each other and the group's goal. Feeling energized by knowing they can handle the "tough stuff," group members are now ready to get to work. Finding themselves more cohesive and cooperative, participants find it easy to establish their own ground rules (or *norms*) and define their operating procedures and goals. The group tends to make big decisions, while subgroups or individuals handle the smaller decisions. Hopefully, at this point the group is more open and respectful toward each other, and members ask each other for both help and feedback. They may even begin to form friendships and share more personal information with each other. At this point, the leader should become more of a facilitator by stepping back and letting the group assume more responsibility for its goal. Since the group's energy is running high, this is an ideal time to host a social or team-building event.

PERFORMING

Galvanized by a sense of shared vision and a feeling of unity, the group is ready to go into high gear. Members are more interdependent, individuality and differences are respected, and group members feel themselves to be part of a greater entity. At the performing stage, participants are not only getting the work done, but they also pay greater attention to *how* they are doing it. They ask questions like, "Do our operating procedures best support productivity and quality assurance? Do we have suitable means for addressing differences that arise so we can preempt destructive conflicts? Are we relating to and communicating with each other in ways that enhance group dynamics and help us achieve our goals? How can I further develop as a person to become more effective?" By now, the group has matured, becoming more competent, autonomous, and insightful. Group leaders can finally move into coaching roles and help members grow in skill and leadership.

ADJOURNING

Just as groups form, so do they end. For example, many groups or teams formed in a business context are project oriented and therefore are temporary in nature. Alternatively, a working group may dissolve due to an organizational restructuring. Just as when we graduate from school or leave home for the first time, these endings can be bittersweet, with group members feeling a combination of victory, grief, and insecurity about what is coming next. For those who like routine and bond closely with fellow group members, this transition can be particularly challenging. Group leaders and members alike should be sensitive to handling these endings respectfully and compassionately. An ideal way to close a group is to set aside time to debrief ("How did it all go? What did we learn?"), acknowledge each other, and celebrate a job well done.

THE ROLES EVERY TEAM NEEDS TO BE EFFECTIVE[6]

Regardless of the project, your industry, or your company culture, these four roles need to be filled on every team for it to be highly effective.

 By Bruce Eckfeldt, Founder and CEO, E&A, Gazelles/Scaling Up business coach@beckfeldt

As a strategic business coach, one of my main goals is to level up the performance of the senior leadership team. There are many models and frameworks I use to assess team behavior and performance. Each of them has pros and cons in different situations.

One of my favorites comes from the psychologist David Kantor and is called the Four-Player Communication Model. It applies to any team solving problems and collaborating to reach common goals. Each role is fairly simple to understand, yet getting them working together on a team can be a balancing act.

Here are descriptions I give to senior executives so they can be more aware of what role they are playing and what roles other people are playing in the situation. Once they are more aware of the roles, they can start adjusting their behavior to balance out the dynamic.

1. THE MOVER

The primary role in any discussion is the mover. They are the ones who initiate action for the team. This could be a question, a suggestion, or putting an issue on the table. Their role is to encourage the team to engage in discussion and debate and move things forward.

Without a mover, a team will get stuck and become apathetic. They will lack the ability to advance, come up with new ideas, and turn ideas into action plans. While many teams are made up of highly driven executives, it's important that the mover help the team advance, not just be impatient and pushy. A good mover serves the team, not their own personal agenda.

2. THE SUPPORTER

[6] https://www.inc.com/bruce-eckfeldt/the-roles-every-team-needs-to-be-effective.html?cid=sf01002

I like to say that while the mover is key, the hardest role on the team is the supporter. This is the person who seconds the motion. They take a stand and get behind the idea, opinion, plan, etc. A mover can kick things off, but without a supporter, they will make little impact or progress.

The key here is that the supporter needs to support the idea, not the person. If the supporter comes across as a sycophant currying favor for political gain, it won't work. They need to put their weight behind the merits of the idea and provide a good rationale.

Often when a senior leadership team is struggling, I see this role missing. Because members of a top team are often used to driving and making decisions, they all want to be movers and nobody wants to take the role of supporter. On really great teams, members know that the supporter role is key to effective decision making and jump into it when they see the need.

3. THE OPPOSER

If it's the supporter's job to add momentum to the mover, it's the opposer's job to provide a check and balance for the team. It's a key role to help make sure that all angles are being considered and possible risks and downsides are fully evaluated. A good opposer will help the team avoid pitfalls and prevent the team from missing other opportunities.

Typically, finding enough opposers is not a problem on a senior leadership team. However, this is not just arguing for argument's sake. A good opposer brings up legitimate concerns and risks and is there to help the team assess all options. Too often I see executives opposing without making a strong case or providing sufficient rationale. Bad opposers will make ad hominem attacks that will destroy a team's trust and effectiveness.

4. THE OBSERVER

Finally, every team needs to have people who maintain a higher-level perspective and keep the bigger picture in mind. These are the team's observers. They help guide the process and make sure the team is considering all of the options and factors. A team with good observers will have a strong process and be much less likely to go down rat holes and spin their wheels.

Every effective team I've worked with has demonstrated the use of these four roles consistently. However, members don't need to stay in each role forever. In fact, in the best teams I work with, members will move between roles as the conversation shifts and they see the need to balance out the dynamic.

6. MANUFACTURING RESOURCES

Harding students have several fabrication and assembly manufacturing resources available. Two very capable and helpful lab gurus are happy to assist you in selecting and using said resources in a safe manner. Wes Plybon coordinates labs in the Science building. Kent Miller coordinates the labs in the Ulrey. Equipment training is required for all powered tools. Some training is coordinated and scheduled for group tours and others are setup with the associated lab coordinator in one-on-one or small group sessions. This training is both for your safety and to instill specific procedures known to extend the life of the equipment and keep it trouble free. You are welcome for our concern in your personal wellbeing and your education expense dollars. Remember to heed all shop rules as posted in the labs.

SCIENCE BUILDING

The majority of fabrication equipment in the Science building and dedicated to engineering students resides in SCI-315 and SCI-316 (affectionately known as the "Holy of Holies"). Major processes include 3D Printing, electronics manufacturing and wood working.

3D PRINTING

Figure 10 shows the Stratasys Dimension uPrint Plus 3D printer and Figure *12* shows the Stratasys F170. Both are based on fused deposition modeling. The uPrint Plus produces parts from ABS plastic. The F170 may produce parts from ABS, PLA and TPU (thermoplastic elastic). Parts formed via ABS thermoplastic have a yield strength of up to 37 MPa. TPU The maximum build envelope is 8" wide by 8" deep by 6" high. Multiple parts may be produced simultaneously provided they fit within the build envelope. The Formlabs Form 3 Resin based printer is shown in Figure *11*.

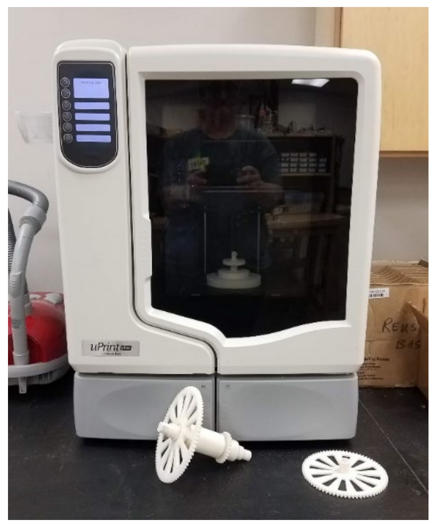


Figure 10: 3D Printer

An *.stl file is required for the part(s) to be produced. These can be created via several modern CAD computer systems. Design for manufacturing tips and Instructions for configuring an *.stl file in Solidworks are available in Appendix C.

