Clemson Engineering Design Applications and Research





A Bit of History and Organization

2/24 Summer 2016

- Formed in 2009 to create a thriving research lab
 - 1992 CREDO (Dr. Fadel)
 - 2002 AID (Dr. Summers)
 - 2006 EIML (Dr. Mocko)
 - 2016 DICE (Dr. Turner)
 - Facts
 - CEDAR Alumni ~170 students (faculty, industry, government)
 - Current CEDAR members ~35 students (MS, PHD, UG)
 - Publications ~600
- Goal:

CEDAR

Collaborations

 Our group's philosophy is to push the state of the art in design while graduating design practitioners, design researchers, and design tool developers. We realize that our main contribution in moving the field of design forward does not come from commercialization of our published research. Rather, our most important impact, our most valuable product, is our students.





- Undergraduate
 - Kinematics and Mechanism Design
 - Machine Design
 - Design Methods
 - CAD/CAM/CAE
 - Design for Manufacturing
 - Senior Design
- Graduate
 - Advanced Design Methods
 - Design Automation for Mechanical Engineers
 - Research Methods in Engineering Design
 - Design Informatics
 - Design Optimization
 - Optimization through Integration





Joshua D. Summers, Professor





- PHD from Arizona State University (Prof. Jami J. Shah)
 - Design Automation Support for Embodiment (parametric/geometric)
 - Design Exemplar (next evolution of features)
- MS from University of Missouri (Prof. Alley C. Butler)
 - Feature Based Design of Submarines in VR (conceptual design)
 - Interned at Naval Research Lab (VR Lab)
- Clemson University
 - Assistant Professor (2002-2008)
 - Associate Professor (2008-2012)
 - Professor (2012-present)
 - Students: 10 PHD, 43 MS, 4 Post-Doc (Current: 6 PHD/7 MS)
 - Publications: 82 journals, 185 reviewed conferences, 3 patents
 - Funding: \$6,717,236 (Summers' Portion: \$2,549,757) (49 proj.)
 - 2 international awards, 4 regional awards, 4 University awards





Courses I Teach

- Undergraduate
 - 1. Kinematics and Mechanism Design
 - 2. Machine Design
 - 3. **Design** Methods
 - 4. CAD/CAM/CAE
 - 5. **Design** for Manufacturing
 - 6. Capstone Senior Design
 - 7. Creative Inquiry (2 current; 1 former)
- Graduate
 - 1. Advanced Design Methods
 - 2. **Design** Automation for Mechanical Engineers
 - 3. Research Methods in Engineering **Design**







Research Defined by Students*

7/24 Summer 2016



ME Department STUDENT PROJECT OPPORTUNITIES





- Three structured opportunities:
 - Creative Inquiry (multi-year, multi-disciplinary, multi-age)
 - BMW LED Headlight design
 - NASA Lunar wheel design
 - Rotary lawnmower blade redesign
 - Tti Advanced Concepts Feasibility Studies
 - ME 4010 (pre-capstone; design method)
 - Service Learning (design, build, install wind tunnels for elementary classrooms)
 - "inventor outreach" (design, build French fry cutting machine)
 - ME 4020 (capstone)
 - Industry sponsored projects
 - Parallel teams on one project
 - Projects assigned an advisory committee (2 faculty + 1 gradvisor)
 - Coordination/Solicitation done by 1 faculty (currently Mocko)
 - Joint program with other universities (~40 students in 2010/2011)





CEDAR Collaborations Creative Inquiry – Traction Systems

10/24 Summer 2016







ME4010 – Service Projects

11/24 Summer 2016

- Want to increase "interest" in the design projects...
 - Faculty "made up" problems are of no interest to students
- Want to create "customer" centric experience...
 - Faculty "playing" customer is not believable to students
- Want to provide a "low pressure" project...
 - Industry sponsored projects include significant pressure for delivering
 - Solution: Design and Build mechanical devices for elementary classrooms (such as wind tunnels)





Value:

