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ECE495E

Homework #1

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Question 1:

The best way to make the project affordable for poorer countries is to make the project open-sourced. By making it open-source, anyone with a reliable internet connection could gain access to the "instruction set" to realize the Electric Field Energy Harvester (EFEH) that we've designed–or at least the research behind it.

I will argue that anyone without an internet connection, and really most people in general, have no use for this project. An EFEH device in principle gathers negligible energy, and at best collects enough for minor data-collection and transmission. The best use for this product in a country in need would be for detecting live voltage where the EFEH device is clamped, but this can be done easily with other and more affordable devices.

Also, 3rd world countries would be more in need of making their electric grids more robust before introducing IoT devices. This can be done without any EFEH devices as it has been done in the past.

In terms of just the device itself, making it 3D-printed and using recycled electronic components is extremely possible and would drastically reduce the cost of the device. However, this is only if a single device was made at a time; the other alternative is to mass produce the device and flood the market with them.

Question 2:

Aluminum would be the best choice for making prosthetics if you're concerned about cost and environmental impacts; the only downside being that we live in a society where having metal limbs makes going to museums and baseball games more inconvenient.

New aluminum production has lowered in the U.S. but the production of raw aluminum from scrap has steadily increased over the past 5 years; the market shifting to accommodate more recycled stock is a plus for producing an environmentally conscious product. Aluminum itself is, as of 02/10/2025 worth $1.20 USD per pound, which is much lower than the costs of both 3D printer filament and carbon fiber.

Long term costs are also lower when choosing aluminum as it is less prone to stress breaks like 3D printed filament (which typically fractures along the grain of the print), and easier to repair in the case of both carbon fiber and aluminum.

Even though carbon fiber is stronger, it is much easier to manufacture parts from aluminum as compared to carbon fiber, especially with the rise of computer numerical control (CNC) machining.

Question 3:

It depends on what "redistribute" means. If someone is just giving their friends, or even strangers, cheap but functioning computers for free (or a lower price), then it might even be considered virtuous to do so, as they'd be providing people with life-changing technology for a bargain.

However, if the person is attempting to upsell trash work for a profit, then that's unethical. Attempting to hoodwink people, especially over large barrier-to-entry items, is predatory and should be condemned. The proper course of action is to properly document the transgressions of the offender and report them to the proper authorities, as mis-advertising a product violates the Federal Trade Commission Act.

Question 4:

This is a complex question to answer as it highlights whether electric vehicles are a public or private issue as corporations are providing access to higher end electric cars, while the state is burdened with making a place worth driving them.

Cities within Illinois presumably have not taken a full force approach when it comes to making EV charging heavily available, as you don't see them as often as a gas station, which is obvious, but to have true effectiveness in any area charging would need to be abundant. Charging for any electric vehicle is bound to be localized more in affluent areas, which are more likely to afford both the cost of EVs and have public funding available to spend on EV infrastructure. So, you'd be happier to be a Tesla owner in the Chicagoland Area as compared to Carbondale, Illinois (though that depends on commutes).

However, Illinois crushes it with nearly two-thirds of the state's energy production being from nuclear energy, so the net carbon footprint of an EV is much lower as compared to a EV owner driving around in West Virginia. This benefit, averaged over the whole, benefits all Illinois EV owners.

Also, the CTA has been serving Chicago with the electrified 'L' trains for decades, though that does little for rural Illinoisans.

But the problem will soon come to a head if utility providers in the North and South cannot get the grid built to withstand the incoming demand if EVs continue to rise.

Question 5:

Standards were chosen given the scope of the project. Knowing that we were designing for high-voltage, the product lives in the utilities sector, PCB design was involved, and our device had unconventional grounding, we could search for the standards written by experts in those areas.

Especially for power transmission projects, where two centuries of industry has honed exactly how to up to code to save lives.

Question 6:

Unless a perfect world government was established, it would be impossible to implement a product with the same efficacy in every single country. However, making 3D-printed prosthetics available in open-source applications could improve the lives of anyone who has access to a sufficient 3D printer.

Small subsets of individuals with access to "maker spaces", like libraries or local maker shops, could set aside resources for helping those in need get prosthetics they need.

Ideally, the open-sourced version of the prosthetics would have approvals from licensed medical professionals, or those who have experience in biomedical engineering. But also, prosthetics libraries could be developed by universities around the world that would be publicly available.

The end prosthetic would be "homemade" but still have a wealth of engineering behind it from experienced makers.

Question 7:

An EFEH device used as an Internet of Things (IoT) device adds redundancy to the systems that monitor power grid health, which for such a critical piece of infrastructure can save millions of lives. When looking back on the Northeast Blackout of 2003, it first started when the state estimator failed, which is the computer system that monitors the grid and makes predictions on its behavior. If the grid was populated with EFEH devices, they would be able to aid in monitoring lines at voltage when the state estimator fails, or feed more useful data into the state estimator to aid in its calculations.

Also, EFEH devices can be scaled down to lower voltages, as shown by CapHarvester, which can be useful in Smart Home applications.

However, it needs to be clear that the use of IoT devices should only be used for safety and automation purposes to make living life more fruitful, and not to collect data for corporations to understand consumer behavior. In this respect, EFEH devices should be installed with firmware that only allows for local transmission of data, isolated to secure networks, and not allow for the routing of data to large datacenters.

Instructions

1. What would you change about your senior design project if you wanted to make it affordable for 3rd world or war-torn countries?
2. Carbon fiber, aluminum, and 3D printed filament are common in the human prosthetic landscape. Between the three of these options which is the most cost effective, which is the most environmental, and which would you choose if you wanted to save money and reduce environmental impact?
3. Imagine someone is attempting to redistribute computers with used lower quality parts than advertised. Is this socially acceptable and how would you go about addressing the problem?
4. Is the effectiveness of the implementation of electric vehicles similar across rural and urban parts of Illinois?
5. How did you accommodate standards into your senior design project?
6. Is a homemade 3D printed prosthetic able to be implemented equally in all countries? Why or why not?
7. Engineers should be socially conscious about what they design. What social impact will your design have, for example, on improving people's lives?