9th Annual School of Science, Engineering, and Health Symposium

Engineering IPC Presentations

9:00 a.m. Welcome and Introductory Remarks

Kim Phipps, President of Messiah College

9:15 a.m. Oxygen Concentrator Modification: Intake Filter Testing and Analysis (Biomedical Group)

Presenters: Jaime Gerhart and Timothy Houck

Oxygen concentrators provide respiratory support for patients in hospitals around the world. However, because of the harsh environmental conditions in rural hospitals in Africa, oxygen concentrators fail frequently. During a visit to Macha Mission Hospital in Zambia in the summer of 2011, we determined that the concentrators were failing because of the high concentration of dust in the air; the filters in place were insufficient to prevent the dust from damaging the device. In an attempt to fix this problem we selected various types of filters from other oxygen concentrator manufacturers and tested their capacity to remove dust from circulating air. We designed an apparatus for accelerated filter testing in which large quantities of dust were circulated in a closed chamber; air from this chamber was drawn through the different concentrator filters. Throughout the testing, we measured the quantity of dust retained by the filters as well as the dust that passed through the filters. Filters that were able to retain large quantities of dust and/or prevent dust from passing through are candidates for further testing. Based on our results, the most durable filters will be selected for use in the concentrators at Macha Hospital.

9:35 a.m. Village-Scale Water Filtration by Hollow Fiber Membrane (HFM) (Water Group)

Presenters: Wesley Hollenbach and Daniel Earl

The Collaboratory has partnered with Forward Edge International and rural communities in Eastern Nicaragua to develop culturally and fiscally sustainable water treatment strategies. Ultrafiltration of water using Hollow Fiber Membrane (HFM) technology for the removal of biological contaminants is widely used in larger scale and higher cost applications the developed world. More recently, the HFM filtration products of Sawyer Products, Inc. have achieved significant success in developing world applications. This project seeks an implementation of Sawyer's 10" HFM filter for village-scale water treatment in a design that can be replicated and maintained by local people in a developing world context, and facilitates backwashing where there is no access to pressurized potable water. The presentation will include the results of prototype testing in Nicaragua, an overview of design modifications made in response to prototype testing, and pressure-flow performance data through cyclic backwashing. Additional prototype systems will be installed in Nicaragua this May 2012.

9:55 a.m. India Mark II Deepwell Handpump Redesign (Water Group)

Presenters: Derek Smith and Zachary Sizemore

The Collaboratory is partnering with World Vision to improve the reliability of India MK II pump installations in Mali, Niger, and Ghana. The hand pumps represent a large donor investment and are a critical part of the beneficiary communities' water and sanitation strategy. Our work focused on identification of critical failures based on field observations in Mali and Niger. Currently, we are working on finding Installation and design solutions to reduce or eliminate these failures. The Project will help World Vision to provide communities with a more dependable and cost effective water lifting solution.

10:15 a.m. Village-Scale Batch Water Treatment using Ozone (Water Group)

Presenters: Eric Kauffman and Tim Yoder

The Village Water Ozonization System (VWOS) is a village-scale water purification system developed by the Collaboratory to produce potable water for communities that lack access to clean water. The design uses a combination of filtration and ozone to disinfect water. Unlike filtration alone, the presence of ozone in water delivered from the VWOS system provides residual disinfection capability to purify containers used to collect and transport water, but without the unpleasant taste of chlorine. A standard biological challenge to the system using non-pathogenic bacteria was developed to standardize measurement of the effects of design modifications. Baseline tests were performed as a benchmark for future results. Test results showed that the ozone contact time needed to increase, resulting in the addition of a series of flow turns through large diameter pipe chosen to decrease water velocity and thereby increase contact time. A new venturi was also installed to increase the mixing efficiency of the ozone. The location of a future prototype implementation will be explored with the client organization, Forward Edge International, in eastern Nicaragua this May 2012.

10:35 a.m. Garden Water Access Project (Water Group)

Presenters: Lindsey Adomat and Zachary Mino

The Collaboratory Water group is partnering with Serving in Missions (SIM) and Open Door Development in Burkina Faso to design low cost well drilling and water lifting technologies to complement their Survival Garden program. We have focused our efforts in three main areas this year: a low cost hand pump, a bailer, and a set of hand augers. We plan to provide SIM with a complete well drilling and water lifting solution for small scale vegetable production by spring of 2013.