- S11: Midway Elementary, 6 Wind Tunnels (~120 elementary students)
- F11: East North Street Academy, 4 Wind Tunnels (~80 elementary students)
- F11: Six Mile Elementary,4 Wind Tunnels (~80 elementary students)
- F13: Midway Elementary, 8 Manufacturing Systems (~120 elementary students)
- F14: Mt. Lebanon Elementary, 4 Manufacturing Systems & 3 Wind Tunnels (~150 elementary students)
- F14: Central Elementary, 3 Manufacturing Systems, & 2 Wind Tunnels (~110 elementary students)
- S15: Clemson Elementary, 4 Manufacturing Systems & 4 Wind Tunnels (~200 elementary students)





ME4020 Semester-Long Projects

12/24 Summer 2016

- Industry sponsored projects:
 - ~15 weeks in duration
 - Parallel teams (4-5 students) on projects
 - \$10k per project (donation to department)
 - Teams design, prototype, test, build solutions
 - Advisory committee (2 faculty; 1 gradvisor)
- Objectives
 - Expose students to unstructured problems
 - Challenge students to develop professional communication skills
 - Give students the ownership of the projects

Fall 2011 Projects

- BMW: Ergonomic plug installer
- Cryovac: Beef primal fixture
- Rotary: Lawn mower blade testing
- TTI: Reciprocating saw test







Student demonstration a tail light installation fixture on a BMW X5 with associates.



Design of a road surface cleaning system for tire wear analysis (scale: diameter ≈ 20 ft)





Graduate Design Project - 2011

13/24 Summer 2016

Local entrepreneur had created a prototype small form factor personal tennis ball machine. Clemson addressed cost reduction, improved functionality, and addressed user interaction. The engineering team, two graduate students advised by faculty, held bi-weekly design reviews with the sponsor.





Value:

- To students: a design and build experience
- To students: experience in working with external sponsor
- To customer: engineering support for component selection
- To customer: new concepts to simply system





Consulting Work - 2013

Hoowaki needs fast analysis and optimization work done. Want to find alternative geometries that can support given loads with a defined volume. Need external validation from University in support of the effort to "impress" Hoowaki customer.





Value:

- to students: a parametric design and analysis project, experience in scope creep
- to customer: new geometries; external validation





Design Project - 2008

15/24 Summer 2016

Customer wanted a system to test prototype treads for mud release. Team at Clemson designed and built a system that is currently in use at sponsor's research and development facility. Project included a follow-on validation project.





Value:

- To students: a design and build experience; experience in working with external sponsor
- To customer: engineering support for component selection; new concepts to simply system





- Fresh look at your problems through impartial eyes
 - Student teams can bring a clean slate to your problem
- Extended access to graduating engineering students
 - An opportunity to "interview" an entire cohort of Clemson students
- Exposure to the latest tools, techniques, and technology
 - Students and faculty are trained in the latest design and analysis tools, in addition to a broad exposure of cutting edge research
- Multiple solutions using teams
 - Three to four distinct solutions developed, prototyped, and tested for every problem
- Access to Clemson facilities and faculty expertise
 - ME at CU is the largest engineering program in SC, and recognized as one of the top five Design Research programs in the nation
- Five solutions patented in the last five years
 - Sponsors have first right of refusal on all IP developed in the course is available













- Innovation/Prototyping Lab
- Clemson University student teams (Creative Inquiry) can work on future concepts from TTI IdeasFarm in a InnovationLaboratory.
 - Creative Inquiry teams could rapidly explore basic concept feasibility
 - These teams would be graduate coached, but populated by undergraduate students
 - Each semester, the team could address multiple open concepts provided by Tti based on the IdeasFarm
 - Functional Analysis
 - Design for Manufacturing and Assembly
 - Physical Prototyping
 - Nominal donations provided by customers (support for graduate coaches and for materials/equipment in InnoLab).





