 SENIOR DESIGN  
FALL 2015
think about my future every day • never settle for less than my best • push myself harder than ever before • value my education • stand up for what I believe in • go to ALL my classes • actually study for said classes, a lot. • challenge those who doubt me • never forget how awesome I am • connect with my classmates • encourage my classmates • realize that good things come to those who work • apply for a scholarship (hey, you never know) • put my education first • understand that college is supposed to be hard • never give up • have many goals • keep in mind that excellence is not an exception; it is a prevailing attitude • be a leader • be honest with myself, my professors, and everyone else • ask 10,000 questions • look up answers • be patient with myself • admit to failure without loss of enthusiasm • turn my weaknesses into strengths • anticipate HARD classes • constantly pursue knowledge • create simplicity out of clutter • take advantage of opportunity • make myself stand out • silence my phone when I know I need to focus • not submit to the black hole of distraction that is the internet • stay awake during class, no matter how tired I am • join a student organization • be open about my degree path • study abroad • attend senior design as an underclassman • study before going out, not after • not be embarrassed to learn from a tutor • try not to complain about my workload • not immediately switch my major just because it requires less math • not roll my eyes at my professor • exercise my creativity • exercise my body • consider my options before making decisions • try new things • think about how my ideas can effect the world • not be too proud to retake a class • utilize the strengths of my classmates • not let my extracurriculars get in the way of academia • **engineer a better future**
Building the Functional Engineer

Building the functional engineer requires a commitment to exposing students to everyday problems. At the culmination of Senior Design Day, students are prepared for graduate school or ready to impact a workforce and region in need of innovation and creativity. At the College of Engineering and Engineering Technology, our students not only learn how to think, but to innovate and communicate new ideas and concepts.

Congratulations to all the students who have worked tirelessly to achieve the goal of becoming engineers or technologists and discovering #WHYENGINEERING. We are grateful for your fortitude, and wish you luck in your future endeavors.

This booklet contains the projects for the Fall 2015 Senior Design students. We are committed to providing high-quality theoretical learning combined with the access to state of the art facilities, real-world challenges, and internships which provide practical learning.
## MASTER SCHEDULE

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<td>Judge Refreshments</td>
<td>321 - Dean's Conference Room</td>
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<td>MEE Presentations Begin</td>
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<td>ELE Research Presentations Begin</td>
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<td>ELE Presentations Begin</td>
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<td>TECH Presentations Begin</td>
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<td>Lunch</td>
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## PRESENTATION SCHEDULES

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<td>Pallet Release System</td>
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<td>8:25 a.m.</td>
<td>Optics Based Active Control System</td>
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<td>8:50 a.m.</td>
<td>Off Grid Aquaponics</td>
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<td>9:15 a.m.</td>
<td>Assist - ump</td>
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<td>9:40 a.m.</td>
<td>Methane Flare Energy Transformation</td>
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<td>10:05 a.m.</td>
<td>Dump Truck Release Agent Coating System (DTRACS)</td>
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<td>10:30 a.m.</td>
<td>Motion Tracking Optic</td>
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<td>Automated Solar Powered Irrigation System</td>
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<tr>
<td>11:20 a.m.</td>
<td>Active Tracking Solar Collection Apparatus</td>
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<td>Multi-Powder Shaker</td>
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<td>Pharmaceutical Tube Evacuation</td>
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<tr>
<td>1:50 p.m.</td>
<td>QUIN-4.0 Smart Drone*</td>
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* Interdisciplinary Project

### Department of Electrical Engineering

#### Independent Research

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<td>ELE 499 - Nathan Freitag</td>
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### Department of Electrical Engineering

**Senior Design**

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<td>Electromagnetic Softball Pitching Machine</td>
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<td>Model Train Communication System</td>
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<td>DC Motor Dynamometer</td>
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<td>New Voice</td>
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<td>11:20 a.m.</td>
<td>Spectogram with Note Recognition</td>
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<td>1:25 p.m.</td>
<td>Neurofeedback Tool</td>
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<td>QUIN-4.0 Smart Drone*</td>
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<td></td>
<td>* Interdisciplinary Project</td>
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### Department of Industrial & Systems Engineering

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<td>SPX Consolidating and Improving Process of Hytec Lines</td>
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<td>VNA Process Improvement and Cycle-Time Reduction</td>
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<td>1:00 p.m.</td>
<td>Caterpillar Medium Wheel Loader Guarding Area Improvement</td>
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<td>Daubert Integrating Bulk Silo to Eliminate Manual Material Handling</td>
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<td>Xylem New Warehouse Layout</td>
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### Department of Technology

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<tr>
<td>10:55 a.m.</td>
<td>Solar Powered Electric Vehicle</td>
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<td>Improved Knee Walker</td>
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<td>Automated Candle Making Process</td>
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<td>1:25 p.m.</td>
<td>Operational Amplifier Tester</td>
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Each senior design project merges profitable concepts from both academia and industry, using applied research and product development to find industry-driven solutions. Combining the two-way culture of academia and industry is cost effective and beneficial to both parties.

