Supplemental Materials

Table of Engineering Terminology

	Definition
Brainstorm	A method of shared problem solving in which all members of a group spontaneously and in an unrestrained discussion generate ideas. *
Constraints	A limit to a design process. Constraints may be such things as appearance, funding, space, materials and human capabilities.*
Criteria	Guidelines, rules, or tests by which something can be judged. Criteria are specific and measurable.
Design	An iterative decision-making process that produces plans by which resources are converted into products or systems that human needs and wants or solve problems. *
Design Brief	A written plan that identifies a problem to be solved, its criteria, and its constraints. The design brief is used to encourage thinking in all aspects of a problem before attempting a solution.*
Design Process	A systematic problem solving strategy, with criteria and constraints, used to develop many possible solutions to solve a problem or satisfy human needs and wants and to winnow (narrow) down the possible solutions to one final choice. *
Engineer	A person who is trained in and uses technological and scientific knowledge to solve a problem. *
Innovation	An improvement of an existing technological product, system, or method of doing something.*
Invention	A new product, system, or process that has never existed before, created by study and experimentation.*
Iteration	Repetition of the design process applied to the solution of a previous application. Many products undergo multiple iterations before meeting all design criteria.
Model	A visual, mathematical, or three-dimensional representation in detail of an object or a design, often smaller than the original. A model is often used to test ideas, make changes to a design, and to learn more about what would happen. *
Optimization	An act, process, or methodology used to make a design or system as effective or functional as possible within the given criteria and constraints. *
Process	1.Human activities used to create, invent, design, transform, produce, control, maintain, and use products or systems. 2. A systematic sequence of actions that combines resources to produce an output. *
Product	A tangible object produced by means of either human or mechanical work, or by biological or chemical process.*

Prototype	A full-scale working model used to test a design concept by making actual observations and necessary adjustments.*
System	A group of interacting, interrelated, or interdependent elements or parts that function together as a whole to accomplish a goal.*
Technology	The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants. *
Trade-off	An exchange of one thing in return for another; especially relinquishment of one benefit or advantage for another regarded as more desirable. *
Trial and error	A method of solving problems in which many solutions are tried until errors are reduced or minimized.*
Troubleshoot	To locate and find the cause of problems related to technological products or systems. *

*Definition comes from The Standards for Technological Literacy (ITEA, 2000)

Get the Salt!

Physical Science
West High School, Smithville, IL
Design Brief: Get the Salt!

Context:

Salt has many uses in today's world, one of which is to add flavor to food. Most of the salt we use is either evaporated from the ocean, or mined in salt deposits beneath the earth. In both cases, it is important to be able to separate the salt from other materials. You are an engineer for a salt mining company that mines salt that is mixed with sand and iron. As all three materials are valuable and need to be separated to be sold, it will be your job to develop a process that will separate salt, sand, and iron filings.

Challenge:

Your team will be given 10 g of a solid salt, sand, and iron mixture (mass percent of the mixture will be known). You should develop a method to separate the mixture so that 98% of each pure substance is collected. Your team will be required provide an explanation of how your process, the mass percentage of each substance in the mixture, and then an analysis of your process, including accuracy of the process and improvements you would make after testing.

Resources:

Your team may use all of the available lab equipment to develop your engineering process. You may also have a small 1.0g sample of the pure raw materials (sand, salt, and iron), if you would like to test any physical properties of the substances as you design your process. You must present your process to your instructor for approval before you can begin.

Constraints: You will only get one 10g sample of the mixture to separate. You will be given two classes to complete this assignment. The first class will be devoted to research and developing the process and the second will be testing your process, collecting your data. Your lab report which includes your procedure, reported mass percentages, and analysis will be completed as homework.

Evaluation Summary:

You will be evaluated on your team's ability to completely separate the materials, along with the quality and completeness of the lab report. For full credit, your reported mass percentages for each substance must be at 98% of the known mass percentages.

