Example Outline: Senior Project Outline Phase

Directions

This outline is to help you organize your information into a coherent and useful format. It is due on Friday to BOTH myself and your Senior Project Advisor (attach it to your SPAM request letter). When creating this outline, please do the following:

1. **Formatting:** This outline must be typed, in 12 pt. Times New Roman. Any outline not conforming to this will not be accepted.
2. **Outlining:** This must be in outline form. This means that each topic must be numbered or lettered, and sub-points must be bulleted or lettered. See the examples linked on my DP for what yours should look like.
3. **Heading:** At the top of your outline, you must list:
    a. **Name:** Your Name
    b. **Research Question:** The final beautiful version
    c. **Senior Project Advisor:** Their Name
4. **Correctness:** As always, spellcheck and proofread.
5. DO NOT COPY! All points and sub points MUST be written in your own words
6. You MUST use this example side-by-side with the "Elements" handout that describes, in detail, the vital portions of your senior project paper. Please have both handouts with you when you begin to construct your own outline.

On the following page begins a science example from a graduated senior. See the Senior Project page of my DP for two more excellent examples.

***Before you begin**, make sure you clearly state your name, your full refined research question, and your senior project advisor's full name (first and last)*

Name: Tucker Levitt
Research Question: "*Do water arc explosions release internal water energy? If so, what is the source of the released energy?*"
Senior Project Advisor: Steve Smith

***So What???** Why is your question urgent, or of importance??? Intro should address this an d provide a thesis statement that is focused on your research question*

Part I: Introduction

What are "water arc explosions?"

1. How water arc explosions work
2. Empirical measurements have shown that the explosions are much stronger than expected and that an an explosion's kinetic energy can even exceed the electrical energy of the pulse that initiates it.
3. The problem: there appears to be more energy coming is going in (violation of law 2 of thermodynamics)
    a. Violation of the laws of physics?
    b. Where is the "extra" energy coming from?
    c. We need a better understanding of where the energy in these explosions comes from.

Hook – an excellent and intriguing question!!!

Thesis Statement: Make sure your thesis statement is clearly stated at the end of your introductory section. You should use a concessive, and acknowledge the counterargument you will ultimately refute in your essay.

Part II: Historical Context

Notice that the title of the section is numbered, in bold-faced text, and centered. It should be this way for your outline AND your final paper.

Physicist Peter Graneau

1. "Arc-Liberated Chemical Energy Exceeds Electrical Input Energy."
2. Study produced unanticipated results: Energy coming out was more than going in.

How Graneau approached his study

1. How he set up the experiments
2. Techniques for gathering data
3. Observations – more energy coming out than coming in, and how much.
4. Conclusions
    a. No other studies confirmed or denied this conclusion

For this section, you need to put your question into its historical context. What factors make your topic important to study right now? What events are occurring in our everyday world that highlight the need for your research?

Transition: This paper proposes a theory on the source of the energy released during a water explosion and presents experimental evidence supporting this theory

Part III: Summary of Past Research

This section should be heavily cited, and include arguments from most of your major sources. Do not include your voice or opinion, you must present opinions of others in a non-biased way.

Tip: *Organize your summary into "kinds" of arguments, don't necessarily go source by source.*

The origin of water arc explosions

1. First described in 1907 by John Trowbridge (Harvard), but not studied in detail until Graneau in mid 1980s.
2. Focus on Graneau's detailed study
    a. How he constructed experiments
    b. His observations (explosions unusually strong)
    c. Photographic Evidence (Hathaway and Graneau)
    d. Not steam, but water
    e. Water explosions actually tear the water, whereas steam creates "adiabatic" expansion.
    f. They coin the term "cold fog explosions" to acknowledge the important differences between the properties of water and steam.

Azevedo's studies.

1. 1986: Azevedo established that water explosions can accelerate the fog to supersonic speeds and that the explosions are highly current dependent (electricity input).
2. Graneau confirms that water arc explosions do exceed the electrical energy of the current pulse used to initiate it.
3. Subsequently, Graneau conjectures: "the most likely source of the explosion energy is that stored by hydrogen bonds between water molecules. This bond energy is said to be equal to the latent heat of evaporation..."
4. Graneau does not provide experimental evidence to support theory.

Neil Graneau (Graneau's son) offers more data

1. Electrospraying
2. Disassociating the water into a highly ionized aerosol.

Hathaway: a critique of Graneau

1. Graneau's claim's violate the second law of thermodynamics
2. Ambient heat cannot be converted directly into directed kinetic energy
3. Graneau's rebuttal

Check it out! It is vital to your essay that you provide competing arguments in this section. Without this, your analysis/conclusion will suffer.

