Engineering World Health

Senior Design Projects That Matter

2008/9

New for 2008/2009:
Legacy projects. There are some projects where significant progress has been made, but not enough to complete the project. You'll need to write to get the details for each project. These can be very high impact with very little additional effort.
Research Projects: Sometimes a plea for a device reaches EWH, but there is so little work done in the area that it isn't ready for design yet.

Engineering World Health is an extraordinary fusion of engineers, scientists and physicians who donate their time and talents to positively impact the quality of healthcare in disadvantaged areas around the world. Our vision is embodied in the "Cycle of Caring," which begins with donated medical equipment and parts and relies on professional expertise to recycle and restore the technology for reuse. We then deliver and install the refurbished machinery for a community in need. Our commitment does not end there. Unlike any other organization in the world, volunteer engineers and students return to that same equipment year after year to ensure that it remains in good working order.

Our ultimate goal is to train local engineers and technicians to maintain their own equipment. However, this ultimate goal is constantly frustrated by the lack of adequate testing equipment. Even where the staff are adequately trained, they lack testing equipment which Biomedical Engineers in the developed world take for granted. The objective of these projects is to design testing equipment that can be provided as kits and built by engineers in the developing world.

Individuals, groups of students, senior design teams, BMES or IEEE chapters or just a bunch of friends can submit designs. Designs are generally accepted in December or January, but can be submitted at any time. If your design meets the design criteria, you will receive up to $150 to build a prototype. If your prototype works, it may be selected to be produced. If you wish, in the summer following the production of your design, you, or your team, can travel to the developing world to distribute the product by participating in the EWH summer program.

In order to participate, you must meet several criteria:

A) Your design must be documented, including 1) a description of the theory of the device (approximately two pages) including the specific specifications (accuracy and such) that your device will meet, 2) a detailed parts list, including source, quantity, part number, price (in quantities of 1 and 5) and anything else that would be required for one to order the parts. Your design can be kit-able (requiring no custom parts). Some projects require kit-ability. 3) engineering drawings including construction drawings for the enclosure, if there is one, top and side views of the completed item (multiple if required), 4) a requested amount (up to $150) for the prototype with the detailed budget to support the request, and 5) a cover letter stating your team members (name, address, telephone and e-mail for each) and to whom the prototype check should be made and sent. Additional documentation may be provided, if you deem it necessary. Your cover letter must state if you are designing a locally produced item (all parts on the parts list are from a developing world country of origin) or a kit (some parts must be ordered singly from a US distributor and shipped to the developing world) or a typical product (all components purchased and assembled in the US and then shipped to the developing world). Preference is often given to locally produced items.

B) The cashing of the payment you receive constitutes a license to Engineering World Health to freely produce the final design non-exclusively, for donation to hospitals anywhere in the world in kit, documentation or final form. Engineering World Health is also licensed to publish all technical specifications on its web site for general use.

C) All submissions must be made electronically in Word format.

When your design is complete, you will also need the following documentation for the design to enter production:

A) Updated documentation of anything that has changed. Be sure to update the kit/locally produced status of your design.

B) New diagrams which include: 1) detailed construction instructions. If a kit, instructions for assembly of the kit of parts in the developing world with no special or custom parts. No special tools must be required. Assume a high school student or person in the developing world could construct your device from, typically, a sequence of photographs. For local construction, use mostly pictures of each stage of construction. For traditional products, assembly diagrams are usually sufficient. 2) testing instructions so that the builder can confirm that it is working. 3) operating instructions (must be in pictorial form, not words).

C) Calibration data and testing data to show that your design works.

We prefer that you write us before beginning the design (robert.malkin@ewh.org). That way, we can give you any updates or clarifications on the design criteria. If you decide to send a letter ahead of time, please include your projected date for the submission of the design and documentation and your mentors name and title. However, it is not necessary to write ahead of time.

Any design which meets the published specifications and the criteria set out above receives the $150 to construct the prototype. If the criteria are met on your first submission, you will typically receive the $150 within four weeks or less. If you have written ahead of time, you may be able to receive the $150 sooner.

We may select your design if 1) it the final prototype testing data shows that it meets the specifications, and if 2) its performance exceeds (lower cost, more features, higher reliability, etc.) any item which we are currently producing in that category and any other designs submitted that year of the same type. If you write ahead of time, we can inform you of what other teams have selected the same item, and what items we are currently producing in the selected category.

