Academic Program Review

Engineering Graduate

Master's Program

Self-Study Report

Academic Years Fall 2016 - Summer 2021

Table of Contents

Preface and History

A. Preface 1

B. History of the University of Tennessee at Chattanooga 3

C. Background of the Graduate Engineering Program 4

Part I. Learning Outcomes

1.1 Learning Outcomes 6

1.2 Program Evaluation 6

A. Thesis or Projects 7

B. Assessment and follow up actions 9

1.3 Use of Evaluation Information 10

1.4 Institution's Mission 11

Part II. Curriculum

2.1 Curriculum Review 13

2.2 Course Scheduling and Offerings 14

2.3 Comparison with Similar Undergraduate Courses 17

2.4 Alignment with Learning Outcomes 17

2.5 Curricula Structure 18

2.6 Professional Practice 23

2.7 Online and In-Class Parity 27

2.8 Pedagogical Methods 27

Part III. Student Experience

3.1 MS Engineering Program Enrollment and Peer Identification 29

A. Admission Requirements 30

B. Recruitment 30

C. Enrollment 32

D. Degrees Awarded 33

3.2 Quality Evaluation 33

3.3 Professional Development Opportunities 34

3.4 Enrichment Opportunities 34

3.5 Diverse Perspectives 35
3.6 Academic Support 36
Part IV. Faculty
4.1 Engineering Graduate Coordinators 37
4.2 Faculty Teaching Load 40
4.3 Faculty Diversity 41
4.4 Faculty Professional Development 41
4.5 Improvement Processes 42
4.6 Faculty Evaluation 43
Part V. Learning Resources
5.1 Equipment Evaluation 44
5.2 Learning and Information Resources 51
A. UTC Library General Information 51
B. Library Collections 53
C. Library Services 55
5.3. Library Technology and Spaces 59
Part VI. Support
6.1 Operating Budget 61
6.2 Enrolment and Effectiveness 62
6.3 Program Responsiveness 62
6.4 Graduate Student Data Collection and Placement Evaluation 62
6.5 Procedure Review 63
Appendix
A. Rubric 64
B. Undergraduate Syllabi Examples 67
C. Graduate Syllabi Examples 77
D. Course Learning Evaluation 90
E. Expenditures 99
F. Diversity 100
G. Example Curriculum Vitae 101
a. Resume of Ignatius Fomunung, Ph.D. 101

b. Resume of Kidambi Sreenivas Ph.D. 105
H. Laboratory Equipment Training and Management Policy 113
I. Facilities and Equipment 114
J. Library Information 118
K. Employment and Placement 120

A. Preface

The last review of the MS Engineering program at the University of Tennessee, Chattanooga (UTC) was conducted in 2016. Two main recommendations were made to improve the program: enrollment and research growth.

A number of steps have been taken over the years after the last MS Engineering program review to support existing efforts to increase the capacity for distance learning (DL). These resulted in a growing number of DL students in the program with a total of 10 since the launch of the DL program in Spring 2020. Specific steps taken were:

- Improvements in the marketing efforts for the program. These efforts targeted audiences inside (current undergraduate engineering students in the college) and outside the University, including the employees of local industries, through lunch and learn events. The marketing efforts also targeted international students.
- Revision of the program curriculum to address the needs of students.
- Modifications of admission process and minimum admission qualifications to improve the enrollment of domestic students.
- Development of an online MS Engineering program through partnership with an external company (Focus EduSolutions). This partnership improved the process of nurturing prospective students and broadened the footprint of the program in the region, nationally, and internationally through various online advertisement programs.
- Creation of a streamlined application process with reduced turnaround time in order to expedite the process of admission after completed applications are received from prospective students.
- Improved advising activities to support students in the program and promote retention via assistance from MS Engineering Graduate Program Coordinators.

Significant steps were also taken to improve research activities to support the MS Engineering program. The growth in research capacity is evidenced by increases in the number of publications from 74 to 124, a 67.5% increase, and the amount of external research funding attracted by the college to support the program from $451,005 to $2,227,072. Below is a summary of some of the steps taken.

