2015 Research and Development - Final Project

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The New Product Development Challenge

The New Product Development Challenge follows a proven hands-on, real-world problem-solving approach to learning. Students work in teams to design and develop an original solution to a valid open-ended technical problem by applying the engineering design process. Students perform research to choose, validate, and justify a technical problem. After carefully defining the problem, teams design, fabricate, and test their solutions while working closely with industry professionals who provide possible mentoring opportunities. Finally, student teams present and defend their original solution.

Throughout the Product Development Challenge, students learn and apply the design process, acquire strong teamwork and communication proficiency, and develop organizational, critical-thinking, and problem-solving skills. Through this hands-on project, students apply engineering standards and document their work. Students use industry standard 3D modeling software to help them design solutions to solve proposed problems, document their work using an engineer's notebook, and communicate solutions to peers and members of the professional community. Students use the same industry-leading 3D design software used by companies like Ford Motor Company and Lockheed Martin.

Students will discover the answers to questions like how are things made and what processes go into creating new and innovative products? They learn how a product is developed from the ground up and the associated costs. They will also see the struggles some companies face when challenged with communication issues, outsourcing of work, material shortages and difficult employees. They explore mechanical design and precision fabrication while applying engineering concepts related to Product Development. Topics include mechanisms, energy, statics, materials, and kinematics. They design, test, and actually construct a working prototype and/or device used in real-world applications while working collaboratively on a crowning innovative project. It's STEM education, and it's at the heart of today's high-tech, high-skill global economy.
The Product Development Challenge complements traditional mathematics and science related courses and can serve as the foundation for STEM-centered or specialized engineering education. The project is designed to prepare students for life after high school and to pursue a post-secondary education and/or careers in STEM-related fields.

KEY QUESTIONS

- Why emphasize developing engineering specifications?
- How can you identify the "customers" for a product?
- Why is it so important to understand new product needs and work to translate this into engineering specifications?
- How can you best benchmark the competition to understand design and business opportunities?
- How can you justify taking time at the beginning of a project to do specification development instead of developing concepts immediately?

At the end of the section students should be able to:

1) Describe how engineering drawings are the communication between engineers and manufacturers
2) Create a timeline complete with formatting tasks, dates and persons assigned to tasks
3) Accurately represent how a prototype is used and or developed with complete drawings, pictures and photos
4) Design an product that is complete, matches the proposed design and needs minimal improvement
5) Create a 3D software model of the product
6) Select appropriate materials for the application and properly applied or manufactured
7) Create a product according to specifications while working with more advanced building tools and materials.
8) Describe the Human/Product interaction
9) Construct a product that is aesthetically pleasing, has no visible flaws with logos or colors that are appropriate for the consumer
10) Clearly state the problem to be solved
11) Review how Business and Industry were involved with the development of the final product
12) Describe the sources for supplies and the utilization of appropriate materials for their application
13) Defend the data and information that is presented in the solution
14) Presents easy-to-follow information that is logical and adequately detailed.
15) Convey a clear and concise message about the process taken to design the product, and its features
16) Describe calculations, complete with detail, relevant formulas and labels
17) Design drawings complete with detail and relevant materials and labels & associated back with a 3D model
18) Perform a complete formatted cost analysis with pricing, sources and total costs per item
19) Accurately represent the team product and the process that was completed to generate the final product
20) Conduct a presentation that was with no bias and in a professional manner

Objectives

The focus of the Product Development Challenge is the integration of marketing, design, and manufacturing functions of a company in creating a new product. The project is intended to provide you with the following benefits:

- Competence with a set of tools and methods for product design and development.
- Confidence in your own abilities to create a new product.
- Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
- Ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective.
- Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting.
- Enhanced team working skills.