(Simple) Rubric:

Procedure Presentation to Teacher before Begin:

	Not Met	Partially Met	Met Expectations
Detailed Procedure Explained	0	1	2
Procedure justified (reasons for steps provided)	0	1	2
Justification for Procedure scientifically accurate	0	2	4

Lab Report:

	Not Met	Partially Met	Met Expectations
Problem Defined	0	1	2
Material and Constraints Given	0	1	2
Detailed and Complete Procedure Provided	0	1	2
Rationale for Procedure	0	2	4
Organized Data and Calculations Provided	0	1	2
Analysis of Results including a discussion of success	0	2	4
Conclusion including your recommended procedure.	0	2	4
Successfully Solved the Challenge	0		2

Improving your Environment

Biology
West High School, Smithville, IA
Design Brief: Improving your environment

Context:
People play an important role in the natural environment surrounding us, just as the environment surrounding us plays a role in our lives. We often modify the environment around us to improve our lives, and we can do this in ways that improve the environment as well.

Challenge:
You will need to select an outdoor space where you live that you would like to improve. This could be a balcony, backyard, or even a garden. Think of one thing you would like to improve to make the space more enjoyable. Some examples include adding or attracting desirable plants and animals, increasing the shade or sunlight in a space, removing unwanted attributes such as allergens, water courses, or animal excrement. It will be your task to utilize the design process, identify a problem or an opportunity, and create a plan, including drawings or sketches, which would improve the environment where you live. Part of the project will include justifying and explaining how the plan will improve the environment around you and how that improved environment will impact you personally. Then you will build your design and over the course of the year collect data to assess it's effectiveness. At the end of the school year, you will present the results of your design solution and how you will improve or modify it.

Resources:
You will have all available resources to research and develop the design. This includes the internet, textbook, and library books. You will be supplied with graph paper for sketching and the use of computer graphic programs is allowed. Materials to build your design may be provided depending on your design or you will have to provide you own materials.

Constraints:
This project will be developed over three class periods. Student are encouraged to identify the problem and brainstorm possible solutions during the first class, develop the design during the second class, and write the justification and explanation of the design during the third class and possibly begin construction of your design. You have to carry out your design so think about materials and budget which you have access to. Outside of class you will complete your design. You will turn in short monthly progress reports about the effects of your design. At the end of the school year, you will give a short 10-minute maximum presentation about your design and its effects on the environment.

Evaluation Summary:

Students will be evaluated on the design submitted and the accompanying justification and explanation. Then they will be evaluated on their monthly reporting of the results, and the final presentation which clearly communicates the results of the project and improvements for the future. Successful impact to the environment does not have to occur within the time frame of the project, but clear communication of the design, rationale, results, and improvements is required.

Heating Water with the Sun

Environmental Science
West High School, Smithville, IL
Design Brief: Heating Water with the Sun

Context:
A team of environmental scientists are studying how the water quality in the forest in central Illinois changes over the year. The team of three will be living in a small off-grid cabin while they do the study. The cabin relies on solar panels and a wind turbine for electricity. In order to be energy efficient and economical, the team will need a solar assisted hot water heater.

Challenge:
Your team must research, design, and develop plans for a solar assisted hot water system for three people. The plans must include drawings or sketches of the final design, materials list, total cost estimates, and an explanation of how it works. All of the research, design, planning, explanations, and estimates must be documented in a single notebook or file.

Resources:
Your team will have all available resources to research and develop the design. This includes the internet, textbook, and library books. You will be supplied with graph paper for sketching and the use of computer graphic programs is allowed.

Constraints:
Your team must design a system that costs less than $600 to build and will heat water to 90 degrees Fahrenheit. The system will need to provide enough hot water for three people to perform daily tasks such was showering, washing clothes, and dishes. The cabin will have a back-up electrical water heater for days when the sun does not shine, but the electrical system does not allow for using this more than a few days a month. Your team has three class periods to complete this project.

