ENERGY CHALLENGE

For American Indian/Alaskan NativeYouth

Welcome to the

AISES ENERGY CHALLENGE TEACHER AND STUDENT TOOL KIT!

This tool kit was created as a resource for students and teachers to facilitate participation in the AISES Energy Challenge. The kit can be printed and provided directly students or teachers can use it as a guide for supporting student projects. It is filled with tips, worksheets, and other resources and administrative tools needed to create a successful project! The kit can be used as a whole or any part of it can be used as a standalone tool.

All general Energy Challenge information is also available online at http://fairs.aises.org/.

Thank you and welcome to the Energy Challenge!

AMERICAN INDIAN SCIENCE AND ENGINEERING SOCIETY

Engineering Websites to Inspire Students:

https://www.eia.gov/kids/ (good site for basic energy information)

https://www.engineergirl.org/ (basic information about engineering)

http://www.greatachievements.org/ (information on great engineering achievements)

http://www.discovere.org/discover-engineering (a good site about engineering and what engineers do)

http://tryengineering.org/ (website has pages of information on engineering plus some games)

https://www.engineering.com/ (loads of links to current engineering topics)

http://www.efunda.com/home.cfm (college level material covered in engineering schools)

https://www.engineeringtoolbox.com/ (good collection of free engineering magazines)

https://www.howstuffworks.com/ (a complete package of science, technology, entertainment, fun and adventure)

http://www.eng-tips.com/ (professional forum discussing engineering)

http://www.fun-engineering.net/ (blogs on engineering, notes, research, etc.)

http://www.discovere.org/ (site of basic information plus games, activities, etc.)

http://pbskids.org/designsquad/ (shows how engineering is all around us)

http://futuresinengineering.org/ (all you want to know about engineering)

http://www.egfi-k12.org/ (great collection of magazines related to engineering)

http://www.thecivilengineer.org/ (devoted to civil engineers with a focus on environmental engineering, structural engineering, transport engineering, geo-engineering etc.)

http://www.thestructuralengineer.info/ (huge collection of journals, software, magazine and online library)

http://www.engineeringchallenges.org/ (good site focusing on international issues and challenges for engineers providing video as well as text explanation of the problems like managing nitrogen cycle, making solar energy more economical, etc.)

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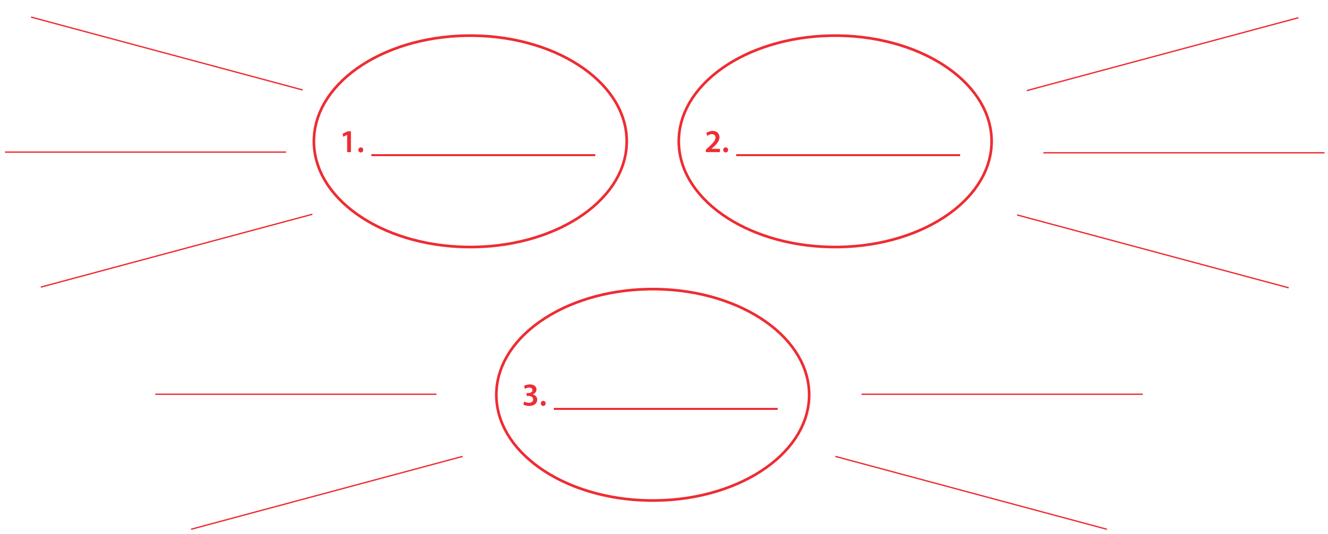
IDEA GENERATOR:

Problems of the World/My Community…

Come up with the tree biggest problems facing the world and/or your community today and into the future and put into each circle below. From each main problem, come up with three possible solutions and write them on the three lines radiating from the problem circles. Now use these terms to research more about your problems and the proposed solutions!