Today, we welcome our corporate partners and mentors, thanking them for the service they provide, and celebrating the critical nature of the teaching and learning process. Our relationships with business and industry foster many of these projects, but always provide our students with the essential opportunity to apply their knowledge and skills to real-world problems.

**Thank You to Our Corporate Sponsors**

- Fitzgerald Equipment
  Pallet Release System

- MTH Pumps
  Dump-Truck Release Agent Coating System

- SPX Flow
  Consolidating and Improving the Process of Hytec Lines

- Rexroth Bosch Group
  Quin-4.0 Smart Drone

- VNA Health Care
  Process Improvement and Cycle-Time Reduction

- Freedom Field
  Solar Assisted Vehicle

- Caterpillar
  Medium Wheel Loader Guarding Area Improvement

- Daubert
  Integrating A Bulk Silo to Eliminate Manual Material Handling

- Xylem
  New Warehouse Layout

- 315 Machine Design
  Pharmaceutical Tube Evacuation
MECHANICAL ENGINEERING

Chair: Pradip Majumdar
Senior Design Instructor: Federico Sciamarella
**Pallet Release System**

**Problem Statement:**
Pallet trucks are used daily across every industry. When an empty or lightweight pallet is moved and the operator attempts to unload the pallet, it will often be dragged by the pallet truck. This is caused by the wheels of the pallet truck getting stuck on the first board of the pallet as the operator attempts to back out. In order to free the pallet, an operator must find an alternative method of removing the pallet or physically assist the removal. This has led to three main industry wide concerns regarding this issue.

- Safety
- Efficiency
- Employee Morale

**Final Design/Deliverables:**
- The final design consists of a channel, track, carriage, brake, and brake control
- Working prototype completed
- Prototype tested and meets system requirements
- System successfully aids in removal of empty or lightweight pallet

**Design Tasks:**
- Design system to aid in pallet removal
- Build around or into current framework
- No interference of normal operation
- Address safety, efficiency, and morale concerns

**Business/Cost Analysis and Results:**

**Business Potential**
- Pallet moving equipment sales total over one billion new units annually

**Target Markets**
- New design from factory to give competitive edge
- Aftermarket sales direct to repair and maintenance facilities as add on part
- Direct sales to user for small business and agricultural outfits.

**Cost**
- Total single side prototype cost: $200

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**Figure 1:** CAD Rendering

**Figure 2:** Prototype Track Setup
Problem Statement:

- Full control on the Robotic arm using LabVIEW.
- Balancing the ball that is on the plate so the ball won’t be fall off the plate.
- Webcam has to track the motion of the ball and sending ball coordinate to the computer.
- Uploading the whole system to the myRIO device so it can be control wirelessly.

Design Tasks:

- Research and develop the Robotic arm control system using by LabVIEW.
- Create the vision tracking system using by LabVIEW.
- Based on the first two points to create a ball balancing system.
- After all the above system is being created upload the LabVIEW to myRIO device for wireless control.

Final Design/Deliverables:

We have develop the LabVIEW code for control the ROBAI robotic arm. We were be able to create the 2 axis movement that can be used for ball balancing system. We have the 60 FPS camera that can be used for motion tracking. We have the myRIO device ready for uploading.

Business/Cost Analysis and Results:

The total cost of the system is 506.92. The ability of the robotic arm is to have balancing capability feedback system. Feedback system is a big deal in the industry. Many companies have been tried to use robotic to do many things such vacuum the floor, and separate the pills etc.
Problem Statement:
Reliance on alternative energy sources have an inherent risk of intermittent power shortages which can cause damage to the crops. Current raft type aquaponics systems require constant water flow for the plants to survive. The OGA systems insert and growing media can be incorporated into any current raft system and will absorb water and nutrients for the plants to use while the water pump is off and the system is dry, thus allowing flexibility to go off grid without sacrificing production.

Final Design/Deliverables:
• Using the insert will allow the user to reduce power consumption of the pump by nearly 95%
• Allowing user to take their system off-grid with confidence

Design Tasks:
• Create and design a 3D model of the insert for universal system application
• Verify seed germination and sustained growth
• Calculate power consumption reduction and cost savings
• Prototype design of wind turbine and solar panels to make system off grid

Business/Cost Analysis and Results:
Since this concept would be new to the market, OGA is providing a different outlook as to how aquaponics can become cost effective. This design will reduce electricity usage and maintenance on the entire system while providing the user with off grid capability. The market share for aquaponics was $180 million in 2013 and is predicted to reach $1 billion by 2020. As such, the opportunity for OGA is quite large.
Problem Statement:

Problems
- Baseball Umpires make inconsistent calls
  - 14% of pitches are called incorrectly
- Amateur leagues often do not have a trained Umpire

Solutions
- Assist Umpires with borderline calls
- Help train Umpires and Pitchers
- Give amateur teams / leagues the ability to play with a consistent strike zone

