FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Development of an automatic system to determine gems' shapes and dimensions

Group size: 4 students

Supervisors: Prof. Lilong Cai (email: melcai@ust.hk)

General Description:

Gemstones are generally manufactured in different shapes according to their natural occurrence in rough form, maximizing its value and yield for making jewellery. Their sizes and shapes need to be accurately sorted for classification. The use of an automatic machine to perform such measurement will greatly reduce human errors within manual methods. Also, the sorting process can be done with higher efficiency. Figure 1 and 2 show different shapes of gemstones.

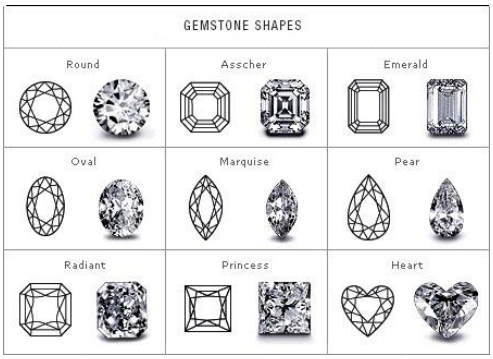


Figure 1. Gemstones in different standard shapes

Figure 2. Real gemstones in different shapes and dimension

Scope of Work:

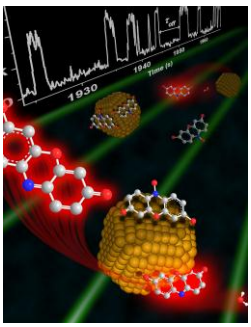
The objective of this project is to develop a PC-controlled electromechanical system for performing measurements of gems' shapes. The target size is around 2.0 mm in diameter. To achieve the requirement of this measuring system, the research areas include a vision system, image processing module and an electromechanical mechanism. The developed system will replace the present manual method that relies on the skill/experience of an expert. It will produce results with high precision and improved efficiency.

What is expected from this project and arrangement of students are:

1) A prototype of automatic mechanical system for determining gems' shapes and dimensions. This part requires two students to develop the light source, image capturing device and control system.
2) Development of software for determining gems' shapes and dimensions. This part requires two students to investigate both the algorithm and program implementation by Matlab (or C) to determine the shapes and dimensions of the gems.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Development of a Nanofluid Enhanced Adsorption Cooling System



Group size: **3-4 students**

Supervisor: **Prof. Christopher Y.H. Chao** (email: meyhchao@ust.hk)

General Description:

In recent years, research of nanoparticles on heat transfer and nanofluid on fuel droplet evaporation has become a very hot topic. Nanofluids are solutions containing particles of sizes typically in the range of 10 -100 nm. They are known to exhibit different thermo-physical properties from their base fluids such as thermal conductivity, surface tension, wettability, and non-Newtonian viscosity [1], [2] and [3]. This is because they have a very high surface to volume ratio. For metal nanoparticles such as zinc and silver, the percentage of atoms on the surface dramatically increases when the size is below 10 nm [3]. Available results indicate that nanofluids made from metal particles and water or engine oil can improve heat transfer by up to 40% [1]; more than 250% improvement has been shown for multiwalled carbon nanotubes (mean diameter and length of 25 nm and 50 nm, respectively) [4]. Such enhancement could occur for particle concentrations lower than 1% and as low as 0.001%. These phenomena could not be explained by the conventional theories developed for pure fluids. These effects of nanoparticles have implications in liquid evaporation practice. In other words, if the nanoparticles can help increase the evaporation rate of their base fluids, the cooling performance of an adsorption cooling system could be improved accordingly. This project aims at developing an enhanced adsorption air conditioner using nanofluids.

Scope of Work:

1. Study and select the most suitable metal nanoparticles;
2. Prepare different concentrations of nanofluids based on the metal nanoparticles selected before;
3. Design and fabricate an experimental set-up to measure all the thermal related properties of the nanofluids prepared before;
4. Experiments and performance evaluation (e.g. thermal conductivity, surface tension, surface energy, evaporation rate, heat of vaporization etc.);
5. Design an enhance adsorption air conditioner using the nanofluids and performance testing.

Some of the above scopes will involve all students working together. The students will also be assigned individual tasks. Both laboratory-based experimental work and system fabrication in the mechanical engineering workshop will be required.

Reference:

[1] X. Wang, X. Xu, S.U.S. Choi, Thermal conductivity of nanoparticle–fluid mixture. *J. Thermophys. Heat Transfer*, **13 (4)** (1999), pp. 474–480.
[2] K. Sefiane, J. Skilling, J. MacGillivray, Contact line motion and dynamic wetting of nanofluid solutions, *Adv. Colloid Interface Sci.*, **138** (2008), pp. 101–120.
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[4] S.U.S. Choi, Z.G. Zang, W. Yu, F.E. Lookwood, E.A. Grulke, Anomalous thermal conductivity enhancement in nanutube suspension, *Appl. Phys. Lett.*, **79** (2001), pp. 2252–2254.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Development of Low-Cost Kite for Airborne Wind Turbines

Group size: 4 students

Supervisor: Prof. Francesco Ciucci (email: mefrank@ust.hk)

General Description:

Over 65% of the electrical energy used today is generated by burning fossil fuels, such coal, natural gas or petroleum. However, due to stricter regulations concerning carbon dioxide emissions and higher costs of hydrocarbon fuel sources, electrical energy generation from renewables will likely replace traditional fossil-fuel-based technologies. The most optimistic forecast on the diffusion of wind, photovoltaic, and biomass sources estimates no more than a 20% contribution to total energy production within the next 15–20 years. Wind turbines are currently the largest source of renewable energy. Unfortunately, wind turbines require heavy towers, foundations, and large blades, which require substantial capital investments. Airborne wind turbines, which utilize flying kites, provide an exciting alternative to traditional wind turbines and could prove to be more cost effective. In fact, they can be deployed at higher altitude were winds are stronger and more predictable and typically such kites do not require such large infrastructure. In this project the students will design and manufacture a low-cost kite.

A flying kite from makanipower.com

Scope of the work:

The work will cover several key areas of aeronautical engineering including aerodynamics, flight mechanics, preliminary design, stability, structural design and manufacturing.

