Designing an Alternative Project for a Product Design Curriculum for High School Students

by.

Jeffrey Kirby

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ABSTRACT

An alternative curriculum is designed for Engineering the Future, a high school level engineering curriculum developed by the Boston Museum of Science. It is designed on the premise that a hands-on curriculum providing an authentic engineering experience is the best method of teaching high school level engineering. The main design challenge the students are faced with is the design and manufacturing of a unique pinhole camera for a potential business they will be starting. The design challenge takes the student through the design process from the initial concept during brainstorming to a functional prototype. During the process, the students will validate their ideas with sketch models and investigate solutions to critical issues with mockup models. Throughout the project, the students will investigate solutions with the aid of the design process and make intelligent decisions based in reason. The curriculum offers an engaging opportunity for teachers to use within their high school engineering class at the beginning phase of a yearlong class on engineering.

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1. Background of Engineering in Secondary Education

In 2000, the National Commission on Mathematics and Science Teaching for the 21st Century released a report detailing the grim scenario the United States was in with respect to mathematics and science education. They identified a lack of sufficient mathematics and science education for K-12 students. Particularly troubling was that they found that American children in the 4th grade were among the best assessed of 41 nations by the Third International Mathematics and Science Study (TIMSS). However, by the high school level, American children were almost last. America has traditionally benefited from a strong industrial spirit; however, other countries are currently outpacing the United States. The report goes on to say that "34.6 of all bachelor's and 44% of all master's degrees in engineering, mathematics, and information science" were received by nonresident aliens. Upon graduation, these students who have been outcompeting American students at the university level return to their native lands and utilize the technological expertise they have gained within the U.S. (National Commission on Mathematics and Science Teaching for the 21st Century, 2000, p. 6-8).

The single most striking statistic presented in the report was the degree to which the United States declined in performance relative to other nations—from among the top to among the bottom. Children can be described has possessing a natural curiosity that fits well with a hands on curriculum—often the typical type found within an elementary situation (Kearns, Rogers, Barosky, Portsmore, & Rogers, 2001, p. 1). This hands-on approach to learning gradually decreases until the secondary level in which students are typically taught in lecture style with minimal lab interactions.

A proposed solution for raising mathematics and science assessments is to introduce

Engineering into the curriculum as a method for tying the two fields together through an authentic learning experience. The American Society for Engineering Education (ASEE) promotes that engineering provides real impact within the classroom. They say that "hands-on learning is effective, math and science come alive through engineering, and engineering is 'academic glue'" (American Society for Engineering Education, 2008).

The current trend among high schools has been to pressure educators of traditional science or vocational courses to include components of engineering within an already established curriculum in order to expose students to the material. Many of these teachers are either ill-equipped in terms of classroom resources or in their understanding of the engineering material since they are usually not certified to teach engineering, much less highly qualified. Furthermore, this type of approach doesn't allow the student to fully explore engineering from a hands-on perspective or with the depth necessary to understand the material. This method doesn't allow the unique combination of mathematics and science to occur that would normally be achieved in a dedicated engineering course (Hannon, 2008).

This in turn has resulted in many schools, the past few years, establishing their own engineering courses and states constructing standards for engineering courses to guide those schools. With the material so relatively new, many educators are at a loss for what to include in the curriculum. There has also been a rise of many outside agencies creating engineering curricula geared at high school students. The University of Colorado has established a website, TeachEngineering.org, geared at providing several activities for teachers to use within their classrooms when teaching engineering. The website is driven by community participation in terms of developing new modules for use within the classroom. Several of these activities are excellent examples of what can be used within the classroom to teach engineering. However,

since the website is focused on community involvement, there tends to be a large amount of activities to sort through with varying degrees of effectiveness. Furthermore, there is not a cohesive set of curriculum a teacher can use for an entire year within the classroom that has been aligned directly with a given states standards. This results in a website that is an excellent resource for finding supplemental activities or exercises to include in a class, but not a core curriculum to design a classroom around.

One curriculum designed for the secondary school with state standards in mind is Engineering the Future (EtF) put forth by the National Center for Technological Literacy (NCTL) at the Boston Museum of Science. The NCTL's mission is:

> ...to foster appreciation and understanding of the human-made world by infusing technology and engineering into K-12 schools and museums nationwide. By applying science and mathematics as well as engineering processes, children and adults will solve real world problems and learn about the creation and implications of technologies.

Engineering the Future has gone through an initial publication and two revisions with the latest occurring in 2008. As of publishing, the EtF curriculum was field tested among 126 teachers at 83 schools within 8 states (National Center for Technological Literacy, 2008).

The curriculum itself is comprised of a 4 unit textbook divided into 32 chapters. The style of the textbook, *Engineering the Future: Science, Technology, and the Design Process*, is unique compared to other textbooks in the relationship it has with its readers. A typical textbook presents information in a very direct and objective manner. However, in the EtF textbook, each of the chapters are written through the personal account of a different engineer in the first person perspective. The stories these engineers tell often include anecdotes from their lives as they relate to the engineering and the design process. The effect is to personalize the material students are learning while keeping it interesting and relevant. Furthermore, this is also

expressed in the Book Overview for the textbook:

> *Engineering the Future* tells the stories of real engineers, engineering students, technicians, and people who work closely with engineers. All of the chapters are based on personal stories, but of course they are not complete—it is impossible to compress a lifetime into just a few pages. Each chapter communicates not only what people do on a day-to-day basis, but also what prompted them to choose this career, and the motivation that keeps them excited about their work. Finally, each chapter presents important concepts about engineering, science, and mathematics in the context of real-world engineering jobs (National Center for Technological Literacy, 2008, p. xi).

The 4 units cover the duration of the school year and are meant to each take a quarter of the year. Unit 1, Creators of the Designed World, has the students focused on learning the design process and becoming acquainted with engineering and the thinking associated with it. In Unit 2, Sustainable Cities, the students learn about engineering static systems, structures, and supports. Unit 3, Going with the Flow, introduces dynamic systems, in particular those relating to fluid and thermal dynamics. Finally, Unit 4, Power to Communicate, focuses on electricity and its relation to communication.

These units are meant to be aligned with the National Science Education Standards as well as several state standards around the nation. Primarily, since Engineering the Future was originally introduced to Massachusetts, the state standard alignment should be highest among all states. However, data to validate this is not easily accessible since it depends on each school's test MCAS test results (available) and the curriculum they use (not easily accessible). Furthermore, the MCAS results for Technology/Engineering is significantly lower than either Biology or Physics MCAS passing rates for the state. Regardless of this, several schools using the EtF curriculum have had far better results with students passing the Technology/Engineering MCAS exam than in Biology or Physics. Because of this, the Technology/Engineering

curriculum is becoming an attractive option for many schools, especially when they learn of the EtF curriculum (Gonzalez, 2008).