10:55 a.m. Light Sport Aircraft Nuts and Bolts (and a few rivets) (Transportation Group)

Presenter: Alyssa Mylin

Every major project is composed of a large number of small details. Some of these attract more attention than others, but all must be carefully considered, addressed, and completed before the project is finished. This presentation covers several aspects of the Light Sport Aircraft (LSA) project that may seem disconnected, but all of which contribute to making the LSA project unique. The construction of the wings for the LSA is a major undertaking, and unique in that most of the internal structure of the wings is made from material left over after the wing skins were cut out. Additionally, the attachments of two key components were designed, the pilot/passenger seating and the mounting of the medical evacuation backboard. The wing construction had been started a few years back by the Messiah College Flying Club; however this work has now been taken over by the Transportation Group. If construction of the LSA as a whole is to stay on schedule, then the construction of the wings must move forward as well. Also, as the design of the plane develops and changes are made, it is crucial that key elements such as the backboard mounting system be considered as other subsystems evolve. Finishing the design of the backboard and seat mounting systems will insure that these elements will not be left out when the other LSA components and subsystems are completed.

11:15 a.m. Light Sport Aircraft Main Gear Suspension: Flexible Rods and Safe Landings (Transportation Group)

Presenters: John Sletta and Benjamin Jarvis

During the past year the Light Sport Aircraft (LSA) Suspension team has been focusing its efforts on finalizing the main gear suspension system for the Light Sport Aircraft. Since the LSA has a tricycle

type landing gear, the plane will come in for landing nose up, leaving the back two wheels to touch down first. Consequently the suspension system supporting these wheels will take the full load of landing. The focus of the design is on a flexible pultruded fiberglass rod, which will deflect and take the load of the aircraft landing. This year's work has included selecting, mounting, and testing of the fiberglass "flex rod." The flex rod design of the main gear suspension is an innovative design offering many unique advantages along with some interesting design challenges. Analyzing the rod and the suspension system it supports has necessitated the use of tools and techniques beyond the scope of normal undergraduate classes. Despite unforeseen roadblocks, goals were achieved using creative problem solving and timely decision making. With the design stage finished and the prototyping phase in full swing, the project is on pace for a 2012 completion date. Join the LSA Suspension Team for a talk on the nearly completed main gear suspension system covering topics such as nonlinear deflection theory, flexible rod testing, and various suspension design considerations.

11:35 a.m. Lunch

1:10 p.m. Welcome and Introductory Remarks
Kim Phipps, President of Messiah College

1:20 p.m. Light Sport Aircraft Engine Integration Team (Transportation Group)
Presenters: Andrew Basom, Andrew Breighner and Jacob Francis
The engine integration team, a vital component of the Light Sport Aircraft (LSA) project, began back in 2005. Originally, the team had chosen a rotary engine, but due to circumstances beyond their control, this engine was grounded in 2009, requiring much of the work they had accomplished to be redone. After several semesters of research, the team selected the HKS 700E as a suitable replacement for the defunct rotary. Most of the redesign work has been completed, and it is now nearing the point where it can be integrated into the fuselage of the LSA. Over the past year, we have acquired all necessary engine components, constructed an exhaust system, designed a housing for the radiator, designed and fabricated a special thrust mount for our test stand, designed gas tanks for the fuselage, and created and analyzed models of the proposed base mount and thrust mount in SolidWorks. We accomplished all of this work while assembling our engine with all its components on our test stand. With the addition of our recently acquired Powerfin propeller, the LSA powerplant is complete. Once the test program has been completed, including measuring such things as thrust and fuel consumption, the engine and all its components will be ready for final installation in the fuselage.