1. Overview airborne wind technologies by categorizing various kite designs with respect to flight mechanics and electricity generation strategy;
2. Develop the preliminary design of the kite and assess its aerodynamics, flight dynamics and stability;
3. Design the main structural elements of the kite and assess suitable materials needs;
4. Manufacture the kite with low cost materials;
5. Perform flight tests.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Development of a Portable Surface Profiler

Group size: 3 -4 students

Supervisor: Prof. Yongsheng Gao (email: meygao@ust.hk)

General Description:

In this project, a portable surface profiler will be developed and assessed for use in precision machining. A surface profiler is to obtain surface topography $z(x,y)$ (Fig. 1-2) for assessment of machining quality in terms of form error and surface roughness (Fig. 1-2). For roughness measurement, there are many indirect methods. But for form error, mostly direct methods are used. This means that $z(x,y)$ must be obtained prior to a process of precision assessment.

Most of existing profilers suffer two major problems: (a) Vertical resolution in z direction is very high but measurement range in x and y directions are very limited and (b) Measurement has to be conducted in metrology laboratory. A portable surface profiler (Fig. 3-7) will mainly address issues of (b), so that measurement can be done on site and on machine and without removing the part from its original mounting position. Such design will greatly improve productivity without loss of precision (Fig. 3-7). An initial version of the profiler $z(x)$ (Fig. 8) has a laser sensor for z (Fig. 3-6) and a motor driven table (Fig. 7) for moving a part but only in the x direction.

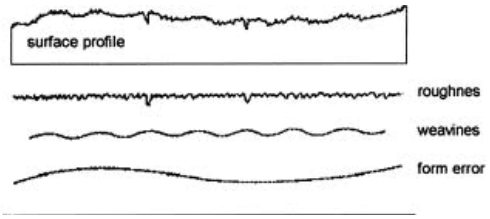


Fig. 1

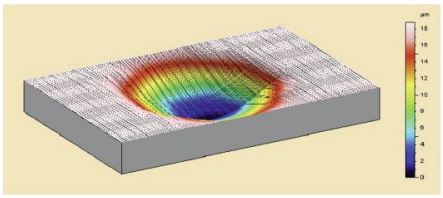


Fig. 2

Fig. 3

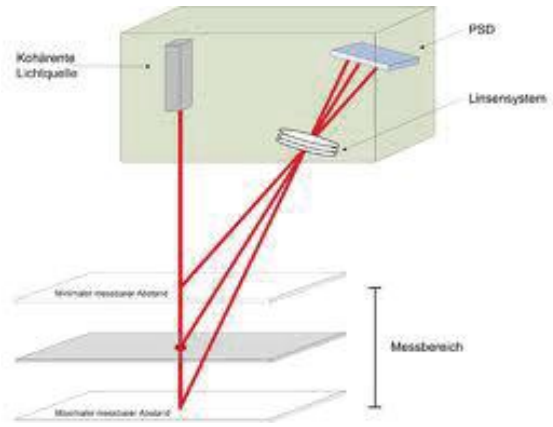


Fig. 4

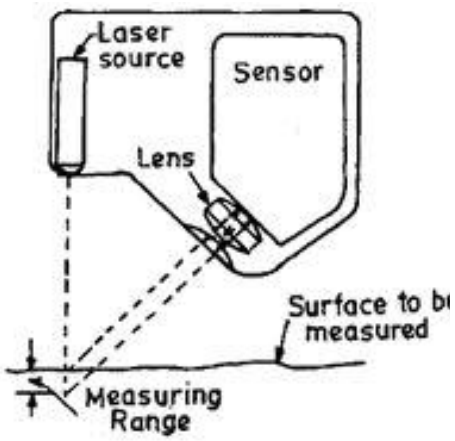


Fig. 5

Fig. 6

Fig. 7

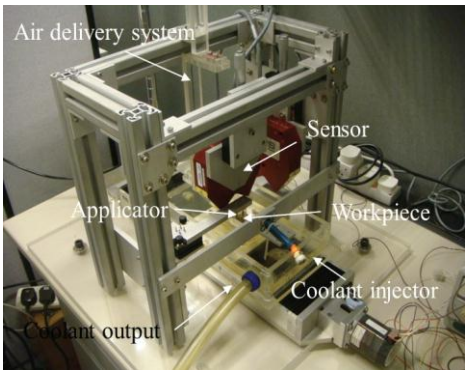


Fig. 8

The students of the project are expected to develop an improved system for $z(x,y)$. The students of the project team will gain knowledge and experiences in mechatronic and precision system design and development.

Scope of Work:

(1) **Structure**. The profiler system will of a noncontact type and will have laser sensor (Fig. 3-6), an *x-y* table (Fig. 7) to position the laser sensor in the *x* and *y* directions, and an air/water jet system (Fig. 8) for surface cleaning to displace coolant and tiny objects on the surface to allow precision noncontact optical measurement of the surface on a machine tool to obtain $z(x,y)$ information.

(2) **Requirement**. A key requirement is to design and develop a portable surface profiler under spatial and weight constraints and with electrical and pneumatic/hydraulic interfaces provided for easy connection. The system must be light weight and compact for mobility.

(3) **Background**. Currently, an initial version is available for reference (Fig. 8). The existing design is not portable and cannot satisfy the mobility requirement. Improved designs are expected in this project.

(4) **Tasks**. The tasks include literature review of the existing technologies and system working principles, specification development, concept design, detail design, modeling and analysis, mechanical system manufacturing, test and adjustment, system performance evaluation under test run and machining conditions.

Title: Development of an EDM System for Micro Feature Machining

Group size: 3-4 students

Supervisor: Prof. Yongsheng Gao (email: meygao@ust.hk)

General Description:

In this project, a compact/portable EDM system will be developed and assessed for micro feature machining in a part (Fig. 1) of metallic or ceramic materials.

EDM (Electric Discharge Machining) uses many micro electrical discharge sparks to erode material for removal of excessive materials of many kinds. Micro sparks are realized by a pulsed electrical current passing through an electrode and the part (Fig. 2-7).

Currently, shallow/thin micro features can be made through use of lithography and etching in MEMS which works well for a few kinds of materials. There are still many difficulties (a) in making deep/thick micro features on/in (b) wider choice of metallic or ceramic materials.

A compact/portable EDM system (Fig. 2-9) will be able to address issues of (a)-(b). Such design will offer greater possibilities in micro feature machining (Fig. 1).