For Massachusetts, high school engineering classes are held accountable to specific standards the Massachusetts Department of Education decides upon. Those standards are focused on Engineering Design, Construction, Materials, Tools, and Machines, Fluid Systems, Thermal Systems, Electrical Systems, Communication, and Manufacturing. A detailed listing of the standards and description of each standard can be found in the Appendix.

There is also a major design project to be completed during each of the units. These projects are related to the unit's subject material and require the students to think analytically about the academic topics through the lens of an engineer. During all of these projects, the design process stresses making intelligent design decisions. The EtF curriculum also includes a project notebook, or engineering notebook, to be completed during the duration of the project to aid in this. These notebooks contain all the worksheets students are supposed to work on during the project and are meant to guide them through the material as they make decisions related to the engineering design.

It is important to note that the project notebooks do not contain empty pages like a traditional engineering notebook. This doesn't allow the student to work on the design process directly on the page, but rather requires an additional notebook for the student to work on their design from. This doesn't mean the EtF curriculum is lacking in this aspect, it just showcases that the project notebooks are meant to guide the student during the design process rather than to let free process take place. The open nature of the design process is supposed to take place outside of the design notebook were free-thought can occur and the results are meant to be placed within the project notebook.

2. A Closer Look at Engineering the Future

Engineering the Future effectively educates students by being able to relate to students easily through the textbook. The textbook is extremely easy to read since it is written in Conversational English and is easily comprehensible, personable, and relatable. This allows high school students to be interested in the textbook and enjoy reading it. Also, the projects tend to be challenging, requiring students to explore multiple ideas and further their understanding of scientific topics and the design process.

This is further complemented by the high degree to which the assignments can be tailored uniquely for each school. Additionally, the task requirements can also be tailored for each individual student. For this to be accomplished successfully, the instructor would have to possess an extensive knowledge of the material being taught—this is the same for any sort of differentiated instruction occurring within any classroom teaching any curriculum. However, as stated earlier, high school engineering education suffers from the lack of a qualified population of teachers. Most engineering teachers were either trained in the sciences or vocational studies and thus they may possess some of the understanding; however, they do not possess the unique combination of skills an engineer needs.

Additionally, funding is always an issue with classes and in particular in classes that are being introduced for the first time. Engineering the Future takes this issue into consideration and is able to provide a relatively low cost curriculum, while still offering students the opportunity to explore engineering. This is mostly accomplished by having the primary building materials be cardboard, poster board, manila folders, staples, glue, and other common office supplies. In addition, EtF does require a few more expensive recurring expenses every year for a couple of

the projects. This low cost aspect is very attractive to many schools. When compared to other engineering curricula, some high schools consciously make the decision to choose Engineering the Future based on the monetary cost of the curriculum rather than by academic merit. This doesn't mean that EtF isn't accomplishing everything the best. EtF is a great curriculum for the price point; this opens up the opportunity for it to be used in many different high schools that couldn't afford pricier curricula throughout the nation (Hannon, 2008).

The Boston Museum of Science has also created a website dedicated to supporting EtF teachers by sharing curriculum material and lesson plans they have developed independently with other teachers using EtF. This support network is an excellent resource for teachers and is very attractive to new schools implementing the program as well. The website takes the form of a message board with the capability of uploading documents and images to the website.

For most of the projects, the level of engagement is high since the projects introduce new, challenging, and novel projects. However, not all of the projects can be described in this manner. The first two projects both possess this quality, to varying degrees. As a result, the student's academic understanding that serves as a basis for the rest of the course is composed primarily of material that can be perceived as uninteresting or even boring. This in lies the area for the greatest level of improvement: student engagement with the material.

In particular, the first project, Designing the World's Best Organizer, doesn't excite student interest as much as the other projects included within the curriculum or of potential projects. Even though this project is well aligned with state standards and offers an experience the students can tie together with the design process to further their understanding, students will be unable to utilize the curriculum fully because it is not aligned with their interests. The task of building an organizer seems distant to many students and uninteresting in a world where data is

primarily kept in a digital format. Furthermore, high school students are stereotyped as unconcerned with organization since they are known for being messy and unorganized. This is particularly troubling because it is the first project and thus it sets the tone for the student-teacher relationship and the student's initial perception of the class. These initial perceptions will cause challenges as the student has lost interest in the class and the teacher will now have to put forth a large effort in order to gain the student back.

Furthermore, the emphasis of the first project is not entirely on the design process as it should be. In particular there is a week and a half dedicated to just technical drawing which is not within the context of engineering. Because the students are not encountering any engineering during this period, they do not have the context to understand its purpose and reason behind the way it is performed. Lastly, once again this format discourages the learning of the students by not presenting it within an appropriate forum such as an engineering design challenge.

As is shown, there is a growing and compelling need for engineering education in secondary schools. One of the textbooks used in such curricula, Engineering the Future, has been utilized at many schools across the country; however, this particular curriculum does not meet all the needs of the secondary school student. This thesis suggests ways that Engineering the Future materials can be further improved to better suit the educational needs of students.

3. Alternative Curriculum Approach

When designing an alternative curriculum for Engineering the Future, it is important to take into consideration the positives and negatives of the original project as well as the curriculum as a whole. Besides being accurate and aligned with state standards, the primary goal was to produce a project that was engaging to the student while being affordable for the school to implement. A project having students design and build their own pinhole camera was decided upon for being engaging, focused, and offering many different design possibilities.

The level of engagement was gauged based upon feedback from several instructors and instructors-to-be of the EtF curriculum, students at a local Boston high school, and students at the Massachusetts Institute of Technology. The pinhole camera offers high school students the opportunity to design a product they probably would not have had experience building or using previously. This allows all students to start from equal footing and learn the material together. Furthermore, their product can be taken home after the completion of the project and used on a daily basis if they wished to. This will allow the students to gain a sense of joy and accomplishment when they use it at home; other children will also be able to learn about engineering when they come across the pinhole camera at the student's home. The pinhole camera also introduces students to photography when they may not have previously had the opportunity.

The pinhole camera project is also focused and appropriate with respect to scope in that it requires the students to design and build a pinhole camera. The principles of a pinhole camera are very simplistic in nature and require the use of a minimal amount of equations. This lends itself very well since the students can be use with freshman to seniors in high school and the

curriculum can be taught in heterogeneous or homogonous classrooms. This means that the range of students that could encounter this project can be highly variable and it needs to be designed in such a way that doesn't alienate or cater to any singular subset of students.

This type of project also permits the instructor to only have to be knowledgeable in the construction of a simple camera instead of being presented with a project topic that may encompass many different projects and the technical and scientific challenges associated with facilitating them. This reduces the overall stress on the instructor in an already stressful field of employment. Furthermore, it allows the teacher to really become an expert in the pinhole camera field and eventually pass these understandings on to the students.

Additionally, this type of project allows the design process to be the focal point of the project. This will be accomplished since the students would all be trying to differentiate their designs from everyone else's to gain a sense of individuality even though they also share a common function (i.e. taking pictures). Through this they can see how the individual designs begin to become unique and what key decisions are made along the way. This will help them to identify new perspectives in which to consider design challenges and the solutions to them in the future.