- Hiring of faculty with strong research experience and track record in cutting-edge areas to drive research activities.
- Procurement of several new facilities, equipment, and laboratory spaces to support research activities.
- Increase in the number and amount of extramural research proposal submissions to attract external funding to support research activities.
- Provision of start-up and internal research funding for research activities of new faculty to expedite the process of training graduate students in new research areas.
- Creation of new research centers that engage and provide resources to students in the program to work on specific research areas.
- Emphasis on research as a key component of faculty workload to establish clear expectations and encouragement for pursuing research.
- Organizing grant writing workshops for faculty to improve the quality of research proposals submitted to funding agencies.
- Encouraging and supporting collaborative and interdisciplinary research activities with other colleges and universities.
- Strengthening ties with local industries and encouraging faculty members to explore opportunities to collaborate with the local industries (e.g. TVA, EPB, Volkswagen, Amazon, City of Chattanooga and others) in their research activities.

B. History of the University of Tennessee at Chattanooga

The University of Tennessee at Chattanooga is a metropolitan university located in the southeastern corner of the state of Tennessee. Chattanooga's metro area has a population of approximately 423,000 people who reside in Chattanooga, North Georgia and Northeastern Alabama.

The University of Tennessee at Chattanooga (UTC) became part of the University of Tennessee System in 1969. The System consists of five major campuses located in Chattanooga, Knoxville, Martin, Memphis and Pulaski. Governance is provided through the UT System President, Chancellors on each campus, and the University of Tennessee (UT) Board of Trustees. The Governor of the State appoints Board members, including the Chairman of the Board.

Prior to becoming part of the UT System, the university was a private university, known as the University of Chattanooga (UC). UC was founded by an agency of the Methodist Episcopal Church in 1886. Chattanooga City College (CCC), a predominately African-American University, also became part of UTC during the UT System-driven merger in 1969.

At the time of the merger in 1969, UC's student population was slightly more than 2,200. Now as a public institution, UTC serves 11,457 students. Approximately 12 percent of UTC's students are enrolled in graduate programs.

Overall, UTC's students come from not only Tennessee (coming from 93 Tennessee counties), but also from more than 40 states and 45 foreign countries.

C. Background of the Graduate Engineering Program

The Master of Science (MS) degree in Engineering (http://www.utc.edu/college-engineering-computer-science/graduate-programs/msengr.php) at UTC is designed for people with engineering or science backgrounds seeking technical advancement in their field of expertise. The program has five concentrations: chemical, civil, electrical, mechanical, and automotive systems engineering.

These, along with any respective focus areas, are listed in Table 1.

Table 1. Program Concentrations and Focus Areas

Concentration	Available Focus Areas
Chemical	Chemical Science
Civil	
Electrical	Power and Energy
	Communications and Signal Processing
	Microelectronics and Computer Systems
	Power Systems Management
Mechanical	Energy
Automotive Systems	

The graduate engineering curriculum is made of courses coming from four different areas, as shown in Table 2. To earn a master's degree in engineering, graduate students must complete a minimum of 30-33 credit hours depending on the student's selection of thesis or project.

Table 2. Areas of Graduate Engineering Program

Area I	Mathematics or Engineering Analysis	3-6 Hours
Area II	Approved Electives in Mathematics, Science, or Engineering	6-9 Hours
Area III	Engineering Concentration	12-16 Hours
Area IV	Thesis or Special Project and/or Internship	6 Hours

Within the guideline shown in Table 2, the graduate engineering program in the College of Engineering and Computer Science ensures the curriculum, with sound academic practice, meets

individual student's needs. Toward that end, a student can choose their courses from a number of focus areas, called concentrations.

Concentrations in the engineering master's program are supported by four areas of courses, consisting of math or engineering analysis, approved electives, concentration, and thesis/project courses. With the approval of the Graduate Engineering Committee, students can fulfill the six hours of 5000-level courses and three hours of Engineering Project course or six hours of Thesis course when they perform work in industry or in governmental organizations. Required semester credit hours for graduation range from 30 to 33, depending on the student's selection of thesis or project.