A wire EMD version (Fig. 2-7) is currently being developed. The device requires complex handling of metal wire, does not permit use of an electrode, and can only position a part through a 2D precision *x*-*z* table.

Fig. 1

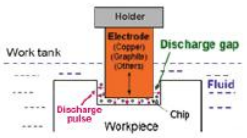


Fig. 2

Fig. 3

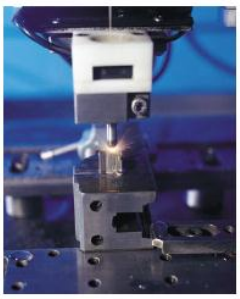


Fig. 4

Fig. 5

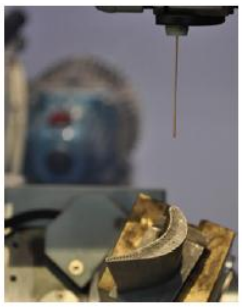


Fig. 6

Fig. 7

Fig. 8

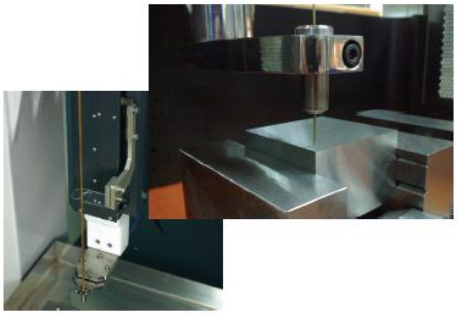


Fig. 9

The students of the project are expected to develop a new EDM system which uses an electrode and uses a 3D precision *x*-*y*-*z* table for part positioning.

The students of the project team will gain knowledge and experiences in mechatronic and precision system design and development.

Scope of Work:

(1) **Structure**. The EDM system will of die sinking electrode cut type and will have an electrode handling sub system (Fig. 9), a dielectric fluid delivery sub system (Fig. 3), and a sub system for workpiece positioning (Fig. 8) in *x*, *y*, and *z* directions. A pulse current generation sub system will also be used in the proposed EDM system.

(2) **Requirement**. A key requirement is to design and develop an EDM system under a spatial constraint. The system size has to be limited to fit to a location of limited space. The EDM system is to be compact for mobility.

(3) **Background**. Currently, a wire EDM system is being developed. The existing system is complex in metal wire handling and is not of a die sinking electrode type. New designs are expected in this project.

(4) **Tasks**. The tasks include literature review of the existing technologies and working principles, specification development, concept design, detail design, modeling and analysis, mechanical system manufacturing, test and adjustment, system performance evaluation under test run and machining conditions.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Self-powered Wireless Sensors for Environmental Monitoring

Group size: 4 students

Supervisor: Prof. Baoling Huang (email: mebhuang@ust.hk)

General Description:

Wireless sensor networks are frequently used to monitor temperature, air quality and other environmental parameters at different locations over a wide region in recent years. However, the limited battery life posts a constraint for large sensor networks. It is highly desirable to power these wireless sensors by harvesting energy from the ambient environment, such as thermal energy and solar energy. Since the different energy harvesting strategies have their own limitations, to ensure the durability and stability, integrating multi energy harvesting strategies into a single module may be the most promising solution for powering these wireless sensors.

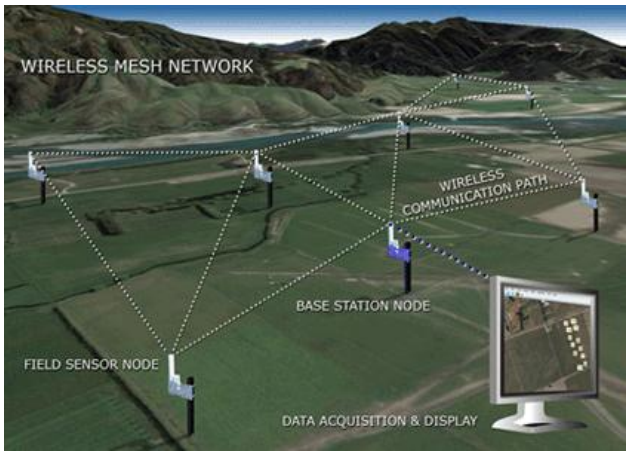


Figure 1. Wireless sensor network for environmental monitoring

Scope of Work:

1. Design and characterize an energy harvesting module that can harvesting various forms of energy from the ambient environment, such as solar energy and thermal energy;
2. Integrate the energy harvesting module with a wireless sensor for environmental monitoring
3. Test the integrated system and improve the design

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

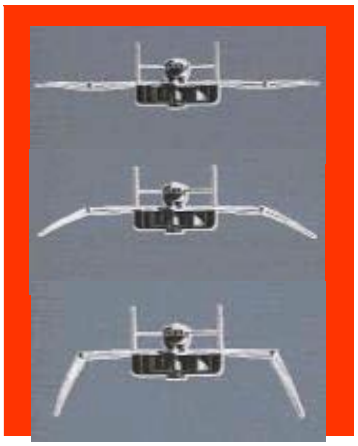
Title: Shape Memory Polymer Nanocomposites for Morphing Applications

Group size: 3 – 4 students

Supervisor: Prof. Jang-Kyo KIM (Email: mejkkim@ust.hk)

General Description:

Polymeric composite materials have found widespread use in many industries, such as aerospace, automobile, medical etc. for varied applications. Shape memory polymers are a class of polymeric materials that are capable of responding to an external stimulus by altering their physical and/or chemical properties. The stimulus can be in the form of heat, electricity, magnetism or even light. These materials are being researched for applications as multi-functional materials. The proposed project is also one such attempt at developing multi-functional material configurations using nanofillers in a shape memory polymer. The project is aimed at developing nanocomposites that are in addition to being stiff, strong and electrically conductive, possess shape morphing capability.



The project aims to develop epoxy-based shape memory nanocomposites with carbon nanofibre / graphene as the reinforcing nanofillers. A thermosetting epoxy resin system with shape memory capability is chosen for the purpose. The thermomechanical properties of the resin system are to be studied. Nanofillers are then added to the epoxy resin and the effects of nanofiller addition on the shape memory capabilities of the resin system are to be evaluated along with other important mechanical and multi-functional properties of the composites. Carbon nanofibres in the form of a distributed network (paper form) are then combined with the matrix system to yield the nanocomposite. The carbon nanofibre network is employed to function as a heating element, which

serves as the stimulus effecting shape morphing in the material system. The morphing capability of this material configuration will be characterized. The demonstrated concept facilitates the development of sensors, actuators, morphing skins for aircraft and other moving systems. Typical such systems in aircraft include i) landing and take-off flaps, ii) variable sweep wing with stretching and sliding skins that meet change requirements and iii) vortex generators.