Expectations

This project has been designed to demand approximately 10 hours per week of your time. It is expected that each student will prepare for and attend all of the class sessions and will regularly enhance class discussions. Most important though are substantial and continuous contributions to the progress of the team project. Experience with project-based design courses is that students often develop high expectations for their projects and devote substantially more time than is required by the instructors. The Design Technology staff applauds this enthusiasm, but this class will not penalize students who establish a ten hour per week average time constraint for their efforts. After schools hours are always optional. Ask instructor for dates and time.

Quick Project Overview

Introduce the design method adopted by the class and enlighten students concerning engineers' responsibilities beyond simply designing a solution. Engineers do more than design solutions. Their responsibilities in new product development begin before the design challenge is defined and continue after the product has entered into the market. It is useful to adopt official project terminology because most of industry operates using a project model. Practically, investing time up front to clearly define the class project (schedule and deliverables of each phase) is likely to make the team more effective in the long run. In this ***Multi-Step Process*** students will exercise a mini-project approach including project planning, practice, a formal design method, fabricating a fully functional multi-level project and formally presenting all work to industry professionals. Students will have to communicate effectively and efficiently while working together to build and develop a product that will be precision made and meet the highest quality standards set forth by the industry.

The Problem and Challenge

You are a newly developed company planning on designing and fabricating a new innovative product that is safe and reliable for the consumer. The CEO of the company has hired you to design and build their companies first commercially available product. Each new product must pass through rigorous testing and standards and perhaps the most important testing that occurs is the ***Final Test***. New products are tested to their limit and safety is always the number one priority. Your product will be subjected to the harshest testing scenario developed by the national safety industry.

Background

Much of industry has moved to the project model of business operations. A project is a temporary endeavor with a definite beginning and an end. Appropriately, project teams are assembled for the unique challenge and then disbanded when the project is completed. In recent years project management has become a lucrative career choice. This class will engage in a new product development project and a fabricated component. As in industry these two projects are NOT independent from one another. Marketers help direct which products are developed and engineers remain involved with the product well after the marketing campaign is underway.

STEP ONE: Choose Team

Each team will consist of no more than 4 members that will have many different roles during the entire process of this challenge. It is prudent to have team members that are willing to work towards one common goal for the betterment of the company. You will need team members that are well-rounded and are able to do multiple tasks. Your staff will have to be designers, engineers, fabricator, laborers, office staff, photographers, writers and accountants. To make this challenge as realistic as possible volunteers will be asked to be the Team Leader but remember this comes with great responsibility and one that should not be taken lightly. You will get the opportunity to choose your first employee. (Note: sometimes your best friend is not always the best employee.) This person should be your right-hand man/women and one that can step in when you are not present or are off doing another task. The choice will be based on the experience and knowledge of each person and their strengths that they can bring to the team. In the end you want to have a team approach and one that will work together to design and build the best product on the market for your customer.

STEP TWO: Company Name and Logo

What's in a name? Everything!!!!! Each team will have the opportunity to choose and design a company name and logo that best describes and defines their product. Keep in mind that you are working in the engineering and/or manufacturing area.

STEP THREE: Company Organizational Flow Chart

With each great company comes a working understanding of its Chain of Command and the duties each team member brings to the table and how the company operates on a daily basis. Each member of the company is just as important as the next from the top down to make the best product for the customer. Remember without you there is no product in the end. Design a Company Organizational Flow Chart with job titles and duties using one of the following: CAD, Excel, Power Point or MS Word. (See example or research another idea)

STEP FOUR: Product Name

Your product could be worth millions or pennies depending on the name given. Some companies have great products but terrible names for example, what are the following products from one well-known manufacturer: dv8000z, PSC 2350, vp6300? One is a printer, one is a laptop computer and one is a projector. How can you tell? How can you differentiate one product in a given range from another? The answer is, quite simply, that you can't. While others have names like iPhone or the iPod or the iPad. A product's name is part of its identity. If you tell someone you have an iPhone 6, most people will know what it is, and they'll know it's made by Apple. Choose a product name that reflects that great things your company creates.