Required training is available in 45-minute sessions offered on an as-needed basis and coordinated with Wes Plybon. These are for up to three people at a time. Each must bring a small sample *.stl file from a 3D model they have created.

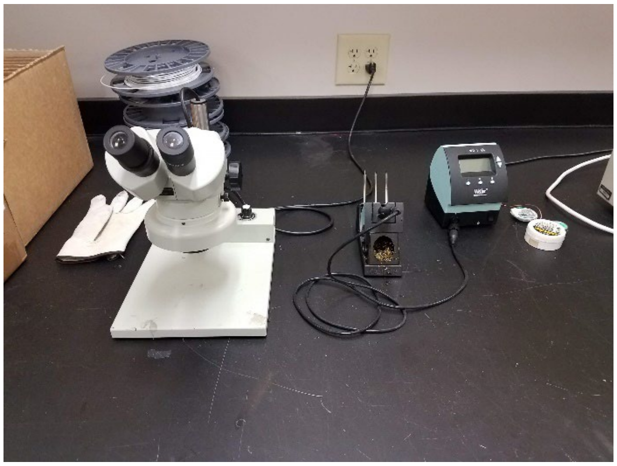
Figure 12 Stratasys F170

Figure 11 Formlabs Form 3 Resin Printer

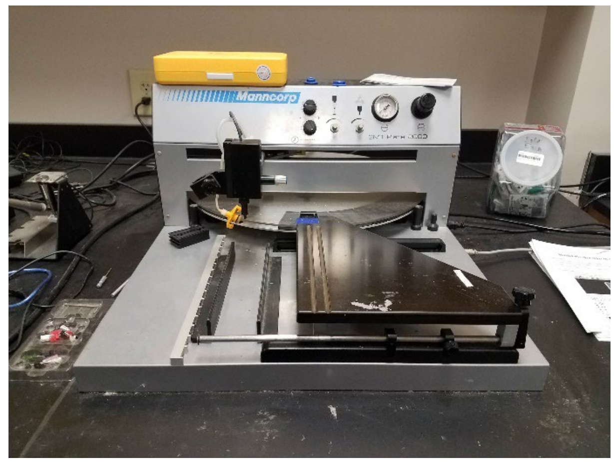
ELECTRONICS MANUFACTURING

Several manual and semi-automatic fabrication and assembly apparatus are available for your needs. See Wes Plybon for required training before using equipment.

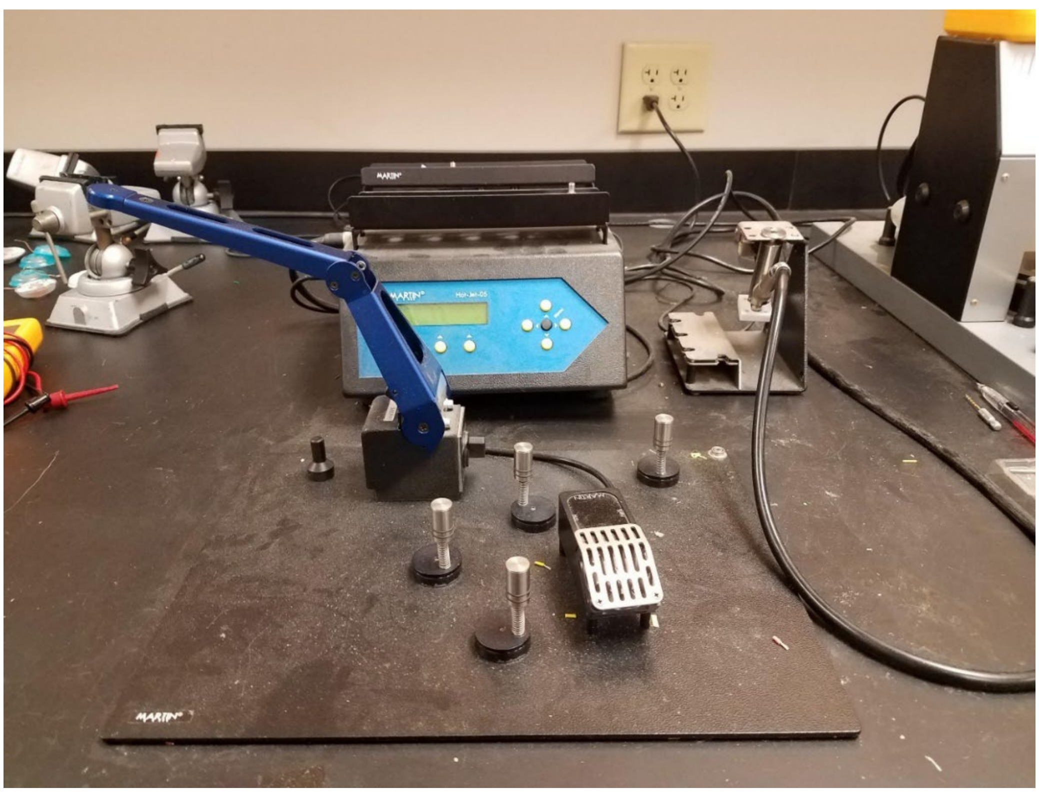
Figure 13 Shows multiple manual assembly stations. Part a shows one of several soldering stations available throughout the labs. Some have magnified lighting. The one shown includes a small microscope for viewing and working with small component foot prints.



a) Soldering Station



b) manual SMT Pick and Place



c) rework station

Figure 13: Manual Assembly Operations

Part b shows the manual pick and place station. It is useful for assembling surface mount technology, SMT devices, onto printed circuit boards, PCB. Another use is dispensing solder paste. Dimensional precision depends on human eyesight. Part c shows a manual rework station for SMT devices.

SMT COMPONENT ASSEMBLY

Figure 14 shows the newer manual SMT pick and place machine.

Figure 14: SMT Pick and Place Machine

WOODWORKING

The woodworking lab is located in SCI-316. Formal training is required before using any equipment in this lab. See Wes Plybon for the group training schedule.

Figure 15: Small Vertical Band Saw

Included are: the small band saw, Figure 15, for cutting contours in thin wood and plastic sheets; the drill press, Figure 16, for precision locating drilled holes; the mitre saw, Figure 18, for cutting through wood boards and a table top grinder, Figure 17.

Likewise, every team may use a case of hand tools including wretches, sockets, screw drivers and pliers. See Wes Plybon to check out a set. See Figure 19.

Other tools available include: table saw, Dremel, circular saw, drills, sander, and hacksaws.

Figure 16: Drill Press

Figure 18: Mitre Saw

Figure 17: Table Top Grinder

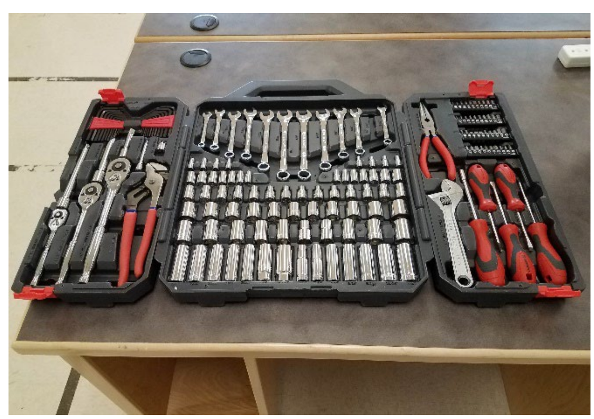


Figure 19: Mechanics Toolset

LASER CUTTING

The GlowForge laser cutter, see Figure *20* Glowforge Laser Cutterboth etches and cuts acrylic, wood and leather up to ¼" thick. Capabilities are well discussed at www.glowforge.com. See Dr. Jon White for account setup.