Don't hesitate to write an e-mail to info@ewh.org or robert.malkin@ewh.org if you have any questions. Your efforts can have a tremendous impact on the developing world.

Projects:

These items have been requested by personnel working with Engineering World Health in developing world hospitals. These project specifications are intended to be used as guidelines. You should design your device to deliver the maximum possible performance while still staying within the cost specification. Some deviation from the cost specification may be tolerable if the benefits in performance warrant. Where superior performance specifications are given, they need not be followed for the design to be acceptable. Be sure to note if the design is for a kit, local production or traditional production.

We cannot accept designs which are not on this list. However, we can accept suggestions for items to be added to the list. Feel free to suggest a new design project. If the project is accepted, it will be added to the list for everyone to see, and you will be able to submit your design as well. Write an e-mail describing your idea in one paragraph to info@ewh.org or robert.malkin@ewh.org to find out if it is a project that we can support.

In the following paragraphs, all costs are for parts only (no labor costs) and include all the costs of production, even costs that you may not encounter in the prototype, like the box or printed circuit boards. You can assume that the parts are purchased in the developing world or the US, as appropriate.

LEGACY PROJECTS:

Non-electronic Oxygen Concentration Test

Engineers are often faced with oxygen concentrators of unknown quality. This device should allow the engineer to quickly determine if the device is producing concentrated oxygen (perhaps greater than 80% or 90%) without using electricity (batteries, etc). An ideal device would allow a crude (within 20%) estimate of the oxygen concentration. The designer can assume access to elements often found in hospitals (CO2 absorbing material, matches etc).

Legacy: A team has designed a system based on the burning time of match, coke bottles and a lump of clay. However, the system is a bit hard to read and needs to be calibrated for every size of coke bottle. Is there a way to calibrate the device based on the volume of the coke bottle? Can it be made easier to read?

Pulse Oximeter for Heart Rate

The pulse oximeter is one of the most common medical instruments, and is the most frequently requested piece of medical equipment. Prices have dropped for this product to the point where nearly every patient in a US hospital will be connected to such a device. However, in the developing world, pulse oximeters are still difficult to find. The most important function is to display heart rate. Displaying oxygen concentrations is a secondary desire. The device must use non-disposable sensors. It should operate on a finger of an adult. It should provide audible (beeps) for each heart beat and ideally also provide a digital display of heart rate.

Legacy: A team has designed a low-cost circuit that beeps on every heart beat. Now someone needs to add the display of heart rate. Probably needs a PIC programmer.

Relevant additional specifications
Device available for kit design or local production only
Cost: <$8 in quantities of 1

Universal Surgery Light Bulb Replacement

Approximately 80% of the surgery lights that are found unused by Engineering World Health are sidelined by the lack of lighting. These older machines have light bulbs that are broken. While the replacement is simple, the bulbs are expensive, not available in many developing world countries, and in some cases not available anywhere due to the age of the surgery lamp.

What is needed is a system for replacing light bulbs in lamps with LED light bulbs. What circuitry would allow the housing of the bulb to be spared, but the new bulb to be wired into place? What intensity of bulb could be found to match?

Legacy: A team has developed a preliminary circuit that appears to meet the needed specifications for surgery lights. However, the circuit does not work over a wide enough range of voltages. Also, it has no housing.

Relevant additional specifications
Device available for kit design
Cost: <$5 in quantities of 1000

Non-Legacy PROJECTS:

Bovie Pen Hardening

Electrosurgery is the most common form of cutting, perhaps even more popular than the scalpel. However, most developing world hospitals must re-use the same disposable bovie pen time-and-time-again. This project is to develop a technique for hardening disposable bovie pens so that they can survive reuse.

Relevant additional specifications
Device available for local intervention only
Cost: <$1 in quantities of 1

Hardened Non-Invasive Blood Pressure Machine

Non-invasive blood pressure machines are now available for about $25 at some drug stores and on-line shops. The expectation is that they would be used once or twice per day at home (about 300-600 cycles per year). These devices will last many years when used according to expectations. However, when these are donated to the developing world, they are used 24 hours per day, seven days per week (about 5000-10,000 cycles per day). The devices last only a few days under these conditions. This project should adapt a low-cost, non-invasive blood pressure machine, designed for home use, for continuous use in the developing world.