Design Tasks:
- Decrease strike zone error to less than 8%
- Successfully detect a fastball up to 110 MPH
- Product that is mobile which allows it to be taken to any ballpark or field
- Durable
- Easy to use and install
- Use cost effective parts and materials

Final Design/Deliverables:
- Three Parallax Ultrasonic Ping Sensors and an Arduino Uno mounted to a modified home plate
- Program written so that all three sensors must detect the ball simultaneously, and fall within a pre-determined strike zone distance
- Testing shows that strikes are accurately shown by LED

Business/Cost Analysis and Results:
- Baseball is a multi-billion dollar industry
- Target buyers anywhere from peewee to minor leagues
- Training purposes for both Umpires and Pitchers
- Retail Price ~ $250
METHANE FLARE ENERGY TRANSFORMATION

Problem Statement:
Methane from landfills, accounting for about 18% of all U.S. methane emissions (EPA), is flared above ground where wasted heat is emitted into atmosphere.

Flaring reduces the net greenhouse gas emissions than if just released without flaring. However that flare goes unused.

Implementing a Stirling engine for capturing that methane flare in an enclosure and converting it into energy is one way of achieving cleaner energy sources.

Design Tasks:
- Material selection of components to withstand high temperatures of up to a controlled 2000°F.
- Create CAD model/assembly in Creo Parametric so system will run efficiently with innovations.
- Produce parts on CNC using DXF files for simplification for mass production.
- Assemble physical prototype conforming to constraints and specifications.
- Assessments of analytical and actual results.

Final Design/Deliverables:
Taking advantage of the highly efficient closed thermodynamic Stirling cycle, a calculated theoretical average of 19.1 kW of electrical power is possible.

Pre-pressurizing our Stirling engines in series for this particular unique application by 10 psi allows for increasing output power by 167.9% for our prototype based on team formulated Excel Spreadsheets relating mechanism and thermodynamic conditions as a system.

Business/Cost Analysis and Results:
With over 3000 Landfills in the U.S. alone, this makes for a profitable business market. Approximate cost to produce full scale is roughly $2,300 per unit, while sale price can be set at $10,000 from market research.

This can potentially generate millions of dollars in revenue, not to mention create a new market for energy distribution to local areas in need of a lower cost solution.

PTC Creo Assembly of Prototype
Actual Prototype Based on 3D Model

Theoretical Results from Pre-pressurization
Dump-Truck Release Agent Coating System (DTRACS)

Problem Statement:
Over time while dump trucks are hauling materials they can bond and cure inside the trailers body. Removing this can be a dangerous and time consuming task.

DTRACS is an automated trailer spraying system product built to coat the inner tub of dump truck trailers to prevent material build up.

DTRACS central focus is to improve safety and efficiency of large and small scale dump truck construction operations while keeping the environment in mind.

Final Design/Deliverables:
- DTRACS has a six, 90 degree full-cone spray nozzles which can effectively cover the entire bed as shown in Figure C
- DTRACS has a 5 gal reservoir which allows use for 10 times
- DTRACS has proven to be successful by eliminating the operator from having to manually clean out the trailer tub
- Fully operational prototype available for demonstration purposes

Design Tasks:
- Develop a system to ensure maximum spray coverage inside the trailers body
- Integrate a switch mechanism inside the cab allowing the operator to power the system (On/Off) with ease
- Perform fluid analysis using Bernoulli’s principle and head loss equations to determine system behavior and requirements
- Size, assemble & test all components based off of fluid analysis results and requirements
- Provide a robust system to withstand rigorous work environment conditions

Business/Cost Analysis and Results:
- Our product guarantees a time savings of ~10min in between loads. This time savings can result in a potential extra load per day based on travel conditions.
- An extra load per day can lead to a potential $26,000 increase of annual revenue.
- DTRACS system can reduce up to 32% of worker compensation claims caused by slip/fall injuries on the job.

Figures A & B: Equipment & mounting location

Figure C: 3-D model demonstrating spray pattern & coverage
Problem Statement:
For an inexperienced firearm operator, engaging a moving target can often be challenging due to several varying parameters. The project design allows the operator to be able to engage these targets at ranges extending between 0 to 1000 yards also eliminating the need to manually lead the moving target.

Final Design/Deliverables:
- Arduino Motor Shield: used in conjunction with an Arduino Uno to control the motor and sensors.
- Stepper Motor: used to transfer needed adjustments from the program code to the firearm optic.
- 3-Axis Gyroscope: used to determine speed of a target at a given range value.
- LCD: used to allow the operator to know what range value is being used in the calculations.

Design Tasks:
- Derive equations for velocity of the target, bullet travel time, and MOA adjustment.
- Determine code for receiving gyro values, executing equations, and creating motor outputs.
- Design a universal mounting system to attach hardware to rifle.
- With hardware attached to the rifle the motor is capable of adjusting the scope turrets when required.