Tag's study (1980)

1. Presents mathematical defense of Graneau
2. Liquid can hold more energy per unit mass that water vapor.
3. Condensation is exothermic
4. Transition: Tag concludes that the amount of heat energy released during condensation is slightly less that the latent heat of vaporization...

Part IV: Findings and Analysis

Intro: I built a contraption to try and replicate Graneau's experiment, and to discover to what extent I can reach similar conclusions with my own data.

1. How I designed the experiment
    a. The power source
    b. The measuring instruments
    c. The explosion chamber
    d. The projectile

2. Applied mathematics
    a. I will present the formulas I used to calculate the movement of the projectile, and the meaning of this movement for energy released. I will show my calculations and data in this section

3. My Data
    a. Present my data
    b. What my data means (data analysis)

The findings/analysis portion is the most difficult for students. This is where you want your voice and opinion to shine through.

If you did your own research, your techniques (methodology) go here. It is also a place to address the strengths and weaknesses of your work.

If you did not, this section will be shorter and is meant to find gaps, omissions, and common ground within the arguments of others (presented in part 3). Cite heavily. Think of it this way: This is how the research of others is flawed, conclusive, or incomplete, and how your research is different.

Part V: Conclusions

Use this section to draw meaningful conclusions about your research question in a convincing way.

Your voice – no (or few) citations!

What does past research (pt 3) and your interpretations of that research (pt 4) have to say about your research question?

SO WHAT??? Why are your conclusions important going forward? What are the implications of your research? Circle back to intro.

Conclude by returning to your research question and answering it. Your audience should be clear it has been answered, be reassured of the importance of answering this question, and be excited about the future implications of your research conclusions. GO OUT STRONG!

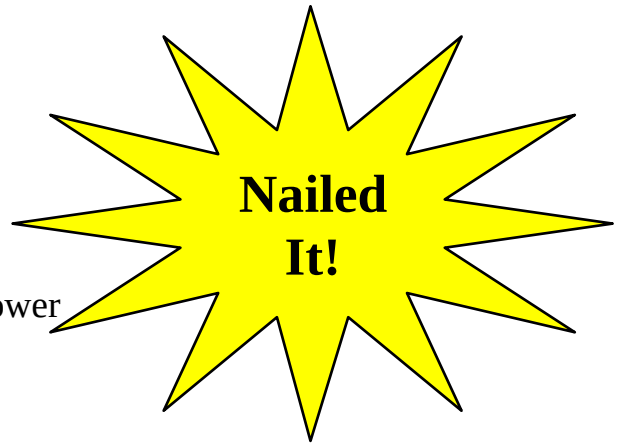
1. My first goal of this project was to verify that water arc explosions liberate stored potential energy.
    a. My data indicates that this is indeed a possibility
    b. Show data in terms of this goal, and elaborate on this possibility
    c. My data is consistent with the findings of Graneau
    d. Note: accuracy of kinetic energy measurement depends largely on the explosion's actual velocity-mass distribution. I'll elaborate on this further in a separate paragraph.

2. My second goal: determine the nature and source of the energy released.
    a. Restate the idea of an “over-unity” explosion (more output than input)
    b. Restate properties of liquid vs properties of fog and water vapor.
    c. Look at findings in terms of my goal, and the above stated properties
        i. The amount of energy released is proportional to the difference in the heat capacities of the water and fog. Show equation.

3. The conclusions my data provides:
    a. Problems with water's optimal droplet size, and what this means for my data
    b. Energy released during an explosion should be directly proportional to the water's temperature.
    c. Analyze the above: further experimentation needed to determine relationship between explosion strength and temperature.

4. A framework for understanding
    a. On a molecular level, the release of energy during a water explosion can be understood as a reorganization of the water's hydrogen bonding network.
    b. Strong versus weak bonds

c. Tearing of water droplets into fog
d. This bond reformation would release energy and could conceivably supply the kinetic energy of a water explosion.
e. Return to data and show that the above could be the case.
f. Alternative theories: evaporative cooling



5. Implications moving forward.
    a. Can these explosions be harnessed to do meaningful work?
        i. The possibility of a water explosion engine
        ii. Replacing gasoline, more efficiency and less waste
        iii. Driving magnetohydrodynamic generators to produce electrical power
        iv. Jet propulsion system using water explosions

6. Conclusion: the need for future research:
    a. The above uses for this research are beyond the scope of this project
    b. More research is needed to assess feasibility of the above
    c. Designing and testing such a device would be a worthwhile topic for future research.

Bibliography:

Paste the bibliographical citations on their own page below, in alphabetical order by author's last name (MLA)