Lastly, the pinhole camera project allows for many different designs possibilities and the decisions associated with them. These designs may not deal with the actual function of a pinhole camera or how it works at the basic level, but there are numerous options for a unique design. Among these potential design considerations are the structure of the body, modifying the aperture shape, size, and number, focal length, film or paper size, and any additional mechanisms a student may wish to add. These additional mechanisms can serve any number of purposes; several potential ideas include a manual film roller/dial instead of having to set the film for every

shot, a viewfinder to help aim the shot, or an attached flash to provide extra light for a shot. These additions are where the real opportunity for the design process to take hold lies. The opportunity is present for any student to create something entirely different and unique. Through this, the potential for student ideas becomes increasingly greater as the students have the previous years' projects to work from and improve.

4. Curriculum Results

The alternative curriculum is mapped in place of the first unit of the Engineering the Future curriculum. Only a few of the original tasks are still used; however, a majority of the material has been replaced. Furthermore, the alternative project was designed to use Unit 1 of the Engineering the Future textbook as reading and reference material. This allows the personal accounts of engineers and engineering to remain a part of the education students will be receiving.

The alternative project departs from the structure of the Project Notebooks allowing the design process to be the centerpiece of the unit. This is achieved by no longer utilizing the Project Notebooks and instead replacing them with an open-ended and empty design notebook. The intent of many of the worksheets will still be accomplished throughout the alternative curriculum; however, they will now be in the context of the design process and notebook. This is important since the emphasis during the first unit is for the students to become familiar with the design process instead of learning new scientific material or their potential applications.

Furthermore, there are abbreviated lesson plans for the teacher to work from when designing their lesson plans. These abbreviated lesson plans include the lesson's topics, special notes, handouts, and homework assignments due or assigned. The decision was made not to include more detailed lesson plans to allow teachers the opportunity to incorporate their own teaching style and examples instead of stressing material they may not be comfortable with and forcing them into a style not their own. This way, critical information is identified for the teacher to include for each lesson easily.

Perhaps one of the simplest, yet greatest, changes was the alteration of the presentation of

the design challenge. Instead of having the prompt of working for a struggling company that seems distanced from the student, the student is working with a friend to start their own pinhole camera company. The student serves as the engineer and is given the task of designing and building the pinhole camera. Even though the change from the two scenarios is slight, the difference in the mind of the student can be huge. For one, the actions of the student are greater in the pinhole camera activity because there is a more personal relationship with the project. The student will also look at how they can introduce their product to the people around them (their family, friends, and fellow students). Finally, this activity can also introduce them to entrepreneurship and business and their relationship to engineering. Realistically, this experience can get some, but not all, of the students to begin to think of the world in this manner, eventually making them better engineers.

In order to support students during this period, the students will learn the basic technology of cameras and their functions. Furthermore, students will independently investigate pinhole cameras and determine their operation and important variables to successful operation. Lastly, students will formally be instructed in pinhole cameras to verify their previous research or alter it. This approach will help to focus effort on the design process and differentiating ideas rather than having all the students learn the same material, (i.e. learning how a pinhole camera works).

This 9 week unit is organized in such a manner that the fundamentals are stressed in the earlier weeks so that these skills can be used throughout the rest of the term and the students can possess an educated vocabulary to use within the engineering context. These fundamental skills are the steps of the design process, brainstorming, and technical drawings. The 9 weeks are also divided into 4 major milestones: an ideas poster session, a sketch model showing validation of an

idea, a mockup model of the most critical module, and a prototype of the entire product. All of the milestones are either presented to the entire class or a smaller group depending on the time restraints and structure of the class.

The ideas poster session is when the students initially present their first concept of a few ideas for further exploration. The ideas the students will be presenting will focus on designing unique variations and solutions to a pinhole camera, which students will learn have been taught This is also an opportunity for the other students to witness other potential ideas and even pursue them or a variant if they wanted. This option will help with students who have been having trouble brainstorming an idea they wanted to pursue. The ideas poster session is also provide a context for the students to practice the technical drawing and presentation skills. Students will also participate in critiquing their peers by providing feedback to them in terms of how to improve the designs as well as offering insights they may possess.

The sketch model will help to prove whether the ideas presented within the ideas presentation are feasible and will serve as one of the chief methods for deciding which design to pursue. During this model, students will focus on making cheap models effectively with minimal time dedicated to the activity while answering questions they may have about their ideas. This will help them to realize the need for efficient thinking as well as utilizing low resources for such a low level model. Once again, students will critique and offer feedback to their peers.

For the next two milestones, the students will be focused on further developing only one of the ideas. During the mockup model, the students will be focused on solving their idea's toughest challenges or most critical modules. The form this model can take will vary greatly depending on the need of each design and how the student decides to approach it. Ultimately,

this model is meant to help the students determine how they will manufacture their design concept. If the student already has a detailed solution for their pinhole camera design and is ready to pursue a prototype at this time, they can investigate adding additional mechanisms or creating a unique body and visual design work. Finally, students will critique and offer feedback to their peers.

Students will finish the unit by building a functional prototype that looks and acts like the final product as if it came off a production line. The product should be demonstrable and finished photos should be able to be developed. Students will present their product and business to the class as the culmination of the unit.

The first three milestone deadlines occur at 1 and 2 week intervals with the final milestone occurring after a 3-week gap. A schedule of deadlines is shown below.

Week	Milestones
Week 1	
Week 2	
Week 3	Ideas Presentations
Week 4	Sketch Models
Week 5	
Week 6	Mockup Models
Week 7	
Week 8	
Week 9	Alpha Prototype

Table 1. Schedule of Deadlines for Alternative Curriculum

5. Validation and Critique

When fully completed, this engineering curriculum will be assessed within an academic setting in the future. However, the perceived strengths and weaknesses can be judged now. It is important to remember that this does not replace a more proper assessment occurring from actual field testing of the curriculum. It is still useful for the instructor to enter the class knowing these strengths and weaknesses so that they can counteract them in their actual instruction until a better solution or design is developed.

In terms of its strengths, the pinhole camera alternative project is a cost effective and engaging project for a high school engineering class. The single most expensive component of a pinhole camera will be the film, which is sold for just a few dollars plus the cost for the film to be developed. Every other component can be made from low cost parts such as cardboard or discarded items such as a shoebox or aluminum can. The modifications a student may make to the camera will increase the cost; but, if this is done while keeping in consideration the materials needed to manufacture the part, the cost should not rise considerably.

Furthermore, the simplistic nature of a pinhole camera allows the instructors to become familiar with the concepts of the project and explore evolutions of it. It is also extremely easy to mockup many different ideas cheaply and quickly which can be useful both to the teacher and student during the design process. This allows the brainstorming and sketch model phases to be done extensively in order to model different ideas while deciding between multiple decisions. Lastly, the topic is easy to explain to people not familiar with cameras or photography resulting in this not being an barrier to understanding the engineering design process.