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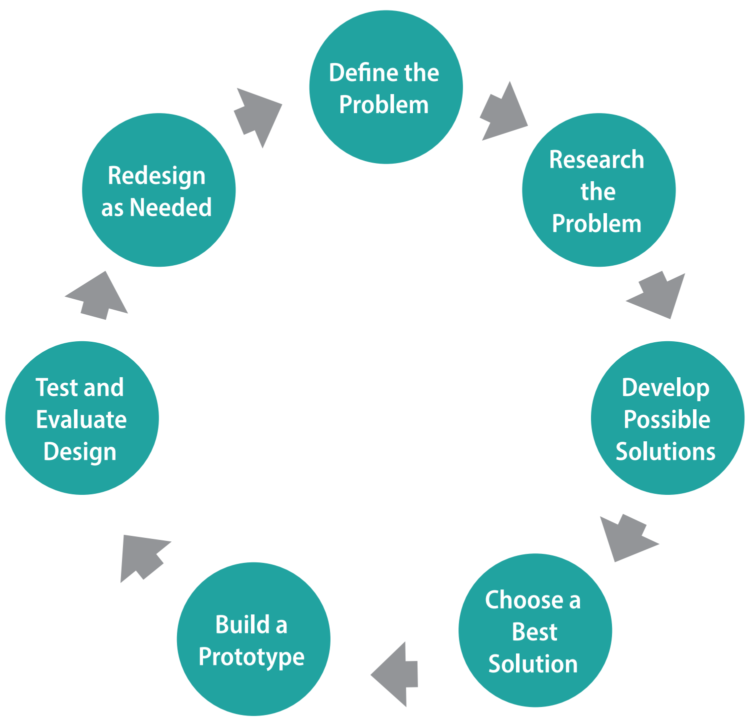
THE ENGINEERING DESIGN PROCESS IN A NUTSHELL:

- The engineering design process is a series of steps that engineers follow to come up with a solution to a problem.
    - Often the solution involves designing a product (like a machine or computer code) that fills a specific need and/or does a certain task.
    - If your project involves designing, building, and testing something, you should probably follow the Engineering Design Process.
- The steps of the engineering design process are to:



I. Define the Problem (Identify the Needs and Constraints)

II. Research the Problem

III. Develop Possible Solutions

IV. Choose the Best Solution

V. Build a Prototype

VI. Test and Evaluate the Design

VII. Redesign as Needed

- Engineers do not always follow the engineering design process steps in order, one after another. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change to your design.

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BACKGROUND RESEARCH GUIDE

Problem to Be Solved:

Key Words: (General topic area; specific terms)

Use These Questions to Guide Research:

- Who uses _____?
- How is _____ used?
- What is _____ usually made of?
- When was _____ first used?
- What changes have been made to the design over time?
- How does _____ work?
- What is a desired function of _____?
- How much does ______ cost?
- What are the parts of _____?
- Where is _____ used?
- Who invented _____?
- What problem did _____ solve?

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ENGINEERING NOTEBOOK SPECIFICS:

"An engineering notebook is a book in which an engineer formally documents, in chronological order, all of the work that is associated with a specific design project."