Figure 20 Glowforge Laser Cutter

ULREY LABS

The Ulrey Labs house the majority of our metal and plastic fabrication and assembly equipment. You must pass a quiz on the shop rules and complete training on each machine before intended use. See Kent Miller, skmiller@harding.edu, for training, consultation and fabrication strategies. A fabrication plan must be developed with Mr. Miller before using shop equipment.

In the below, a relative learning curve time is depicted with one ⏱ to four ⏱ ⏱ ⏱ ⏱. Four clocks represents substantial time and mentoring to produce the first part. Students should consider such when developing their fabrication plan.

CNC VERTICAL MILL ⏱ ⏱ ⏱ ⏱ (see Figure 21)

- For parts requiring complex contours and other curved shapes.
- Good for repetitive operations.
- Precision holes and their locations.
- Odd sized holes.

Figure 21: CNC Vertical Mill

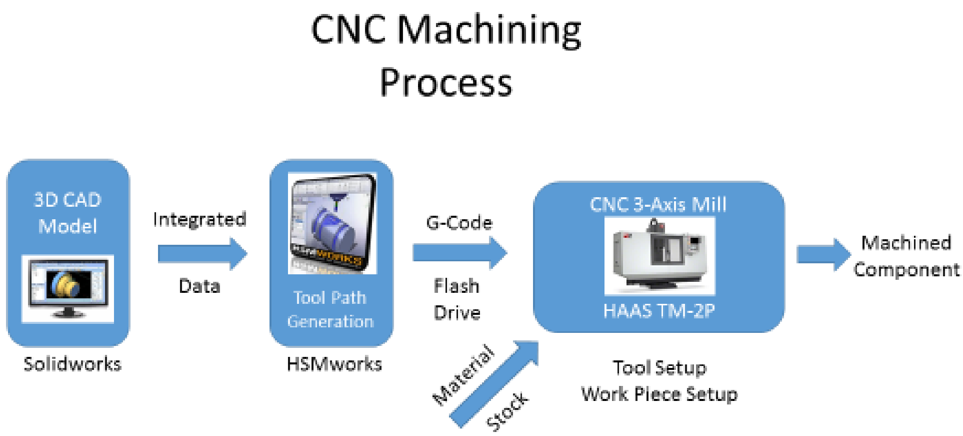


Figure 22: CNC Machining Process

CNC machining requires extensive programming that is usually accomplished within 3D CAD modeling environments. The process for machining with CNC is depicted in Figure *22*. One should use caution to understand the upfront programming time before embarking on a full CNC machining endeavor.

CNC LATHE (Figure *23*) ⏱ ⏱ ⏱ ⏱

- For cylindrical parts
- -O.D. Turning/Profiling
- -I.D. Turing/Profiling
- -O.D./I.D. Threading
- -Max O.D. 6 Inch

Figure 23: CNC Lathe

CNC PLASMA CUTTING TABLE (Figure *24*)

⏱ ⏱ ⏱

- For intricate 2D cut outs from metal plate
- Constructed by Harding Faculty, Staff and Students

Figure 24: CNC Plasma Cutting Table

MANUAL VERTICAL MILL (Figure *25*)

⏱ ⏱ ⏱

- Most versatile for single part machining.
- For mostly straight cuts.
- Three Bridgeport brand mills available.

Figure 25: Manual Vertical Mill

MANUAL LATHE (Figure *26*)

⏱ ⏱ ⏱

- For cylindrical shaped parts
- Diameters: 0.25 to 10 inches
- Maximum Stock Length: 30 inches
- Two available:
    - LeBlond (pictured)
    - Clausing

Figure 26: Manual Lathe

HORIZONTAL BAND SAW (Figure *27*)

⏱⏱

- For rough cutting bar stock

Figure 27: Horizontal Band Saw

VERTICAL BAND SAW (Figure *28*)

⏱⏱

- For rough cutting material
- Contouring
- Cut offs

Figure 28: Vertical Band Saw

MIG WELDING STATION (Figure *29*)

⏱⏱

- For permanent joining of metals.
- Minimum steel thickness: ~ 0.100 inches
- Minimum aluminum thickness: ~0.125 inches

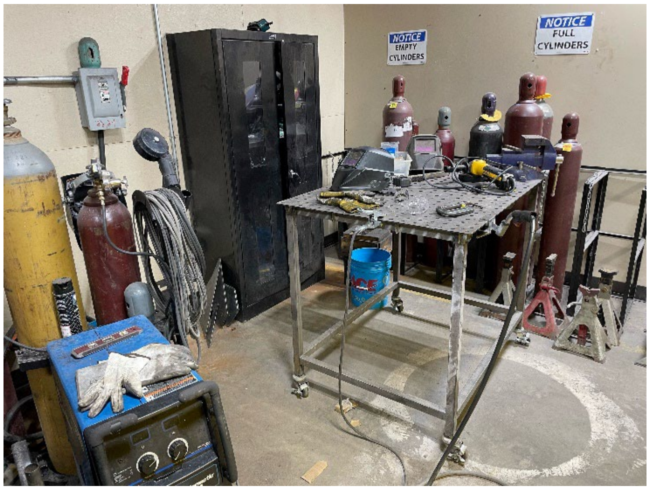


Figure 29: MIG Welding Station

PEDESTAL GRINDER (Figure *30*)

⏱⏱

- Minimal stock removal
- Deburring operations
- Small manual profiling

Figure 30: Pedestal Grinder

VACUUM THERMAL FORMER (Figure *31*)

⏱⏱⏱⏱

- Thin plastic sheet forming
- Student fabricated and assembled

Figure 31: Vacuum Thermal Former

BELT AND DISC SANDER (Figure *32*)

⏱⏱

- Large pieces
- Heavy deburring
- Metal only

Figure 32: Belt and Disc Sander

METAL BRAKE (Figure *33*)

⏱

- Sheet metal folding and bending
- Maximum thickness: ~0.063 inches

Figure 33: Metal Brake

OMAX ProtoMAX Waterjet (Figure *34*)

⏱⏱

- For intricate 2D cuts requiring more precision than plasma can provide.
- Good for cutting just about any material up to 1" thick (steel, aluminum, titanium, wood, foam, plastics, glass, rubber, etc.).
- 12"x12" cutting area
- +/- 0.005" tolerance

Figure 34: WaterJet

DRILL PRESS (Figure *35*)

⏱⏱

- Semi-precision holes
- Drilling and Reaming

Figure 35: Drill Press

FURNACE (Figure *36*)

⏱

- Heat Treating
- Max Temperature: 1000 ^{0}C
- Chamber size: 8” w x 8” d x 6” h

Figure 36: Furnace

PLASTIC INJECTION MOLDING MACHINE (Figure *37*)

⏱⏱⏱

- Molds thermoplastic materials
- Max part volume: ~0.8 in3
- Must design and machine your mold

Figure 37: Plastic Injection Molding Machine

HAND POWER TOOLS (Figure *38*)

⏱

- Drills
- Angle Grinder
- Dremel
- Heat Gun
- Rivet Gun (manual)

Figure 38: Hand Power Tools

GENERAL TOOL BOX (Figure *39*)

⏱

- Calipers and other gages
- Wrenches
- Screw drivers and pliers
- Drills, Counterbores, Countersinks
- Files, Micrometers
- Adhesives, Tape
- Hammers, Scissors

Figure 39: General Tool Box

TOOL CRIB (Figure *40*)

⏱

- Fasteners
- Endmills
- Other cutting tools
- Hand power tools
- Other small equipment

Figure 40: Tool Crib

Wire EDM (Electrostatic Discharge Machining) (Figure *41*)

⏱⏱⏱⏱

- Precision through all profiles.