One of the most important areas a curriculum needs to be validated in is in the alignment

with state standards. If a curriculum is developed, but is not aligned with state standards, it will not be used within the classroom, regardless of how interesting, engaging, or useful it may be. If a teacher cannot comfortably use the curriculum in the classroom without added effort or activities, they will just not use it and find an alternative solution. This is primarily a result from time restrictions and time commitments places on the teacher which leave many without much time to plan and develop lessons.

This curriculum meets the following Massachusetts state standards in Technology/Engineering for High School:

1.1 Steps of the engineering design process.

1.2 The engineering design process is used to solve problems, advance, society, and modify technologies, objects, and processes.

1.3 Multi-view drawings and pictorial drawings are produced using various techniques.

1.4 Scale and proportion are applied to orthographic projections and pictorial drawings.

1.5 Plans, diagrams, and working drawings are used in the construction of prototypes and models.

All of the standards are addressed repeatedly throughout the course of the 9 week unit. Standard 1.3 and 1.4 are the only ones that may not be addressed as fully as the others and they have their own dedicated work days so that the students will have experience with multi-view drawings and the techniques to draw them. Students are also encouraged to use scale and projection during their drawings to help them fully understand the size and relation of parts for their designs. This compares the same to the first project, which meets the same Massachusetts state standards. Therefore from a standards perspective, the alternative curriculum can be substituted for the first project as part of the Engineering the Future curriculum.

6. Conclusions and Recommendations

Primarily, the largest influencing factor for any area of improvement lie in the validation of the curriculum and the need for it to be field tested in a school environment. Without this level of quality assured, there will always be questions regarding the effectiveness of the curriculum within a school. This is why this curriculum will be released to the Engineering the Future message board for teachers to view and use in their classroom as well as specially adapted for a Boston area high school in the fall. These steps can help to further the development of the alternative curriculum as potential areas for improvement are identified and solutions are created.

From the student perspective, the level of interest and engagement will need to be assessed better. This may require a quantitative assessment or can be done subjectively. Furthermore, the students' incoming knowledge needs to be assessed to ensure that the level of questions asked of them will not be too hard or too easy for them to solve. However, this will probably not be a problem, since the topics are themselves easy, while the challenge lies within the actual design process and can be adapted on a student-by-student basis.

From an instructor's perspective, the curriculum can be expanded to include detailed lesson plans that are suitable for a substitute teacher to use and understand should the classroom teacher be unable to attend class. These lesson plans should include all the important relevant data for each day's lesson such as topics, notes, and schedule. Also, as each year progresses, documentation of past years will be important to have for teachers to share with their students. This will serve as examples for the teacher to use during lecture or board material. The teacher can also use these examples as stimuli for introducing new topics or having students determine how they would improve certain designs.

The next step in designing the curriculum is to redesign all the materials in a professional manner so that they fit the look of the Engineering the Future project notebook structure. This will allow consistency from project to project as the students complete the different units throughout the year. Furthermore, the curriculum can benefit from the inclusion of more consistent examples and diagrams throughout the pages of the project notebook. This will allow the student the option of referencing a page when completing their own work.

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Appendix-Nine Week Schedule of Lessons and Homework

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1	Course Intro What is Engineering	What is Product Design	Mini Design Challenge	Mini Design Challenge Presentations	Creativity and Strategies
	Read Chapter 1 *Task 1.1*	*Read Chapter 2* *Task 1.2, Part 1*	*Task 1.2, Part 2*		*Read Chapter 3*
2	Design Challenge Brainstorming	Customer	Finding Information	How Cameras work	Ideas Presentation Logistics
	Individual Brainstorming	*Observation Exercise*	*Read Chapter 6*	*How Pinhole Cameras Work*	*Determine Ideas for Presentation* *Read Chapter 4*
3	Tools for Technical Drawing	Technical Drawing	Work Day for Ideas Presentation	**Ideas Presentations**	Choosing the Best Idea
	Task 1.3	*Read Chapter 5*			*Pugh Charts and Decisions*
4	Sketch Models	Product Teardown	Teardown Activity	Gantt Charts Murphy's Law	**Sketch Model Presentations**
	Chapter 7		*Teardown Activity*		

5	Mockup Models	Deciding on a Mockup Model	Customer Needs and Product Form	Safety and Design for Assembly	Mockup Work Day
	Determine areas that contain questions for camera design	*Detailed Description of Mockup Model*	*Customer Needs*	*Read Chapter 8*	
6	Ethics	Mockup Work Day	Mockup Work Day	**Mockup Presentations**	Alpha Prototypes
	Personal Code of Ethics Read Chapter 9				*Final Technical Drawings of Alpha Prototype*
7	Plan, Design, and Prototype Improvements	Aesthetics	Final Presentation Logistics	Alpha Prototype Work Day	Presentation Design
		Gantt for Final Presentation			
8	Product Analysis	Business Plans	Alpha Prototype Work Day	Final Presentation Work Day	Alpha Prototype Work Day
	Product Analysis Task 1.2, Part 2	*Business Plan*			
9	Presentation Practice	**Presentations**	**Presentations**		

Appendix-Lesson Plans

Course Intro and What is Engineering

Topics Covered	Class Specifications, Expectations, Goals Class Syllabus Student Experience How the course is graded Engineering • Definition • Sample engineering fields
Special Notes	Wikipedia: "Engineering is the design, analysis, and/or construction of works for practical purposes." *It puts science to work!!!* Engineering fields • Mechanical Engineering • Chemical Engineering • Electrical Engineering • Systems Engineering • Biological Engineering • Aero/Astronautical Engineering
Hand Outs	Syllabus Other first day required sheets or parent forms
Homework Due	*None*
Homework Assigned	Read Chapter 1 Task 1.1

What is Product Design

Topics Covered	Product Design 3 C's of Design Design Process
Special Notes	Product Design: the process of using engineering to develop a product for a specified purpose Stress: in design there are many right answers (offers lots of possibilities) ...and even more wrong answers (compare to different scenarios when engineering has gone wrong such as Space Shuttle Columbia or Challenger) 3 C's of Design • Creativity to se unique viewpoints-*many possible solutions* • Capability to understand/analyze viewpoints-*academics* • Creativity to address viewpoints uniquely-*constraints and criteria* Design Process 1-Define the problem 2-Research the problem 3-Develop possible solutions 4-Choose the best solution 5-Create a prototype 6-Test and evaluate 7-Communicate 8-Redesign
Hand Outs	*None*
Homework Due	Task 1.1
Homework Assigned	Read Chapter 2 Task 1.2, Part 1

