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Example

Research Plan

A. **Question:** How can the adverse effects of hearing loss be frugally combatted using bone conduction?

B. **Rational**: Hearing loss is an issue caused by disease and old age. Many of the problems associated with hearing issues occur in the outer and middle ear. Bone conduction allows sound waves to be transmitted through the skull (bypassing the outer and middle ear) directly to the inner ear. While bone implanted hearing aids provide optimal sound, these may be unwise for patients either for health or financial reasons.

C. **Hypothesis/ Engineering Goals, Expected Outcomes:** The goal of this experiment is to develop the understanding of bone conduction and its practical applications in the medical field, specifically in hearing aids. The team intends to further research in less expensive areas of bone conduction, providing the optimal sound quality with minimal cost.

D. **Methods:** The experimentation done by the researchers will be two fold. Using their knowledge of bone conduction and the workings of the inner ear, the team will build prototypes of bone conduction hearing systems and design them for usage. The team will then use voluntary participants to test the sound systems, scrutinizing each and every

detail of each system on sound quality and overall effectiveness. The team will then make a conclusion as to which prototype is the most effective.

a. **Procedures**

The researchers will begin their project by designing varying prototypes of bone conduction devices. They will use different piezo transducers and design ideas to construct these prototypes. After the initial prototypes have been constructed, the researchers will then ask participants to evaluate each of the prototypes based on comfort level and sound quality.

b. **Risk and Safety**

Potential risks include an uncomfortable sensation associated with vibrating metal and wearing headphones. If sound volume is not controlled, it is possible that some of the participants may experience minor discomfort on either side of their skull. No other risks pose a significant threat to the participants. The team will minimize the risks associated with this research by (1) informing all participants of said risks and (2) adequately controlling sound volume.

c. **Data Analysis**

In order to analyze the data collected from the experiment, the team will provide the participants with a scoring sheet for each prototype, allowing them to evaluate the overall quality and effectiveness of each bone conduction device prototype. The scores collected will then be used as data and will be analyzed between age brackets and prototypes. The team will also take some initial

measurements, including but not limited to the frequency output, weight, and piezo transducer of each prototype.

E. **Human Participate Research**

a. **Participants**

The participants of the study will be broken into three age brackets: teenagers (ages 13-18) , adults (ages 19-49), and seniors (ages 50+). The team will collect data from at least 10 people of each age bracket. Participants will be human beings consisting of both genders, and diverse racial and ethnic composition reflective of the area research is conducted in. Recruited participants will be found among the friends and family of the team members, church members in good relationship with the testers, and classmates of the testers. Each participant will be invited to participate either in person or via email. A carefully constructed message will ensure that they understand the full implications and risk assumptions of their participation in the research. The participants will be asked to use a custom made bone conduction device, designed by the team, and evaluate it on its sound quality. The team will use questionnaires to determine the most effective bone conduction device created.

The participant's involvement in the project should last between 1-2 hours; however, the researchers will ask that all contact information be kept throughout the end of the district fair, in case of complications dealing with further research. Participants may be contacted at times following their initial participation date for additional feedback.

Potential risks include an uncomfortable sensation associated with vibrating metal and wearing headphones. If sound volume is not controlled, it is possible that some of the participants could experience minor discomfort on either side of their skull. No other risks pose a significant threat to the participants. The team will minimize the risks associated with this research by (1) informing all participants of said risks and (2) adequately controlling sound volume. If the team's research is successful, society will benefit greatly from effective, low-cost bone conduction hearing systems.

b. **Protection of Privacy**

Identifiable information limited to phone numbers, email addresses, names, and ages will be collected from the participants. The phone number, email address, and name of each participant will remain anonymous and be collected in a private notebook used by the team. The participant's confidentiality will be ensured; regardless of circumstance, no information will be given, in whole or in part, to anything nor anyone. All participants will volunteer for this project with the understanding that the team will not distribute or relinquish any personal information given during the testing period. The data will be stored in a private notebook kept permanently at the residence of one of the team members. Only team members and their parents will have access to the information. All information other than the age of the participants will be destroyed after the science project has concluded.

c. **Informed Consent Process**

Upon being invited to participate in the study, the participants will be presented with a detailed description of the purpose of the project, the implications of participation, and their rights as participants. They will be free to stop participating at any time; and any and all physical recordingsof the contact information that they provide the research team with will be destroyed forthwith after the conclusion of experimentation. An email log consisting of communications that (1) occurred between team members and participants and (2) did not disclose any sensitive or private information of said participants will be kept and included in the team's comprehensive report.