1:40 p.m. Intelligent Battery Balancing with Multiplexers (Transportation Group)
Presenters: Erik Hornberger, Jordan Wiker and John Wolgemuth
Providing energy to hybrid and electric vehicles presents a unique challenge. Unlike in most other applications, the load on an electric vehicle's battery pack is undetermined. The batteries that power electric vehicles experience large non-uniform loads while the vehicle is being driven and so tend to unbalance. Battery packs can only be used until their least charged cell is completely depleted, so correcting this imbalance is desirable for increasing the range of electric vehicles. We have created a unique system for balancing charge in high capacity battery packs, with specific application in the Transportation Group's Solar Commuter Vehicle. In our system, a microprocessor monitors the charge on each string of batteries in the pack and uses an algorithm to intelligently route charge between the highest and lowest batteries using sets of multiplexers and a capacitor array. Two of the advantages

our balancing scheme offers are expandability and efficiency. Unlike some other balancing systems which continually move charge to and from all batteries, our intelligent system achieves balancing faster by focusing on the batteries with the greatest imbalance. Most charge balancing systems have a set capacity - the balancing current cannot exceed a certain value without damaging the circuit. Our design uses parallel multiplexers controlled by a single multiplexer, so the maximum balancing current can be increased linearly simply by adding more multiplexers to the circuit board.

2:00 p.m. User Interface for the Electric Motorcycle (Transportation Group)

Presenter: Sara Finn

The field of human computer interaction is concerned with designing technology in such a way that user interactions with the device feel natural. Creating a user friendly interface is especially important in situations where user safety is concerned, for example when operating machinery. Riding a motorcycle is an example of a complex and dangerous task, requiring the operator not only to monitor the machine, but also to be very aware of road hazards and other drivers who may not notice him/her. Due to the inherent dangers of riding a motorcycle it is very important that motorcycle riders keep their eyes on the road as much as possible. The electric motorcycle that is being developed by the Collaboratory has several subsystems that produce a significant amount of data. Some of this data is relevant only during charge cycles, but several key parameters, such as the remaining level of charge, are important during operation and must be monitored by for the operator. If this data it is not displayed in an easily readable format then the rider's safety could be compromised. The onboard computer system must sort the information by level of necessity and then display the required information to the operator in a way that minimizes the amount of time required to view and comprehend that information.

2:20 p.m. Electric Motorcycle Final Assembly (Transportation Group)

Presenters: Joshua Sorrell, Bryce Watkins, Jamison Hunsberger and Judah Fickett

Our project has been developed with the ever climbing gas prices and the growing push for more efficient vehicles that save the environment in mind. Many different companies have been working to make electric vehicles a viable option. The Transportation Group is currently working towards the same goal as major automotive companies: making a vehicle that uses absolutely no fossil fuels. The electric motorcycle brings together technology commonly seen in production vehicles including a brushless electric in-hub motor, a lithium ion battery pack, and a solar charging station. The goal is to prevent this motorcycle from being an “elsewhere emission” like many others in the field. Through work, experience, and real world testing the Transportation Group has proven that solar powered electric vehicles are becoming a classroom buildable method of transportation. This past year we have continued to progress in our prototyping of the vehicle. We have added a battery read out display and a motor shield. We have also completed our lithium ion battery packs and the circuitry to allow us to control the motor. We will continue to push to finish and improve our electric motorcycle while we search for the next step in bringing solar and electric vehicle technology to the world so that we can create a more eco-friendly sustainable vehicular pattern.

2:40 p.m. Mobility Tricycle Project History and Electric Tricycle Control Box Redesign (Disability Resources Group)

Presenter: Justin Stevenson

The Mobility Tricycle Project partners with the Center for the Advancement of the Handicapped in the village of Mahadaga, Burkina. The purpose of the mobility tricycle project is to design personal

transportation technologies for those with limited mobility. Project goals include assisting the fabricators in designing sustainable, simple, and appropriate solutions to be built and maintained by the fabricators at the center. Past project work provided two different style tricycles: a hand-powered tricycle and an electric-powered tricycle for those with limited upper-body strength. Different iterations of the tricycle designs have reduced weight, cost and fabrication time. Currently the uniform frame design allows builders to use one frame design for both the electric and the hand-powered tricycles. The present project involves revising the design and manufacturing process for the control box for the electric tricycle and documenting this process. The existing assembly consists of many parts with a time-consuming manufacturing process requiring careful detail. To cut-down on assembly time and make the assembly process easier, a template has been developed to aid in manufacturing some of the prefabricated parts. Documentation of the final assembly for the control box has also been developed and includes engineering drawings of the individual parts and fabrication instructions for the prefabricated parts. A SolidWorks assembly drawing supplements the documentation and will aid in future project work. Future project work includes researching alternative designs to modify and improve upon the current design. Prototypes of this modified design and testing of this design will continue next year.