Figure 41 Wire EDM

HORIZONTAL SURFACE GRINDER (Figure *42*)

⏱⏱

- Precision flat surface finishes

Figure 42 Surface Grinder

SHEET METAL SLIP ROLLER (Figure *43*)

⏱

- Forms gradual bends in sheet metal

Figure 43 Sheet Metal Slip Roller

7. TEST EQUIPMENT

Many types of test equipment are available in the engineering and physics labs in the science building and within the Ulrey labs. These are for electrical, biomedical and mechanical systems. Below are a few additional unique testing equipment often useful for your project.

TACHOMETER (Figure *44*)

- Measures rotational speed in RPM
- Contact: Wes Plybon

Figure 44 Tachometer

ANEMOMETER (Figure *45*)

- Measures wind speed
- Contact: Wes Plybon

Figure 45 Anemometer

SOUND LEVEL METER (Figure *46*)

- Measures sound/noise levels
- Contact: Wes Plybon

Figure 46 Sound Level Meter

THERMOCOUPLE THERMOMETER (Figure *47*)

- Measures a wide range of temperature levels
- Contact: Wes Plybon

Figure 47 Thermocouple Thermometer

PORTABLE MULTIMETER (Figure *48*)

- Measures DC and AC Voltage
- Measures resistance
- Measures DC and AC current (contactless)
- Contact: Rich Wells

Figure 48 Portable Multimeter

PHYSICS DEPARTMENT

- Multiple measurement systems
- Scales
- Data acquisition systems
- Contact: Dr. Steven Barber

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9. APPENDIX

APPENDIX A: PRESENTATION ASSESSMENT TOOLS AND RUBRICS

Name of Company____________________ Name of Evaluator_______________________________________

Date___________________ Title of Project____

ENGR420 Project Launch

Presentation Content (40%)	Possible	Given
Thorough coverage of the topic (breadth)	10	______
Sufficient details supplied (depth)	10	______
Relevance of all material presented	5	______
Technical aspects adequately explained	5	______
Obvious structure and organization	5	______
Transitions and connections between topics	5	______
Oral Presentation Mechanics (20%)		
Voice audibly projected	4	______
Pace neither too slow nor too fast	4	______
Length close to 15 minutes		
Deduct if too long or too short	4	______
Proper grammar, pronunciation, and enunciation	4	______
Smooth and natural flow, enthusiasm and confidence	4	______
Visual Presentation Mechanics (20%)		
Appropriate number of electronic slides	4	______
Relevant, succinct and concise text on slides	4	______
Appropriate font, background, and layout	4	______
Correct grammar and spelling	4	______
Relevant and enlightening graphics	4	______
Level of Project Analysis (20%)		
Sufficient analysis of customer needs	8	______
Sufficient analysis of technical requirements	8	______
Sufficient analysis of schedule	4	______
	Total 100	______
Deductions:		
Inappropriate appearance or dress	-10	______
Inability to answer reasonable questions	-10	______
Lack of handout	-10	______
	Final Score	______

Comments:

Title of Team ____ Date_____________________

Name of Evaluator_________________________________

ENGR4201 Fall	☒ System Design Review,	☐ Detail Design Review,
ENGR4202 Spring	☐ Build Design Review,	☐ Product Readiness Review

Prototype Progress (45%)	Possible	Given
Sufficient technical progress achieved toward project outcomes	15	____
Demonstrated sufficient engineering analysis	10	____
Decision-making process based on sound logic	10	____
Proper codes and standards considered	5	____
Realistic constraints (e.g., safety, culture, environment, etc.) adequately addressed	5	____

Presentation Content (45%)	Possible	Given
Thorough coverage of the topic (breadth)	3	_____
Sufficient details supplied (depth)	3	_____
Relevance of all material presented	3	_____
Technical aspects adequately explained	3	_____
Obvious structure and organization	3	_____
Voice audibly projected	3	_____
Pace neither too slow nor too fast	3	_____
Length ~ 30 minutes (Deduct if long or short)	3	_____
Proper grammar, pronunciation, and enunciation	3	_____
Smooth and natural flow, enthusiasm and confidence	3	_____
Appropriate number of electronic slides	3	_____
Relevant, succinct and concise text on slides	3	_____
Appropriate font, background, and layout	3	_____
Correct grammar and spelling	3	_____
Relevant and enlightening graphics	3	_____

Level of Project Planning and Analysis (10%)		
Sufficient resource planning	4	_____
Sufficient analysis of schedule	3	_____
Sufficient analysis of budget	3	_____
	Total 100	_____

Deductions:		
Inappropriate appearance or dress	-10	_____
Inability to answer reasonable questions	-10	_____
Lack of handout	-10	_____
	Final Score	_____

Comments:

Title of Project: ______________________________

ENGR420 Senior Design Project 1
System Design Review
Technical Rubric

Gate Reviewer: ______________

Date: ____________

	5	4	3	2	1
Performance Requirements Specification	All important performance criteria identified and quantified in engineering terms	Most performance criteria identified and generally expressed in quantifiable engineering terms	Gaps in performance criteria exist and specifications are not quantified in engineering terms	Very few performance criteria identified. General lack of understanding regarding performance specifications.	Specifications do not exist.
Identification of Specifications Based On Other Realistic Constraints	All important realistic constraints are considered and factored into design plans.	The critical realistic constraints are considered and factored into design plans.	Some realistic constraints considered but some critical realistic constraints are not considered	Few realistic constraints considered. Constraints considered are trivial. For example, only economic and schedule constraints are considered.	Constraints not considered.
Idea Generation	Many creative and innovative ideas are provided along with standard design ideas	Few creative or innovative ideas are provided along with standard designs	Only standard design ideas are provided, little creativity or innovation shown.	One design idea provided with little or no creativity.	No feasible ideas proposed or evaluated.
Feasibility Evaluation and Selection	All ideas generated are evaluated at the appropriate depth using appropriate engineering equations and tools. All reasonable constraints are considered.	All ideas generated are evaluated but may lack sufficient depth or appropriate engineering analysis. All critical constraints are considered.	Selection is made with some engineering rationale and/or analysis or with some supporting data. Some critical constraints are not considered.	Selection is made without engineering rationale and/or analysis or without supporting data. Little or no constraints are considered.	Design decisions not complete.
System Block Diagram	Block diagram reflects logical major functions and clearly defines all interfaces and technical risks.	Block diagram reflects all major functions and defines most interfaces.	Block diagram reflects most major functions and defines most interfaces.	Block diagram reflects some functions and interfaces.	Block diagram does not exist.
Calculations/ Simulations	Calculations and/or simulations conducted for all high risk system requirements.	Calculations and/or simulations conducted for most high risk system requirements.	Calculations and/or simulations conducted for some system requirements.	Calculations and/or simulations conducted for some requirements.	No calculations or simulation conducted.
Design Illustrations	Illustrations clearly depict major design decisions and are consistent with specifications and the system block diagram.	Illustrations depict most design decisions and are consistent with the system block diagram.	Illustrations depict some design decisions and roughly follow the system block diagram.	Illustrations vaguely depict the intended design direction.	No illustrations.
Budget	The project spend plan clearly reflects priorities and lead time requirements for critical items. Plan to stay within budget.	The project spend plan reflects most priorities and timing requirements. Plan to stay within budget	The project spend plan is complete but does not indicate priorities or timing requirements. Plan to stay within budget.	The project spend plan is incomplete or shows inability to stay within budget.	A spend plan does not exist.
Resources	Roles and responsibilities clearly align with project needs and timing. Team member contributions are appropriately distributed based on skill set and workload.	Roles and responsibilities align with most project task and timing needs. All team members are involved.	Roles and responsibilities are loosely aligned with project needs. Some team members need more responsibility.	Roles and responsibilities do not support project needs. Some team members are not participating.	Roles and responsibilities are not defined. The team appears to be dysfunctional.
Plan to proceed	Tasks, roles, and responsibilities are clearly defined for the two semester duration of the project.	Tasks, roles and responsibilities are not clear for the latter portion of the Spring semester.	Tasks, roles and responsibilities are not clear for the Spring semester.	Tasks, roles and responsibilities are not clear for the remainder of the academic year.	Tasks, roles and responsibilities are not defined for the project going forward.