Scope of Work:

The project would involve the following work:

1. To identify and characterize the thermomechanical properties of shape memory capable epoxy system(s).

2. To study the effect of nanofiller addition on the shape memory characteristics of the epoxy system along with other important mechanical and multi-functional properties. This would include optimization of material parameters such as carbon nanofibers and graphene, and their contents.

3. To designing a method(s) and develop the set-up for resistance heating of the carbon nanofibre network embedded in the epoxy composite system.

4. To demonstrate and evaluate the performance of the above material system(s) with respect to morphing capability under service environments.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Intelligent Energy Management System for PCs and IT networks

Group Size: 3 – 4 students

Supervisor: Prof. David Lam (email: david.lam@ust.hk)

General Description:
After lighting, computers and monitors have the highest energy consumption in the office environments. For an UK office with 20 PCs, study showed that PC energy management can save such firm up to GBP1,200 per annum (http://www.1e.com/energycampaign/calculation.aspx) or more when secondary energy storage hardware and energy management software are used simultaneously.

In addition to the cost savings and eco-benefits from energy savings, a principal mode of data loss on a PC is power failure. To avoid data loss, uninterrupted power supply (UPS) is supplied to high-end PC to safeguard the PC against power failure and data loss.

The target of the FYDP team is to provide low-cost data security (avoidance of data loss) function in an intelligent eco-friendly power supply for the PC.

The team is to develop a prototype and to demonstrate the UPS function, the eco-friendliness and the cost savings afforded by the prototype power supply.

In addition, the team is tasked to develop a business plan and model for submission to the HKUST Entrepreneurship Competition in Spring 2013.

Scope of Work:
1. Develop a monitoring and control system for the energy management of personal computers to reduce energy cost (specifically to take advantage of low electricity cost at night).
2. Design the package and assembly of secondary storage batteries (UPS) to avoid data loss.
3. Test the performance of the UPS.
4. Characterize the energy savings from the system.
5. Develop a business plan and presentation for the HKUST Entrepreneurship Competition.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Design and Prototyping of 3D LED Cube and Sphere Displays

Group size: 4 students

Supervisor: **Prof. Ricky Lee** (Office: Room 2560; Tel: 2358 7203; e-mail: rickylee@ust.hk)

General Description

Light emitting diodes (LED) have been used for signaling and display for a long time. In recent years LEDs are further used for back lighting and general lighting. With the evolution of high brightness LEDs, there are more and more demands for wide area solid state lighting (SSL) using LED arrays. In the past few years, several LED lighting projects have been exercised at HKUST. Now it's time to practice the LED display projects. Most of current LED displays have a 2D panel format as shown in Figure 1. Compared with LCD displays, LED displays are much brighter but have much coarser pixels. Therefore, LEDs are typically used for messaging, decoration, and large screen public displays. These kinds of LED panel displays have been widely implemented in the industries. Recently there appears a new format for LED displays. LED arrays may be arranged in a 3D structure to form a LED cube display. However, their assembly process becomes much more difficult and the thermal management may be a challenging issue. The objective of this project is to design and prototype a 3D LED cube display as those shown in Figure 2 (http://technabob.com/blog/2008/04/06/led-3d-cube-color-display/). In addition, a variation in a 3D sphere format similar to the example shown in Figure 3 may be considered as well.

Scope of Work

This project consists of several essential elements, namely, components and parts sourcing, mechanical design and assembly, thermal management, and electrical circuitry. Participating students will develop design, assembly, characterization, and analysis skills from designing and prototyping a 3D LED cube display. Both team work and individual effort will be emphasized. Each student will be responsible for one of the following tasks:

1. Sourcing of Components/Parts: *select and source suitable components and parts.*
2. Packaging and Assembly: *design and implement mechanical packaging and assembly processes.*
3. Electrical Circuitry: *design and implement electrical interconnections and control circuits.*
4. Thermal Management: *design and implement heat transfer schemes for thermal management.*

Fig. 1: 2D LED Panel Display

Fig. 2: 3D LED Cube Displays

Fig. 3: 3D LED Sphere Display

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Design and Fabrication of a Microfluidic CTC Chip for Cancer Diagnostics

Group size: 3 -4 students

Supervisor: Prof. Yi-Kuen Lee (email: meyklee@ust.hk)

General Description:

Cancer is one of the top killers in Hong Kong and the other world. Conventional cancer diagnostics using invasive biopsy and/or positron emission tomography in hospitals is expensive and time-consuming. The counting of the circulation tumor cell (CTC) in human blood has been shown to be one new possible way for cancer diagnostics. However, the concentration of CTC in comparison with the other blood cells is much lower (hundreds of cells per mL). CellSearch^{TM} System (Veridex LLC, USA) has been approved for CTC analsys by US FDA. However, CTC analysis using CellSearch is very expensive. In recent years, there are two possible approaches for microfluidic chip to capture CTC: antibody-based and filtration according to cell sizes (typical CTCs are larger than blood cells). This project is to design and fabricate a new type of filtration-based microfluidic chip for CTC analysis by using MEMS technology.

Scope of Work:

The design and manufacturing of this prototype are challenging. Each student will be responsible for one of the following design and manufacturing:

1. Design and chacterize the deep reactive ion eching (DRIE) technique for fabrication of microfluidic CTC chip,
2. Design and fabricate the packaging of microfluidic CTC chip,
3. Characterize the performance of microfluiidc CTC chip using fluorescence microscopy,
4. Conduct computation fluid mechanics study to optimize the design of microfluidic CTC chip.