- Entrepreneur to Engineer Connection
- Clemson University student teams might serve as a resource for entrepreneurs that have product ideas that require engineering for reduction to practice
 - Creative Inquiry teams might be created to act as service engineering groups (ML customers present concepts to teams)
 - These teams would be graduate coached, but populated by undergraduate students
 - Each semester, the team could address one (well scoped) engineering refinement need from a local entrepreneur
 - Functional Analysis and Redesign
 - Design for Manufacturing and Assembly
 - Physical and Software Prototyping
 - Nominal donations provided by customers





- Creative Inquiry Incorporated
- Creative Inquiry teams of undergraduates, coached by graduate students and ML advisors, pursue new product development, from needs finding to conceptualization to invention disclosure to market prototyping
 - Semester 1: Graduate students take product realization class and identify general domain of interest (energy harvesting for hikers); end of semester they will recruit freshmen and sophomores
 - Semester 2: Graduate students take an entrepreneurial class and coach team in needs finding and preliminary conceptualization
 - Semester 3: Team pursues promising concepts to reduction to practice and files invention disclosures
 - Semester 4: Team develops marketing prototypes
 - Semester 5: Team pursues business plans (licensing, launch, ...)
 - No sponsorship fees; internal university material support





CEDAR Collaborations New Opportunity: CEDAR Consulting

20/24 Summer 2016

- CEDAR Consulting and Engineering Services
- Clemson University might be able to provide extension service to small industry through onsite staffing of an engineering advising office
 - CEDAR students can offer best practice tools and methods through short seminars and workshops to entrepreneurs
 - CEDAR students would gain experience in engineering consulting and fast turn around
 - CEDAR students could provide quick engineering advise on product ideas
 - CEDAR students could link the entrepreneurs to other on-campus resources (fabrication, testing, marketing, ...)
 - Two days a week staffing would require significant volunteer work on already stressed graduate students (~70-80 hours work week)
 - Research work release could be supported with fellowship funding





- Senior Design
 - Industry Sponsored (ME 4020) (\$10k)
 - Service Oriented (ME 4010)
- Graduate Design
 - Semester Long graduate team projects as course (\$5-10k)
 - Research projects (graduate students employed on projects) (~\$60k/year/student)
- Creative Inquiry
 - E2E Consulting groups (\$2-5k)
 - CI Inc
- CEDAR Workshops
 - Short Workshops on Design Tools and Processes (\$3k-\$10k)
- All monies are used to support students, materials, faculty





Joshua D. Summers, Professor
 203 Fluor Daniel Engineering Innovation Building (EIB)
 Clemson Engineering Design Application and Research Group
 Department of Mechanical Engineering
 Clemson University
 Clemson, SC 29634-0921
 864.656.3295 (office)
 jsummer@clemson.edu