STEP FIVE: Associated Costs / Expenses

Costs and expenses are all part of making a quality product. The saying that "nothing in life is free" is exactly true. Making a simple product costs money and the more employees you have, the more parts and supplies you have, the more changes you make all add up. But there is an efficient way of doing business. Understanding your product and your manufacturing process can greatly reduce the bottom line.

Use a cost guide to determine the cost of your product from the day you start your company. You can find the cost from internet sources using industry averages. Your goal is to design and fabricate the best product in the most efficient way possible as this is what your customer expects. Keep a detailed invoice of all your used parts and material. (see example)

Final Cost Analysis

Your product will have a final cost associated with it and you will see for yourself how cost effective your company was compared to others that build a similar product. Remember it's not always the cheapest that's the best it's the final product results. Ask yourself - Does the customer like it? Does it work as designed? Does the product meet the minimum safety requirements? Are you proud of the final result? I'm sure if you had another opportunity you could always make changes and make it better.

STEP SIX: Project Planning and The Design Process

There have been many formal project planning and the design process methods published in the last few decades. In fact, just about every expert engineer has their own unique way of approaching challenges. Some have defined only a few abstract "steps" in the process while others break the process down into more steps. Truth is that design is more philosophical than it is analytical. This fact will be a complete surprise to those that think of engineering as mind numbing number crunching. Design can never be reduced to a formula. It is a divergent then convergent dance that relies on the creativity, knowledge, and motivation of the designers to overcome a challenge. It is taught to many novice engineers because of the simple, easy to understand terminology that defines each step. Though it neglects the nuances that distinguish expert designers (things like conceptual-embodiment cycling and iterating with increasingly detailed information), it certainly works to help the novice cover the entire basis. A formal design method will NOT ensure that the optimum solution is reached. However, it will drastically increase the chances of finding a good solution to the challenge. It is difficult to overstate the importance of learning how to design well. Every person's daily life is full of problem solving activity...it is full of design challenges. Arming students with a good problem solving process to fall back on will serve them for many years to come.

The Design Process

The **Design Process** is the formulation of a plan to help companies build a product with a specified performance goal. This process involves a number of steps, and parts of the process may need to be repeated many times before production of a final product can begin.

Research the design process and review the sample. Choose a design process that best fits your company's needs and use this as a guide to point your company in a positive direction. (see examples)

STEP SEVEN: Designs

Your drawings are a road map to the final product and one of most essential parts of the overall concept. These drawings will be seen by the customer for review and used by the fabrication department to build the product to the exact manufacturing specification. To complete the design process the following below will be needed to complete the project.

- Complete Detail and Assembly Drawings
- 3D Models
- Presentation Renders
- Exploded Isometric with Balloons

STEP EIGHT: Fabrication and Manufacturing

As students learn more about the fabrication and manufacturing process, they use their final drawings or 3D models created to evaluate, design and manufacture final products before the process begins. Teams will work with more advanced materials and tools, such as Sintra, Plexiglas, metals, epoxies, welding materials, fasteners, and machining tools. Student will fabricate a fully functional product for review and testing.
The fabrication and manufacturing process is a critical part of product design. Once an engineer has developed a design for a product, s/he often creates an engineering drawing to be used by a machinist or manufacturer to create the product. In this design step, engineers must be careful about the details to assist in creating products that can be efficiently manufactured.

Creating a final product is the culmination of the engineering design process. And, that's where manufacturing comes in. Basically, manufacturing is the use of machines, tools and labor to make things for use or sale. Manufacturing is most commonly applied to industrial production, in which raw materials (such as iron ore, logs or crude oil) are transformed into finished goods on a large scale. Generally, it is more economical (per piece) to manufacture goods on a large scale because you can produce a lot at one time.

Although you will be manufacturing a final product, you won't be doing so on a large industrial scale. Instead, to create your final creation, you will work with more advanced materials than what you used to make your prototype. Possible materials are plywood, sheet plastic, metals, epoxies and adhesives, fasteners, as well as machining tools.