Revision date: 29Sep2011

Title of Project: ______________________________

ENGR420 Senior Design Project 1
Detail Design Review
Technical Rubric

Gate Reviewer:_____________

Date: ___________

	5	4	3	2	1
Design Selection	Competing ideas are evaluated and the final design chosen based on how well each idea meets the identified specifications and constraints.	All critical specifications and constraints are considered when selecting the final design.	Some but not all critical specifications and constraints are considered when selecting the design.	Selection is made with little or flawed engineering rationale and/or analysis or by considering a small portion of the specifications.	Selection is made without engineering rationale and/or analysis or without consulting the specifications.
Detailed Synthesis	Synthesis methods employed to identify, layout, and size each system element. Analytical synthesis tools are employed where appropriate. Subsystem interrelationships are considered.	Synthesis methods are used to identify all critical system elements. Sizing specifications for some elements may be incomplete. Most subsystem interrelationships are considered.	Synthesis methods are used to identify most system elements. Sizing specifications for some elements may be incomplete.	Synthesis methods are haphazard or are not based on sound engineering judgment. Many sizing specifications are incomplete.	Little or no synthesis tools used for subsystem components.
Engineering Analysis/ Evaluation	Mathematical models are generated for all system components and connectivity between components is demonstrated. Analysis results are evaluated relative to design specifications and syntheses/analysis steps are reiterated where appropriate.	Mathematical models are generated for most system components and connectivity between most components is demonstrated. Analysis results are evaluated relative to design specifications. Some iteration between synthesis and analysis is performed.	Mathematical models are lacking for several system components and little connectivity between components is demonstrated. No iteration between synthesis and analysis is performed.	Minimal mathematical modeling is performed and connectivity between components is not considered.	Grossly inaccurate or no modeling performed.
Physical Mockups	Mockups clearly depict major design considerations including spatial, motion (if applicable) and function.	Mockups closely resemble intended functionality. Missing one of spatial, motion or function.	Mockups are not clear or only depict one of spatial, motion or function.	Mockups provide little insight into intended prototype capability.	Mockup not provided.
Budget and other resources (update)	Updates (if applicable) to the project spend and team responsibilities plan clearly reflect priorities and align with project needs and timing. Plan to stay within budget.	Updates to the project spend and team responsibilities plan reflect most priorities and timing requirements. Plan to stay within budget	Updates to the project spend and team responsibilities plan are complete but does not indicate priorities or timing requirements. Plan to stay within budget.	Updates to the project spend and team responsibilities plan are incomplete or shows inability to stay within budget.	Needed updates were not provided.
Plan to proceed	All tasks, roles, and responsibilities are clearly defined for the duration of the project.	Most tasks, roles and responsibilities are clear for most of the duration of the project.	Tasks, roles and responsibilities are not clear or major gaps exist for the duration of the project.	Tasks, roles and responsibilities are unrealistic or poorly planned.	Tasks, roles and responsibilities are not defined for the project going forward.

Title of Project: ______________________________

ENGR421 Senior Design Project 2
Build Design Review
Technical Rubric

Gate Reviewer:______________

Date: ____________

	5	4	3	2	1
Construction Build Progress	Construction of prototype is ahead of schedule.	Construction of prototype is on schedule.	Construction of prototype is slightly behind schedule.	Construction of prototype is behind schedule.	Construction is grossly behind schedule.
Issue Resolution	Issues are identified and solutions found using appropriate analysis techniques and engineering judgment.	Issues have been identified. Solutions are needed to complete.	Issues are being identified. Some solutions have been found.	More issues are unknown than known.	Insufficient progress to recognize issues.
Product Testing Plan	A test plan is identified that demonstrates all system and subsystem performance specifications (nominal and extreme) and all tests are valid.	A test plan is identified that demonstrates all system specifications and most but not all subsystem specifications, and all tests are valid.	The test plan considers all system specifications but neglects some subsystem specifications or some tests within the plan are not valid.	The test plan considers most system specifications and neglects most subsystem specifications.	No test plan is defined.
Budget and other resources (update)	Updates (if applicable) to the project spend and team responsibilities plan clearly reflect priorities and align with project needs and timing. Plan to stay within budget.	Updates to the project spend and team responsibilities plan reflect most priorities and timing requirements. Plan to stay within budget	Updates to the project spend and team responsibilities plan are complete but does not indicate priorities or timing requirements. Plan to stay within budget.	Updates to the project spend and team responsibilities plan are incomplete or shows inability to stay within budget.	Needed updates were not provided.
Plan to proceed	All tasks, roles, and responsibilities are clearly defined for the duration of the project.	Most tasks, roles and responsibilities are clear for most of the duration of the project.	Tasks, roles and responsibilities are not clear or major gaps exist for the duration of the project.	Tasks, roles and responsibilities are unrealistic or poorly planned.	Tasks, roles and responsibilities are not defined for the project going forward.

Title of Project: ______________________________

ENGR421 Senior Design Project 2
Prototype Demonstration
Technical Rubric

Reviewer:___________________

Date: ______________________

Score : _________________

Specification/ Requirement	Points => Weight	100	80	60	30	0
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
		Quantitatively meets the requirement.	Meets the requirement qualitatively but performs slightly outside of the specified range.	Performs significantly outside of the specified range.	Does not function.	Design feature is missing.
TOTAL	1.00					

APPENDIX B: PROCUREMENT FORMS

PURCHASE REQUISITION
HARDING UNIVERSITY

PLEASE RETURN TO PURCHASING DEPARTMENT AT BOX 10772 OR SEND TO FAX **#5222**
PURCHASING OFFICE IS LOCATED ACROSS FROM HUMAN RESOURCES IN THE EZELL BUILDING
PHONE 279-4396

SUGGESTED VENDOR: (Must include complete address, phone & FAX)		**Page ___ of ___.**	
VENDOR NAME:		SUBMISSION DATE:	
ADDRESS		IS PAYMENT REQUIRED WITH THIS ORDER?	
CITY	STATE/ZIP	YES	NO
PHONE	FAX		

DESCRIPTION OF ITEM	QUANTITY	UNIT PRICE	TOTAL
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
Notes: Senior Design - [add team name here]		Subtotal	$ -
		Shipping	$ -
		Sales Tax	$ -
		Total	$ -

Account(s) to be charged:					$ AMOUNT	**Requested delivery date:**
FUND	ORG	ACCT	PROG	Dept Name		
1010	3j0900	705001	1b		$ -	
FUND	ORG	ACCT	PROG	Dept Name		**Delivery Site:**
						SCI-100

BUDGET MGR. PRINT NAME	**BUDGET MGR. SIGN NAME**	**Person Requesting Order:**
Brad Miller		*[Your Name & phone]* / Rich Wells 5251

PURCHASE REQUISITION
HARDING UNIVERSITY

PLEASE RETURN TO PURCHASING DEPARTMENT AT BOX 10772 OR SEND TO FAX **#5222**
PURCHASING OFFICE IS LOCATED ACROSS FROM HUMAN RESOURCES IN THE EZELL BUILDING
PHONE 279-4396

SUGGESTED VENDOR: (Must include complete address, phone & FAX)		**Page 1 of ___.**	
VENDOR NAME:	McMaster - Carr mcmaster.com	SUBMISSION DATE:	10/1/2018
ADDRESS		IS PAYMENT REQUIRED WITH THIS ORDER?	
CITY	STATE/ZIP	YES	NO
PHONE	FAX		