A good Engineering Notebook will…

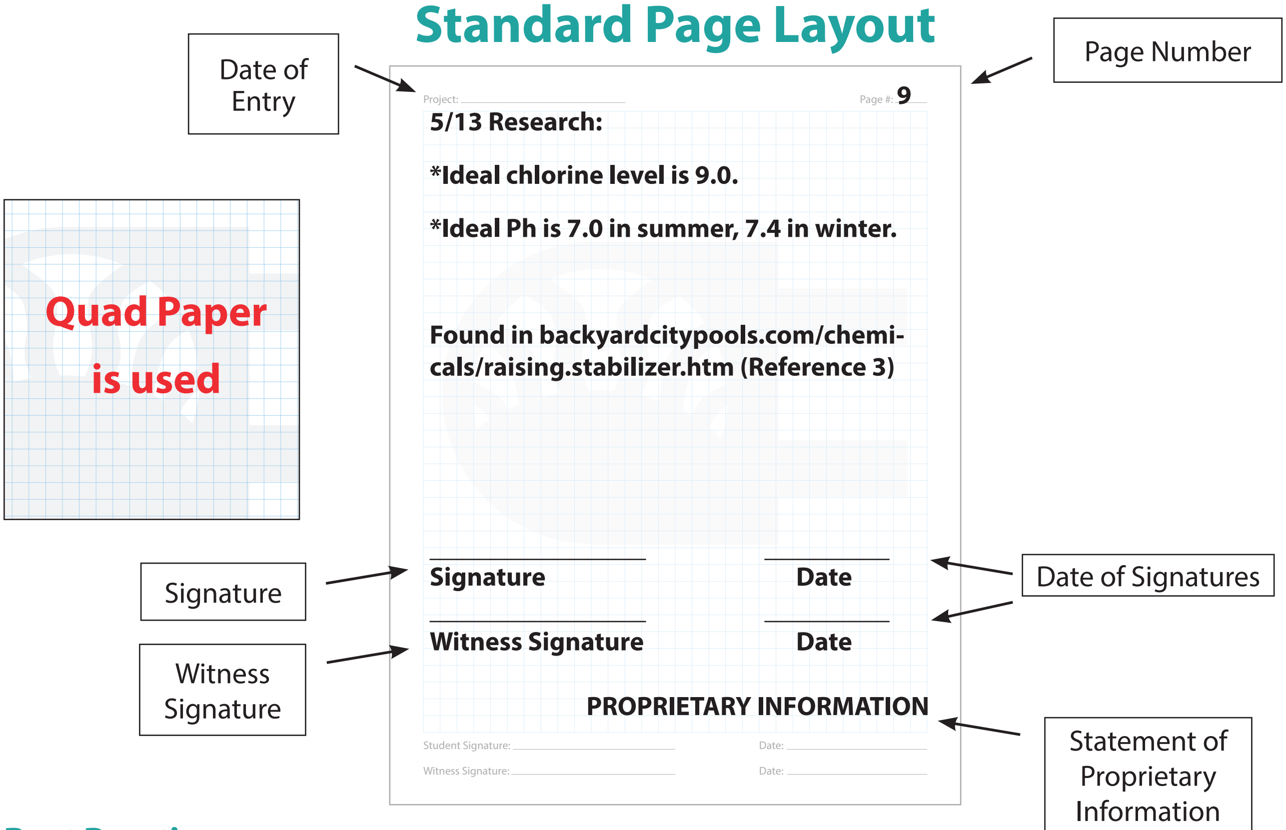
- **Include a clear and detailed description of your design process.**
- **Allow someone unfamiliar with the work to take over project without additional information.**
- **Reflect on tasks accomplished, successes, and failures.**
- **Reflect on future needs and tasks to be completed.**

The following content should/could be in your notebook:

- Discovering the problem
- Research
- Sketches with labels and descriptions
- Brainstorming
- Calculations
- Your daily thoughts and ideas
- Pictures
- Expert input (names, positions, contact info, details of conversations)
- Work session and meeting summaries
- Test procedures, results, and conclusions
- Digital technical drawings
- Design modifications
- Everything you do/think related to a specific design project
- Table of Contents

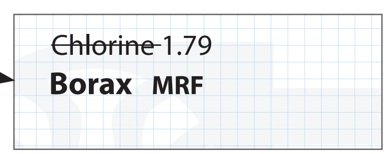
BE NEAT, BE ACCURATE, BE LEGIBLE AND BE THOROUGH!

Standard Page Layout



Best Practices:

- All work is in pen.
- Markers that bleed through the paper are not used.
- Pages are sequentially numbered in ink on the top outside edge.
- Notebooks are bound. (Cannot add pages; cannot remove pages!)
- Entries begin at the top of the page, working left-to-right and top-to-bottom.
- Do not leave blank space. If there is extra space, draw a line and sign the line.
- If you make a mistake, draw a line through it, enter the correct information, and initial the change.



- Never erase or remove anything.
- Date each entry.
- Inserted items are permanently attached
  - Glue is preferred – No loose items!
- Sign your name so that it extends across both the notebook page and the inserted document.
- Sign and date each page before the next page is started.
- A colleague or mentor should corroborate the events and facts on each page and sign as a witness.
- Store the notebook in a safe location.
- Include sketches and be certain to describe each sketch.
  - Label all parts of the sketch.
- Calculations and figures are clearly labeled.

Project: ______________________________ Page #: ______

Student Signature: ______________________________ Date: ______________________

Witness Signature: ______________________________ Date: ______________________

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Bibliography Requirements:

- At least five total sources. Of these, three reputable sources that are NOT websites must be used.
- Each source includes: Author's name, Title of article/book/etc., publisher, location where published and date.
- There should be a variety of sources (research journals, articles, books, etc.).
- The sources cited are relevant to the topic and include necessary information.
- The sources are cited in proper format.

What Does Proper Format Look Like*?:

(*Follow all formatting as shown below, including puctuation!)

Book

Author's Last name, Author's First name. *Title of Book*. Place of Publication: Publisher, Year of Publication.

Magazine or newspaper

Author(s). "Title of Article." *Title of Periodical.* Day Month Year: page(s).

If you are using a fancy scholarly journal, like American Mathematical Society Monthly, there is a different format:

Author(s). Year of Publication. "Title of Article." *Title of Journal.* Volume # (Issue #): page(s).

Website

Author(s) of site (if available) or Name of Organization. *Title.* Name of the website or Name of institution/organization affiliated with the site (sometimes found in copyright statements), if applicable. Complete URL<location=electronic address (this is generally "https://www.something.com")> (Date you accessed the site)

Devitt, T. *Lightning injures four at music festival.* The Why? Files. http://whyfiles.org/137lightning/index.html Accessed January 23, 2001.