Before we start manufacturing, let's return to the drawing or 3D concept your team created. What you want to do is select the most successful attributes of your final concept drawing and incorporate them into your final product. For example, maybe you designed a promising hinging mechanism for your prototype that could work even better with sturdier materials—say pieces of sheet metal and screws. Or maybe you had trouble joining two parts of your prototype using regular classroom glue. For your final prototype you can use a more advanced adhesive, such as an epoxy.

Once you have identified the successful attributes of your final concept and thought through how you might incorporate these attributes into your final product, you will create a final engineering drawing. An engineering drawing fully defines all geometric features of a design in enough detail and clarity that another person could build that component or product. For example, "design for manufacturing" (DFM) is a process that takes the different available machining processes into consideration when completing a drawing. This approach improves communication with a machinist and the quality of the final product.

Some of the materials and building processes you use to manufacture your final product may be similar to or the same as those used to make your concept drawing. Although your final product may resemble your concept, you want to focus more on craftsmanship and aesthetics—making your final product look good! When you created your concept, you were more concerned with functionality and testing different design alternatives. Now that you have worked out the kinks in your design, you can devote your attention to manufacturing a functional and polished final product.

Fabrication

It's time to build! Now that all of your documents have been assembled and approved by the customer you can finally begin the building process. Rule number one: **SAFETY FIRST!** If at any time you abuse the fabrication lab rules and compromise the safety of yourself or your peers you will be removed from the team for a day and given a severe violation penalty of 50 points. Once again, you're on a team for a reason! Assign tasks to each member to make the process go faster.

Have you heard the carpentry expression "measure twice, cut once"? The same idea pertains to engineering. Precision cutting and manufacturing is of the utmost importance. Machines are made to cut theoretically perfect; while hand sanding is an inaccurate process. The customer expects quality over quantity at this point and a better product means a better outcome for both you and the customer…***YOUR GRADE***.

Remember other groups are using the same tools as you so be patient and wait for an open machine. Also remember you will only be given supplies and materials that are documented. If you make a mistake this costs time and money and will be added to your final cost analysis.

STEP NINE: Testing and Engineering Changes

Testing is the validation that your product works as designed and is proof of concept. Testing and verification are important parts of the design process. At all steps in the process, you may find that your potential solution is flawed and have to back up to a previous step to get a workable solution. Without proper testing at all stages in the process, you may find yourself making costly mistakes later.

Your product will be analyzed and tested to its full ability using the industry standard: ***Engineering Verification Testing (EVT)*** Engineering Verification Testing (EVT) is a specific product verification test performed on prototypes to verify the design meets desired product specifications, safety and performance. EVT consists of basic functional tests, parametric measurements and specification verification.

Unfortunately Engineering Changes are inevitable and a part of life, it's how you react to change is what makes the difference from your company being successful or not. Within the industry changes are a daily occurrence. Engineering changes can make your product better, safer and more efficient but at a cost to everyone. One simple change could cost a company millions of dollars so researching the best solution is always important before making any change. Your project will have engineering changes along the way so be patient and positive. All changes will be documented for future use which helps guide the product to the final outcome.

STEP TEN: Presentation and Final Summary Documentation

This project ends with students presenting their project plan and results of their design process with a fully defined product. Engineers in industry are responsible for making presentations in a variety of situations. Mastering public speaking will make almost any engineer more valuable in the marketplace. The basics of written and oral engineering communication are not covered in this curriculum. It is presumed those topic have or will be covered in the students' academic classes. However, it might be helpful to review the basics.

Fundamentally, communicating any idea requires that the presenter clearly identifies the relevant topic, research and gather information, then organize and reduce the information to best communicate the topic to the known audience.