Evaluation Summary:
Students will be evaluated only on the materials presented in the engineer's notebook. This must include research notes, brainstorming, designs, sketches, planning, justifications, materials lists, and explanations.

Rubric for Design Notebook for Heating Water with the Sun

Notebook Includes	**Not Present**	**Present, but little effort or inaccurate**	**Met Expectations**
All notes recorded in pen. Mistakes crossed out with an X.	0	1	2
Notebook is Labeled and Dated	0	1	2
Brainstorming Notes- at least 2 ideas considered and sketched	0	2	4
All Notes and research recorded (or pasted) into notebook	0	1	2
Final Design Clearly Indicated	0	1	2
Final Design Understandable and Labeled	0	1	2
Justification for Design Provided, clear and well written	0	2	4
Justification is scientifically accurate	0	1	2
Materials List provided	0	1	2
Resources/References Listed or noted within notebook so they can be found again.	0	1	2
Design meets Criteria/Constraints	0		2

Design Brief Template.

PROGRAM /COURSE TITLE
Your School & Town
Design Brief: Title

Context:

A narrative description of the problem-solving situation. Place the challenge in a context that gives meaning to the problem for the student and fits into the realm of the course.

Challenge:

A statement which describes the design problem which the student needs to be solve.

Resources:

The basic materials and equipment provided for students to complete the challenge.

Constraints:

A list of tasks to be performed or parameters that must be adhered to during the course of the design problem.

Evaluation Summary:

A summary of how the student will be evaluated with a list of expectations that defines what the student needs to present to the teacher upon completion of the challenge.

Template
Design Loop Rubric

Competencies	Low (0-3 points)	Developing (4-7 points)	Competent (8-10 points)
Problem statement	No problem statement or problem is misidentified	A problem statement is given, but may not be clear or well defined.	The problem statement is clear and well defined.
Criteria	Few constraints and criteria are identified or criteria may not be measurable	Several constraints and criteria are identified and are measurable, but key criteria are not identified or are not measurable	All constraints and criteria for success are identified and are defined in measurable terms
Brainstorming	Only a few ideas and sketches are presented and they lack clear explanations	Several ideas and sketches are presented but they may lack explanations or rationale or only a few ideas are presented with clear explanations	Many ideas and sketches are presented in a clear manner and include clear explanations
Exploring possibilities	Only a few ideas and sketches are presented and they lack clear explanations or evaluation to meeting criteria	Several ideas and sketches are presented but they may lack explanations and evaluation for meeting criteria or only a few ideas are presented with clear explanations and an evaluations for meeting criteria	Many ideas and sketches are presented in a clear manner and include clear explanations and evaluations for meeting criteria
Selecting an approach	The selected approach consists of a rough sketch or drawing	The selected approach consists of a quality sketch drawing with little detail included	The selected approach consists of a quality drawing or sketch with accompanying details
Building the model	The model is poorly constructed and cannot withstand repeated testing and is not visually appealing to contest judges	The model either cannot withstand repeated testing or is not visually appealing to contest judges	The model is well constructed, can withstand repeated testing and is visually appealing to contest judges
Evaluating the design	There is limited or no evaluation of the design and no modifications were made to the design when model testing failed	There is a limited evaluation of the design, or design modifications were made without accompanying justification	There is a complete summary of the model testing including an evaluation of the design and include justification for changes to the design
Communicating	The final solution	The final solution consists	The final solution

the final solution	consists of rough sketches or drawings	of a quality sketch or drawing but may have limited details in the drawing	consists of a quality sketch or drawing with sufficient detail including dimensions that are neat, orderly, and on time

From: Greenhalgh, S.; Deneault, E. (2014) Problem Solving Guide. 2014 Technology and Engineering Educators Collegiate Association Competitive Events Manual. Retrieved June 3, 2014 from https://sites.google.com/site/competeteeca/problem-solving