Industrial Engineering
The Clemson University Department of Industrial Engineering (IE), which is the only IE program in South Carolina, has evolved into a highly productive department with a strong national and international reputation. With 19 tenured, tenure-track, research and adjunct faculty, I.E. is engaged in cutting-edge research in the information technology driven emphasis areas of production and service systems, human factors and education and learning systems. The IE program offers accredited programs leading to Bachelor of Science (B.S.), Master of Science (M.S.), Master of Engineering (M.Eng.) and Doctor of Philosophy (Ph.D.), degrees. Clemson IE grads are sought by a multitude of industries ranging from manufacturing (e.g., automotive, electronics, chemical) to service (information technology, aviation, financial, consulting). One of the defining characteristics in the success of IE graduates is the dedication of IE staff and faculty. By working closely with external constituents, the faculty has developed an innovative industrial engineering curriculum that reflects the state of the art in industrial engineering education and the needs of the profession. A defining attribute of our program is the ability of the faculty to develop student strengths in basic industrial engineering knowledge, use of industrial engineering tools, problem solving, computer skills, communication and teamwork thereby preparing them for careers in industrial engineering.

Facilities

The IE department has electronic or technology-enhanced classrooms that integrate networking, computers, and audiovisual technologies. Presentations require little setup and faculty can work with their laptop computer to familiarize themselves with the hardware and software outside of the classroom. Ethernet connectivity provides access to information outside the classroom.

Office Classrooms and Laboratories

Separate office spaces are available for each faculty member, staff and assigned desk space is provided to teaching assistants/graders/lab assistants. In addition, the department has at its disposal multiple meeting areas that include seminar/studios/conference rooms. Freeman Hall contains the following facilities for classroom and instructional use:
• Two smart classrooms scheduled and maintained by the University - 116 and 202 Freeman Hall

• One smart classroom scheduled and maintained by the Department - 129 Freeman Hall

• Two wired classroom scheduled and maintained by the Department - 128 and 138 Freeman Hall

• One student seminar room scheduled and maintained by the Department - 118 Freeman Hall

• Laboratories (Design Suite, 140 Freeman Hall) and classroom with wired and wireless network connections. The Design suite has 11 workstations, 1 TV, 1 DVD, 1 LCD projectors and laptops for student team use.

In addition to Freeman Hall classrooms, classes are also scheduled in university wide classrooms that have smart room facilities which include 101 Lowry, 119 McAdams, 111 Rhodes Annex, and scale-up facilities in 200/100 Holtzendorff. Several of the IE courses meet in Freeman Hall, and it is possible for all classes to employ modern instructional technology simultaneously. Digital cameras, laptop PCs and portable LCD projection panels are available for student use in projects. In addition to the aforementioned facilities, the Department maintains the laboratory space described below.

CCIT Labs

All PCs accessible to undergraduates are connected to the campus network. Students also have access to computing labs operated by CCIT described under Computing Resources.

Computer Labs

CCIT maintains public computer labs across campus and provides support for engineering labs. The major open laboratories available to the students are housed in Brackett Hall (open 24 hours), Cooper Library (follows posted library hours), Hendrix Center (follow Hendrix Center building hours), Lowry 11 (open Monday through Friday from 8:00 am – 5:00 pm), Martin Hall (open 24 hours), and Sirrine G24 (open Monday through Friday from 8:00 am – 4:30 pm).
Campus Software

CCIT provides and supports university-wide systems such as our Learning Management System, BlackBoard Learn™. CCIT also contracts for university site licenses for operating systems, Microsoft Office™, antivirus software and many other software packages used by our faculty and students. In addition, engineering students have licenses for additional software like Matlab, Maple™, Autocad®, Mathtype™, Solidworks®, COMSOL, Mathcad®, LabVIEW, Abaqus FEA, ANSYS®, Xwin, Minitab® and ChemDraw.

Classroom Technology

CCIT designs, builds and maintains Technology-enhanced classrooms for instruction across campus. In addition to podium computers and projectors, these classrooms may include technologies such as videoconferencing and broadcasting tools, audio conferencing equipment, clickers, SMART Podiums™ and SMART Boards™.