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CHECKLIST: PARTS OF THE ABSTRACT

The Abstract is typically the last item to complete because it is an abbreviated version of the entire project. In this case, the Abstract will be a concise version of your *Research and Design for Phase 1* only.

Your Abstract should include:

(I.) Your energy problem and solution.

- Why do we care about the problem?
- What practical, scientific, theoretical or real-life gap is your research filling?

(II.) How you plan to measure and demonstrate your solution.

- What will you do to get your results?
- The method(s), procedure(s), and approach of your study is included here.

(III.) The potential social or community impact(s) of your solution.

- What will the larger implications of your findings be?
- Who will be impacted either positively or negatively?
- How will people be positively or negatively impacted by your findings?

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ENGINEERING NOTEBOOK GRADING RUBRIC

	3 points	2 points	1 point	0 points
Resources Adequately Documented	All resources are documented	Most resources are documented	Some resources are documented	Only one or fewer resources are documented
Research Adequately Documented	All research is fully documented	Most research is documented	Some research is documented	One or fewer entries related to research
Includes Drawings, Charts and/or Tables	Notebook includes 10 or more drawings, charts and/or tables	Notebook includes 6-9 drawings, charts and/or tables	Notebook includes 2-5 drawings, charts and/or tables	Notebook includes one or fewer drawings, charts and/or tables
Calculations and Measurements are Accurate	All calculations and measurements are clear and accurate	Most calculations and measurements are clear and accurate	Few calculations are clear and accurate	No calculations or measurements are shown or results are inaccurate or mislabled
Neat and Orderly	All pages are numbered and dated; All pages are signed and dated by the author	Nearly all pages are numbered and dated; Most entries are signed and dated by the author	Many pages are not numbered and dated (7-10); Many pages are not signed and dated by the author (7-10)	Majority of the pages are not numbered and dated; Majority of the pages are not signed and dated by the author
Total Score:				**/15**

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DESIGN PLAN GRADING RUBRIC:

	1 point	2 points	3 points
Problem	Addresses a practical need to which there is already a common solution, or addresses an issue of little practical value.	Addresses a somewhat practical need some people have, which may have an expensive or uncommon solution.	Creatively addresses a practical need some people have, which may have an expensive or uncommon solution.
Research	Cites one or no information resource (such as text, encyclopedia, businesses, magazines, catalogs, internet, or interviews). Material is copied rather than written in the student's own words.	Cites few information resources. Mentions known similar ideas with some elaboration. Makes a general connection to a similar idea in the student's own words.	Cites at least four types of resources. Makes a clear connection with a known similar idea in the student's own words.
Possible Solutions	Proposes three or fewer solutions, some of which may be silly. Solution description is limited.	Proposes at least three practical solutions with a short description.	Proposes three or more practical solutions. One or more are very creative. Provides sufficient description for reader to understand.
Plan and Create	Provides few details, leaving the reader unclear about how the invention works. Fails to analyze obstacles related to the practical design and function of the invention.	Provides adequate details giving the reader a general understanding of how the invention works. Provides adequate analysis of the obstacles.	Explains the invention, addressing all details, giving the reader a clear understanding of how the invention works. Provides a good analysis of the obstacles.
Revised Solutions (Problem Solving)	Revised solutions do not address the obstacles mentioned or are not practical.	Revised solutions partially address the obstacles mentioned.	Revised solutions practically address the obstacles mentioned and consider durability or other future issues.
Science Concepts	Provides limited or no explanation of science concepts. Explanation may not apply to the project.	Provides an adequate explanation of at least one science concept, which has some application to the project.	Provides in-depth explanation of at least one science concept directly applying to the project.
Total Score:			/18

DESIGN PLAN EXAMPLE:

Peltier Energy Harvesting

Holly Kaapu
Kamehameha Schools Kapālama
Grade 12

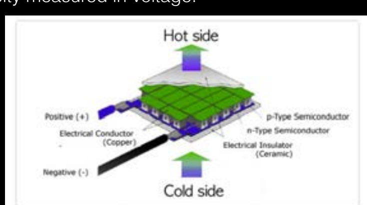
Adult Sponsor: Gail Ishimoto
Mentor: Peter Grach

Problem

Electricity is an expensive resource in Hawaii, averaging 34 cents per kw/h, the highest price in the nation. Native Hawaiians living on the rural Hamakua Coast of Hawaiʻi Island struggle to access electricity and water to maintain their traditional aspects of sustainable living. This community relies on propane as their primary energy source. Solar power and wind power are not economical options for this community. I wanted to find another way to produce clean energy that would help people who can't access the standard electrical supply. My design plan includes an eco-friendly portable device made of peltier modules that would produce a sustainable source of energy.