Business/Cost Analysis and Results:
- Arduino LCD kit - $65
- Arduino Motor Shield - $40
- 3-Axis Gyroscope - $30
- Stepper Motor with gear head - $40
- Mounting hardware - $15
- Estimated manufacturing labor cost - $500
- Total Cost - $690

Above: Aluminum Housing for mounting electronics to the rifle.
Left: Arduino hardware and Stepper Motor.
Problem Statement:
All gardens, orchards and nurseries require: water and power for irrigation.

In some areas electrical power may not be an option.

In other cases, electricity may be considerably expensive.

Our project will provide a self-sustaining, efficient system as an irrigation option for remote areas.

Final Design/Deliverables:
• Created self-sustaining, dynamically controlled drip irrigation system
• Solar panels to provide a trickle charge to the battery – makes it a sustainable system
• A wireless need based soil hygrometer sensor to read when the soil is parched

Design Tasks:
• Create a wireless soil hydration sensor
• Integrate solar panels to supply power to system
• Automate water distribution process through microprocessors
• Mobilize system
• Utilize local and conserved water sources

Business/Cost Analysis and Results:
• Total cost of prototype system: $247
• The global micro irrigation market stands to develop from $2.8 billion in 2013 to $8.1 billion by 2020
• Irrigation water consumption will decrease with our system, helping drought stricken areas

Visit our Facebook page through this QR code to see a functioning prototype
**Problem Statement:**
Current thermal solar collectors rely on passive tracking of the sun using circular tubing. The Active Tracking System (ATS) allows for the optimal angle to the heat source to be maintained for all seasons and for all times of day. Active tracking allows for greater efficiency by maintaining the ideal orientation to the Sun, which can increase collection efficiency by over 29%.

**Final Design/Deliverables:**
The design uses multiple pin and sliding joints attached to linear actuators, as well as an electric motor and gearing system to allow for 360° rotation as well as vertical axis actuation. Tracking is accomplished by use of a photovoltaic prism which outputs a differential voltage to determine angle to the sun. The figures below illustrate these mechanisms.

**Design Tasks:**
The initial task was to determine how to allow panel angle changes. After several iterations, a pin and actuator system was selected. Code was written for the Arduino microcontroller to control this system. Material constraints meant weight saving measures such as hollowing were done. FEA was then done on the model to ensure strength was not compromised by the weight saving measures.

**Business/Cost Analysis and Results:**
The total cost to manufacture a full scale prototype using typical casting methods was found to be approximately $1,500. To ensure strength, the weight was reduced to a minimum of 550 pounds, making the primary cost being the custom steel and aluminum components. Using a chart of average insolation values throughout the country, it was found that adding a multi-axis tracking system can allow for an capacity increase of 30-70% over a flat plate collector dependent on location. With this increase, payback period is increased by 125-200% but the post payback benefits are greater.

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**Figure 1:** Pin joints and slider-pin mechanism

**Figure 2:** Gears and motor mount
Problem Statement:
The objective of our project is to improve the powder drink mixing process and increase convenience for consumers by eliminating the need to carry extra powder for additional drinks and to limit the need for rinsing the bottle between uses. In addition the project will minimize chunks of powder within the drink mixture.

Design Tasks:
- Model MPS in SolidWorks
  - Design lid with ability to change to each liquid compartment
  - Design seal and release mechanism for powder chambers
  - Design spring to move the second grate for mixing the combination
- 3-D print prototype of design
- Test and improve design
- 3-D print final iteration
- Make suggestions for future products

Final Design/Deliverables:
The MPS is a shaker bottle designed with three powder compartments attached to three liquid chambers for storage and mixing. The double-grate release mechanism (two opposite grates pressure sealed with a latch) is utilized to separate and mix the powder. Grates will ensure that chunks of powder will not reach the user.

Business/Cost Analysis and Results:
- Protein supplements currently has a market of $2.5 billion dollars
- Protein supplements predicted to grow at compounded annual growth rate of 9.1% for the next several years.
- Product designed for protein and other work-out supplements but can be applicable to all powder drink mixes
Problem Statement:
• Compounding pharmacists are extracting a fluid drug from packaging tubes manually:
  • Only a 93% volume extraction efficiency of a fluid drug
  • Excessive money loss ($1M yearly) associated with current extraction method
  • Undesirable manual operator involvement using high paid people to do low skill operation

Design Tasks:
• Design a machine that will operate in an ISO 7 clean room environment
• Maximum machine space: 48" x 48" x 96"
• Minimize operator labor and improve ergonomics at the pharmacy
• Explore evacuation methods for high viscous fluid

Final Design/Deliverables:
• Overall machine design for manufacturability, safety, and low maintenance
• Pneumatic schematic design
• Bill of materials for manufacturing
• Assembly and 2D drawing generation
• FMEA/Risk assessment
• Frame and loading design studies

Business/Cost Analysis and Results:
• Processing 4000 tubes of 100 g Diclofenac per month
• Increasing the drug removal efficiency by 3% will generate a savings of $18 per processed tube
• The payback period for the machine is under one month at a continuous 8-hour workday operation
INTERDISCIPLINARY PROJECT

Department of Mechanical Engineering & Department of Electrical Engineering
Problem Statement:
Develop a collision mitigation system for use on drones. The system must be capable of obstacle avoidance, altitude detection and correction, as well as real-time indoor positioning.