Mini Design Challenge

Topics Covered	Review of Design Process Mini Design Assignment Work session for Mini Design Challenge
Special Notes	Have the student's complete Task 1.2, they should be complete with building their cell phone holder by the end of the day. So that they can begin on analyzing their product in terms. They should analyze their product in terms of physical characteristics, cost models, etc. These are all described in Task 1.2, Part 2 of the EtF curriculum.
Hand Outs	*None*
Homework Due	Task 1.2, Part 1-Completed cell phone holder by end of period
Homework Assigned	Task 1.2, Part 2-Analysis of project

Mini Design Challenge Presentations

Topics Covered	Finish analysis Present product and analysis to small group of students
Special Notes	Students should have finished analysis at home. You can give them time in class to finish or clarify any questions if needed. Leave enough time for students to present their product and analysis to a group of students. The groups should be split into 4-5 students and they should take turns presenting. Have the students watching the presentations give feedback or fill out rubrics.
Hand Outs	*None*
Homework Due	Task 1.2, Part 2-product and analysis
Homework Assigned	*None*

Creativity and Strategies

Topics Covered	Strategies to boost creativity (Relation to 3 C's of Design) Relation to Brainstorming
Special Notes	Look for the next right answer • Think outside the box • Don't think what everyone else is thinking • Don't believe there is only one right answer Look from multiple viewpoints • Shift the context you are looking at things from • Understand other people's perspective • Think of things along different academic perspectives Defer all judgments (don't criticize or have bad thoughts) If you have the following thoughts, you are probably passing judgment • There is only one good answer • That's not logical • Follow the rules • Be practical • Play is frivolous • That's not in my area • Don't be foolish • Avoid ambiguity • To err is wrong Challenge Assumptions • Questions any assumed boundaries, norms, rules, etc. • Where you explicitly told that something is a constraint?
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	Read Chapter 3

Design Challenge and Brainstorming

Topics Covered	Design Challenge Group Brainstorming
Special Notes	Design Challenge-Start your own pinhole camera business *Your friend has been into photography for several years now and has the great idea of starting his own business. He plans to create a camera known as a pinhole camera and sell it to friends and family members.* *However, your friend doesn't understand how to design or manufacture the pinhole camera.* *Your job is to design and manufacture a prototype of the pinhole camera for your potential business. The potential options are limitless!!!* Move immediately into the group brainstorming session. Leave at least 30 minutes for this part of the lesson. Explain the setup of the group brainstorming session and divide students into groups of 5 and have them begin working immediately. Students will need: • Blank paper • Markers • Large poster paper
Hand Outs	Group Brainstorming
Homework Due	*None*
Homework Assigned	Individual Brainstorming

Customer

Topics Covered	Product Opportunity Customer
Special Notes	Product Opportunity = idea + customer +market +feasibility *Everything but feasibility is an opportunity* Customer • Who will use the product • Who will buy the product Conduct Interviews will possible customers • Identifies potential for opportunities • Clearly defines product goals, constraints, and criteria • Refines and tests idea Break students into their groups of 5 and divide the observation exercise locations among each other. Remind them this will be due Thursday.
Hand Outs	*None*
Homework Due	Individual Brainstorming
Homework Assigned	Observation Exercise

Finding Information

Topics Covered	Share Resources and how to use them Information Scavenger Hunt
Special Notes	Potential Resources • Libraries • Textbooks • Journals and Magazines • Google Scholar • Wikipedia (though not the most reliable source) • Patents • Websites • Etc. Have students break up into groups to complete information scavenger hunt. Tell them it will be due by the end of the period.
Hand Outs	Information Scavenger Hunt
Homework Due	Information Scavenger Hunt due at end of Period
Homework Assigned	Read Chapter 6

How Cameras Work

Topics Covered	Observation Exercise Sharing Session Cameras and how they work
Special Notes	Allow 5-10 minutes for students to share with their group what they observed. Resources • www.howstuffworks.com/camera.htm • www.howstuffworks.com/question131.htm • www.instructables.com (excellent resource for building projects) • en.wikipedia.org/wiki/Pinhole_camera Students should know what each of the following is, its purpose, and how it effects photographs: • Pinhole size • Pinhole depth to film • Type of film or photographic paper Students should also know what flashes, tripods, zooms, shutters, viewfinders, etc., so they can decide if they want them in their design.
Hand Outs	*None*
Homework Due	Observation Exercise
Homework Assigned	How pinhole cameras work

Ideas Presentation Logistics

Topics Covered	Logistics of Idea Poster Session Grading Criteria for Ideas Poster Session Work session for Ideas
Special Notes	Logistics • Each person will come up with 1-3 ideas (is determined by length of period and amount of students. If each student can present 2 times, than each student will prepare 2 ideas). • Each person will present their ideas in a 1 minute elevator style speeches for each idea • Presentations will be to their group • Students watching will fill out a critique form • Posters will be a standard size determined by the teacher
Hand Outs	*None*
Homework Due	How pinhole cameras work
Homework Assigned	Determine Ideas for Presentation Read Chapter 4

Tools of Technical Drawing

Topics Covered	Rules • Use basic shapes • Doodle/practice makes better technical drawers The Basics • Lines • Ciricles • Ellipses • Perspective • Shading and Lighting • Shadows • Highlights Draw Lego Pieces
Special Notes	Students should bring in or use fine liner and a black tip marker for drawing.
Hand Outs	Drawing Basic Shapes
Homework Due	Ideas for Presentation
Homework Assigned	Task 1.3

Technical Drawing

Topics Covered	Pop-quiz on Technical Drawing Work on Task 1.3 in class
Special Notes	Quiz should only take 5-10 minutes at the beginning of class
Hand Outs	*None*
Homework Due	Task 1.3 at the end of class
Homework Assigned	Read Chapter 5

Work Day for Ideas Presentation

Topics Covered	Work day for Ideas Presentation
Special Notes	Provide materials for posters and drawing Students can also practice speeches
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	Finish posters for presentation tomorrow

Ideas Presentation

Topics Covered	Student Ideas Presentations
Special Notes	Give instructions for presentations and hand out feedback forms Break into groups of 5 students and begin presentations Students should hand in forms by the end of the class period
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Choosing the Best Idea

Topics Covered	Pugh Charts Student Pugh Charts
Special Notes	Create a sample Pugh Chart using common products such as cell phones. Have the students determine the metrics with your guidance and then rank them. Students should start to make their own Pugh charts. Also pass out critique forms from yesterday without names Remind students that they should not use the Pugh chart to calculate the best idea. Rather they should use it to help formulate and organize their ideas when going through the process of deciding.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	Pugh Charts and Decisions

