Engineering World Health

Senior Design Projects That Matter

2007/8

<u>New for 2007/2008 – Based on popularity, more projects are listed for diagnostics and adjunct devices. Devices can also be kit, conventional or local production.</u>

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. 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. If you have written ahead of time, you may be able to receive the $150 sooner.

We may select your design if 1) it still 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 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 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.

PROJECTS:

Ionizing Radiation Meter

A device which electronically indicates the production of ionizing radiation from a typical medical X-ray imaging system. Should respond only if intensity peaks above a typical diagnostic minimum. Superior performance could include a connection for an oscilloscope or other mechanism to measure exposure time. Superior performance could also include an integrator to indicate the total radiation exposure. Air chambers, Ge diodes and other similar detectors are acceptable.

Relevant additional specifications
Cost: <$4 in quantities of 5
Size: 5"x4"x5"

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%). 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 (CO_2 absorbing material, matches etc).

Relevant additional specifications
If reusable Cost: <$5 in quantities of 1
If disposable Cost: < $1 in quantities of 1

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.

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

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

Aspirator

One of the most basic pieces of equipment in any hospital is the aspirator (suction machine). Yet most developing world hospitals that Duke-EWH visits do not possess operating suction machines. The main problems are the lack of available spare parts, the cost of a replacement unit, and dependence on consistent electricity. The objective of this project is to design a suction machine that can be manufactured from locally available materials (and therefore repaired using locally available materials and expertise). The device should run on 12V batteries. A hand (or foot) power backup is desired but not required. It should provide the broadest range of applications possible. The device should include autoclavable suction tips.

Relevant additional specifications
Must be completely manufactured from locally available materials
Cost: < $100.

Cold Box

There are many substances that must be kept cold in a hospital. Vaccines are the best known. For this reason, most health care facilities have at least one refrigerator. However, these cold boxes are typically concentrated in one part of the hospital, perhaps the blood bank. A subset of substances are sometimes needed on very short notice, far from the refrigerator. For example, oxytocin (used to contract the uterus after delivery) is unpredictably needed on short notice. Or, they may be required in very remote areas, where they must be carried by hand. Having no access to refrigeration, but knowing the need for the substances, many facilities simply leave a vial of the substance on the counter or exposed to heat and hope that it does not loose its potency. What is needed is a refrigerator of very small volume. It should be sufficient to store one days worth of the chemical (perhaps 5 ml) without the need for electricity or, preferably, any outside fuel. The cavity should be able to be maintained at about 10 degrees C for 12 hours. It could require shaking, cranking, solar, a hot piece of charcoal or any other non-electric fuel source.

Relevant Additional Specifications
Cost: <$100 in quantities of 500

Infant Ventilator (CPAP)

Many premature infants and underweight infants are born with insufficient levels of surfactants and have other related breathing problems. These infants can suffer from a great deal of difficulty keeping their lungs inflated. This problem is particularly serious in the developing world where underweight births are 80% of all births.   What is needed is a very small and portable ventilator capable of delivering CPAP (continuous positive airway pressure). It should meet the air pressure specifications of clinically available (in US) CPAP machines. It should be applicable without intubation and not require bottled air (or O2). It should not require disposables (all tubing and masks should be reusable). It must be battery operated or powered in some other way (avoid the use of mains 120V or 220V). This should operate in rural and transport situations (a baby transported on a donkey cart, ideally, but at least on a motorcycle).

Relevant Additional Specifications
Cost: <$100 in quantities of 500

Clorox Mixture Monitoring

It is common to use free chlorine in water as a sterilizing agent in developing world hospitals. This is typically accomplished by diluting a stable concentration, like 10-20% (Clorox bleach) to about 0.5%. Because the low concentration chlorine solution is not stable, it must be mixed each day, where it is needed. In remote areas of the world, this is problematic because the person mixing the chemical has no formal education, no access to a calculator, etc. What is needed is a chemical or strip that can be added to water so that the water or strip changes color (or shape) to indicate that the amount of free chlorine is adequate for sterilization. This is similar to a test strip used for swimming pools. It should be very cheap, easy to use, ideally reusable (or must be even cheaper), and adapted to the appropriate application. Safe, effective storage in remote areas must also be considered.

Relevant Additional Specifications
Cost: <$2 in quantities of 500, if reusable
Cost: <$0.02 per test if consumable

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.

I assume the question is for a project that is designated for local construction. In that case: 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 chose.

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 chose the preferred design.