Good presentations will always have an introduction portion, main content, and summary or conclusions. Students may benefit from discussing examples of effective visual aids including:

- Tables to present numerical data
- Various types of graphs and charts (bar charts, pie chart, line graphs). All need clear titles and units to be effective.
- Schematics (or line drawings)
- Photographs and maps
- Prototypes and other physical models
- Appropriate physical media will depend on the classroom resources and the time allotted to each presenting group. Consider carefully which you will use (transparencies, computer slides, blackboards, poster boards, or handouts) because each media has its own advantages and disadvantages.

Team Presentations: Each team will prepare a 10 minute presentation about its project. Students will explain the problem or need that the product is designed to solve, talk about the target audience, show how the product works and what it does, and explain the design process followed. Each team will be given a written feedback to help them think about any final product modifications. See the Presentation Rubric for grading.

Your presentation should identify the following areas:

- Have identified a target audience
- Designed a product to solve a specific problem or need
- Designed a safe product
- Designed a functional product
- Used materials appropriately

Final Summary Reflection Report

This is the final section of the project. Once you've created your product your team will be required to turn in one group Final Summary Reflection Report. Your instructor will discuss with you the details and requirements of this final report. See Summary Report Reflection Report Handout.

IMPORTANT INFORMATION

Time Management

This Product Development Challenge process often takes longer than students expect. At the beginning of class, ask yourself "what will I/we accomplish today?" and then at the end of the day with see if you met your daily goals. This helps all team members stay on target and be accountable for the project. Students must manage their time to complete the project on time and within budget. Students should plan their work while keeping in mind that other students will be work on a similar project and using machines in the fabrication lab. (see Time Management example or research your own model)

Materials and Supplies

Students may use any material or supplies needed for their project already in the fabrication lab inventory. Any special type of items or product must be approved by the instructor. Keep in mind that if you order a special part that it may take weeks to order and secure. Students can order from the following suppliers only.

- MSC Direct
- KBC Supplies
- Reid Tool
- Carr Lane
- McMaster Carr
- Others (special orders by approval)

Fabrication Lab Equipment

Students will have access to any and all equipment in the fabrication lab that has been safely instructed to them in class. At no time will a student use a machine they are not familiar with until the instructor signs off on its use. Students should plan and work with the Instructor and Fabrication Lab Technician to schedule time needed to help with any machine set-up or custom made parts. It may take weeks to design and fabricate new parts and products using the CNC machines or welders. Failure to make arraignments to use machines and work with instructor is the responsibility of the group. Instructor will have a sign-up chart to help each group. ***"First come…..First Serve"*** Please plan your groups work in advance and be ready to work on the scheduled build date(s). If your group is not prepared and organized on the given date(s) you will be placed at the end of the list.

Helpful Hints and Questions to Consider

- The possibilities are almost endless, but why wait, Let's create something right now! Within the Product Development Challenge you and your group will work to take an idea and make it into reality. This challenge will go beyond the computer, and into the actual building of a product. Now's your chance to apply what you've learned!
- Be sure to read each of the steps listed above, and follow them closely. Should your group get stuck be sure to ask your instructor for help to get you back on track. Most importantly, be safe and have fun!
- Though it may seem like a big project with a lot of grades and responsibility try not to get discouraged. The important thing is to work with your team and stay organized. We've set aside plenty of time for you to get everything done as long as you stay on task and work hard.
- Work with your new group to start ***brainstorming*** some ideas. Don't get caught up in trying to figure everything out today. Here are a few suggestions of things to get started on:
    - Team name
    - Create a list of at least 5 different ways to complete the challenge
    - Assign roles to your team members
    - Share contact information (email, phone numbers, etc.)
- Create a calendar and assign each person task to complete. Start to sketch some ideas on paper to show what you want to build.
- Keep people constantly informed of your progress and what you are working on.
- What are the most important attributes of a successful engineering business and product?
    - ***Self-Awareness:*** Understand your capabilities, strengths and weaknesses
    - ***Foresight:*** Be aware of coming trends both economically and in your field
    - ***Adaptability:*** Do not limit yourself or be afraid to grow or expand
    - ***Integrity:*** Never sacrifice quality for financial gain
    - ***Honesty:*** Always be upfront with your clients
- All team members have a voice and are sure to offer ideas and suggestions to make your project better. After all, participation is part of your grade!
- Remember that you're part of a team for a reason!
- Be prepared to make sacrifices
- Assemble the RIGHT team and do not discount chemistry
- All team members have a say in the direction of the new product
- Before a single part is cut you'll need to turn in a complete set of drawings with a bill of materials and cost analysis. When thinking about different parts consider the tradeoffs. While one material may far exceed your requirements its cost may be outside of you or your budget.