Sketch Models

Topics Covered	What are Sketch Models How to make sketch models
Special Notes	Stress that sketch models answer questions and they are not just 3-D representations of the poster. If the student did not learn anything new about their design than they haven't made a sketch model. Sketch Models are a 3-D analog to sketching • Articulate an idea • Understand the products scale • Explore user interaction and operation • Understand workings of the idea *A sketch model is very simple model used to showcase ideas in 3 dimensions. Most sketch models can be distinguished into two segments: works like or looks like models. A works like model is used to show how something will function or to see if an idea is achievable. A looks like model is used to show how something will look. More often than not, a works like model is preferred since the function of a product is more important than the form (to an extent). However, there are a few instances where knowing what something looks like is extremely important during the design process.* *A sketch model can take almost any form. The most important idea is to get the idea across to people and most importantly to answer any questions you may have about you idea.* Sketch models are supposed to be cheap. Have the students make them out of old/used materials, cardboard, foam core, manila envelopes, i.e. think cheap.
Hand Outs	*None*
Homework Due	Pugh Charts and Final Decisions
Homework Assigned	Read Chapter 7

Teardowns

Topics Covered	Teardown Exercise
Special Notes	In their groups, students will take apart a single-use disposable camera and complete the teardown exercise Students will need: • a single-use disposable camera • a white pegboard or poster board • zip ties and mounting tape • product and part information stickers Deliverables are a pegboard or poster board that shows: • the function and form of the product • the parts and subassemblies in the product • descriptions about the parts, subassemblies, and product
Hand Outs	Teardown Exercise Product Stickers Part Stickers
Homework Due	*None*
Homework Assigned	*None*

Teardown Activity

Topics Covered	Finish Teardown Activity Informal Teardown Question and Answer Session
Special Notes	Students will have time to finish the teardown activity During this part, the teacher should go from group to group and ask question students about certain functions of the product and parts. Why were certain decisions made? What can they use from this activity that they can use in their own designs? Etc.
Hand Outs	*None*
Homework Due	Teardown Activity
Homework Assigned	*None*

Gantt Charts and Murphy's Laws

Topics Covered	Time estimation pop-quiz Gantt Charts Murphy's Laws
Special Notes	The pop-quiz will show the necessity of planning ahead and being realistic in time estimations. Origami Ball Instructions Origami Ball from http://www.hardin.k12.ky.us/japan/orig_ball.htm Pop-quiz instructions: 1. Have the students estimate the amount of time it will take them to make the origami ball and their experience with origami 2. Hand out the instructions and origami paper to them 3. Start the timer and have students start 4. As students finish, have them record the amount of time it took them 5. Collect data on finishing the origami ball. See how likely it was that they went over the time. • You can also do different statistical analysis on the data for fun or to satisfy interest Present Gantt charts and their purpose in organizing tasks. Present Murphy's Laws Basic Definition: "If anything can go wrong, it will." Key takeaways • Start early • Create a manageable product scope • Make decisions based on time • Increase workload • Outsource or engage other resources • Focus on critical components • Eliminate components • Do things in parallel, not serial operation
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Sketch Model Presentations

Topics Covered	Sketch Model Presentations
Special Notes	Present sketch models to group in same fashion as Ideas Presentation Rest of students should critique and offer feedback to presenter
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Mockup Models

Topics Covered	Define Mockup Most Critical Module or Component
Special Notes	Stress that the mockup model is to be used to answer or solve the toughest questions or challenges they have about their design. In order to have a successful Mockup Model, they will need to prove their idea will work. Share the different types of mockup models • Visual (what it looks like) • Ergonomic (how people interact with it) • Functional (working physical models) • Analytical (solid models, simulations, spreadsheets, etc.)
Hand Outs	Types of Mockup Models
Homework Due	*None*
Homework Assigned	Determine all areas in which you have potential questions about your design.

Deciding on a Mockup Model

Topics Covered	Deciding on a mockup model
Special Notes	Have students break into the groups and work together in deciding a good mockup model for each person. Students should start by sharing their homework from the previous nights which had them look at the areas of their design they had the greatest questions. Other students should also share if they think there are other areas that may be hard or troublesome as well. Afterwards, the group should work together in thinking of a solution to these questions and potential mockup forms. By the end of the period, each person should have an idea of what they are doing for their mockup model or be on track to doing so. The teacher should walk around and facilitate discussions and offer insight into the problems.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	Detailed Description of Mockup Model

Customer Needs and Product Form

Topics Covered	Customer Use Product Form
Special Notes	Remind students to keep talking to their customers and getting ideas for solutions. Major Product Success Factors • Strong connection to customer need • Contact with users • Appropriate Scope • Understandability of technology and context • Ability to test • Demonstrable Consequence: Find out key needs of your customer Interview/talk to your customers continuously • Don't have your customers fill out survey's you lose information that way and don't have the option to follow up questions or answers Sample questions • How would you like to use this product? • What do you like about current products? • What do you dislike about current products? • What would make you either buy or not buy this product? • What improvements would you make to the product? Human Use-Decompose the lifecycle • What is the products purpose? • What are the steps? • What can go wrong? Key: Form follows Function • Smooth surfaces invite touching • Red colors to avoid or draw attention • Hinges should look like the way they turn • Buttons that look like they need to be pushed
Hand Outs	*None*
Homework Due	Description of Mockup Model
Homework Assigned	Customer Needs

Safety and Design for Assembly

Topics Covered	Safety Procedures and Rules Design for Assembly
Special Notes	For an intro you can make a slideshow of the 5 or 10 safest work habits You can use www.mastclimbers.com/off_the_wall/default.asp Remind students to design their cameras so they will be easy to assemble. • Decide if parts are necessary • Combine parts • Design so that screws, tape, etc, can easily be applied • Use standard fasteners, ex. use Phillips screws not torque screws • Use Symmetry, if not label where each side goes Students should think of how to make their designs easy for assembly
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	Read Chapter 8

Mockup Work Day

Topics Covered	Work on Mockups in class
Special Notes	Provide basic materials for students to work in class. Students should make some progress on their mockup even if it is planning what their mockup will be in greater detail.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Ethics

Topics Covered	Personal Ethics Professional Ethics Examples
Special Notes	Have the students develop an idea of an ethic and compare it to the dictionary definition. Have them also give examples of personal ethics. Sample Ethics from ASME (American Society of Mechanical Engineers) *"Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by using their knowledge and skill for the enhancement of human welfare ... striving to increase the competence and prestige of the engineering profession."* Principles **Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:** **I. using their knowledge and skill for the enhancement of human welfare;** **II. being honest and impartial, and serving with fidelity the public, their employers and clients; and** **III. striving to increase the competence and prestige of the engineering profession.** Canons 1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties. 2. Engineers shall perform services only in the areas of their competence. 3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision. 4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest. 5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others. 6. Engineers shall associate only with reputable persons or organizations. 7. Engineers shall issue public statements only in an objective and truthful manner. 8. Engineers shall consider environmental impact in the performance of their professional duties.