Relevant additional specifications
Device available for kit design or local production (prefer local production)
Cost: <$5 in quantities of 1
Cost: <$2 in quantities of 500

Respiratory Rate

During surgery it can be critically important to monitor the presence or absence of breathing, as well as during recovery. This device should produce an audio pulse (a “beep”) each time the patient breaths. If the impedance plethysmography approach is used, the electrodes should be permanent and reusable. Display of the respiratory rate is a secondary feature. Alarms for respiratory rate are a secondary feature. Device must be highly reliable.

Relevant additional specifications
Cost: <$20 in quantities of 1
Cost: <$5 in quantities of 500

Nebulizer

The rates of asthma and pneumonia are very high in the developing world. However, their access to appropriate medicine is hindered by the lack of robust nebulizers. While home use nebulizers are inexpensive, they last for only a few weeks or months once transported to the continuous, heavy use environment of a developing world hospital. However, the basic components of a nebulizer are available in the developing world. This project is aimed at using commercially available (in the developing world) air compressors and tubing to construct a robust, hospital grade nebulizer.

Relevant additional specifications
Only available for local production
Cost: <$100 for single compressor with ability to treat 4-8 simultaneous children (manifold type).

BP Assist Device

While many philanthropic studies focus on "high-profile" killers such as HIV and malaria, the primary cause of death throughout the developing world still stems from issues related to the heart. The WHO has begun to seriously consider the growing number of hypertensive patients throughout the world, and as a result we are focusing specifically on improving the diagnostic capabilities of hospitals throughout developing countries.

This project will develop a low cost, easy to use, device is to assist a minimally-trained person in taking the blood pressure using a sphygnomanometer. Assuming the assistant has inflated a cuff around the arm and is now slowly allowing the pressure to drop, the device should "beep" when the pressure should be read for systolic and "beep-beep" when the pressure should be read for diastolic. The device should **not** measure pressure.

Relevant additional specifications
Only available for traditional production
Cost: <$5 in quantities of 2000 or more

Hardened Pulse Oximeter

It is now possible to purchase a pulse oximeter for about $100. Yet, this is one of the most requested pieces of medical equipment in developing world hospitals. The problem is that donated, low-cost, pulse oximeters quickly break in the continuous use environment of the hospital, and the batteries can be difficult to replace. The objective of this project is to take the elements of an off-the-shelf, low-cost, pulse oximeter and adapt them for long-term continuous use in the developing world.

Relevant additional specifications
Adaptation should ideally be accomplished as a kit. However, traditional manufacturing can be considered
Cost: <$25 (for the adaptation kit/parts in quantities of 100)

Hand Cranked/Shaken Otoscope

One of the most basic pieces of examination equipment is the otoscope. However, when physicians are stationed in remote locations far from electricity and replacement batteries, standard otoscopes are ineffective. This project is intended to adapt a standard otoscope to use in remote, resource poor settings. The device should operate by cranking, shaking, pulling or otherwise generating energy without batteries or access to electricity. Only the energy storage/delivery apparatus must be adapted, not the optical sections.

Relevant additional specifications
Only available for traditional production
Cost: <$100 in quantities of 10 or more

Liquid Medication Delivery System (2 projects)

The number of children infected by HIV continues to grow. There may be as many as 2.1 million children worldwide infected with HIV. Over the past 15 years, several options have become available for treating children and preventing the transmission of HIV from mother to child, including zidovudine (AZT), didanosine (ddl) and nevirapine. However, infants are unable to swallow pills, and so the drugs are donated to developing world pharmacies in 20-200 ml bottles.

The problem is that a single, small dose of 0.5 ml must be provided to a mother so that when she gives birth, some number of months later and many miles away, she can deliver the dose to her newborn. In poor countries, liquid medications are now given in plastic bags, open syringes or recycled plastic bottles, all of which lead to medication spoilage and loss. For the poor pharmacy, extracting the correct dose from the bottle without contaminating the bottle and presenting it to the mother in a form she can transport home and use safely and effectively has presented serious challenges.

This project will develop a medical device for the distribution point (usually a pharmacy) that includes Project 1) a bottle topper capable of resealing the bottle and measuring the correct dose, and Project 2) a packaging system that places the medication into a sealed, foilized, polyester pouch (without requiring electricity). The pouch is similar to the foil pouches used for mustard or ketchup at fast-food restaurants.

Relevant additional specifications
Only available for traditional production
Cost: <$2 in quantities of 2000 or more

Stimulator to Prevent Post-Partum Hemorrhage

Worldwide, nearly 540,000 women die every year from complications due to pregnancy or childbirth, many of them from post-partum hemorrhaging (bleeding after birth). When women give birth in health facilities where drugs, equipment, blood supplies and the people who know how to use them effectively can be found, the odds of survival are much higher. However, in developing nations such well-equipped facilities are a rarity. Most women deliver at home in the presence of a traditional birthing assistant (a midwife).