Research Conducted

- Peltier modules are made up of two ceramic plates, one having n-type semiconductor, the other having p-type semiconductor, with bismuth telluride between the plates.The peltier module works when each side of the module is touching both a hot and a cold surface. This will cause the semiconductor on the inside (Bismuth Telluride) to react to the difference in temperatures. With the difference in temperature the semiconductor will create an output of electricity measured in voltage.



"New Powerful Cooling." *Central DS*. N.p., 2006. Web. 22 Oct. 2015.

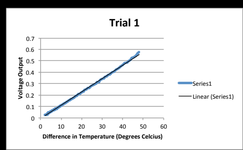
Preliminary Testing

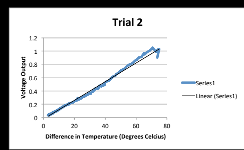
I put two peltier modules between two copper boxes that I constructed (using copper because it holds heat well). 60 degree Celsius water was placed in box 1 and 3 degree Celsius water was placed in box 2. I hypothesized that the most voltage output will be when the temperatures are significantly different. I predicted that the data will generate a linear graph according to reverse reaction of the nonlinear peltier effect (L ́opez, et.al 2014). According to (Juarez-Acosta, et.al 2015), when the two extreme temperatures reach ambient temperatures, the system will produce little to no voltage. I predicted that there will be temperature leakage over a period of time due to copper box reacting on the other three sides with the ambient air (figure 1). I then constructed an insulation box to help reduce the amount of temperature leakage (figure 2). For both systems I ran tests until ambient temperatures were reached in both figures.

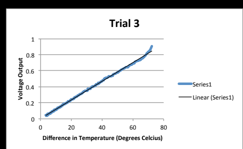

Figure 1

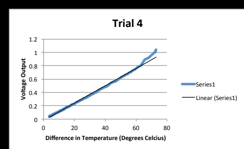

Figure 2

Preliminary Data from Non-insulated Box



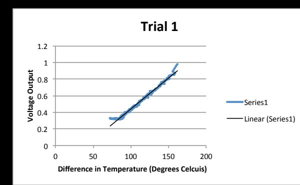


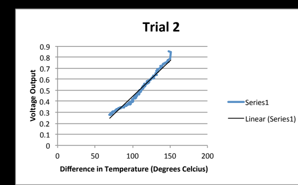




The graphs show that when the difference in temperatures decreases, the voltage output also decreases. Ice water (2 deg. C) was used for cold temperatures.

Preliminary Data from Insulated Box





The graphs show that when the difference in temperatures decreases, the voltage output also decreases. Dry ice (-82 deg. C) was used for the cold temperatures in these trials.

Data Analysis

- The data in trials 1-4 with non-insulated box shows that the trends are similar. As T2-T1 = ΔT decreases, voltage output also decreases. It also shows that when the ΔT is at an 80 degree difference then the voltage output will be greater than or equal to one volt. From this data it shows that an 80 degree difference can sustain one volt until it reaches a 75 degree difference. From the 75 degree difference mark to 40 degree difference, the voltage output can sustain ranges varying from .99 to .5 volts. From a 40 degree difference to ambient temperatures the voltage ranges from .49 to 0 volts
- The data in trials 1-2 with insulated box, shows that the trends are similar. As T2-T1 = ΔT decreases, voltage output also decreases. Dry ice was used to see what the voltage output would be at such extremes. Towards the end of the trial there was evidence that the boxes were too close together. Heat sinks might need to be utilized because the dry ice temperatures cooled the hot water to the point that there was ice on one wall of the box parallel to the other box. This data was similar to the first four trials in the way that when the temperature difference was more drastic then it produced more voltage. Better insulation will be needed to produce higher voltages that will be able to sustain themselves over a period of time.

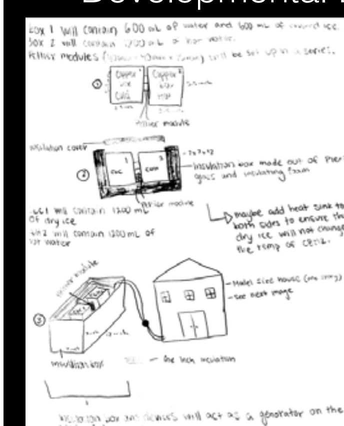
Proposed Prototype

- Based on this data analysis the prototype would include 6 peltier modules arranged in a series to light up the scaled down house with 10 LED lights. The house will be constructed with detachable panels for standard shipping.
- Pipes for hot and cold water will be placed throughout the prototype like a normal house would have.
- Fresnel Glass will be placed on the roof to heat up the water in the pipe.
- This prototype is multipurpose because the fresnel glass is heating up the water to 80 degrees Celsius for everyday use and then the hot water is circulating through the peltier system that produces electricity from the difference of temperatures (80 deg. C and ambient temperatures).