Additionally, design and build an ancillary suspension system, to protect the drone and onboard electronics, and develop a robust drive system for ground control.

Final Design/Deliverables:
Our final design consists of:

- An integrated collision avoidance system with added capabilities of auto take-off, landing, and altitude correction.
- An integrated indoor 3D positioning system based on a UWB module utilizing the IEEE 802.15.4-2011 standard.
- A spring/piston based suspension system tuned to overall weight.
- A low RPM, high torque Omni-wheel drive system.
- The entire system fully integrated on to a custom designed, tiered, 'X' frame quad-copter chassis.

Design Tasks:
- Designing and build a system for automated avoidance of obstructions and objects.
- Resolving in-air balance without user control.
- Research and development of indoor positioning.
- Automated coordination of motors.
- Ensuring component safety upon landing.
- Ground motion without heavy turning mechanisms.

Business/Cost Analysis and Results:
- Designed to successfully compete in the 29th annual Midwestern Robotics Design Competition (MRDC).
- Modular components, can be adapted to any base drone design.
- Full aerial automation can be achieved via integration with mission planner or similar software.
- Drive and suspension system allow for multi-terrain, multi-environment use.
- Combined costs of all systems are about $1000, up to 10x lower than similar positioning systems.
ELECTRICAL ENGINEERING

Chair: Donald Zinger
Senior Design Instructor: Venu Korampally
Problem Statement:
- Goal: Design low cost sensors for biomedical applications using grating patterns from consumer media disks
- Uses electromagnetic phenomenon called Surface Plasmonic Resonance to allow for sensing and amplification
- The physical design incorporates Fabry-Perot Cavities to help create the resonance

Design Tasks:
- Manufacture single grating patterns of various sizes
- Combine two grating patterns into a two layer setup
- Optimize two layer grating for best results using simulations and experimental tests
- Create documented process for further study and alternate applications

Final Design/Deliverables:
- Optimized process for manufacturing double layer grating pattern to maximize sensitivity
- Preformed simulations to show the best two layer grating pattern ratio
- Created detailed process for the Microcontact printing of the patterns onto a substrate

Business/Cost Analysis and Results:
- Very low cost in materials
- Uses readily available materials: consumer media disks and basic lab chemicals
- Micrometer/Nanometer scale allows for use in small form factor (often low cost) applications
**Problem Statement:**
To address the issue of in vivo application of nanoparticles to living cells for use in various biomedical applications.

**Final Design/Deliverables:**
- Research was conducted in College Of Engineering and Engineering Technology’s clean room to reconstruct the silicon shelled nanoparticles.
- To complete the process the following occurred:
  - Binding nanoparticles with a specific fluorescent using various methods and equipment.
  - Adding a PVP to the nanoparticles.
  - Letting the particles age.

**Design Tasks:**
- To aid in the method of reconstructing silicon shelled nanoparticles.
- To test different methods to naturally get the fluorescent nanoparticles into living cells.

**Business/Cost Analysis and Results:**
- All equipment is provided by Northern Illinois University.
- Results:
  - Successfully reconstructed silicon shelled nanoparticles.
  - More time is needed to come up with a successful method to verify that fluorescent nanoparticles are able to get into living cells besides the method of shocking them.

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_Scheme_ 1. Schematic illustration of the synthetic procedure for magnetite nanocrystal/mesoporous silica core-shell NPs.
ELECTROMAGNETIC
SOFTBALL PITCHING
MACHINE (ESPM)

Problem Statement:
Current pitching machine designs feature a large inertial wheel requiring the user to be in close proximity during operation. There is a physical hazard due to the large inertial wheel. Power demand limits the user to locations that have a standard 120VAC outlet. These designs are dangerous and have limited mobility.

Final Design/Deliverables:
• Final product meets all design criteria
• Simulation verifies concept
• Testing verifies design and is repeatable
• The softball pitch meets USSSA pitch regulations
• The design utilizes a 25 VDC battery bank. The battery bank is used with a boost converter to increase the stored potential in capacitor banks. Each bank is discharged into electromagnetic coils to generate a magnetic field that propels a projectile. The projectile hits the softball, transferring all of its energy.

Design Tasks:
• Improve upon existing mechanical designs by reducing the amount of moving components
• Design a portable electromagnetic pitching machine to perform a softball slow pitch per USSSA guidelines

http://cdn.instructables.com/FSU/LMGG/GJ2831SB/FSULMGGGJ2831SB.MEDIUM.jpg
MTCS (MODEL TRAIN COMMUNICATION SYSTEM)

Problem Statement:
Model Railroaders with large intricate layouts have the problem of many blind corners, and do not have a way to know the location of the many trains operating at once. Accidents happen because of this fact, and can damage model trains costing upwards of hundreds, even thousands of dollars. An inexpensive add-on system that would should the location of other trains and track switch states which can help eliminate this problem.