References:

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FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: DESIGN AND MANUFACTURE A MINI ROBOT FOR DANCING

Group size: 3 – 4 students

Supervisor: Prof. Yang LENG (meleng@ust.hk)

Industrial Sponsor: RADAR Co., Ltd

General Description

The project is to design and manufacture a mini human-like robot that can dance with music. The robot dancing is one of popular types of robot contests. The robot should perform a number of dance movements when music starts. This design project includes several primary components: power system, mechanical structure, control system, and aesthetic design. The manufacturing and assembling of such robot are challenging. Its performance and functions are expected to reach a level of commercial mini robot, or even better. Students will go through training of a product design and prototype realization in this project. Both team work and individual efforts will be emphasized. Individual team member will be responsible for one of the following design and manufacturing:

Scope of Work

1. Robot structure and function design

Design objectives: design the whole robot structure and functions, and define the capabilities of the dancing robot.

2. Power system and motion design

Design objectives: provide sufficient power supply for a 5-minute dancing and sufficient movements and stability in motion.

3. Mechanical structure and aesthetic design

Design objectives: Make robot structure with sufficient strength to support all components and minimize the total weight of robot. Design the appearance of robot.

4. Control system and synchronization with music.

Design objectives: Make automatic synchronized movements with music.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Design of Radon Detector

Group size: 4 students

Supervisor: Prof. Zhigang Li (email: mezli@ust.hk)

General Description:

Radon is a radioactive, odorless, colorless, and tasteless noble gas that is released from the normal decay of uranium in soil/rocks. Radon can enter homes through cracks in the foundation, floors, and walls. Radon may also be present in the water supply in homes that have well water. Radon is the second leading cause of lung cancer after smoking, and the number one cause of lung cancer in non-smokers.

Typical domestic exposures are of approximately 100 Bq/m^3 indoors. If the concentration of radon exceeds a few hundred Bq/m^3, it can represent a serious health risk, leading to lung cancer. Depending on how houses are built and ventilated, radon concentrations in a house may differ in different locations. Also, the concentration in one room of a building may be significantly different from that in an adjoining room. Therefore, constant monitoring of indoor radon concentration is important, especially in high radon areas.

In this project, a radon detector is to be designed, manufactured, and tested. The detector should be sensitive to radon concentration (up to 100 Bq/m^3), reliable, and stable.

Scope of Work:

1. Literature review of technology employed in the available radon detectors.
2. Design of the measurement system, including sensing techniques, data acquisition, and display system.
3. Manufacture and integration of the detector.
4. Testing of the detector.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Development of Flapping Wing Micro Air Vehicles (MAVs)

Group size: 4 students

Supervisor: Prof. Huihe QIU (meqiu@ust.hk)

General Description:

Nowadays there is an increasing interest in the development of Micro Air Vehicles (MAVs) from the civil sector to military industry. There is a wide range of possible usages of them from exploring environmental hazards to surveillance. They can be non-lethal weapons or tools of entertainment. Their main design factors are maneuverability, size and propulsive efficiency. To realize hovering flight and high efficiency under small size are especially challenging. Traditional lift mechanisms lose efficiency as size decreases. However, small MAVs can potentially benefit from a number of unique aerodynamic phenomena, which bugs and birds naturally utilizing.

Flapping wing type MAV is an attractive solution to answer these conditions. The advantage of a flapping wing MAV is envisioned to lie in its maneuverability, smooth transition from hovering to forward flight and low noise flight signature, as compared to the same scale fixed or rotary wing aircrafts. The engineering task, as well as the ultimate goal of this project is to learn from natural evolution of flying bugs and birds, and implant it to the design of innovative flapping wing MAVs.

In this project, a flapping wing MAV will be developed. The flying mechanism of birds and bugs will be experimentally studied using state-of-the-art optical diagnostic techniques to refine our knowledge in regarding the interplay between the kinematics and aerodynamics.

Scope of Work:

1. Design and fabrication of the wing structure for a MAV

Design objectives: Frame structure and material design, selection and fabrication will be conducted. Different chopwise and spanwise structures and flexibilities will be fabricated. Material selection will be considered.

2. Design of transmission system for flapping wings

Design objectives: Mechanical and electrical transmission system for wing flapping motions will be design and fabricated. Optimization will be performed using experimental data.

3. Control and communication system

Design objectives: A micro controller based on wireless remote control system will be developed to control the wing motion and flight.

4. System integration and aerodynamic tests

Design objectives: Design of methodologies for aerodynamics and fluid flow measurements, system integrating, test and experimental results. The performance of MAV will be evaluated in wind tunnel facility.

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* This is a self-proposed project and a group of 4 students have already been assigned to the project.

A Dragonfly

(MAV proposed by US Air Force)

Smart Bird (FESTO)

Title: Remote Hill Fire Monitoring System

Group size: 3 – 4 students

Supervisor: Prof. Moses Ng (Email: memoses@ust.hk)

General Description:

Hill fires destroy ecological environments such as grasslands, shrub lands and plantations which are the habitats of many wild animals. Having burnt off the vegetation cover, hill fires also cause soil erosion and in some cases, threaten human property and life. Modern inventions such as cameras with functions including image processing and data transmission provide means of off-sited monitoring of hill fires. Power needed for these operations could be obtained from natural resources such as solar photovoltaic and wind in places where power lines are not available. This project integrates several modern technologies to effectively monitor hill fires remotely.

Scope of Work:

(1) Camera monitor and image processing

Camera with zooming mechanism will be used to monitor the situation. The captured image of possible hill fire will be zoomed in for detailed examination by an on-site microprocessor to determine if the hill fire is genuine in comparing with set images of known hill fire. The exact position of the possible hill fire will be located for further action.

(2) Data transmission

Images and other data of the possible hill fire noted will be transmitted back to the depot for additional determination and further action. As the monitor system is positioned in remote places, the data transmission will be processed by mobile internet arrangement.