Networking

CCIT provides high-speed access to the National LambdaRail, Internet2, and other national and international research networks to Clemson students through its operation of C-Light, a Regional Optical Network (RON) direct fiber link between Clemson, Greenville, Atlanta and Charlotte. Clemson provides students with opportunities to collaborate with other institutions within the state which also connect to C-Light.

Creative Inquiry Studio (123 Freeman Hall)

The Creative Inquiry program is a University wide initiative which encourages research and real-world problem based learning at the undergraduate level. Team-based investigations are led by a faculty member and can span 3-4 semesters. The Industrial Engineering Department has gone a step further to incorporate Creative Inquiry into the curriculum through Sophomore and Senior Design projects, as well as the mentor led projects. In response, the Creative Inquiry Studio was designed to accommodate team meetings and a professional environment for
midterm and final presentations with the clients/mentors. The Creative Inquiry Studio is equipped with one 65” LED screen with podium and laptop connection.

Library

The library of Industrial Engineering holds information for research and instructional support. A complete collection of graduation reports; 6,000 books, 100 periodical subscriptions; video programs and lecture notes are also available.

Computing facilities (111b Freeman Hall)

The Computing Laboratory is equipped with 10 PC workstations with an instructor's PC server. This lab also contains work areas to support group meetings. Undergraduate students have access to the following software:

- Productivity Suites: Microsoft Office 2010 Professional Plus, Microsoft Expression Studio 4, Microsoft Visual Studio 2008,
- Engineering Applications: AutoCAD, Arena 12, Minitab 16, Matlab 2009b, Maple 13, OPL Studio and other ILOG simulation software.
- Misc. Software/Utilities: Mcafee, Winrar, X-Win32, Novell

Conference rooms

IE has three conference rooms available and offices for MS students, PhD students, and a student lounge. All PhD students have their own desk and computer in an office that is typically shared with one or two other students. Research students have full access to the departmental facilities including: photocopying, color and black and white laser printing, telephone, libraries, internet access and email.

Additional Seminar Rooms

Freeman Hall is equipped with five seminar rooms that are utilized by both students and faculty. These seminar rooms are 101, 103, 118, 122, and 123 Freeman Hall. Seminar rooms Freeman 103 and 122 are housed within the CELDi Lab and the Human Factors & Ergonomics Control Room Lab, respectively. However, their use is not restricted to the needs of the lab
activities. All seminar rooms have either a Panasonic HD projector or LCD panel with laptop connections.

Research

The laboratories within the Clemson University School of Industrial Engineering (MSE) conduct research in quality control, ergonomics, machine systems, industrial ergonomics, the evaluation of new engineering curricula, human computer system design, and supply chain engineering. These labs, housed in Clemson University’s Freeman Hall, are the Advanced Quality Engineering Lab, the Advanced Technology Systems Lab, the Ergonomics Lab, the Education and Learning Systems Research Lab, the Human Computer Systems Lab, and the Supply Chain Engineering and Optimization Lab.

Center for Engineering Logistics and Distribution (CELDi) Lab / Supply Chain Engineering and Optimization Laboratory (SCEOL) (103 Freeman Hall)

CELDi (Center for Engineering Logistics and Distribution) is a multi-university, multidisciplinary National Science Foundation sponsored Industry/University Cooperative Research Center. Headquartered at the University of Arkansas, CELDi provides an avenue for university resources to focus on problems specific to individual corporations. The mission at CELDi is to provide integrated solutions to logistics problems through modeling, analysis and intelligent-systems technologies. The CELDi organization currently consists of nine universities; University of Arkansas, Clemson University, Lehigh University, University of Louisville, University of Nebraska, University of Oklahoma, Oklahoma State University, and Texas Tech University along with over thirty industry members. Clemson has been a CELDi member for over 6 years and currently has four research initiatives in progress. Five faculty members participate in the CELDi research program with over six graduate students.