Part I. Learning Outcomes

1.1. Learning Outcomes

The desired learning outcomes of the MS Engineering program graduates are as follows:

- **Effective Oral Communication Skills:** Prepare and deliver an effective presentation
- **Engineering Fundamentals:** Understand and apply engineering fundamentals
- **Effective Technical Writing Skills:** Write an effective thesis or project report

1.2. Program Evaluation

The outcomes of the MS Engineering program are regularly evaluated using rubrics developed by the College to measure students' mastery of engineering fundamentals along with communication and technical writing skills.

Workshops focused on writing and presenting a thesis and/or project are provided each semester to enhance students' preparation for these assessments. Additionally, students who pursue a master's degree in engineering without an undergraduate engineering degree are required to take additional undergraduate coursesprior to beginning graduate-level engineering courses to ensure they acquire vital foundational skills.

Building on the goal to enhance student achievement, the Electrical Engineering (EE) Department offers a Graduate Seminar (1 hour) course to inform graduate students of the expectations for this concentration, introduce faculty and their areas of expertise, develop students' professional connections through guest speakers from campus and industry, and assist students with project selection and technical writing. Other departments are currently proposing a Graduate Seminar (1 hour) course using the EE course as a model.

A. Theses or Projects

The thesis or project is the application of engineering theory to the real world. To complete a thesis or project, students must conduct a literature review of topics related to the thesis/project, collect and analyze the data, and draw conclusions, whichculminates in the submission of the final thesis/project. Projects are usually more applied research and stem from real world situations. On the other hand, a thesis requires a more theoretical work. Documentation of professional quality and an oral defense are required for both the thesis and project options. Below are the steps that graduate students must follow to complete the thesis/project:

- Identify a potential thesis/project of interest and discuss it with a facultyadviser;
- Write a proposal;
- Develop a schedule;
- Select committee members;
- Conduct literature review;
- Collect data;
- Analyze data;
- Write conclusions and recommendations; and
- Write a thesis or project report and present it.

For the last two years, graduate engineering students have completed a variety of theses/projects in collaboration with various local and regional industries. Table 3 shows a selected list of these theses or projects.

Table 3. Short List of Theses/Projects Completedby UTC Engineering Students			
Student	**Thesis/Project Title**	**Committee Chair**	**Program**
1	Numerical investigation of effects of pressure and chemistry on characteristics of turbulent premixed flames	Reetesh Ranjan	Mechanical Engineering
2	Creation of a trimmed powered aerodynamics database for a generic hypersonic vehicle	Kidambi Sreenivas	Mechanical Engineering
3	Numerical modeling of water vapor absorption for water harvesting applications	Sungwoo Yang	Chemical Engineering
4	Solar thermal energy harvesting using transparent aerogels	Sungwoo Yang	Chemical Engineering
5	Low-cost deep learning UAV and Raspberry Pi solution to real time pavement condition assessment	Weidong Wu	Civil Engineering
6	Improvement of pavement mechanistic-empirical design (PMED) virtual weather station interpolation model using radial basis function – Tennessee case study	Mbakisya Onyango	Civil Engineering
7	Improving inter-area oscillations damping of power systems through cooperative active power control of distributed energy resources	Vahid Disfani	Electrical Engineering
8	The manipulation of RF-DNA fingerprints through the use of a phase-modulated clock in IEEE802.11a Wi-Fi signals	Donald Reising	Electrical Engineering

B. Assessment and Follow up actions

The University of Tennessee at Chattanooga has an institutional assessment process whereby outcomes are assessed. Anthology-Planning is used as a repository for student learning outcomes, service outcomes, program outcomes, assessment results, follow up actions planned, and strategic plans. By using the information captured in Anthology-Planning, UTC is able to provide evidence of outcomes being assessed and those results being used for continuous improvement. The College of Engineering and Computer Science completes a MS Engineering Program assessment that is performed as a composite of the outcomes from the different concentrations based on the student learning outcomes (SLOs) of the program. Students' learning performance is assessed based on the three learning outcomes, from Section 1.1, as follows:

- **Oral Communication:** The College of Engineering and Computer Science provides thesis workshops throughout the semester to prepare students for their final capstone/thesis presentations. The thesis oral communication assessment rubric for graduate students evaluates organization, content, presentation length, visual aids, attention to audience and speaking skills. The written communication assessment rubricfor graduate students evaluates drafting, editing, revision, final draft, and timing. An example of a rubric is shown in Appendix A. The minimum requirement for the program is to have 80% average performance for the criteria. The latest assessment conducted in 2021 shows all students meet the minimum requirement for these criteria and no follow up action was necessary.