(3) Power Logistics

Power is needed to move the camera, process the images captured, send the information back to the depot, etc. As this system is stationed in places where the power lines are usually not available, energy from the natural resources such as solar photovoltaic and wind could be used for these purposes. Since solar power is not available at times such as cloudy or rainy days, or after dark, and wind blows intermittently, these two natural resources should be used in combination to provide constant power supply for the system. In addition, batteries will be employed to store the electricity generated when the renewable energy is available that power could be provided when needed.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Mini-green energy generator by thin NiTi wire

Group size: 4 students

Supervisor: Prof. Qingping SUN (email: meqpsun@ust.hk, Office: 2358-8655)

General Description:
The creation of pollution-free green energy has become one of the main concerns in our modern society, the whole engineering field and the energy industry. This project aims to build a mini-green-energy generator made of thin shape memory alloy (TiNi) wires or thin NiTi micro-tubes. The project includes several components: Design principles for the energy generation, mechanical structure, electric and thermal-fluid parts, design and manufacturing, and assembling and testing. They are all very interesting, exciting and challenging. The performance and functions of the green engine and the efficiency will be assessed so that it can be used for demonstration and to nicely attract the high school students in the Outreach Day of the Department and the Engineering School. It will also be considered to donate this device to the Hong Kong Science Museum. Students will go through a series of training in both product design and prototype realization in this project. Both team work and individual efforts will be emphasized. Each student or a group of students will focus on and be responsible for one of the following work:

Scope of Work:

1. **Design Principles, Criteria and Objectives:** Physical principles for the mini- green energy generator, and the estimated performance.
2. **Selection of the materials and test characterization to evaluate the performance***:* to complete the material testing and data acquisition.
3. **Mechanical design and performance control, especially on how to achieve an easy observation***:* to finish all the required mechanical, electrical and thermo-fluid components.
4. **Manufacturing process***:* to produce all required components.
5. **Assembly and testing***:* to demonstrate that the designed and manufactured green engine can perform all the designed functions for the purpose of demonstration.

Job assignment among the team:

All the 4 students are required to participate in the design, fabrication, calculation and tests processes but with different focus of concentration. The project leader will coordinate the whole project.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Robotic Earthworm

Group size: 4 students

Supervisor: Prof. Kai Tang (email: mektang@ust.hk)

General Description:

Robots that move like an earth worm have many applications in which traditional man-walk like robots are not suitable, i.e., moving on sand or rough and uneven terrains. A typical design of a robotic earthworm, as shown in Fig. A, is actually more like a centipede than a worm. It simulates the septa muscles of a worm with groups of rings of mechanical fins which are controlled by electric motors. The robot moves forward, backward, or turns based on the coordinated group movement of the rings of fins. There are serious limitations and shortcomings of this design. First, since each group requires a separate motor, to realistically simulate a worm which can usually have more than 20 rings (Fig. B), many motors are needed which make the robot too heavy for real use. Second, fins are not stable due to its point-contact nature, so will be the robot. Actually, a real worm doesn't have these problems because its movement is realized by both circular muscles and longitudinal muscles, as shown in Fig. B. There has been increasing demand on new types of robotic earthworms that simulate not only longitudinal but also circular muscles, such as the one shown in Fig. C.

Fig. A. A typical robotic earthworm

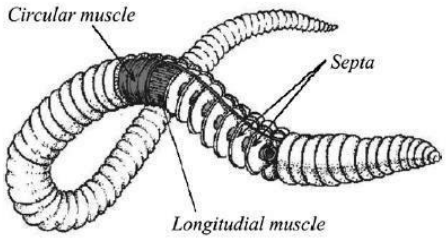


Fig. B. A real earth worm

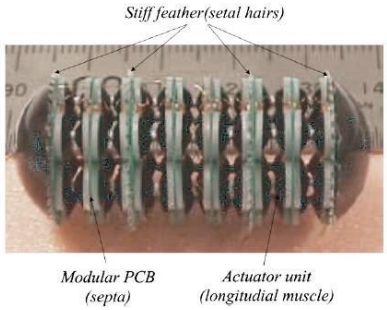


Fig. C. Desired robotic earthworm

The objective of this project is to work out a new and intelligent design of a robotic earthworm that will simulate both longitudinal and circular muscles of a real worm.

Scope of Work:

1. A thorough study of various designs of today's robotic earthworms, in particular their actuations and control.
2. A new design of a mechanism for simulating the longitudinal muscles.
3. A new design of a mechanism for simulating the circular muscles.
4. A new design of actuation mechanism in which all the mechanical rings and/or fins are actuated by a single motor.
5. All the control PLC of the system.
6. Finally, make it and test it on sand, grass, carpet, uneven grounds, climbing hills, etc.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Thermal Characterization of Phase Change on Nanoengineered Surfaces

Group size: 3-4 students

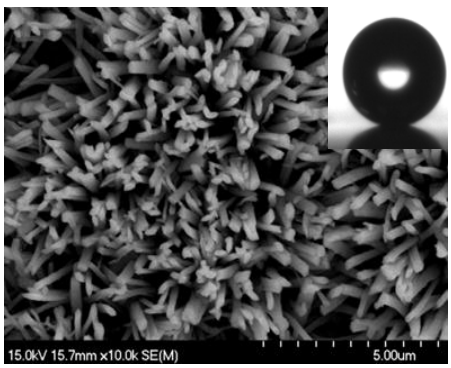
Supervisor: **Prof. Shuhuai YAO** (email: meshyao@ust.hk)

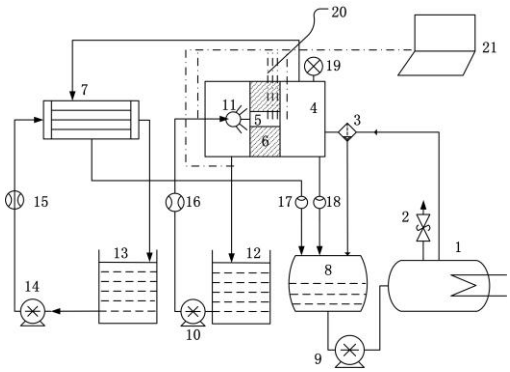
General Description:

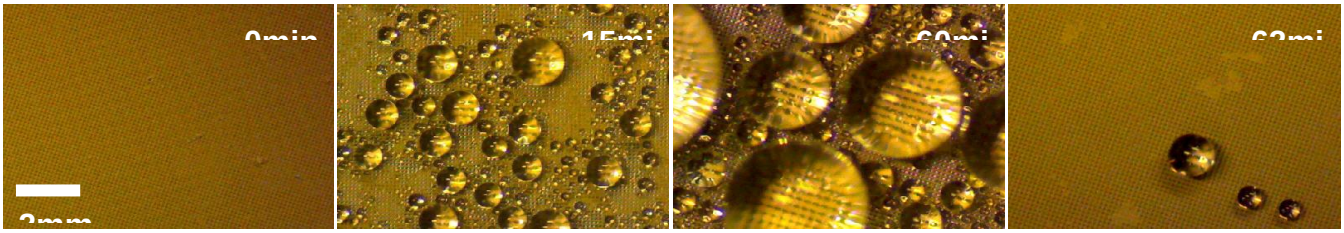
Phase change phenomena are encountered widely in the energy and water industries. For example, in the electronics industry high power density systems are increasingly limited by thermal issues. Two-phase heat exchangers that utilize phase change between an evaporator and a condenser offer superior cooling strategies. Innovative nanoengineered materials promise to significantly enhance thermal performance in vapor chambers or heat pipes, leading to cost savings and allowing improved thermal management. Research on water evaporation and condensation will advance these thermal management systems to achieve higher energy efficiency and potentially influence various industries including automobiles, electronic devices, refrigeration, distillation, power plants, etc.