	Engineering Ethics **Your are on thin ice when you hear ...** from Lockheed Martin "Well, maybe just this once..." "No one will ever know..." "It doesn't matter how it gets done as long as it gets done." "Destroy that document." "Everyone does it." "We can hide it." "No one will get hurt." "This will destroy the competition." "We didn't have this conversation." "If they are that stupid, they deserve to get hurt."
Hand Outs	ASME Code of Ethics
Homework Due	Customer Needs
Homework Assigned	Develop own Personal Code of Ethics, up to 8 canons Read Chapter 9

Mockup Work Day

Topics Covered	Finalize mockup Models
Special Notes	Students should work on their mockup models and presentations for the full time Presentations should be PowerPoint if capable.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Mockup Work Day

Topics Covered	Finalize mockup Models
Special Notes	Students should work on their mockup models and presentations for the full time Presentations should be PowerPoint if capable.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	Mockup Models and Presentations are due Tomorrow

Mockup Presentations

Topics Covered	Mockup Presentations
Special Notes	Students will present their mockup presentations to the entire class. Students will be asked to fill out feedback forms for presenters in their group as well as write down any feedback they may have for any of their peers in the class.
Hand Outs	*None*
Homework Due	Mockup Models and Presentations
Homework Assigned	*None*

Alpha Prototypes

Topics Covered	Mockup Model Presentations Recap Alpha Prototypes
Special Notes	What is an Alpha Prototype? The first design model that: • functions like the manufactured product • looks and feels like the manufactured product • made of materials similar to manufactured product • is manufactured differently than product Basically, it should look like, feel like, function like your final product!!!
Hand Outs	Mockup Model Feedback Forms
Homework Due	Personal Code of Ethics
Homework Assigned	Final Technical Drawings of Alpha Prototype

Plan, Design, and Prototype Improvements

Topics Covered	Work day for finalizing design
Special Notes	Students will have time to work on their final design in class as well as have any questions answered.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Aesthetics

Topics Covered	Aesthetics User Interaction
Special Notes	Aesthetics • Takes into account how the user interacts with the product along all 5 senses (Multi-sensory Design) • Generally true: People will buy what looks better as long as it meets the basic functional requirements Pleasing Objects • Golden Rectangle 1:1.618 • Simplicity vs. Complexity • Colors: Analogous and Complimentary • Smooth, curved surfaces What else makes aesthetically pleasing products?
Hand Outs	*None*
Homework Due	Final Design Drawings
Homework Assigned	Create a Gantt Chart for your project up until the Final Presentation

Final Presentation Logistics

Topics Covered	Final Presentation Logistics
Special Notes	Final Presentations will last 5 minutes All should attend and be on time Things to include: • The merits of your design • The prototype • Key needs of your customer • Technical innovation • Simple business case • Outstanding issues • Results of photographs taken with your camera The design of the presentation and its execution will be graded Let the instructor know the Friday before Final Presentations about any props or technology you will need for your presentation. *** If you can arrange it, you can invite people throughout the school to view the results of the students work the past 9 weeks. They can also offer their input on feedback forms and "grade or rank" the students.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Alpha Prototype Work Day

Topics Covered	Work on Alpha Prototypes
Special Notes	Have students work on Alpha Prototypes. Students can work on determining how to implement functions, building the model, making it look good, or on presentation design.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Presentation Design

Topics Covered	Presentation Design and Basic Structure Graphic Design
Special Notes	Basic Presentation Structure Overview, Introduction, Body, Conclusion No one can remember more than 3 points • Early on, what is your product's core benefit? What is your presentation's take away message? Develop your product's story • Go through the idea and how it has changed. • Why did you make certain decisions? • How did you find out/what are your product's user needs • You can use story boards to show how your idea has progressed along the different stages Graphic Design Layout Reminder: less is more, more is less Use systematic and consistent partitioning. Have you title in the same position all the time, etc. People like this. Use devices purposefully Borders Bullets Boxes Open Spaces Alignment/Justification Font (serif vs. sans-serif) Line length (use short ones generally) Color Differentiate role of text within presentation (red for title, etc.) Common Mistakes Can't read text (competition with background) Improper justification Using All Caps Clipart cliché's = boring!!!
Hand Outs	*None*
Homework Due	Final Gantt Chart
Homework Assigned	*None*

Product Analysis

Topics Covered	Economics/Cost Size, Weight, Power Requirements, etc.
Special Notes	Things to determine about the market • How big is it and how many people will buy • How much are they willing to pay for the product - How does this change with cost Cost • What is the baseline cost of the product - You can estimate this based on other similar products on the market Physical Characteristics • Determine size, weight, etc. for packaging requirements • Does your design have any power requirements or any variable costs such as disposable film or batteries Much of the analysis is the type required in Task 1.2, Part 2. You can use that as a guide for completing this section.
Hand Outs	*None*
Homework Due	Gantt Charts for Final Presentations
Homework Assigned	Product Analysis, Complete Task 1.2, Part 2

Business Plans

Topics Covered	Business Proposals and Plans

Special Notes	How to convince people to give you money?
	Have a credible business proposal
	
	What do you need to prove?
	• Your product is not "me too" or a copy of another idea
	• clear target market
	• Know why customers will buy
	• Know why customers will not buy
	  o Product Issues
	  o Competition
	• Anticipate a positive cash flow
	• You are confident and enthusiastic
	
	Important take away messages:
	• We have an attractive market (how big is the market and how is it going to change with time)
	• We have a competitive product (how does it compare to others on the market)
	• We have a viable business
	  o Amount of sales you can project
	  o How much it will cost to manufacture (guess based similar products or your cost analysis)
	
	What are the product's risks?
	• Market
	• Technical

Hand Outs	*None*
Homework Due	Task 1.2 Part 2 for Alpha Prototype
Homework Assigned	Business Plan

Alpha Prototype Work Day

Topics Covered	Work Day
Special Notes	Students can work on their alpha prototype and presentations
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Final Presentation Work Day

Topics Covered	Computer lab work day
Special Notes	Students can work in the computer lab on PowerPoint presentations for the entire period. This will be the only designated class period to complete the presentation. Any additional time will have to be done at home or schedule outside of class.
Hand Outs	*None*
Homework Due	Business Plan
Homework Assigned	*None*

Alpha Prototype Work Day

Topics Covered	Work Day
Special Notes	Students can work on their alpha prototype and presentations
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Presentation Practice

Topics Covered	Presentation practice
Special Notes	Students will have time to practice their finalized presentations and make sure everything works out.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Alpha Prototype Presentations

Topics Covered	Alpha Prototype Presentations
Special Notes	Students will give their 5 minutes alpha prototype presentations. Group members will rate their group's presentations.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Alpha Prototype Presentations

Topics Covered	Alpha Prototype Presentations
Special Notes	Students will give their 5 minutes alpha prototype presentations. Group members will rate their group's presentations.
Hand Outs	*None*
Homework Due	*None*
Homework Assigned	*None*

Appendix-Assignments and Handouts

Business Plan

As you develop your pinhole camera design, you will be faced with finding funding for actually manufacturing it. In order to get the money, you need to find people who will fund you (your parents, friends, etc.). To convince them, you decide to write a business plan for the pinhole camera business.