Constraints

- Development of insulation system with heat sinks is needed for this prototype, which includes completely separate insulation sections for each side to create maximum temperature differences that will produce the most voltage.
- Peltier modules have limitations on how much voltage they are able to produce depending on the size of the module. For the preliminary data, two modules were used that were only able to produce 12A.
- Fresnel Glass is a constraint for the device because depending on the thickness of the glass it will help to produce higher or lower temperatures.
- Good weather conditions are needed to test prototype and its effectiveness.

Developmental Design Sketches

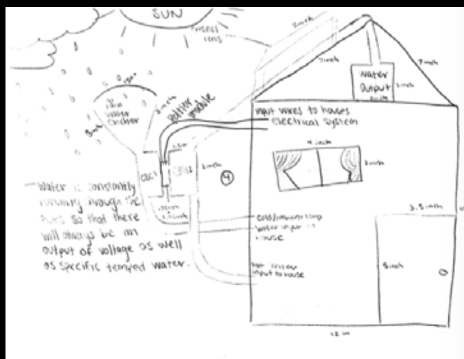


Design 1, includes two copper boxes and two peltier modules in the model.

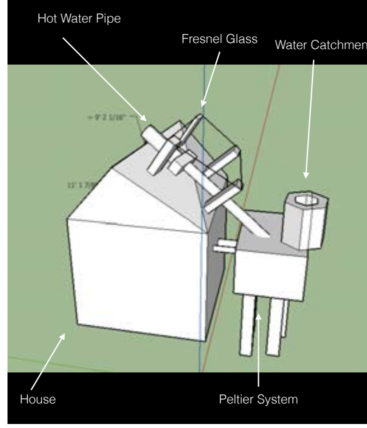
Design 2, includes everything that design 1 has except now the boxes are in a insulation box.

Design 3 is putting design 2 to the test on a model home.

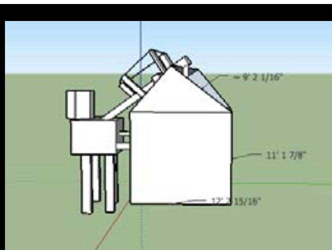
Final Design



3-D Final Sketch

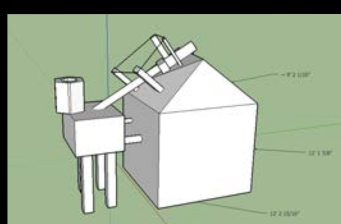


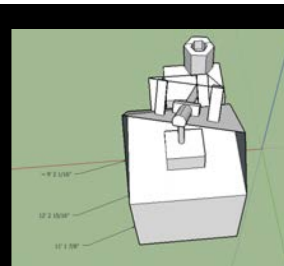
This is the prototype house with the hot water pipe coming from inside the house on to the roof, getting heated by the sun using a fresnel glass, then going through the peltier system where electricity is being generated to power the house. Then the hot water is going back into the house for consumption when needed.



View from front door.

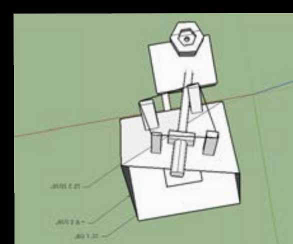
View from back side of the house.





View from above, looking into attic with roof removed.

View from above.



Budget

Total $1419.64

- 2 ft by 8 ft Copper Sheet (16-oz) $152.36
- 3 ft by 4 ft by 5/8 inch Plexi Glass Sheet $37.77
- 3 ft by 12 ft by 1 inch Foam Sheet $22.18
- Five Piece Soldering Torch $57.97
- Flux $9.36
- Solder $21.67
- Peltier Modules (6) (40mm x 40mm x 15mm) $159.85
- Plywood 4ft by 8ft by 1 inch $12.55
- Philips Bugle-Head Coarse Thread Sharp Point Polymer Coated Exterior Screws (pack) $8.91
- 10 LED single lights $74.40
- Electric Wiring 250 ft $41.57
- 3/4 Inch x 100 ft Blue PEX Pipe $61.44
- 2 Light Water Pump $22.88
- 5 Pack Fresnel Glass 7in by 11in $24.85
- Miscellaneous Construction Supplies $150.00