Design Tasks:
• Control system
• Control system software
• Power system
• LED signaling system
• Train Detection system

Final Design/Deliverables:
The final product will be a small layout with a LED signaling system that will detect all trains and track switch states, determines proper LED signal colors, and sends that information to all LEDs. Thus telling us how far away the next train is, and which state immediate track switches are in.

Business/Cost Analysis and Results:
To implement our system, which consisted of 32 LEDs, making 21 signal lights, the total cost of this system was $85.

A microcontroller is also need, we used a $25 microcontroller. For bigger systems, a microcontroller with more memory may be required for the software, which can be $40.

Our Total = $110
Problem Statement:
RC racers need an objective test platform to obtain data on their motors and motor upgrades to verify their modifications are effective, without requiring that they actually install the motor in their vehicle. An objective test should provide a controlled input to the motor while being subjected to the same torque load, and then provide the user with an analysis of the motor’s performance to aid in the user’s upgrade decisions.

Final Design/Deliverables:
This design intends to provide users with a data acquisition system for the purposes of obtaining motor performance data. The test provides a controlled input to the motor and analyzes its performance under a constant inertia load to the motor’s output. The data gathered is then processed and interpreted through graphs and text to include peaks and averages.

Design Tasks:
Using closed-loop feedback, a microcontroller was programmed to provide a variable duty cycle PWM to an H-bridge motor drive for the purposes of providing a constant 5VDC input to the motor. A photo-interrupter triggers an interrupt at each rotation of the motor, and the time duration of every rotation and motor’s current draw is gathered and stored in an external memory module. When the motor has reached its top speed, the test ends and the data is then shifted to a PC for processing and displaying results.

Business/Cost Analysis and Results:
The results of this project provide RC racers with a decent alternative to unnecessarily spending time installing and uninstalling motors to find that the motor or motor upgrade that was applied was not an overall improvement. The monetary cost of this project was on the order of $300.
Problem Statement:
To create a device that involves wearable technology which translates American Sign Language to written word to address the communication barrier that exists amongst individuals in the deaf and/or mute community and those that are not a member of that community.

Final Design/Deliverables:
Our final design constitutes of five flex sensors, five 10K resistors, an accelerometer to detect orientation in space, a microcontroller to transmit data from the glove to a monitor which will display the written and spoken words of the gestures.

Design Tasks:
• To create a glove that uses flex sensors and an accelerometer to detect American Sign Language gestures.
• Design a code that translates American Sign Language into written and spoken word.
• Use a laptop to display and output written and spoken word from gestures.

Business/Cost Analysis and Results:
Estimated cost for one glove is $191.44
We were able to create a design that utilized wearable technology to convert American Sign Language gestures with one hand. With further funding, a design with two hands could be possible.

```java
boolean inbetween(int pin, int minval, int maxval) {
    if (pin>=minval && pin<=maxval) {
        return true;
    } else {
        return false;
    }
}
```

Above represents a snippet of our code.
Problem Statement:
We set out to provide a powerful handheld spectrogram that rivals existing software implementations. This device would be used as a tool to bridge the gap between multidisciplinary problems and their potential solutions. Note recognition is one application that we chose to implement in order to showcase the functionality of the spectrogram and also because it appeals to a wide demographic.

Final Design/Deliverables:
We used the STM32F746NG board which contains the ARM M7 processor, a 480x270 LCD screen, and an audio codec. We also etched a daughter board to go along with the STM microcontroller. This consisted of two rotary encoders with encoder IC’s in order to communicate through SPI and push buttons with Schmitt triggers for denouncing.

Design Tasks:
• Programming the sliding DFT
• Displaying the spectrogram
• Interfacing with the audio codec
• Programming the harmonic product spectrum for note detection
• Etching daughter board for speed and resolution control
• Configuring SPI to interface the rotary encoders
• Use Schmitt triggers to denounce the push buttons

Business/Cost Analysis and Results:
• $50 – STM32F746NG Board
• $24 – 2 X Rotary encoders with encoder IC
• $13 – Battery
• <$10 – Schmitt trigger, 3D printed case, daughter board etching
Problem Statement:
The human brain’s amazing power has allowed man to create technology and it leads us to continue with innovation. By increasing our brain’s performance, each one of us can be more successful in any endeavor that requires mental activity. The purpose of this project is to build a device capable of recording the electrical signal emanating from the brain, analyze, interpret and then provide real-time feedback to the user. The science of Neurofeedback has been around for decades and has seen great results in treating mental conditions such as ADHD, substance abuse, depression and anxiety. Now we will try to investigate how we can apply this promising field to the goal of reaching top mental performance.