Things to address:

- The products concept and scope. How it is different than other designs
- Your target market
- Explain why customers will or will not buy
- Rough estimate of sales by month or year
- Cost to manufacture
- Selling price
- Risks
    - Market
    - Technical
- Distribution strategy

Assignment: Write a 1-2 page business plan for you new company and product.

Customer Needs

You will need to determine you customers needs related to your product.

The best way to do this is to interview your customer.

Come up with a set of questions you will want to answer your customer.

Example questions can be:

- How do you use or want to use the product?
- What would make you buy this product?
- What would make you not buy this product?
- What do you like best about other products on the market?
- What do you dislike about other products on the market?
- How would you improve these products?
- How would you improve this product (the one you are designing)?

Once you have determined a list of questions (5-10), you will need to interview at least 5 people.

Your assignment is to turn your list of questions, a summary of the interviews and the information you learned, and a customer needs diagram.

Group Brainstorming

Group brainstorming is a group problem-solving technique that involves the spontaneous contribution of ideas from all members of the group. The key is to keep the group large enough to keep momentum going, but small enough to keep all engaged.

Within your group you will conduct a group brainstorming session. The greatest benefit of group brainstorming is the opportunity to build upon each other's ideas and come up with many more during the process. There are many different methods to brainstorming. Today, you will practice just one method of brainstorming outlined for you.

Setup
Breakout into groups of 5-7
Seat participants around a table
Place appropriate props on the table if there are any
Provide each participant with a problem statement and stack of 8.5"x11" plain paper
Elect a facilitator to take notes and ask people questions

Process
Participants familiarize themselves with the problem statement and props.
When a participant has an idea, quickly sketch it on an 8.5x11 sheet (using a marker), and writes a descriptive title on the page (one sketch per page).
The facilitator records every idea with a headline (name) on the easel.

Rules
Defer judgment (don't think if your or your group mates' ideas are good, just come up with them)
Build upon the ideas of others
One conversation at a time (don't speak while others are speaking. It's just respectful.)
Stay focused on the topic (don't start speaking about what you are doing later today…)
Encourage wild ideas (how else can we come up with things people have never seen?)

Categorizing of Groups
Pinup all sketches with headlines on the wall
Groups solutions into similar groups

Make sure each group member has the collection of ideas
You will need this list later…

How Pinhole Cameras Work

Because your project for this unit requires you to build a pinhole camera, you need to understand how they work and how to build one.

Your assignment will be to come up with a 1 page paper detailing how a pinhole camera works. Think of the clearest way to get this across and you can use diagrams to show how they work.

Things to consider:

- The object you are taking a picture of and how the light rays enter the camera
- How the light rays interact with the aperture
- The path of the light inside of the pinhole camera until the film
- How to calculate the size of the aperture size and length to film
- How long the film needs to be exposed
- What is required for the camera to work
- What makes the camera work better

Individual Brainstorming

Think of 20 distinct ideas for a pinhole camera. Write these ideas on a sheet of paper with descriptive names so that you can look back on these and understand what you meant by the name designation.

There are several areas in which you can focus your ideas. You can center on many different aspects of the camera design such as: looks, functions, photo style, etc.

This activity should not take long. Remember, brainstorming is a quick process with many ideas coming out per minute. Don't care about quality; it's all about quantity.

Observation Exercise

Among your group, you will be required to observe each location. Observing means that you will take note of anything that can be helpful during the design process. Some things to consider are how people interact with objects in the area, products that you see in the area, or any lack of technology you see that should be there, or anything that may catch your eye.

Furthermore, this is to be used as a research exercise and aid in the brainstorming process in which you can find a product or a need somewhere and try to fill it with an idea you develop.

Possible Locations can be:

- A camera shop
- An art store
- A Park
- A Mall
- The internet (or specific spots)
- The Library
- Busy streets
- A photography school
- A professional photographer
- Or any place in general where the student can make observations about how people will be using cameras or taking pictures in order to come up with great ideas during the brainstorming process

Report at least one good, feasible idea back to your group

Pugh Charts and Decisions

- Analyze solutions with respect to criteria and constraints in an organized manner
- Use a Pugh chart to aid in choosing the best solution and develop it further

You have already done much of the work in the design process. Now you will need to narrow down your ideas to one that you will invest your time in for the remainder of the project time. You have already come up with many different ideas, now which one will you choose? Engineers commonly use a method called a Pugh chart to systematically rank different solutions and organize their thoughts during the decision process. A Pugh chart shows how the different designs compare to each other in respect to the different criteria and constraints, so as to make it easier to determine which solution is best.

Steps for a Pugh Chart

1. Criteria and Constraints
2. List the solutions
3. Rate the solutions
4. Determine which to use and why

Example Pugh Chart

Criteria and Constraints	**Blackberry Pearl**	**iPhone**	**Sidekick**
Cost	0	--	-
Looks	0	+	-
Call Quality	0	-	+
Extras	0	++	+

Which would you choose? Why did you choose this phone over the others? Was a certain category more important to you than the others?

Now make your own Pugh chart and choose the best solution!!!

Teardown Activity

Learn from the work of others

practice the process: relevant to sketch models learn about how different products are made
organize information so others can understand it practice organizing team to work quickly

deliverable: a white pegboard or poster board that allows one to:
easily understand the product
easily see what parts in the product
obtain specified information about the parts/product

Resources
a product to teardown (on team table)
white peg board mounted to team table
zip ties and foam mounting tape
guidelines for identifying plastics (also on website)
guidelines for estimating costs (also on website)
Polaroid camera
product and part information stickers

Need to fill out a Product Information sticker:

Product Name: Target Customer: Retail Cost: Estimated Production Volume: Location of Manufacture: Estimated Labor Cost: Cost of the Most Expensive Part:	May want to have pictures of assembled and disassembled product Packaging and unpacking experience are part of the product

Fill out Part Information sticker for each one:

Part Material: Method of Manufacture: Estimated Manufacture Cost: Number of Times used in Product:	Estimate your confidence for each answer *Guess* *Hunch* *Educated Estimate* *Know/verified*

Types of Mockup Models

Simple engineering drawings or renderings, geometric models, spreadsheets, simulations, or 3-d models used to resolve fundamental issues and risks associated with a concept.

Tackle what is your riskiest component of your design, not the whole thing. What are you most unsure of? What do you think might not work?

Types of Mockups
Visual (renderings and appearance models)
Ergonomic (functional human interfaces)
Functional (functional physical models)
Analytical (solid models, simulations, spreadsheets)

Visual Mockups
Look like the real thing
Clearly illustrate what the product will look like
Evaluate customer appeal and how the product will fit into its use environment
May be used in interviews or focus groups

Ergonomic Mockups
Test and validate human factors decisions
Determine how people will interact with the product

Functional Mockups
Key operational principle
Resolve key technical issues and functionality
Test components
Verify analytical models

Analytical Mockups
Predict how the product will behave
Engineering analysis, CAD, CAE
Economic analysis