SCEOL supports teaching and research activities associated with the design and optimization of the supply chain. In particular, students and faculty involved with classes and research spanning optimization, production planning and control, supply chain logistics, and simulation use SCEOL facilities. This laboratory also supports mentor led Creative Inquiry projects, capstone design projects and honors theses in supply chain and optimization. The hardware
and software supporting both of these laboratories currently resides in 103 Freeman Hall and are listed below:

- **Hardware**
  - 11 OptiPlex Quad-core personal desktops
  - 1 Dell PowerEdge Server (Network access)
  - CONDOR Computing Grid FRMN CELDi (30 seats)

- **Software**
  - ILOG Suite
    - CPLEX, AMPL, OPL, Concert
  - Microsoft Visual Studio 2008
  - Arena 12 Professional Version (30 seat network license)
  - LaTeX with MiKTeX
  - Standard departmental software image for student labs
  - WinEdt 5.5 (5 seat network license)

**Advanced Quality Engineering Laboratory (AQEL) (150 & 152 Freeman Hall)**

Dr. Byung Rae Cho is the Director of the Advanced Technology Systems Lab (AQEL) in the Department of Industrial Engineering at Clemson University. The four major missions of the AQEL are education, scientific discovery, technology development, and transition to applications by conducting research to discover scientific knowledge and technological solutions that strengthen the leadership in a wide variety of areas of quality engineering. This laboratory also supports mentor led Creative Inquiry projects, capstone design projects and honors theses in quality engineering. All departmental laboratories are open Monday through Friday from 7:00 am – 9:00 pm.

**Education and Learning Systems Research Laboratory (ELSRL)**
Dr. Mary E. Kurz is Director of the Education and Learning Systems Research Laboratory (ELSRIL) in the Department of Industrial Engineering at Clemson University. The current activities of the ELSRL focus on development of materials for Industrial Engineering topics, including the development of an on-line version of Engineering Economic Analysis, and evaluating the effectiveness of materials developed at Clemson and other institutions, such as the University of Florida. Members of ELSRL can take advantage of the larger resources provided by the Clemson University Office of Teaching Effectiveness and Educational Technology Services, which offer workshops in topics such as managing large classrooms, course design and development, and using course management software.

**Human Computer Systems Laboratory (147, 149, 151 Freeman Hall)**

Dr. Joel S. Greenstein is Director of the Human-Computer Systems Laboratory (HCSL) in the Department of Industrial Engineering at Clemson University. The mission of HCSL is to improve the design of human-computer systems so that people can use these systems to carry out their activities productively. The Clemson Human-Computer Systems Laboratory has a long history of successful research in different areas of Human Computer Interaction. The research includes empirical studies of human behavior, and studies of behavior in groups and organizations to inform the design and evaluation of new technologies. Activities within the HCSL focus on understanding the users and their tasks and making use of technology to meet users’ needs. This user-centered design process produces human-computer systems that are both useful and usable. These systems support users in the performance of their tasks and are reasonably straightforward to use. The laboratory applies user-centered design methodologies to develop and refine human-computer systems for a variety of applications within the production and service sectors, including information and knowledge management, collaborative engineering design, quality and process improvement, and education and training. Funded by various federal and private sources, the HCSL involves undergraduates and graduates in research and development activities. There are three main research groups in the Clemson Human-Computer Systems Laboratory.

1. Usable Security Research Group
2. Virtual Environments Research Group
3. Healthcare HCI Research Group
The laboratory supports individual and group design activities, including concept ideation, software development, and usability testing. The laboratory maintains the following equipment:

- Four Dell Optiplex desktop machines (two 960 Quad core 2, and two GX620) with 19-inch LCD monitors, running the Windows 7 Enterprise operating system
- 1 Dell PowerEdge Server
- 2 Apple iPads
- 1 planar touch screen monitor
- A Titmus II vision tester and a set of Ishihara’s plates for the testing of color vision are available to screen participants in interaction design studies and usability tests.