Design Tasks:
• Design for 5 channel input (1 reference electrode, + 4 independent input electrodes)
• Filter signal to remove noise, and isolate desired frequency ranges (Alpha (10 – 13 Hz), Theta (4–7))
• Provide feedback through sound.
• Goal is to increase brain output in Alpha range, while decreasing Theta range

Business/Cost Analysis and Results:
• Parts: $110.00
• Labor and other Expenses: $50.00
• Total Cost under $160.00
INDUSTRIAL & SYSTEMS ENGINEERING

Chair: Purushothaman Damodaran
Senior Design Instructor: Omar Ghrayeb
CONSOLIDATING & IMPROVING THE PROCESS OF HYTEC LINES

Problem Statement:
• 4 manufacturing cells occupying an excessive amount of space, in regards to amount of assemblies produced
• Lack of standardization among assembly process
• Great deal of ideal time

Design Tasks:
• Identify and obtain data for inventory purposes of all production workstation items
• Consolidation of space while improving capacity based on analysis
• Design and Develop recommended workstation cells

Final Design/Deliverables:
• Reduction of manufacturing area
• Incorporation of 5S
• Reduction of bench stock
• Reduction in operator movement
• Implement super market method

Business/Cost Analysis and Results:
• Floor Space Reduction of 67.6%
• Total Travel Distance Reduction of 50.9%
• Bench Stock Reduction of 77.3%
Problem Statement:
- Reduce cycle times within the OB department at the VNA Highland Health Clinic to 65 minutes or below.
- Increase number of encounters
- Create a forecasting schedule for the number of patients per year
- Create simulation
- Optimize staff scheduling
- Create standardized procedures

Design Tasks:
- Developed a simulation
- Create forecasting Model for patient encounters
- Optimize staff scheduling
- Develop SOP’s
- Staff allocation

Final Design/Deliverables:
By creating a forecast of patient encounters staff resources can be better scheduled to meet patient demand. Simulation scenarios will be ran to test different what if proposals. Based on the scenarios operating characteristic curves are created to determine the optimal procedural location and scheduling.

Business/Cost Analysis and Results:
- Reduce procedure deviation times
- Reduced cycle times
- Created visual aids to standardize scheduling
- Developed standard scheduling procedures
- Developed standardized layout procedures in registration
Problem Statement:
- Improve process flow for MWL Guarding area
- Combine both MWL guarding areas (950-972) and (980-982)
- Increase operator utilization to at least 60%

Final Design/Deliverables:
- Combined 2 guarding areas into 1 space
- Proposed 2 floor layouts for the new guarding area
- Produced frequency data for MWLs
- Proposed part layout for new guarding area design
- Reduced operator NVA movement

Design Tasks:
- Construct Parts Heat Map
- Construct Operator Spaghetti Map
- Perform Clustering Analysis
- Construct Pareto Chart
- Develop SKU Affinity
- Develop Precedence Diagram
- Develop Future State Layout

Proposed Layout Combination of (950-972) and (980-982) area
Problem Statement:
Daubert Chemical's aim is to improve production process by incorporating an idle bulk solid silo to eliminate the manual material handling in the lime charging method which will decrease production time and increase cost savings.

Project Objectives:
• Determine if the silo is feasible based on consumer demand
• Create standard reorder levels and safety stock
• Decrease cost by switching to lime in bulk shipment
• Determine payback period for the project
• Improve operator ergonomics
• Implement 5S to the new location
• Design a new layout for the new location of the silo

Final Design/Deliverables:
The team determined that the silo is feasible based on the following analysis:
• Reduced production time
• Improved reorder levels
• Improved ergonomics
• Substantial cost savings
• Short payback period

Design Tasks:
• Define project objectives
• Study the current state process
• Determine the feasibility of the silo
• Calculate the re-order levels
• Calculate the safety stocks
• Design the future state process
• Ergonomics Analysis
• Total Cost Analysis
• Payback Analysis

Business/Cost Analysis and Results:
Estimated results after the analysis:
• Estimated $110,238 in savings after switching to lime in bulk
• 170 production hours gained per year
• Payback period of 1.8 years
Problem Statement:
“In January 2016, Xylem - Morton Grove will be transferring inventory from the Midwest Warehouse to the Morton Grove facility. There is no layout or inventory transfer plan and if left unresolved will result in an overflow of material on site. There is too much inventory at Midwest Warehouse and the proper amount of how much inventory to have on hand for each part is unknown.”