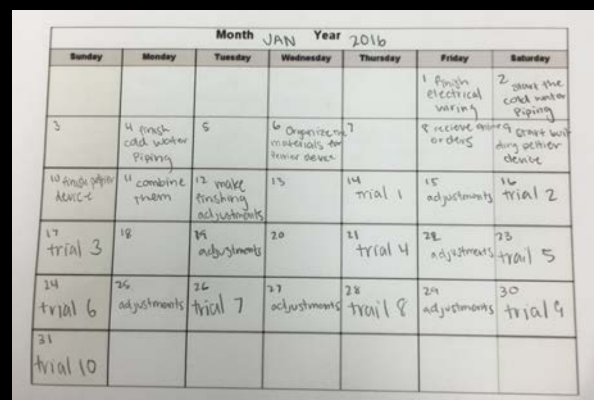
Continued on next page

Additional Supplies to Reconstruct Prototype if Revisions are Necessary

- 2 ft by 8 ft Copper Sheet (16-oz) $152.36
- 3 ft by 4 ft by 5/8 inch Plexi Glass Sheet $37.77
- 3 ft by 12 ft by 1 inch Foam Sheet $22.18Plywood 4ft by 8ft by 1 inch $12.55
- Philips Bugle-Head Coarse Thread Sharp Point Polymer Coated Exterior Screws (pack) $8.91
- 10 LED single lights $74.40
- Electric Wiring 250 ft $41.57
- 3/4 Inch x 100 ft Blue PEX Pipe $61.44
- 2 Light Water Pump $22.88
- Miscellaneous Construction Supplies $150.00

Implementation Plan

Implementation Plan



Implementation Plan

Bibliography

Flipse, J.; Dejene, F. K.; Wagenaar, D.; Bauer, G. E. W.; Ben Youssef, J.; Van Wees, B. J. "Observation of the Spin Peltier Effect."
Effect

Juarez-Acosta, Isaac; Olivares-Robles, Miguel A.; Bosu, Subrojati; Sakuraba, Yuya; Kubota, Takahide; Takahashi, Saburo; Takanashi, Koki; Bauer, Gerrit E. W. "Modelling of the Peltier Effect in Magnetic Multilayers."
Effect in Magnetic Multilayers

López, Rosa; Hwang, Sun-Yong; Sánchez, David. "Thermoelectric Effects in Quantum Hall Systems beyond Linear Response."
Quantum Hall Systems beyond Linear Response
2015.

Cahaya, Adam B.; Tretiakov, Oleg A.; Bauer, G. E. W. "Spin Seebeck Power Conversion."
2015.

DESIGN NOTEBOOK EXAMPLE:

Engineering Design Notebook for AISES Energy Challenge

Katelyn Meylor

Bear River High School

pg. 1

Engineering Design Notebook for
AISES energy challenge

background:

- goal: come up with design that can solve energy. related problem
- ideas: something in relation to local bear river water shed
  - good source of hydroelectric power (relevant to energy challenge)
  - also important because of new proposed hydroelectric dam
  - try to leverage my current work on water quality at the local watershed's i.e Bear River

main problem statement:

- how to balance hyroelectric power with clean water

web research:

- this is an important project to several Native American tribes in the present on reservations etc.
  - i.e. Osage, Cherokee, Nisenan

What is the main impact to a stream from a hydroelectric plant / dam?

pg. 2

follow up answers:

- altered river flow
- trapping of sediment and organic material
- changes in water temperature and chemistry

Are these factors covered in local water monitoring protocols?

protocol used by Sierra Streams Institute:

- SWAMP = Surface, Water, Ambient, Monitoring, Program
  - per California State Water Resources Control Board

water quality parameters covered by SWAMP:

- physical:
  - geology
  - water flow
  - temperature
  - sediment
- chemical:
  - dissolved oxygen
  - conductivity
  - pH
  - nutrients
- biotics:
  - benthic macro-invertebrates
  - algae
  - fish
  - amphibians

pg. 3

Problem Statement
(from conversations with Sierra Streams Institute staff)

- current water monitoring protocol due monthly (~16 sites) for water chemistry
- current water monitoring protocol due 2 times a year (~16 sites) for biotic factors
  - (likely to duplicate this for Bear River Watershed project)
- currently most parameters require a seperate expensive piece of equipment to sample
  - "labor intensive"

list of equipment:	Approx. cost:
1. D-net - macro invertebrate	~ $100
2. flow meter	~ $500
3. thermometer	~ $100
4. pH meter	~ $150
5. dissolved oxygen meter	~ $1000
6. conductivity meter	~ $1000
7. turbidity tester - suspended particles in water	~ $1000
8. bacteria & nutrient testing bottles	~ $50
9. depth gauge	~ $100

total approx. cost:
$4000

pg. 4

problem statement #2
(current sampling tools and techniques make it hard to correlate some data)

i.e. local water velocity and macro invertebrate
- different macroinvertebrate populations prefer different water velocities

BMI feeding guilds:

guilds	water velocity preferences
Shredders	• faster flowing, clean, cold, • high dissolved oxygen
filter collecter	• slower waters without significant turbidity
grazers	• Slower waters
predators	• slow or still waters without turbidity

