Engineering World Health

Senior Design Projects That Matter

2006/7

New for 2006/2007 – All projects must be designed for local production! Kit pricing, not production pricing applies. No custom pieces allowed.

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 must be kit-able – requiring NOT CUSTOM PARTS. If a PCB is required, it must be manufactured as part of your kit, locally and without special tools (see part D for more details), 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). Preference is 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 or final form.

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

D) Certification of the local production level. You must document what level of local production is possible with your design. This involves two steps. The first is that your parts list must have a column for the country of origin of the part you specify. Second you must document contacts with clinical engineers in the developing world showing that they have verified availability of the components in their country. If you do not have a clinical engineering contact in the developing world, contact us at designprojects@ewh.org and EWH will provide you with a contact. You may NOT USE E-MAIL to make your developing world contacts (most clinical engineers in the developing world do not respond to e-mails any way). Almost all clinical engineers in the developing world have a cell phone. You must call and talk with them. Designs without documented telephone conversations (a simple call log with name, date, cell phone number and summary of call is sufficient) will be rejected without further consideration.

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 so that a kit of parts can be put together into a working model 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. 2) testing instructions so that the kit builder can confirm that it is working. 3) operating instructions so that a biomedical engineer could use your device to test the target equipment (must be in pictorial form, not words).

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

D) Data from a locally tested prototype. Your contact in the developing world should attempt to build and use your design, either from a kit or as a locally produced item. Ideally you would document their use with digital photographs that you submit with your design. However, a short report from your contact is sufficient.

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 three 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 for kitting and/or posting 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 designprojects@ewh.org if you have any questions. Your efforts can have a tremendous impact on the developing world. As they say, "if you give a man a fish he eats for a day. If you teach a man to fish, he eats for life." Your design could enable a clinical engineer in the developing world to fish for life.

Projects:

These tools 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.

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 designprojects@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.

PROJECTS:

Volume Meter

General Performance.
A device which can measure the volume of a gas (either oxygen, medical air or CO_2). It should be able to measure medically useful ranges, as are used in ventilators, for example, to within 10% of the measured value. Superior performance would allow for testing at within 1% of certain specific volumes. A separate tool for each volume is an acceptable alternative to continuous readouts. The pressure of the gas is that of normal respiration and/or forced exhalation.

Relevant Additional specifications
Cost: <$1 in quantities of 5
Size: continuous readout – 4x4x1. Single readout – 1x4x1 (can be in parts)

Pressure Meter Gas

General Performance.

A device which can measure the pressure of a gas (either oxygen, medical air or CO_2). It should be able to measure medically useful ranges (post-regulation, such as in ventilators, anesthesia machines, etc.) to within 10% of the measured value. Superior performance would allow for testing at within 1% of certain specific pressures. Readout must be digital. The greatest range of connection flexibility possible is preferred (hose barb, locking ring, quick release, etc.).

Relevant Additional specifications
Cost: <$5 in quantities of 5
Size: continuous readout – 4x4x1. Single readout – 1x4x1 (can be in parts)

<u>Temperature Tester for Water Bath or Incubators</u>

A device which indicates whether a water bath or incubator is at 37 degrees Celsius. A visual or audible alarm should be made when the temperature deviates by more than 0.5 degrees centigrade. The entire device need not be submersible, but this is desirable. The entire device must tolerate extended exposure to temperatures in excess of 40 degrees centigrade.

Relevant additional specifications
Cost: <$3 in quantities of 5
Size: 1”x4”x1”

<u>Ionizing Radiation Meter</u>

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”

<u>Centrifuge Calibrator</u>

Mechanical or electrical device for verifying the RPM of a centrifuge. Must be reusable and applicable to a very wide range of centrifuges. Separate devices for each RPM calibration is acceptable.

Relevant additional specifications

Cost: <$1 in quantities of 5

Autoclave Tester

Mechanical and/or electrical device which verifies the operation of an autoclave. The minimum performance device would measure both temperature and pressure and verify that they exceed at least one combination of minimum values. Additional performance would include an indication that the pressure and temperature exceeded minimums for a set period of time. Additional performance would include multiple indicators for multiple time and pressure combinations. Device must be reusable.

Relevant additional specifications
Cost: <$5 in quantities of 5
Must hold its reading throughout the cool down cycle and for some time after.
Mechanical and/or electrical reset acceptable

Water Purification Check

A minimum performance device would measure the impedance of the water and indicate that it is in the appropriate range for clinical use. Additional performance would add an indication of the presence of excessive amounts of organics. Measurement time can be very long. More advanced devices would have more levels of distinction and would operate more quickly. Chemical techniques are acceptable (with, for example, color coding that the operator must read).

Relevant additional specifications
If reusable Cost: <$3 in quantities of 5
If disposable cost: <0.10 in quantities of 10,000

Electrical Safety Analyzer
A device capable of testing leakage currents of devices to AAMI or ISO standards. The ideal device would test to as many of the standards as possible. No printed record is required. The designer can assume that the user has a digital multi-meter.

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

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 (CO2 absorbing material, matches etc).

Relevant additional specifications
If reusable Cost: <$5 in quantities of 1
If disposable 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 batteries, electrical power (when available) and hand (or foot) power. 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 for under $100.

Alternative Charging Means

Many hospitals in the developing world are using 12V lead-acid batteries to run their equipment. The goal of this project is to provide new ways to generate electricity to charge their batteries. Wind and solar power are common and should not be considered here. Assume a 12V, wet, lead-acid, 75 AHr battery. Could a rocking chair be modified? How about a Sterling engine on the roof and buried in the ground?

There is no cost limit on this project, but the most novel ideas will be immediately distributed to desperate, waiting hospitals.

Frequently Asked Questions

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

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

The tester 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 tester 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 (designprojects@ewh.org).

What environmental conditions must the tester 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.

What if my clinical engineering contact has no use for the design I selected?

This is quite possible, as needs vary from one hospital to another. Try another hospitals. Rarely, a project will get on the EWH list that is desired by clinical engineers in just a few hospitals. If several calls to several different hospitals (preferably in different countries) produce the same answer, then you should consider switching to a new project or contacting EWH to see if there was a special target hospital.

I have exchanged several e-mails with a clinical engineer about my design. Can't I substitute those for a phone call?

No.

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

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.

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 will be rejected.