Final Design/Deliverables:

Design Tasks:
• Pareto analysis
• Flagging important and unimportant items in the warehouse
• Establish new economic order quantities and safety stocks for high-running parts
• Define storage locations
• Determine allocation of new storage by value stream
• Adhere to relevant safety standards and procedures

Business/Cost Analysis and Results:
$250K Capital Implementation Cost
$1M in Annual Savings
Recommendations for new storage layout and flow maps based upon analysis

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<thead>
<tr>
<th>Category</th>
<th>Annual Consumption</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2,000 or more parts</td>
<td>0.15</td>
</tr>
<tr>
<td>B</td>
<td>15 or more parts</td>
<td>0.7</td>
</tr>
<tr>
<td>C</td>
<td>5 or more parts</td>
<td>0.15</td>
</tr>
<tr>
<td>defunct</td>
<td>less than 5 parts</td>
<td>(discounted)</td>
</tr>
</tbody>
</table>

Pareto Analysis by Forecasted Demand

Combined Pareto analysis

Area to be used for new warehouse
TECHNOLOGY

Chair: Cliff Mirman
Senior Design Instructor: Abul Azad
SOLAR ASSISTED VEHICLE

Problem Statement:
Design Power Distribution System Consisting of:
• Solar Panel (PV)
• Solar Charger Controller
• Deep Cycle Lead Acid Battery
• Speed Controller
• Brushless DC Motor
Instrumentation System Consisting of:
• Monitor Battery Voltage
• Monitor Vehicle Speed
• Monitor lighting system (Brake, Right, and left signal

Design Tasks:
• Our task is to help design an energy-efficient vehicle equipped with:
  • Power functional system, (PV, Charger controller, Battery, Speed Controller and DC Motor.
  • The instrumentation system will include gauges for the speed, battery voltage/charge level, and lighting system.
  • Arduino Mega will be our main controller.

Final Design/Deliverables:
• Based on our final design, we have created an completely electrical dependent vehicle, consisting of:
  • Energy assistance via a solar panel, instrumentation via an Arduino Mega Microprocessor and proper system voltage regulation via DC to DC Buck Converters.

Business/Cost Analysis and Results:
• Control interfaced with Arduino: Monitor Speed/Voltage, and lighting.
• Entire Power System and Instrumentation estimate equal ($1700.00). Final Cost is in progress…
IMPROVED KNEE WALKER

Problem Statement:
- Forward/Lateral tipping
- Steering
  - Large turning radius
  - Small rider input translates to large direction change
- Brake
  - Little control
  - Abrupt stopping force

Design Tasks:
- Reduce forward and lateral tipping
- Improve braking force and feedback
- Reduce turning radius and improve steering feedback
- Incorporate sensors and actuators
  - Speed
  - Tipping
  - Braking

Final Design/Deliverables:
- Frame design positioned the rider such that the combined center of gravity is located at the midpoint of the vehicle between the front and rear axles.
- Implemented Ackerman steering system which improved handling and reduced turning radius by 33%.
- Disc brake provided more powerful braking and more control.
- Incorporated electronics to measure speed, and assist the rider with braking

Business/Cost Analysis and Results:
- Current total budget is $193.47 over the $200 budget
- High cost items such as bearings, brakes, and wheels are the most cost effective options we could find that satisfy our design criteria.
Problem Statement:
- Design and develop an automated process that will eliminate human interaction, motors and robotic use from the candle making process.
- Design and produce an inexpensive, reusable, Eco-friendly fixture that holds three wicks.
- The wicks have to be evenly spaced and perpendicular to the bottom of the glass.

Final Design/Deliverables:
The final design consists of:
- 3 wicks propellers 3D printed
- A custom fixture to hold wicks, 3D printed
- Pneumatic air cylinders controlled by a PLC
- LEDs and push buttons controlled by the PLC 8020 aluminum and Cast acrylic glass for the casing.

Design Tasks:
- Design and produce the fixture
- Design and build a process to get the wicks from the spools, to the fixture.
- Design and build a process to get the fixture along with the wicks, onto the glass.
- Program and control the process using LabVIEW and a PLC.
- Machine and fabricate the housing that will enclose the whole automated process.

Business/Cost Analysis and Results:
Resources provided by the Department of Technology were used in order to minimize cost.

The total cost of purchased parts was $72.00
Problem Statement:
Our objective is the design of an integrated-circuit (IC) tester for the 8-pin OP-27E and LM741C operational amplifiers for classroom use and include the following:

- A tester that is portable, affordable, and precise.
- Use a microcontroller that will interface with an LCD to display the diagnostic information as PASS or a FAIL based on the output voltage level of the op-amps under test.

Final Design/Deliverables:
The op-amp final design is contained inside a portable 7” x 5” x 3” enclosure. The insides consist of an Arduino microcontroller which acts as the brains of the system, a 16-bit analog-to-digital converter to precisely measure the output, and an LCD to display the results. All of the components are held in place by a custom and professional PCB.

Design Tasks:
- Use a small and efficient microcontroller to control and process the information.
- Use a precise analog-to-digital converter to convert the output voltage of the op-amp into a digital signal.
- Display the results on an easy to read LCD with a written computer program.
- Must be portable and must test the common LM741C and OP-27E op-amps.
- Design a professional PCB and enclose it all in a small / portable enclosure.

Business/Cost Analysis and Results:
After completion of the project, the tester will reliably test the 8-pin LM741C and the OP-27E op-amps. The op-amp tester is designed with a low budget of less than $200.00. It is easy to use, portable and battery operated.