Medications, such as oxytocin, are particularly powerful at causing the uterus to contract, terminating maternal hemorrhaging. However, most nations, including those in the developing world, restrict access to medications, including oxytocin, to medical professionals. This leaves women, who largely deliver at home where there are no medical professionals, without access to treatment.

This project is intended to adapt a medical device for the purpose of contracting the uterus. Specifically, preliminary data (Uterone 1, Khasin 1984, 1985) shows that an electrical stimulator like a cardiac pacemaker can effectively contract the uterus. The proposed device would be hand cranked and could sit idle in a village for months or even years before a minimally trained traditional birthing assistant could apply the therapy, saving the mother's life.

Relevant additional specifications
Available for traditional or kit production production
Cost: <$100 in quantities of 10 or more

Research Projects

Medical Waste Incineration

This plea came to our attention: "It seems that our hospital in Congo is forever plagued with waste, bandages, and other things that need to be incinerated. But most of it just gets buried in a hole and then we find children and others climbing down into the hole to get stuff which is usually quite contaminated." The problem of medical waste incineration plagues hospital far beyond Africa. We find this problem in hospitals throughout the world.

The project is to design a medical waste incinerator that can be built entirely from locally available materials.

However, we were not able to find any preliminary work on this project. The first task is to scour the literature and determine whether anyone has worked on this project in the past. Secondly, determine minimal specifications that a device could reasonably meet. Will it be possible to meet a minimal set of specifications with locally available materials?

Infusion Pump – Cartridges

Over the last several years, many manufacturers of infusion pumps have moved from a model of using standard infusion tubing to using specialized cartridges that fit inside the pump. The cartridges are specific to each manufacturer, and sometimes each model. The result is that developing world hospitals can easily get donations of infusion pumps, but those donations are not usable because they cannot afford the cartridges.

The project is to determine if there is a possible universal infusion pump cartridge, or at least a set of easily available cartridges that can be recommended. Or, would it be possible to design one after-market cartridge that would fit into most donated pumps. As an alternative, could cartridge-based IV infusion pumps be retrofitted with something that made them compatible with standard IV tubing.

Frequently Asked Questions

The device has to be very simple to use, right?

No. Clinical engineers and doctors in the developing world are just as capable as you and I to learn how to use a device. If you can figure it out, they can too.

The device has to be really quick to use, right?

No. The concept of time is different in the developing world. It is quite an acceptable design to require a significant amount of man-hours (minutes?) to operate your device.

The device has to be maintenance free, right?

Pretty much. If any maintenance is required, it must be something that itself does not require a specialized tool or part. If your design requires maintenance, you probably should write to us first (info@ewh.org).

What environmental conditions must the device meet?

Your design must not be destroyed even with extended exposure to temperatures down to -10 degrees centigrade and temperatures up to 40 degrees centigrade. It should be useable in environmental temperatures ranging from 20 degrees centigrade to 40 degrees centigrade.

My design doesn't meet all the specifications, but it exceeds some. Should I send it in?

If your design doesn't meet all the specifications, you are not guaranteed to receive the $150. However, you may be able to make an argument that the added performance in one area is worth the missed specification in another. Make sure to include a cover letter of one page or less which describes your argument.

How do I know what is locally available for production?

You must contact a clinical engineer and talk with them about this. There is no substitute for a conversation with the clinical engineer that will use your design.

I have just one custom part. Surely that won't affect your consideration of my design.

Assuming the question is for a project that is designated for local construction, yes it will! If you have one custom component, and that component cannot be manufactured in the developing world in single quantities (and those costs are included in your cost estimates), then your design will be rejected.

What if a part is not locally available?

If you really need a component that you can't find locally (a capacitor or fuse, or a special plastic), then you should consider making your design a kit, not local construction. Many of the projects don't specify and you can choose.

What if the component requires programming or burning?

Most PICS and FPLA and such devices require burning or programming. Most clinical engineers in the developing world do not have access to a computer or a programmer. Therefore, your project requires a special tool that is not available in the developing world. It is a conventional design and could perhaps be a kit, but it could not be locally produced.

The project I picked doesn't specify kit, local or conventional. What do I do?

You have the choice. We prefer local construction, then kits and finally conventional construction. If we receive multiple submissions, we'll choose the preferred design.