Scope of Work:

We propose to develop novel nanostructured surfaces on copper substrates using chemical treatment and nanofabrication technology. Both morphology and wettability of the surfaces are crucial in phase change transport phenomena. Super-hydrophobic/hydrophilic or combined heterogeneous surfaces will be fabricated for evaporation or condensation experiments. We will build experimental setup to characterize heat flux and temperatures during the phase change and establish the correlations for heat transfer coefficients. Using experimental visualization and thermal characterization, we are exploring how the morphology and wettability properties of surfaces ultimately define macroscale heat and mass transport during phase change.







~60 minutes After vibration

FINAL YEAR DESIGN PROJECT OF MECHANICAL ENGINEERING
(2012/2013)

Title: A Rotor Powered by the Sun

Group size: 4 students

Supervisor: Professor Wenjing Ye (Room 2548; Tel: 2358 7194;Email: mewye@ust.hk)

General Description:

Looking for alternative energy sources has been a pressing task since the beginning of the global energy crisis. Solar energy certainly is one of the most attractive nature sources. While the majority of work in developing solar energy utilizes the photoelectric effect to convert solar energy directly to electricity, there are other means that can be explored to generate energy from the Sun.

This FYDP aims at developing a rotor powered directly by the sunlight. The principle utilized is the thermal transpiration phenomenon which has been employed in several devices including the famous Crookes Radiometer (http://en.wikipedia.org/wiki/Crookes_radiometer). The successful completion of the project would provide the groundwork for the future development of a helicopter-size rotor powered by the Sun.

Scope of Work:

(1) **Background study and literature research**
   a. Principle of thermal transpiration and rotation mechanism
   b. Crookes radiometer

(2) **Conceptual design and evaluation of manufacturability**
   a. Performance estimation
   b. Preliminary design on major parameters

(3) **Detailed design which includes the following major subsystems**
   a. Rotor: both flat and curved blades
   b. Supporting structure
   c. Setups for rotation and lift force measurements

(4) **Manufacturing and Testing**

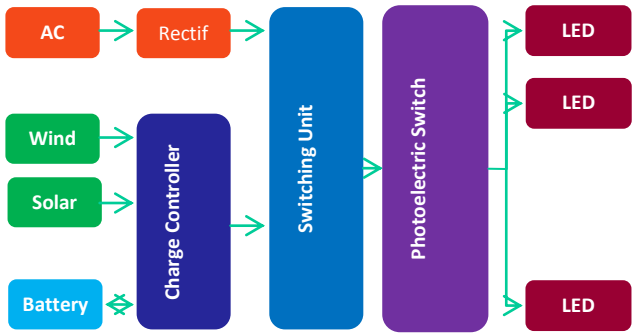
FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: Evaluation of a Wind Turbine Renewable Energy System

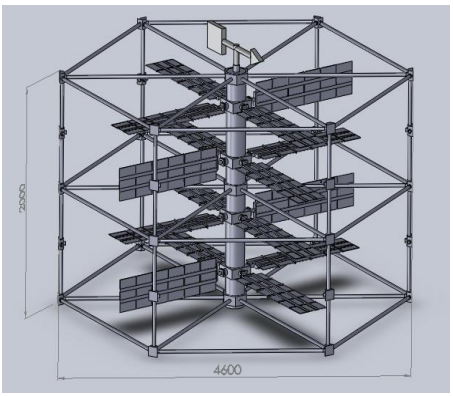
Group size: 3 -4 students

Supervisor: Prof. Matthew M F Yuen (email: meymf@ust.hk)

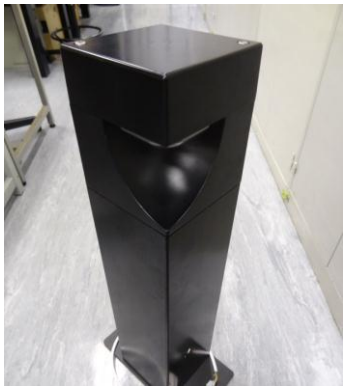
General Description:
A vertical wind turbine system has been fabricated and is to be installed in HKUST. The wind turbine is to drive a set of LED lights with alternative AC power supply and solar panel. The LED lights are run on a DC micro-grid.



Features of the system:
- Wind and Solar Energy as main source, AC from utility as supplementary source.
- Battery energy storage system with charge controller.
- Switching unit with dual coil relay control for renewable energy/utility power supply control
- Photoelectric switch control the LED bollards to switch on at low ambient light
- 24V DC micro-grid to LED



Stackable Vertical Wind Turbine
2 m/s start-up speed



10 x 10W LED Bollard

Scope of Work:
The wind turbine is under construction but the performance is still to be evaluated. CFD calculation has been conducted to evaluate the performance of the wind turbine. It is necessary to study the overall performance of the system, from wind turbine to LED lighting. The scope of work of the project covers:

1. CFD calculation of the wind turbine to optimize the design of the turbine system
2. Conduct measurement for the entire system, from solar and wind power to LED.
3. Design of DC micro-grid system
4. Re-design the system for more efficient operation
5. Re-design the system for scale-up to batch production.

The project will require both analytical skill and experimental skill in data collection and analysis.