3:00 p.m. Disability Resources Tricycle Rear Axle Redesign Project (Disability Resources Group)

Presenters: Ryan Frederick, Charles Kimpel, Andrew Patton and Jean Zipagan

Messiah College has partnered with the Center for the Advancement of the Handicapped in Mahadaga, Burkina Faso to design electric and hand-powered tricycles for persons with disabilities. In 2009 the tricycle frame was redesigned to include advancements in ergonomics, strength, and manufacturability. The new design called for a new axle design for the rear wheels. In this new design, the axle is supported on one side, similar to a wheelchair, rather than on two, as in the old axle design. When the new rear axle design was implemented in Burkina Faso, it was found that because of metal fatigue and wear, the axle failed. As a result, the current project was formed to modify the axle design to solve these problems. This project has had two goals. First, design an axle using high quality parts from the United States, to replace the faulty design. Second, consider design changes which could be used for all future tricycles using locally available material. During the January 2012 trip, the first design was implemented. Simultaneously, the team worked on the axle design to be installed on all future tricycles. Data has been gathered concerning case-hardening the axles to decrease wear. Additionally, a new axle and hub assembly has been designed, prototyped, and tested as a proof of concept. Long term testing, to be carried out by next year's project, is needed to fully evaluate the new rear axle design as a viable option for the harsh conditions it will experience in Burkina Faso.

3:20 p.m. Electric Tricycle Spline Shaft and Bearing Evaluation (Disability Resources Group)

Presenters: Ryan Schroeder and Marc Hoaglin

The drive train for the Disability Resources electric tricycle includes a planetary gear in order to reduce the speed of the motor. The output plate of the planetary gear contains a splined socket which transfers power to the remainder of the drive train via a splined shaft and bearing assembly. Field trials have indicated excessive wear in the splined socket leading to premature failures in many of the planetary gear assemblies. The purpose of this project is to investigate the causes of wear in the splined socket of the planetary gear and to propose design changes which may reduce this wear. Experimental work and research have shown there are two main factors contributing to spline wear: the overhanging

nature of the load on the splined output shaft and bearing, and impact loading of the splined socket upon acceleration, deceleration or change of direction of the electric motor. Based on these two factors, we have redesigned the assembly to include a more robust splined shaft support bearing. This reduces the impact of the overhung load and therefore reduces stress on the splined socket. With less wear and less play, the effect of the impact loading is also reduced. We are in the process of testing this new design.

3:40 p.m. Disability Resources Tricycle Durability Project (Disability Resources Group)

Presenter: Luke Sisson

In many areas of the developing world, adequate transportation is difficult to find, especially for those living with a physical disability. To help alleviate this situation, Messiah College's Collaboratory ministry has teamed up with The Center for the Advancement of the Handicapped (CAH) in Burkina Faso, Africa. The workers at CAH manufacture hand-powered and electric tricycles for the disabled in their local community. These tricycle designs are continuously being redesigned and improved each year by Messiah engineers in order to reduce costs and enhance tricycle performance. Nevertheless, new problems still arise for the end users when the tricycles are ridden. Batteries die out; wheels bend or puncture; and internal mechanisms can rust and render the tricycles unusable until fixed. For the past year, the Tricycle Durability Project team has worked to analyze potential problems and determine the life expectancy of different components of the tricycles. To this end, the team has developed an extensive testing procedure for the tricycles to be put through in future years to determine what tricycle parts fail and how often. With this information, future Durability team members will be able to track the problems that occur with these tricycles and determine the likelihood of the problems reoccurring. This will allow them to find innovative ways to reduce these problems in the future. This project allows the tricycle users to obtain a continuously improving personal transportation device that they can trust in and rely on for years.