- **Engineering Fundamentals: S**tudents with engineering undergraduate degrees do well in engineering fundamentals, but others need additional assistance. These students are required to take additional bridge courses prior to taking 5000-level engineering courses. The latest assessment conducted in 2021 shows all students met the minimum requirement for this criterion and no follow up action was necessary.

- **Technical Writing:** The latest assessment shows students do a good job in technical writing, evaluated using theses and projects. However, more guidance is needed in a particular course. A planned follow up action is to require an initial outline and draft by each student, then to provide feedback to students from the instructor to improve the students' technical writing skills.

1.3. Use of Evaluation Information

The College of Engineering and Computer Science has a Graduate Curriculum Committee with representation from each department, which reviews and makes necessary changes in the graduate curriculum every year based on student evaluationsand assessment results (Section 1.2, B), as shown in Figure 1.

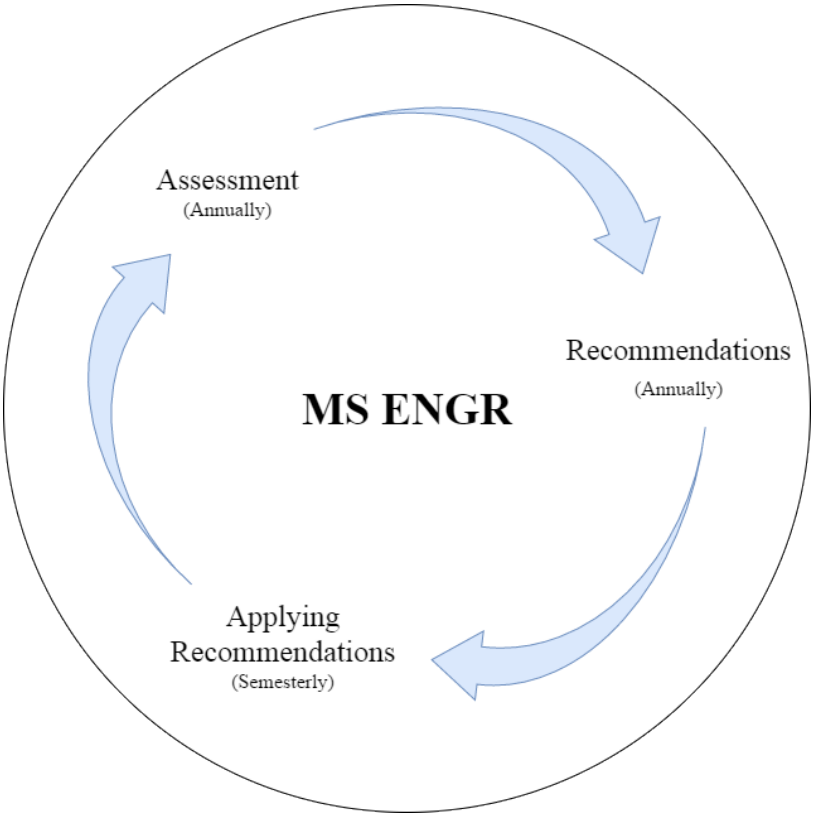

Figure 1. MS Engineering Assessment Cycle

1.4. Institution's Mission

The MS Engineering program is designed to align directly with the UTC and College of Engineering and Computer Science's missions, visions, and values, as shown in Table 4.