F. **Bibliography:** (see attached)

Works Cited

APC International, LTD. APC International, LTD, 2014. Web. 1 December 2015. https://www.americanpiezo.com/piezo-theory/whats-a-transducer.html

APC International, Ltd., has been supplying and distributing piezoelectric ceramics and devices to professional and corporate clients since 1986. The company's knowledge center provides key insight into and information of piezo theory, including but not limited to piezoelectricity, resonance frequency, piezo constants, and applications. The team has chosen to cite the entire website as a great deal of the information contained therein will be vital to successfully completing the project. Although this content is likely posted on APC International's website in order to establish credibility with prospective clients, said information is, nonetheless, wholly relevant to the focus of the team's research with regards to constructing a bone conduction transducer of sorts. With the information from this particular source comes twenty-nine years of experience and knowledge of a conglomerate of people. Their failings and shortcomings are ones that the team, itself, may face. Making use of this source allows the team to circumvent any hurdles and roadblocks that the employees of APC International have encountered. As consequence, this source is distinctively unique.

"Bone Anchored Devices." *Hearing and Balance Center*. University of Maryland Medical Center, n.d. Web. 1 December 2015. <http://umm.edu/programs/hearing/services/bone-anchored-devices>

This source, published by the University of Maryland Medical Center, discusses the advantages of bone implants in bone conduction hearing aids. A bone implant in the

skull behind the ear transmits vibrations from the hearing aid to the inner ear, bypassing the outer and middle ear and the ear canal. Traditional bone conduction hearing aids are less effective than bone implanted hearing aids. With traditional bone conduction hearing aids, the skin acts as a barrier to the sound waves, often distorting or blurring the sound. Bone implanted hearing aids bypass this barrier and provide a clear sound. This work is written for potential patients seeking information on bone implanted hearing aids. It informs the researchers of possible obstacles in their project. Optimal sound quality will not be feasible for high school research.

"Bone Conduction." *Encylopaedia Britannica.* Encyclopaedia Britannica, n.d. Web. 1 December 2015. <http://www.britannica.com/science/bone-conduction>

Encyclopaedia Britannica informs the reader of the types of bone conduction officially recognized. The first type of conduction, known as compressional bone conduction, involves high frequency vibrations affecting individual bones in the skull. The frequencies compress the bony casing of the inner ear and trigger specialized sensory cells in the ear. The second type of conduction, known as inertial bone conduction, vibrates the entire skull, producing the same effect on the inner ear as ordinary airborne sound waves. This source is targeted at students seeking a general knowledge of bone conduction. The article nicely summarizes the different types of bone conduction and provides a general overview of the topic. The article alludes to the possibility that bone conduction can be just as effective as airborne sound waves, a topic of interest for the researchers. Encycaepedia Britannica is a very credible source as it is one of the world's leading encyclopedias.

Eichanauer, Anja et al. "Effect Of Bone-Conduction Harmonic Distortions On Hearing Thresholds." *The Journal of the Acoustical Society of America* 136 EL96 (2014): n. pag. Web. 1 December 2015. <http://scitation.aip.org/content/asa/journal/jasa/136/2/10.1121/1.4885771>

The authors of this piece, Eichanauer and the team, experimented with hearing thresholds obtained with two bone vibrators, the Radioear B71 and the Radioear B81. They were specifically interested in sound distortion. The experiment showed that distortion was decreased by the Radioear B81. This source was intended for researchers in the area of bone conduction. Although this piece is not directly related to the team's purpose, it provides valuable insight into how to run a bone conduction related experiment. Sound distortion is also a concept that could come up in the team's experiment.The procedures and methods of this source will prove useful for the team when they are writing theirs.

"How Bone Conduction Hearing Systems Work." *Oticon Medical*. Oticon Medical, n.d. Web. 1 December 2015. <http://www.oticonmedical.com/Medical/YourTreatment/About%20bone%20conduction/How%20does%20it%20work.aspx>

Oticon Medical uses this article to inform its readers on how bone conduction hearing aids work. Bone conduction is the transmission of sounds via bones in the skull to the inner ear. The hearing aid designed by *Oticon Medical* converts sound waves to vibrational frequencies which are transmitted to a titanium implant and into the skull. Bone conduction hearing aids are especially effective for patients with outer and middle

ear damage. The source is written for potential patients interested in receiving a bone anchored implant for hearing aids. It provides a basic overview on how bone conduction works. This source is useful to the researchers based off of its unbiased description of bone conduction and practical applications in society.