4:00 p.m. Improving Water Access for Persons with Disabilities in Africa (Water Group)

Presenter: Sarah Finney

The Africa WASH and Disabilities Study focuses on designing appropriate technologies to make water and sanitation more accessible to persons with physical disabilities throughout West Africa. My work focuses on two of the three technologies the project has created: pump handle extensions and jerry can tippers. The pump handle extension makes it easier for persons with disabilities to obtain their own water from the India Mark II pump. A jerry can tipper serves to support the large water containers in the home and make it easier to pour the water. Our previous designs for the pump handle extension and the jerry can tippers were not optimized and created some difficulties for the end user. After collecting feedback from pump users on various extension designs and determining the correct weight distribution of the handle, I produced a new pump handle design that corrected our difficulties from previous designs. This design can be used by SOVEMA, the manufacturer of the India Mark II pump, to mass produce our modified handle. For the jerry can tipper, I performed a static analysis that determined the optimum location of the pivot point that minimizes the force required to tip the container while maintaining stability during pouring. A new jerry can tipper will be constructed for demonstration purposes so that African craftsmen can duplicate our design. All of our new designs will be adapted by World Vision International to be used throughout West Africa to serve the disabled community.

4:20 p.m. Oil Pressing and the Sunflower Project (Energy Group)

Presenter: Anthony Hahn

In the summer of 2011, five acres of sunflowers were grown on the Messiah College campus in an effort to implement a sustainable solution to obtaining quality cooking oil and biodiesel. The goal was to harvest the five acres of sunflower seeds, mechanically press these seeds to obtain oil, deliver the pressed oil to Dining Services to be used for cooking oil, and produce biodiesel from the oil once it was no longer usable for cooking. The pressing project is a subset of this sunflower project and focuses specifically on the mechanical extrusion of the oil from the sunflower seeds. The objective of the pressing project is to obtain an efficient, reliable, and safe way to remove the oil from the seeds using a screw press and diesel engine and to optimize the press parameters so that the maximum oil yield is obtained while reducing the amount of gums present in the pressed oil.

4:40 p.m. Biodiesel Centrifuging (Energy Group)

Presenters: Trevor Lee and and Beau Herndon

A critical part of turning waste vegetable oil into usable biodiesel is cleaning the waste vegetable oil of dirt, water, and impurities. One of the ways to do that is through the use of a Raw Power Centrifuge to separate by density the pure oil from the impurities in the oil. This project determines if running a centrifuge was the most efficient way to obtain clean vegetable oil in our current system based on time and cost, and to determine the optimum settings to run the centrifuge. The results of testing have determined the best flow rate and rotational speed that the centrifuge should be run in order to receive the cleanest oil in the most efficient time. The project also determines other possible cleaning techniques that may be cheaper and more efficient options depending on the application.

5:00 p.m. Automated Biodiesel Production System (Energy Group)

Presenter: Philip Martinez

Currently, the production of biodiesel for campus use is labor intensive because the main system is not automated. This slows down production because at the end of a process step if someone is not available, the production stops until someone is available. With student volunteers this may be lead to multi-day delays especially during holidays and semester breaks. The automated biodiesel production project is to allow a batch to be produced without the requirement of a presence of a person at each stage to advance the production process. The project involves the design, construction, and testing of both the mechanical and electrical subsystems of the processor. This presentation covers the testing and lessons learned along with future potential areas of research.

5:20 p.m. Powering Hope in Blanchard Haiti (Energy Group)

Presenter: Trevor Smith

Many communities in Haiti are still trying to recover after the destructive earthquake in 2010, and with a unreliable power grid, solar energy is one of the most viable options for power in the region. Therefore, using the funds produced by Ride Solar, a benefit bike ride, the Energy group has worked jointly with Advanced Solar Industries to design and install a 3.9kW photovoltaic system on a Medical Clinic in Blanchard, Haiti. This will help the community rebuild with an overall goal to help them become more self-sustaining.

5:40 p.m. Kilowatt-Hour Meter Project (Energy Group)

Presenters: Kevin Manieri, David Allen and Jonathon Martin

The goal of this project is to design and implement a reliable, manufacturable device to measure, display, and limit kilowatt-hour usage of a home or other facility. This device was requested by our client, Matt Walsh, with the intent of facilitating the sharing of excess power from an existing solar power system in Mahadaga, Burkina Faso. In addition to allowing equitable sharing of power, this device also promotes energy awareness and conservation. Three such devices have been successfully installed in Mahadaga, Burkina Faso.