Undergraduate Opportunities

23/24 Summer 2016

Course	Description	Contact	Cost	Duration
Creative Inquiry (ME 290, 390, 490)	This is a multi-semester course that allows students at different levels of degree progression (freshmen through seniors) in which teams of students address projects of interest to the team and the faculty. A faculty champion is required. Students might typically commit between 3-10 hours a week to this project. Past projects in Mechanical Engineering have included pediatric/nursing work table design, lab-on-chip design, sand traction concept design, soft-soil endurance testing apparatus design, LED headlight design, and others. All ME faculty might champion a project based on interests.	Varies (Dept. Chair)	Varies (typically pro-bono)	A minimum of three semesters (1.5 years)
ME 401	This course is taught in the senior year and might include one or more projects for multiple student teams (mechanical engineering) to define and solve within the span of 15 weeks (regular semester) or 6 weeks (summer version). Recent projects have included design and build of wind tunnels for elementary classrooms, design and build of French fry cutting machine for carnival vendor, and design and retrofit of runway concrete form installation system. Many recent projects have included a component of design, fabrication, and testing to provide the student teams with a complete design experience in a controlled educational experience. The primary intent of this course is to teach engineering design tools and the systematic approach to mechanical engineering students.	Varies (Summers, Fadel, Miller, Zumbrunnen , Mocko)	Varies (typically pro-bono)	One semester (~15 weeks); ~350 manhours of controlled work
ME 402	This course is treated primarily as an "exit exam" of the mechanical engineering students in which they are expected to demonstrate their design, engineering, testing, fabrication, research, and domain specific expertise through application on an industry sponsored project. The project teams are self-managed, though weekly design reviews (approximately 30 minutes per team) are conducted with an advisory committee that typically consists of two jury members, consisting of one or more faculty, a grad-visor (trained engineering design research/practioner graduate student), and (when available) a retired engineer from industry. The projects are assigned to three to four parallel teams of four to five graduating mechanical engineering students. Non-disclosure and sponsorship agreements and contracts are signed between the industry sponsor and the University and students. Intellectual property issues are controlled through the contracting mechanisms. Projects are scoped well in advance of the semester (March-May for August start and October-November for January start). The scope is typically defined as a value adding, but non-critical path project that might be assigned to a newly hired engineer for an anticipated duration of three months.	Mocko	\$8000 for project + \$500 per team (max of four teams)	One semester (~15 weeks); ~600 manhours
ME 415	This course is an independent study course that is coordinated between a single student and a faculty mentor. The focus of this class is to offer independent research, design, and study in topics that might not be directly covered in courses offered during the ME semester. Honors students can take two ME 415 courses for technical elective credit, while other ME students can take this course for one semester of credit. One project that was recently completed through ME 415 was a manufacturing analysis and redesign project for the Dream Cart, a hunter's integrated cart, tree stand, and trailer from a local inventor. The student created SolidWorks models, conducted strength analysis, offered design revisions based on manufacturing considerations, and participated with the inventor at various marketing and investment activities throughout the semester. Another example project was completed for AnchorTrax LLC to develop concepts and detailed specification for aftermarket pickup truck accessories to complement the existing product lines. The students developed concepts, reviewed them with the customer, created detailed design specifications, and identified vendors for manufacturing.	Varies (Dept. Chair)	Varies (typically pro-bono) but industry partner is responsible for hardware and/or fabrication	One semester (~15 weeks); ~150 manhours Two semesters (~30 weeks); ~300 man hours (Honors student option only)





Graduate Opportunities

Course	Description	Contact	Cost	Duration
ME 870	This is a graduate level course on advanced methods in engineering design. This course is primarily an intensive survey course on different design process models, methods, and tools with application in the course on a design project that may span a few weeks to a few months. The team size and formation varies significantly and the faculty advising and involvement is diverse. Three faculty rotate teaching this course (Mocko, Summers, Fadel). An example of past sponsors include BMW and Michelin.	Mocko, Summers, Fadel	Varies (typically \$10,000 per project)	One semester (fall only); ~5-15 weeks (~120 manhours to 400 manhours)
ME 891	This is a graduate course placeholder for those non-thesis students that are pursuing a project- based Master's degree. These students typically are focused on course work (33 hours) and complete the work in three semesters. A component of this program is that the student needs to complete a project (typical of a one semester course project). This project could be an industry sponsored design or engineering project. Past projects include those sponsored by Rotary, BMW, and TopTennis. The projects could be individual or team driven. This mechanism has not been extensively used in the past (Summers and Mocko have been the primary applicants).	Varies (Miller – Graduate Coordinator)	Varies (typically \$7,500 per project)	One semester (~15 weeks); ~150 manhours if individual
Other	Several graduate level and technical elective classes can also benefit from industrial projects/real life problems. For instance, ME455/655 the design for manufacturing class can conduct reverse engineering case studies, look at design for assembly, and other manufacturing related design issues. ME471/671 can implement a CAD model of some device, do finite element analysis on it, and produce a prototype (at some cost). ME 818 can focus on finite elements of some structural component. ME 871 can consider a design and implement optimization tools in concern with analysis tools to improve some aspect of a design such as reducing weight. Other classes can also be used for projects depending on topic.	Varies (Dept Chair)	Varies (typically \$10,000 per project for graduate class)	One semester (~15 weeks); usually team based ~600 man hours

For any of these opportunities, interested parties can also contact the CEDAR faculty:

- Dr. Mocko (gmocko@clemson.edu)
- Dr. Fadel (<u>fgeorge@clemson.edu</u>)
- Dr. Summers (jsummer@clemson.edu)