DESCRIPTION OF ITEM	QUANTITY	UNIT PRICE	TOTAL
#5231K84 - (1/4" Black PVC tubing 1/2"OD) - (10ft.)	1	$ 0.76	$ 0.76
#5463K628 - "Black" Nylon barbed tube fitting	1	$ 7.63	$ 7.63
#5372K311 - Nylon barbed tube fitting 90 deg elbow	1	$ 5.65	$ 5.65
#8910K12 - Low carbon steel br 1/4" thick - (1/2ft)	1	$ 15.62	$ 15.62
#6659K29 - Bronze flanged sleeve bearing 15 mm shaft	1	$ 2.46	$ 2.46
#2299K32 - Machinable - bore flat sprocket 24 teeth	2	$ 25.51	$ 51.02
#92288A725 - Metric key stock 5mm x 5mm	1	$ 2.38	$ 2.38
#92320A242 - "Screw size: 1/4" unthreaded spacer	1	$ 3.37	$ 3.37
#1439K511 - 15mm dia. Keyed shaft 300mm long	1	$ 26.05	$ 26.05
#1346K17 - 1/2" dia. Shaft 12" long	1	$ 7.51	$ 7.51
#7208K52 - Flange-mounted ball bearing for 1/2" shaft	1	$ 26.34	$ 26.34
#9056K19 - 6061 Aluminum 2-1/2" OD 1-1/2" ID	1	$ 33.38	$ 33.38
#8974K49 - 6061 Aluminum Rod 1-7/8" dia.	1	$ 14.37	$ 14.37
#9556K84 - Light duty gasket material 1/64" thick	1	$ 4.66	$ 4.66
			$ -
Notes: Senior Design [Team 33 - Bison Bath]		Subtotal	$ 201.20
		Shipping	$ -
		Sales Tax	$ 19.62
		Total	$ 220.82

Account(s) to be charged:					$ AMOUNT	**Requested delivery date:**
FUND	ORG	ACCT	PROG	Dept Name		
1010	3j0900	705001	1b		$ 220.82	
FUND	ORG	ACCT	PROG	Dept Name		**Delivery Site:**
						SCI-100

BUDGET MGR. PRINT NAME	**BUDGET MGR. SIGN NAME**	**Person Requesting Order:**
Brad Miller		*Terry Student* / Rich Wells 5251

Check Request/Cash Advance Form
Harding University, Inc.
(return to Box 10772)

Date: ____________ **Mark a selection:**

Pay to: ____________ Request for Check ____

Banner H # ____________

(put Social Security # if no Banner # is available) Request for Advance ____

Complete Address (Required): Request for Direct Deposit ____

Request for Paid Out ($15 or less) ____

Check Amount: ____________ **Date Needed:** ____________

Please charge the accounts listed below:

Account Name	FUND	ORG	ACCT	PRG	ACTIV	LOCAT	Amount
Engineering Supplies	1010	3j0900	705001	1b			

Purpose of check: Senior Design *(add your team name here*)

Choose ONE method of delivery:

A. Mail to Recipient ____

B. Campus Mail (put box #) ____

C. Call for Pick-Up (put ext. #) ____

D. Direct Deposit ____

Signed:

____
Budget Manager

____
Other as Required (see note)

____
Finance Officer

Direct Deposit Number ____

Check Number: ____

NOTE: Check requests for expenses incurred by budget manager must be approved by the budget managers' immediate supervisor.

APPENDIX C: CREATING AN *.STL FILE IN SOLIDWORKS

CREATING AN STL FILE IN SOLIDWORKS CAD

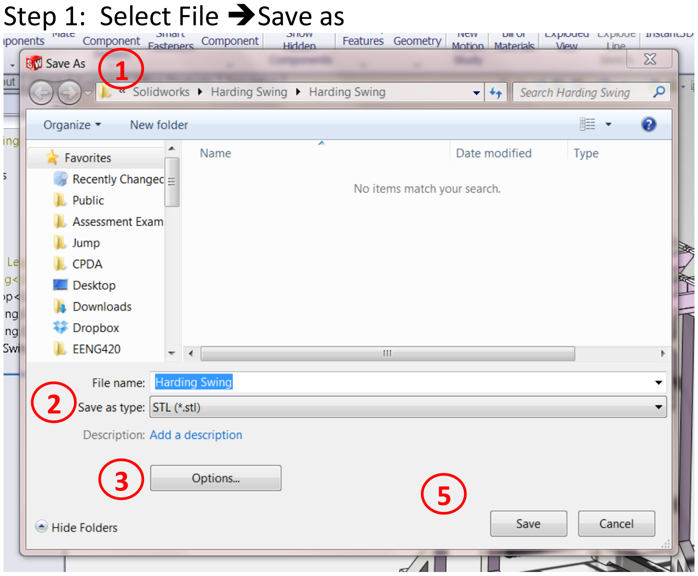
Purpose: Develop 3D Printer design skills while enhancing capabilities in Solidworks CAD

Some design for manufacturing guidelines:

- Accuracy is only to the nearest 0.010 inch which matches the nozzle size where the melted plastic is extruded.
  Any details smaller than 0.010 inch will probably not even show in the final product.
- Smaller wall thicknesses should be in increments of 0.010 inch such as 0.03 (smallest), 0.04 or 0.05 as examples.
- Otherwise, unintentional crevices/holes will probably appear on the inside of the structure.
- You can make multiple parts simultaneously. It is recommended to keep at least a 0.020 inch gap between them to prevent unintended fusing together.
- Generally, outward projecting letters look better than those projecting inward to the part.

Instructions for creating *.stl file:

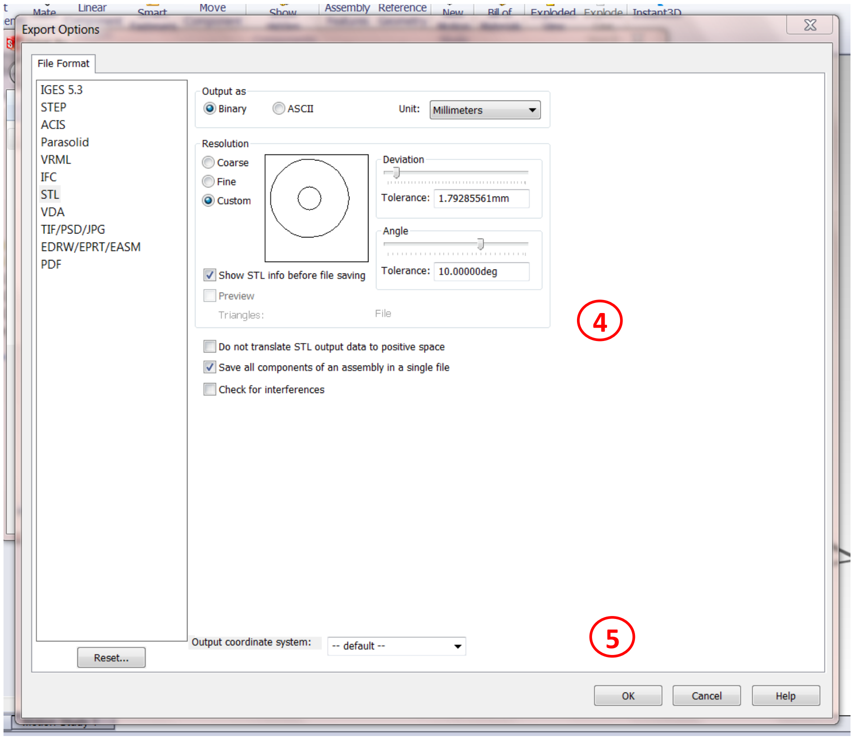
Step 1: Select File ➔Save as



Step 2: Select Save as type: STL (*.stl)

Step 3: Select Options:

Step 4: Match selections on screen below (verify that deviation tolerance < 2mm and angle </= 10 deg).