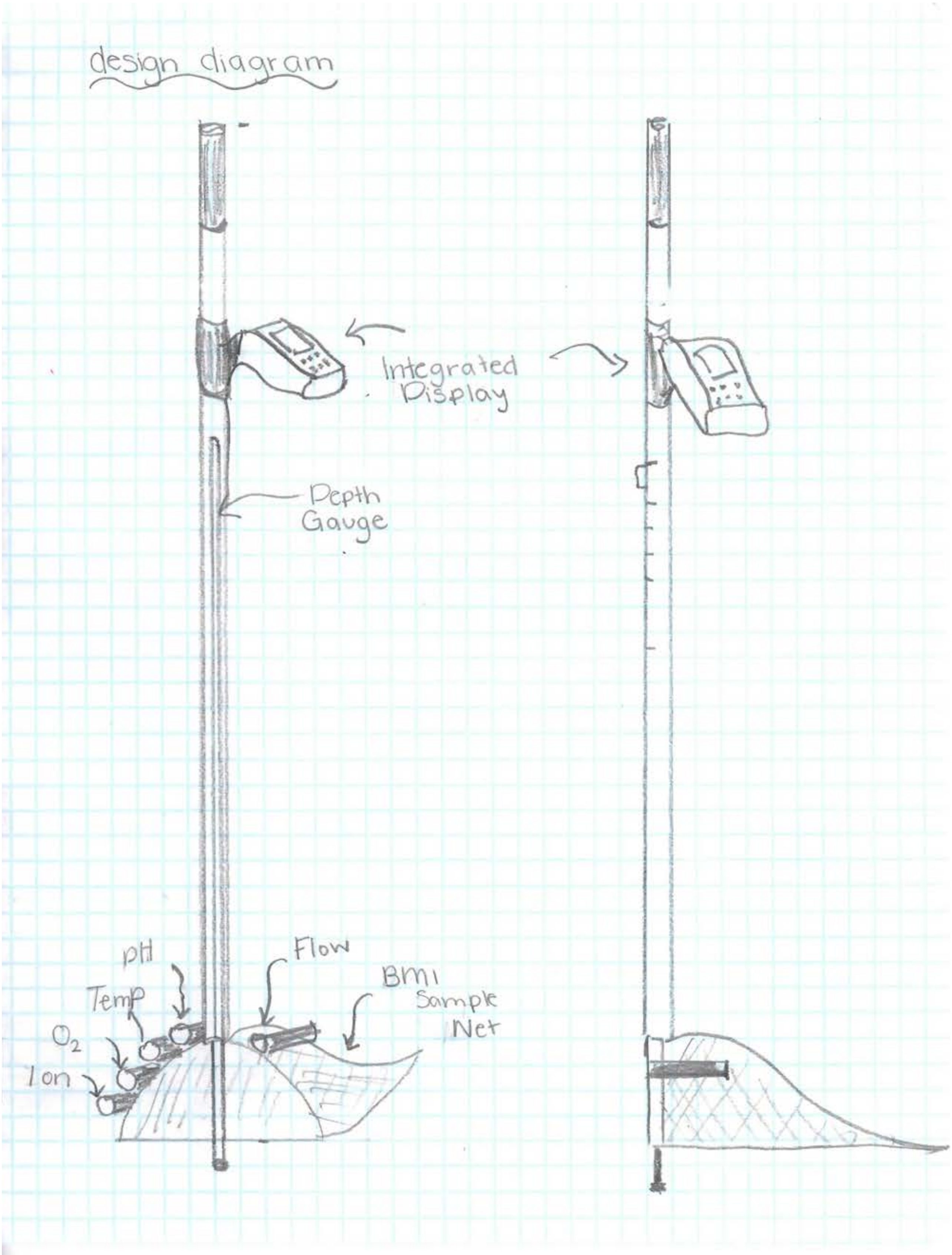
design proposal

pg. 5

- integrate multiple sensors and tools into singular device
- easy to carry by single individual
- easy to record data

design requirments
(per discussion from SSI staff)

- integrate multiple data collection elements into single tool
- easy to carry to and through a water system
- must produce reliable data
- prefer low cost
  (making it more widely available)
- light weight
  (idealy less than 5 lbs)
- must be durable
  (able to drop on rocks, in water)
- flexible
  (allow quick attachment of sensors)
- expandable
  (allow for new sensors to be added)
- provide per-transect sampling
- allow for local data capture and storage
- allow for potential wireless data transfer to stream bank


design diagram
Integrated
Display
Depth
Gauge
pH
Temp
O_2
Ion
Flow
BMI
Sample
Net

pg. 7

prototype phasing:

phase1:

- include macroinvertebrate Dnet + flow meter + depth gauge

prototype testing:

• test with Sierra Streams Institute at 10 transects on a single reach

passing criteria:

• Sierra Streams user to evaluate following criteria

- the device is lightweight, easy to carry and use
- the device allows for succesful collection of BMI + flow + depth with sufficient eqvality

phase 1 prototype cost

item	approx. cost of item
D-net with pole	$ 100
extra nets (10)	$ 50
flow meter	$ 500
thermometer	$ 100
depth gauge	$ 30
macroinvertebrate ID analysis	$ 100
total cost = ~ $ 880	

ENERGY CHALLENGE

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AMERICAN INDIAN SCIENCE
AND ENGINEERING SOCIETY

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