Table 4. Alignment of Mission, Vision, and Values

	UTC	College of Engineering and Computer Science
Mission	The University of Tennessee at Chattanooga is a driving force for achieving excellence by actively engaging students, faculty and staff; embracing diversity and inclusion; inspiring positive change; and enriching and sustaining our community. At UTC… we develop a community on campus…enable students to go into the global community and achieve… provide a nurturing environment that connects students, community and opportunity.	1) Educate and train future technical & engineering management workforce for Tennessee, the nation, and beyond. 2) Discover new knowledge in engineering, management, technology, and computer science. 3) Engage communities through scholarship, service and economic development.
Vision	We Engage Students, Inspire Change and Enrich Community. We nurture students through community connections… tied to our values and our region… grounded in Chattanooga… a great drawing card… we value our place.	To be a preeminent college of engineering, engineering management, technology, and computer science in education and applied research.
Values	• Students are the primary reason we exist as an institution • We live integrity, civility and honesty • We relentlessly pursue excellence • We embrace diversity and inclusion • Creativity, inquiry and scholarship are our culture	• Respect – treat each student, staff, and faculty with dignity • Integrity – be transparent and honest • Service – support each other and the community • Inclusiveness – embrace the spirit of openness to ideas and all persons • Nurturing – develop character in students, support the professional development of staff and faculty • Growth – grow in excellence, expertise and positive impact

Goals	• Transform lives through meaningful learning experiences • Inspire and nurture scholarship, creativity, discovery, innovation and entrepreneurial initiatives • Ensure stewardship of resources through strategic alignment and investments • Embrace diversity and inclusion as a path to excellence and societal change	• Enrich Student Experience • Cultivate excellence in teaching and learning • Enhance applied research capabilities of the college for broader impact to the society • Engage community through scholarship and service with leadership and distinction • Enhance national/international reputation and recognition

Part II. Curriculum

2.1. Curriculum Review

The MS Engineering curriculum has been revised multiple times in the last fiveyears to appropriately address the needs of current students and attract new students. Specifically:

1) Additional graduate courses are now available online;
2) New graduate courses have been added to enhance student learning andpreparation for real world; and
3) An additional student learning outcome covering ethics has been added this year and will be assessed for the first time in next academic year (2022-23).

To increase the flexibility of the MS Engineering Program and to target working professionals, an online MS Engineering program has been created to allow students to complete their MS Engineering degree fully online. New graduate courses have also been added to the MS Engineering program to reflect the changing landscape and the demand of current and emerging industries.

2.2. Course Scheduling and Offerings

The curriculum has been designed to be flexible and convenient with courses offered regularly, enabling students to make timely progress towards their degrees. Students can finish their master's degrees in engineering in two years by taking two courses per semester (including summers). At least two core courses and two electivecourses are offered each fall and spring semester, in addition to the "Special Topics in Engineering" and "Thesis/Project" courses. Table 5 shows the courses that have been offered in the past two years and the enrollment in each.

Table 5. Graduate Engineering Courses Offered in the Last Two Years.