"How the Ear Works." *Hopkins Hearing*. John Hopkins Medicine. n.d. Web. 1 December 2015. <http://www.hopkinsmedicine.org/hearing/hearing_loss/how_the_ear_works.html>

John Hopkins Medicine, the organization responsible for creating this source, provides a general overview of how the ear works. The source describes the passage of sound waves through the outer ear, past the middle ear and into the inner ear. The sound waves are then translated into electronic signals and set to the brain for interpretation. The author of this source intended its use for the layman seeking to understand the workings of the ear. The researchers will use this source as a reference for understanding the other sources listed in the above annotations.

Margolis, Robert H. "A Few Secrets About Bone-Conduction Testing." *The Hearing Journal.* 63.2 (2010): 2, 10, 12, 14, 16-17. Web. 1 December 2015 <http://journals.lww.com/thehearingjournal/Fulltext/2010/02000/A_few_secrets_about_bone_conduction_testing.3.aspx>

The author or this piece, Robert H Margolis, answers questions that some readers may have about bone conduction. He briefly discusses the history of the field of study and then goes through several question regarding bone conduction. The piece discusses hearing thresholds and discusses the discrepancies in air-bone gap data commonly found. This source is intended for readers with a general knowledge of the subject but lacking a

more detailed idea. This resource will prove useful for the researchers because it may answer some issues that come up in their testing. It also provides a general overview of the history of the field.

Martin, Glen. "Stanford Scientist Looks For A Deeper Understanding Of Hearing Through The Bones In Our Heads." *Stanford News*. Stanford University, 5 August 2013. Web. 1 December 2015.

<http://news.stanford.edu/news/2013/august/ear-bone-conduction-080513.html>

Martin uses this source to describe some of the current research being done in bone conduction. Researchers are investigating why humans have three inner ear bones. The answer lies in bone conduction. The researchers in the article studied patients with otosclerosis, a disease that inhibits the motion of the stapes, part of the inner ear. Most patients with otosclerosis do not report low frequency sound hearing loss, when previous research dictates that they should. The researchers created a 3D model and found that inertial bone conduction resulted in low frequency hearing loss but compressional bone conduction did not lead to low frequency hearing loss. They researchers found that compressional bone conduction plays a much larger role in hearing than thought. This article is targeted for researchers interested in the field of bone conduction. This source provides valuable insight into current research on bone conduction and gives the team examples of the practical applications of bone conduction. The article also discusses some of the finer details associated with bone conduction.

Mejia, Jorge, et al. "Bone Conduction Hearing Aids: Into the Near Future." *The Hearing Journal*. 68. 8 (2015): 30, 32-34. Web. 1 December 2015.

<http://journals.lww.com/thehearingjournal/Fulltext/2015/08000/Bone_Conduction_Hearing_Aids___Into_the__Near_.5.aspx>

This source discusses the experimentation of Dr. Jorge Mejia on bone conduction and super-directional beam former microphones. This source provides a valuable factual basis for the team's research. Bone conduction was once thought to have an equal effect on both cochlea but it is now known that one cochlea is affected slightly before the other, although to a lesser degree than airborne frequencies. The source also provides a general overview of some recent research in the field. Binaural bone conduction can come close to normal hearing in sound and effectiveness. This resource is intended for users well familiarized with bone conduction. The source provides a valuable source of detailed specifics for the researchers and discusses the researcher's quest to make bone conduction as similar to natural hearing as possible.

"The Piezoelectric Effect." *Nanomotion: A Johnson Electric Company*. Johnson Electric. n.d. Web. 1 December 2015. <http://www.nanomotion.com/piezo-ceramic-motor-technology/piezoelectric-effect/>

This source outlines the function and history of piezo transducer. A piezo transducer is a substance that, when some kind of physical stress is inputted, the element produces an electric charge. More importantly for this project, the reverse is also true; when an electric charge is added to the element, mechanical stress or vibration is produced. Piezo transducers have a long history, useful in technologies such as sonar, sensors and motors. This source was intended for researchers with no knowledge of piezo transducers. This article is useful for the team because it presents a possible method of

constructing a bone conduction device. The team will use this knowledge when constructing their device.