Step 5: Select Save or OK:

APPENDIX D: HARDING UNIVERSITY INTELLECTUAL PROPERTY POLICY

Harding University Intellectual-Property Policy

SECTION 1: Objectives of the Policy

This policy exists to encourage research and innovation, clarify ownership of intellectual-property rights, create opportunities for public use of university innovations, and provide for the equitable distribution of monetary and other benefits derived from intellectual property.

SECTION 2: Coverage and Definition

a. Unless specially commissioned, traditional works of scholarly activity that have customarily been considered the unrestricted property of the author or originator are excepted from the general policy. Such works include but are not limited to:

- journal articles;
- textbooks;
- reviews;
- works of art, including paintings, sculpture, films and musical compositions; and
- course materials such as syllabi, workbooks, and laboratory manuals.

The university will not claim ownership rights to such works and disclaims any potential rights to do so under “work-for-hire" provisions of the U.S. Copyright Act.

This policy covers all other intellectual property conceived, first reduced to practice, written, or otherwise produced by faculty, staff, or students of Harding University using university funds, facilities, or other resources or by other individuals using university funds, facilities, or other resources on or after August 1, 2017.

b. “Intellectual property,” for purposes of this policy, means the tangible or intangible results of research, development, teaching, or other intellectual activity. It includes but is not limited to:

(i) Inventions, discoveries, or other new developments that are appropriate subjects of patent applications.

(ii) Written materials; sound recordings; videotapes; films; computer programs; computer-assisted instruction materials; and all other material that may be copyrightable.

(iii) Tangible research property such as biological materials, including cell lines, plasmids, hybridomas, monoclonal antibodies, and plant varieties; computer software, databases, integrated circuit chips, prototype devices and equipment, circuit diagrams, etc.; and analytical procedures, laboratory methods, etc. Such property may or may not be patentable or copyrightable.

(iv) All intellectual property assigned to the university in writing.

These four categories are not mutually exclusive; a given article of intellectual property may include aspects of all four categories.

c. “Specially commissioned,” for purposes of this policy, means a work requested in writing by a third party.

SECTION 3: General Policy

a. All rights to intellectual properties as defined in Section 2 are owned and controlled by the university.

b. When a university faculty, staff, or student develops or originates an item of intellectual property that is owned and controlled by the university under the terms of this policy, the individual must report the intellectual property to the University CFO in a written format approved by the CFO. The originator will:

- cooperate in the execution of legal documents and in the review of literature and prior works;
- be given the opportunity to assist in the commercial development of the intellectual property; and
- have an interest in and share in any income derived from the commercialization of such property.

Section 6 further explains the originator’s rights and responsibilities as to the commercialization of the intellectual property.

c. Except as provided in Section 4(b), only works produced in university units whose specific mission includes the production of works for instructional, public-service, or administrative use and who employ faculty, staff, or students for the purpose of producing such works are deemed to be "works-for-hire" under copyright law and therefore university property. Works produced by such units include instructional films and videotapes, telecourses, drawings, slides, models, computer programs, etc. The university will own and control all such works produced in such units. Arrangements with "talent" from other units or from outside the university may include payments based on sales or usage of such works. Such payments are considered costs of production. Commercialization of such works outside the university must be through assignment to the university, which will be responsible for commercialization. In recognition of the differences between these units and regular academic departments, different revenue-sharing arrangements may be made with the approval of the head of the appropriate administrative unit.

d. Rights to intellectual property resulting from sponsored projects will be owned and controlled by the university. In some instances, the provision of substantial funding, background information, product samples, or confidential proprietary data by a sponsor may create a situation in which the sponsor may claim partial or complete ownership of intellectual property that results from the sponsored project. In such cases, final disposition of the property may be negotiated as a part of the sponsored-project agreement. If the final disposition of the property has not been negotiated as part of a sponsored project agreement, the university will proceed as described in Section 6.

e. Artifacts and intellectual property created during periods such as unpaid sabbatical, and unpaid summer activities (provided such activities do not use significant university resources) are owned by the creator. Faculty applications for paid sabbatical should address ownership of artifacts and intellectual property created during periods of sabbatical. If the final disposition of the property has not been negotiated as part of a paid sabbatical agreement, the university will proceed as described in Section 6.

f. If intellectual property is a derivative of or otherwise uses preexisting university-owned intellectual property, the university may assert its preexisting rights.

SECTION 4: Use of Intellectual Property

a. Rights to Publish: Nothing in this policy affects the rights of an originator of intellectual property to publish, except that he or she must agree to observe a brief period of delay in publication or external dissemination if the university so requests to permit it to secure protections for intellectual property disclosed to it by the originator.

b. Use of Teaching Materials: To facilitate joint work on teaching materials and to support collaborative teaching—and notwithstanding ownership rights otherwise granted by this policy—individuals who contribute teaching materials used in jointly developed and taught university courses grant a limited-duration, nonexclusive, nontransferable license to the university to permit other course contributors to continue using those materials in university courses. Due to the continual development of scholarship, jointly produced teaching materials must be redeveloped, or use discontinued, after five years if so requested by a contributor.

c. Library Institutional Repository: Faculty, staff, and students are encouraged to provide their works, or links to their works, for viewing in the library's institutional repository. Works not owned by the university will not be added to the repository without originator approval. Publishing a work in the repository does not affect ownership rights unless agreed to in writing. The library will remove a work from the repository at the originator's request. Faculty and staff may submit student-originated work for publication in the repository but must first obtain the originator's written permission.

SECTION 5: Administrative Procedures

a. The university CFO will determine the legal interests of the university and its staff, faculty, and students in any intellectual property covered by this policy.

b. If the university CFO decides there has been no material use of university funds, facilities, or other resources, the university will release the property to the originator and will not exert further claim to the property.

c. The university CFO may decide the university has a legal interest in the property but that the chances of successful commercialization are minimal or that the costs of pursuing commercialization outweigh the income potential. In such cases, the university may release the property to the originator.

d. If the university CFO decides the university has a legal interest in the property and that there is a reasonable chance for successful commercialization, it will:

(i) inform the originator in writing that the university claims ownership rights to the property; and

(ii) determine and record the rights of the originator to share in any income in accord with Section 6.

e. The university CFO may find that the university has an ownership right in the discovery but that the discovery has not been developed to the point where a decision as to patentability or commercialization is possible. In such cases, the university CFO will:

(i) place the discovery in a pending status;

(ii) provide the originator reasons for taking such action and suggestions as to additional information or data that might be helpful; and

(iii) ask the originator to report back to the university CFO at a specified interval if and when the discovery is brought to a more advanced stage.

f. Except for Section 5(e), if the university CFO takes no action within three months after receiving the originator's initial written report of the new discovery (as required by Section 3(b) of this policy), right to the discovery will be deemed to be released to the originator.

g. In consultation and collaboration with the originator, the university will determine the appropriate method of protection of the property and, where appropriate, obtain such protection. The university will distribute any net income from commercialization in accord with this policy and the decisions of the university CFO . All costs associated with these actions will be borne by the university, except that such costs will be offset against future income in accord with Section 8.

h. Faculty, staff, or students of the university may ask the university to accept, for management and commercialization, intellectual properties that are theirs alone and not originally subject to this policy. Upon receiving such a request, the university, with the university CFO's advice, will determine if there is a reasonable expectation that the property can be commercialized successfully. If the university accepts management and commercialization responsibilities for the property, the property will become subject to, and will be treated in accord with, this policy.

i. Intellectual property referred to or offered to the university by third parties will be treated as any other gift offer and will be channeled through the university. If accepted, the university will manage the property in accord with appropriate parts of this policy and the terms of the gift agreement.

j. The president, in consultation with the provost, will adopt further procedures and appoint individuals to implement this policy.