Supply Chain Engineering and Optimization Laboratory (SCEOL)
Dr. William G. Ferrell is Director of the Supply Chain Engineering and Optimization Laboratory (SCEOL) in the Department of Industrial Engineering at Clemson University. SCEOL is a knowledge center where theoretical and applied research is conducted as it relates to problems in the processes that convert raw materials into finished goods and then deliver these goods to customers. Research activities frequently involve mathematical modeling and computational optimization. The Department of Industrial Engineering subscribes to a departmental license for Microsoft software, including Visual Studio and its associated compilers. Student labs have the free trial version of OPL Studio installed, and any student may download the trial version for their own PCs as well.

Advanced Technology Systems Lab (ATSL)
Dr. Anand Gramopadhye is the Director of the Advanced Technology Systems Lab in the Department of Industrial Engineering at Clemson University. Housed in 120 Freeman Hall, the mission of ATSL is the pursuance of cutting-edge research in human-machine systems, specifically in both theoretical and applied research in quality and process control systems, aircraft maintenance, hybrid inspection systems, and information and learning systems. As a
result, ATSL has been at the forefront in conducting both theoretical and applied research in a variety of complex engineering domains such as quality and process control systems, aircraft maintenance, hybrid inspection systems, and information and learning systems. More specifically the laboratory studies and conducts research on human processes and performance and the modeling of human performance, offering solutions for these technologically complex systems. Current cutting edge research includes the study of human factors in quality control, human computer systems, advanced technology, manufacturing and training. This laboratory also supports mentor led Creative Inquiry projects, capstone design projects and honors theses in human-machine systems. The ATSL has 5 Optiplex 745 core 2 duo computers and has access to the following software:

- ILOG Suite – CPLEX, AMPL, OPL, Concert
- Microsoft Visual Studio 2008
- Arena 12
- LaTeX with MiKTeX

Available hardware includes Video Camera (Digital CCD), and a Still Digital Camera. Visual Inspection software created by the ATSL includes Automated System of Self Instruction for Specialized Training (ASSIST) software for training aircraft inspectors in inspection skills; a Visual Inspection Software (VisIns) inspection simulator for simulating the visual search and decision making components of the inspection task; a Human Factors Database Interface (HFDI) software package for searching journal articles, proceedings and research papers, and an Aircraft Maintenance Team Training (AMTT) software package for training aircraft maintenance technicians in basic teamwork skills.

Current research initiatives include the use of advanced technology to support inspection training in the aviation industry (Sponsor: FAA); the integration of asynchronous technology and virtual reality to support education in aircraft maintenance technology (Sponsor: NSF); developing an automated system of self-instruction for specialized training, specifically an interactive simulator for use in automated inspection tasks (Sponsor: FAA), Using Virtual Reality to Improve Inspection Quality (Sponsor: NASA), and creating a hybrid solution to human machine in inspection systems design problems (Sponsor: NSF).
Virtual Reality Eye Tracking Laboratory (VRET) at Clemson University

The Clemson Virtual Reality Eye Tracking Laboratory is housed in McAdams Hall on the main campus of Clemson University within the College of Engineering and Science. Several computers and supercomputers are available in the VRET Lab. The primary rendering engines, housed in the Virtual Reality Eye Tracking (VRET) lab at Clemson, are Dual-processor 1.5GHz Linux (RH 7.3) PCs equipped with 1G RAM and an NVidia GeForce4 6800 Ultra graphics card. Multi-modal hardware components include a binocular eye tracker mounted within a Virtual Research V8 Head Mounted Display (HMD). HMD position and orientation tracking is provided by an Ascension 6 Degree-Of-Freedom (6DOF) Flock of Birds (FOB). A 6DOF tracked, hand-held mouse provides a means to represent a virtual tool for the user in the environment. The HMD-fitted eye tracker is a video-based corneal reflection unit, built jointly by Virtual Research and ISCAN. Each of the binocular video eye trackers is composed of a miniature camera and infrared light sources, with the dual optics assemblies connected to a dedicated personal computer (PC). In addition three state-of-the-art Tobii ET-1750 eye trackers are available.