FINAL YEAR DESIGN PROJECTS OF MECHANICAL ENGINEERING
2012/2013

Title: The Power Plant inside a Bag

Group size: 3 – 4 students

Supervisor: Prof. Tongyi ZHANG (email: mezhangt@ust.hk)
Teaching Assistant: Mr. Sam JIANG (email: xjiang@ust.hk)

General Description:

In past two decades, the usage of portable and wearable electronics has grown steadily. While they become more powerful and helpful, their energy consumption increases dramatically. Especially, when one is not allowed to charge them according to the situation, like travelling, field work, and outdoor adventure, this problem emerges obviously. On the other hand, a lot of energy generated by machines and human beings ourselves dissipates into ambient via vibration and friction. If we could harvest such kind of energy to power our electronics, good things come in pairs. Piezoelectric materials, which can convert mechanical energy into electrical energy directly, are the ideal candidates to do this job. The 2011~2012 FYDP group designed and fabricated a prototype of piezoelectric shoe to collect the energy of walking steps to support a pedometer. The 2012-2013 FYDP will continue working on piezoelectric materials, which will be used to design a bag to harvest energy. The power of the energy collector in it should be high enough to operate electronics or charge their batters.

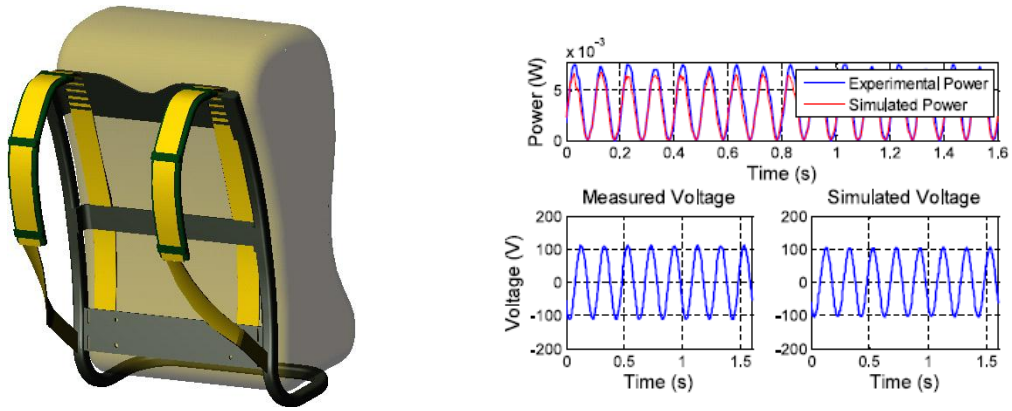


Fig.1 Sketch of the piezoelectric bag with a power generator (yellow belts are made of piezoelectric materials), and the sketch of its power and voltage output

Scope of Work:

Two main tasks are included in this project: material preparation and device fabrication.
For material preparation, the major objectives are:

- To fabricate flexible piezoelectric belts or films.
- To characterize their piezoelectric properties.
- To assemble a simple piezoelectric energy generator.

For device fabrication, the major objectives are:

- To design a structure suitable for human body.
- To choose a feasible and useful personal electronic device for application.
- To assemble all the components to an energy generator, including a bag, piezoelectric materials, personal electronics and circuit.

Title: Design and development of a Fuel-Cell-Battery Hybrid Powered Dinosaur Pet

Group size: 4 students

Supervisors: Prof. T.S. Zhao (metzhao@ust.hk)

General Description:
As a competitive candidate for portable electronic applications, the direct methanol fuel cell (DMFC), offers many unique features such as high-energy density and conversion efficiency, low cost, instant recharging and safety. Although DMFCs can be directly used as power source, solely employing DMFCs is impractical. One of the main weak points of the DMFCs is slow dynamics dominated by a temperature and fuel-delivery system (pumps, valves). As a result, DMFCs have a long start-up time (usually several minutes) and poor response to instantaneous power demands. Another drawback of solely using DMFCs as power source is low efficiency. Since the load power changes in various scenarios (for example, standby, normal operation and cruise), if the DMFC is designed to meet the requirement of one scenario, the efficiency of DMFC stack in another scenario may be quite low. Therefore, to employ a DMFC in portable applications, the electrical system must have at least an auxiliary power source (battery) to improve system performance under different conditions. This project is to develop a dinosaur pet powered by the fuel-cell-battery hybrid system, which offers many advantages, including the high system efficiency, low cost, simple system and rapid recharging.

Participating in this project, students will benefit from the followings:

- Opportunity to work in Prof. Zhao's interdisciplinary research group
  - Different engineering disciplines
  - Different talents (group leader, research, reporting, etc.)
- Develop project skills
  - Communication (oral, written, project documentation)
  - Teamwork
  - Project management
- Participate in "hands-on" design of complex system
  - On the technological frontier
  - Outcome uncertain … couple with research

Scope of Work:
The project is to develop a high-power density DMFC-battery hybrid powered dinosaur pet, which is running on the methanol solution stored in the fuel cartridge and air from the surrounding environment in a passive mode. The work will include design, fabrication, and test of a DMFC-battery hybrid system and integration with a dinosaur pet into a prototype. Each student will focus on a key component of the DMFC stack. He/she will study the mechanical and electrochemical phenomena occurring in the component and come out his/her optimal design and fabrication of the component. Finally, all the group members will participate assembly and performance test.

Student #1: Overall system design of the fuel-cell-battery hybrid powered dinosaur pet
Design objectives: A student, acting as the group leader, is required to lead the group to come out with the overall system design. The design can be different versions and all the pros and cons of the different designs must be presented in the final report. Particular attention has to be paid to the

ance between the size and the output power as well as the balance between the size and the run-time.

Student #2: Membrane assembly electrode (MEA) fabrication and characterization
Design objectives: MEA is the key component of the DMFC. Student#2 will work together with a PhD student to fabricate and optimize the MEAs for the DMFC stack. In particular, the MEA should be designed to attain low crossover rates of methanol and water.

Student #3: Design and fabricate the fuel cell stack
Design objectives: Passive methanol delivery system will be adopted in the hybrid system. To extend the run-time of the dinosaur pet on a single charge, methanol delivery system should be precisely designed to achieve higher energy efficiency (i.e. lower methanol crossover) with higher concentration methanol solution stored. Student#3 will accomplish the design work together with Student#1 and fabricate the require components by himself/herself.

Student #4: Integration of the fuel-cell-battery hybrid
Design objectives: The student will design and fabricate the control system for the fuel-cell-battery hybrid such that under low energy demand, the dinosaur pet is powered by fuel cell only and the battery is charged by the fuel cell until it is full, while under high energy demand, the dinosaur pet is powered by both the fuel cell and the battery. The student will finally assemble all the components with the help of Students#1, #2 and #3.

All Students: Fuel cell assembly and system performance test.
All the students will participate assembly and performance test.