SECTION 6: Commercialization

a. To protect and commercialize intellectual property, the university may seek patent or copyright coverage; may treat the property as proprietary information, technical know-how, or trade secret; or both.

b. In seeking and developing commercialization of intellectual property, the university will be guided by these principles:

   (i) A primary objective and responsibility will be to see that the intellectual property is brought into the widest possible use for the general benefit of society;

   (ii) Intellectual property should be treated as an asset and an appropriate return should be sought; and

   (iii) Active originator participation in all commercialization efforts will be sought.

c. In some situations, it may be in the best interest of the university, the general public, and the originator to enter into commercialization arrangements with entities wholly or partially owned or controlled by the originator(s). Due to their potential benefit, such arrangements may be considered and accepted if they are not prohibited by law and if adequate provisions, including full disclosure of interests, are made to avoid or otherwise protect against conflicts of interest. The university will handle negotiations for the creation of new commercial entities arising directly from the university's intellectual property, or arising from a potential collaboration between the university's faculty, staff, or students and an outside entity.

d. If no commercialization occurs within two years after assigning property to the university, the originator may request that all rights be returned. Such requests should be directed to the university CFO. The university CFO will consider what efforts have been made and what additional efforts are planned. If the university CFO decides there is little chance of successful commercialization, the university will return all rights to the originator, and the university will no longer claim rights to the property. But if the university CFO decides that the university has made reasonable efforts to commercialize and that further efforts offer reasonable chances of success, it will deny the request. Such denials will be accompanied by a summary of the factors the university CFO considered in reaching the decision. If the originator remains unsatisfied with commercialization efforts, this process may be repeated at two-year intervals.

SECTION 7: Collaboration Expectations

a. Faculty, staff, students, and external sponsors are expected to foster an environment of research and innovation. All parties are expected to collaborate in an intellectually responsible manner.

b. Students may maintain full ownership of intellectual property if they receive only limited guidance from university faculty regarding scholarly or entrepreneurial activities.

c. Communications concerning non-public information or trade secrets must remain confidential. To legally protect non-public information or trade secrets, it is the responsibility of the concerned party to have an appropriate non-disclosure agreement signed in advance.

d. Significant contributions made by any party may constitute partial ownership of intellectual property and should be recognized accordingly.

   i. Faculty are encouraged to guide students in student-initiated independent research and innovation.

   ii. Students are encouraged to seek guidance from faculty for student-initiated independent research and innovation. Students seeking such guidance should expect limited time and contribution from faculty.

   iii. Students are encouraged to assist faculty in noncourse-related, faculty-initiated, independent research and innovation. Faculty seeking such assistance should expect limited time and contribution from students.

   iv. If any person is concerned about intellectual property ownership, he or she should require a signed collaboration statement before significant contributions are made.

SECTION 8: Royalty Income-Sharing Policy

a. “Net income” means gross royalties, license fees, or other such payments received by the university on behalf of the originator and the university minus necessary deductible costs, for example, mailing or courier costs, licensing costs, patent enforcement, necessary travel, auditing fees, and sponsor shares.

b. “Gross royalties, license fees, or other such payments" means agreed-upon payments specified in a license or other commercialization agreement usually expressed as a percentage of sales or a fixed dollar amount per unit manufactured in return for the right to use, copy, reproduce, make, or sell an item of intellectual property or product based on such property. The university may suspend income distribution if there is reason to believe that substantial deductible costs will be incurred in the future. The originator will be informed of such decisions. Upon the originator’s request (but not more than annually), the university will make a detailed accounting of income and costs available to the originator.

c. Except as provided through supplementation under Section 8(d), net income derived from commercialization of intellectual property covered by this policy will be shared dependent on the level of responsibility the university chooses to commit. When the university chooses to “Participate Fully”, under section 12(a), the net income will be distributed as follows: 50% to the originator, 10% to the originator's college or school, and 40% to Harding University. When the university chooses to “Participate Tangentiality”, under section 12(b), the net income will be distributed as follows: 90% to the originator and 10% to Harding University. The university CFO is responsible for choosing the university level of commitment and seeing that the university’s associated responsibilities are fulfilled. The university will “Participate Tangentiality”, under Section 12(b) for all activities initiated by students in the university’s entrepreneur center unless other arrangements are made under Section 8(d).

d. In some situations an alternate distribution of net income may be appropriate. In these situations the originator may propose modifications to the distribution scale in Section 8(c) and/or the university responsibilities in Section 12. An alternate income distribution requires university CFO approval.

e. The originator's rights to share in net income (not including the college’s or school’s share) will remain with the individual or pass to the individual's heirs and assigns for as long as net income is derived from the property.

f. Where more than one individual is the originator, the originators will determine among themselves the individual share each will receive. If they cannot agree, the university CFO will decide after giving the individuals an opportunity to present their positions. The university CFO’s decision will be final.

g. Originators are encouraged to consider making a gift of all or a part of their income shares to support university research activities. Upon an originator’s request, the university will retain all or a part of the originator's share in a separate university account for expenditure in accord with the originator's wishes. The originator may restrict such gifts to any particular program or unit of the university, including the originator's own research program. Such requests may be limited in duration to a specific time period or to a specific future event, for example, the originator's retirement or resignation from the university, and may be cancelled or modified by the originator at any time.

h. This policy will not change income-sharing agreements entered into before the adoption of this policy.

SECTION 9: Consulting Agreements

a. Any faculty or staff engaged in consulting work or in business is responsible for ensuring that clauses in the individual's agreements do not conflict with this policy or with the university's commitments, and that the consulting or business institution's rights and the individual's obligations to the university are not abrogated or limited by the terms of such agreements.

b. Faculty and staff must make clear to those with whom they make such agreements their obligations to the university and must ensure that other parties to the agreement receive a current copy of this policy.

SECTION 10: Basis of the University’s Equity in Intellectual Property

This policy constitutes an understanding that is binding on faculty, staff, and students as a condition of their participation in university research, teaching, and service programs and for their use of university funds, space, facilities, or resources.

SECTION 11: Responsibilities of Applicable Individuals

In addition to other responsibilities identified in this policy, faculty, staff, students, and all persons receiving funding administered by the university, receiving other compensation from the university (regardless of funding or employment status), or utilizing university funds, facilities, or other resources have a responsibility to:

a. adhere to the principles embodied in this policy;
b. sign an Intellectual Property Policy Acknowledgement if requested by the university;
c. create, retain, and use intellectual property according to applicable laws and university policies;
d. disclose promptly in writing intellectual property owned by the university under this policy or created pursuant to sponsored research or contractual arrangements with external parties, and assign title to such intellectual property to the university or its designee to enable the university to satisfy the terms of any applicable funding or contractual arrangement; and
e. cooperate with the university in securing and protecting the university's intellectual property, including cooperating in obtaining patent, copyright, or other suitable protection for such property and in legal actions taken in response to infringement.

SECTION 12: University Responsibilities

In addition to other responsibilities identified in this policy, the university has the responsibility to either:

a. Participate Fully
   1. protect its intellectual property; and
   2. fulfill university responsibilities prescribed in all sections of this policy.
   3. provide oversight of intellectual property management and technology transfer;
   4. ensure licensing and patenting intellectual property;
   5. cover all other legal expenses.
   6. promote effective distribution and marketing of intellectual property;
   7. protect the university's intellectual property; and
   8. inform individuals covered by this policy about its provisions.

b. Participate Tangentiality
   1. protect its intellectual property; and
   2. continue to allow the use of university facilities and resources at the normal "scholarly activity" level. Costs for additional resources must be negotiated.
   3. inform individuals covered by this policy of its provisions.

SECTION 13: Compliance

If an employee violates this policy, he or she may be disciplined in accordance with university policies and procedures.

SECTION 14: Effective Date

This effective date of this policy is August 1, 2018.