Time Line – Weekly / Monthly Event Schedule

Description	***Week No.***	***Days of the Month 2016***
• Introduction / Research o Choose Team o Company Name /Logo o Flow Chart o Product Name o Design Process	Week 1	Jan 4th – Jan 8th
• Design o Complete 2D /3D Drawing Set	Week 2 – 9	Jan 11th – Mar 4th
• Fabrication o Material / Parts Distribution o Prototype	Week 10 – 18	Mar 7th – May 6th
• Performance Testing	Week 19	May 9th – May 20th
• Team Presentations	Week 20	May 23rd – May27th
• Engineering Report Due	Week 21	May 31st Only

o *Time line may be subject to change*

- ***Special Note:*** You should be working on all designs, cost sheets and photo documentation from the beginning of the project. These items will be an ongoing process and checked periodically and turned in for grading during each marking period and will culminate with your final grade.

Grading / Assessment

Team efforts are measured according to multiple factors including the design, fabrication, testing and participation. The final product will be measured first, by its function. Does the solution solve the problem defined by the customer and does work properly? Does the solution use unique or just the required materials? Is the solution's starting size within the specified limits? Was solid research used to determine the best outcome of the project? The second is how the solution compares to the competition.
See below for group scoring and grading.

- Points will be earned and calculated by using the entire design and fabrication process while successfully completing the Product Development Challenge. Your group will turn in assignment throughout this entire process. Use this chart below to start gathering your information for turn-in.
    - Company Name – **25 pts**
    - Company Logo – **25 pts**
    - Company Flow Chart – **25 pts**
    - Product Name – **25 pts**
    - The Design Process – **25 pts**
    - Complete Drawing Set – **200 pts**
    - Associative and Final Cost Analysis – **100 pts**
    - Final Product – Fabrication and Finish – **300 pts**
    - Photo Documentation (50 photos minimum) – **75 pts**
    - Teamwork / Participation– **100 pts**
    - Performance Testing – **200 pts**
    - Group Presentation – **200 pts**
    - Final Summary Reflection Report – **100 pts**

    Total Project Points: 1400 pts

Specialized Individual Grading: Though your company and group will be graded in many areas you will also be given an individual grade based on your ability to work on this project.

- Students will earn 5 points a day for their performance in class based on the following area:
    - Attendance
    - Class Participation
    - Research
    - Lab Safety
    - Clean-Up
- Students will lose points for each of the following infractions:
    - Cell Phone Use (per use) – 10 pts
    - Prohibited Internet Use (Examples: non-research, YouTube and or games per use) – 10 pts
    - Safety Issues in Classroom or Fab Lab – 50 pts
    - Other infractions determined by the instructor – up to 50 pts
- Students will receive no points for any and all Unexcused Absences

Note: Instructor will have a daily chart indicating points given. Any questions about points please refer to the instructor for clarification.

Educational Standards

- *Common Core State Standards for Mathematics: Math*
    - 1. Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale. (Grade 7 - 12) [2013]
- *International Technology and Engineering Educators Association: Technology*
    - P. Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. (Grades 9 - 12) [2013]
    - Q. Develop and produce a product or system using a design process. (Grades 9 - 12)
    - R. Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. (Grades 9 - 12) [2013]
- *Next Generation Science Standards: Science*
    - Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (Grades 9 - 12) [2013]
    - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (Grades 9 - 12) [2013]