Smart Classrooms and Wireless Connectivity

The Division of Computing and Information Technology at Clemson University has equipped several classrooms throughout the University as “Smart Classrooms”. These classrooms are designed to provide standard presentation of technology to instructors, ease of use of technology, ease of maintenance, a central point in classroom for technology, security of equipment, and flexibility and expandability. Current equipment includes either a permanent desktop computer or laptop connectivity, TV/VCRs, overhead projectors connected to the computer for projection, and EtherNet connectivity. These classrooms, two of which are located in the building housing the Department of Industrial Engineering, enable the utilization of advanced presentation techniques in the classroom. In addition, several of these Smart Classrooms and additional areas on campus have wireless connectivity for use by students and faculty.

Computer Laptop Program
All undergraduate students in the College of Engineering and Science are required to own laptops satisfying specifications that include wireless communication ability.

Clemson University encourages courses that actively use laptops in instruction, and CCIT negotiates special pricing for a new set of recommended models each year. Students who purchase CCIT recommended laptops, which include extended warranties, can obtain faster service and loaner machines at our support center, although students may purchase a non-recommended laptop. Some Engineering programs recommend a specific model laptop for their students. Since these students will bring their own equipment to specified classes, the faculty teaching those classes can incorporate that technology into their courses. All students are provided Microsoft Office with Excel and Access on their laptops through a university-wide site license.

**Human Factors & Ergonomics Control Room Laboratories (122 Freeman Hall)**

The Human Factors and Ergonomics Control Room Laboratories are specifically designed for students to conduct controlled behavioral studies in accordance with approved IRB protocols. This laboratory also supports mentor led Creative Inquiry projects, capstone design projects and honors theses in human factors and ergonomics. The labs are equipped with reconfigurable settings and hardware as necessitated by each controlled study. This lab is equipped with the following hardware and software:

- **Hardware**
  - 55” LCD Screen with laptop connection
  - Polycom conference telephone with microphones
  - Optiplex Quad core
  - Connected to flight simulator joystick and pedal controls; panasonic HD projector onto 12’ screen

- **Software**
  - Microsoft Flight Simulator X
Ergonomics Laboratory

Clemson Industrial Engineering Ergonomics lab facility supports instruction and research in industrial ergonomics, including environmental measurement, force and pressure measurement and sensing, measurement and analysis for work design, and eye-motion tracking, and work design. Given its mixed use, the formal laboratories required for IE210 Work Analysis and Design and IE489 Industrial Ergonomics and Automation are given priority access to this resource. The following resources are available (* denotes use in formal laboratories):

- Desktop computing: 5 Dell Optiplex i7 (networked) with ErgoIntelligence MMH, ErgoIntelligence UEA, Mannequin Pro and MOST for Windows (five available) *
- Instrumentation computing: Latitude D620 (networked) with LabView and BioBench
- Laptop computing kit: Dell Latitude laptop (wireless capable) with Canon PowerShot SD750 digital camera. In addition to standard software (Microsoft Office 2010), software includes Quetech Work Study Plus and ErgoMaster. (three available) *
- Tool kit: standard toolbox with basic hand tools, measuring tape, 30cm rule. (six available) *
- ABB Sr100 stripchart recorder
- Amprobe THWD-1 Psychrometer
- Applied Science Eye Motion Tracking System
- Biometrics goniometry kit
- Biometrics EMG kit
- CB Sciences EMG system
- Chatillon CSD200 Push-pull dynamometer *
- Extech 407025 Light meter (10 available) *
- Extech 407735 Sound level meter (10 available) *
• Extech 45118 Thermo-anemometer
• Flexiforce load force gage assortment
• Larson Davis hand-arm vibration meter
• Mark 10 Force gage with force and torque sensors
• Metrosonics db-3060 Noise dosimeter
• Quest 1900 Integrating sound level meter with 1/3 octave filter set
• Questemp 30 Web bulb globe temperature meter
• Sony PC100 Digital camcorder
• Process simulation equipment: table-top mill and lathe, table-top robot (four), picking bin set, portable roller conveyor, portable lift table, portable work bench *