Course Enrollment* offered in Past Two Years								
COURSE INFORMATION			ACADEMIC YEAR 2019-2020			ACADEMIC YEAR 2020-2021		
NO.	TITLE	CREDIT HOURS	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING
ENCE								
5420	Finite Element Analysis	4			3			
5640	Adv Structural Analys & Design	4			2			
5670	Advanced Pavement Design	3		5			1	
5700	Advanced Stats & Design of Exp	3		5	2			8
5900R	Engineering Project	3			2			
5910R	Special Topics: Urban Watershed	3		3				
	Special Topics: Urban Stormwater	3			1			
5920R	Graduate Internship in ENGR	1	1	1		1		
5997R	Indv St: Data Fusion	3					2	
	Computer Model and Data Analysis	9			1			
	Individual Studies	9			1			
5999R	Thesis	3					3	
		6		3	4		1	6
ENCH								
5360	Mass Transfer Operations	3					1	
5900R	Engineering Project	3	1	1				
5910R	Scanning Elect Microscopy	4		3	1			
	Transport of Nanomaterials	4			4			
	Molecular Dynamics Simulations	4					1	
5997R	Indv Stu: Molecular Dyn Sim	3		2				
5999R	Thesis	3	1		1			
		6		1				
7950R	Doctoral Research	3						1
		6					1	
		9						1
7997R	Ind Stu: Adv Molecular Dynamic	3			1			
		9						1
7998R	Research	9				4		
ENCM								
7999R	Dissertation	12	4	1	1			
ENEE								
5000R	Graduate Seminar	1			10			10
5020	Linear Systems	3		10			15	
5030	Digital Signal Processing	3					1	
5110	Digital Communications	3						2
5520	Power System Operations	3			9			
5610	Power Electronics & Drives	3					4	
5620	Power System Protection	3		5			8	
5630	Set and Test Digital Relays	3			2			
5660	Smart Distribution Systems	3			7			
5700	Microcomputer Applications	3		1			3	
5720	Power Sys Analysis and Design	3			3			2
5910R	Motion Control Lab	3	3					
	Fuzzy Logic & Intell Cntrl App	3		5				
	Adv Syst Protection Concept	3						9
	Distributed Energy Resources	3						9
	Micro-Controller Based System	3		3				
	Spcl Top Eng: Mod Subst Concept	3		10			2	
	Spcl Top in Eng: Mult-path Cha	3		1				
	Special Topics in Engineering	3		9				3
	Power Systems Stab and Control	3					5	
	System Control Studies	3						3
	System Control Studies II	3					2	
	VLSI Design	3					3	
	Adv Fuzzy and AI Controls App	3			1			
	Industrial Automation Application	3			3			
	Power System Optim - Smart Grid	3			2			
	Power System Optimization	3			8			
5920R	Graduate Intership in ENGR	1	4					1
5997R	Individual Studies	3			1			3
5998R	Research	3					2	
5999R	Thesis	2	1			1		
		3		1	1			1
		4	2	5	4	1		
		6					3	5
7950R	Doctoral Research	9			1	2	2	2
7997R	Individual Studies	3						3
7999R	Dissertation	12	1	2	2	1	2	2

Table 5. Graduate Engineering Courses Offered in the Last Two Years (cont'd).

Course Enrollment* offered in Past Two Years								
COURSE INFORMATION			ACADEMIC YEAR 2019-2020			ACADEMIC YEAR 2020-2021		
NO.	TITLE	REDIT HOUR.	SUMMER	FALL	SPRING	SUMMER	FALL	SPRING
ENME								
5010	Intro to Comp	3		6			6	
5032	Mechanics of	3						3
5060	Automotive E	3		8				
5100	Computation	3						5
5320	Adv Thermod	4					8	
5350	Viscous Flow	3						13
5380	Heat Conduct	4		10			2	
5449	Engr Analysis	4						2
5900R	Engineering F	3		1			2	3
5910R	Spec Top in E	3	3				3	
	Automotive S	3		1				
	Spcl Top in Er	3		2			2	
	Special Topic	3		6			8	
5999R	Thesis	6	1	5		4	7	8
7950R	Doctoral Res	9				2		1
7997R	Individual Stu	3						1
* Collected from the Teaching Load Summary each semester.								

2.3. Comparison with Similar Undergraduate Courses

The MS Engineering program curriculum frequently covers academic contents that build off the fundamentals taught in undergraduate courses such as the two courses in Appendix B. In such cases, graduate coursework delves deeper into the conceptual points of the field. Students are encouraged to spend time on key derivations rather than focusing solely on outcomes as a way of illustrating methods they will find useful. The syllabi for two undergraduate courses (Thermodynamics and Protective Relaying) and their respective graduate courses (Advanced Thermodynamics and Advanced Protective Relaying Concepts) are provided in Appendices B and C, respectively, as a couple of examples; all graduate courses provide students with progressively more advanced academic content.

2.4. Alignment with Learning Outcomes

The MS Engineering program has clear learning outcomes (identified in 1.1) related to communication skills, engineering knowledge, and technical writing skills that graduate students must master to successfully complete the program. The outcomes are aligned with the MS Engineering curriculum as shown in Figure 2.

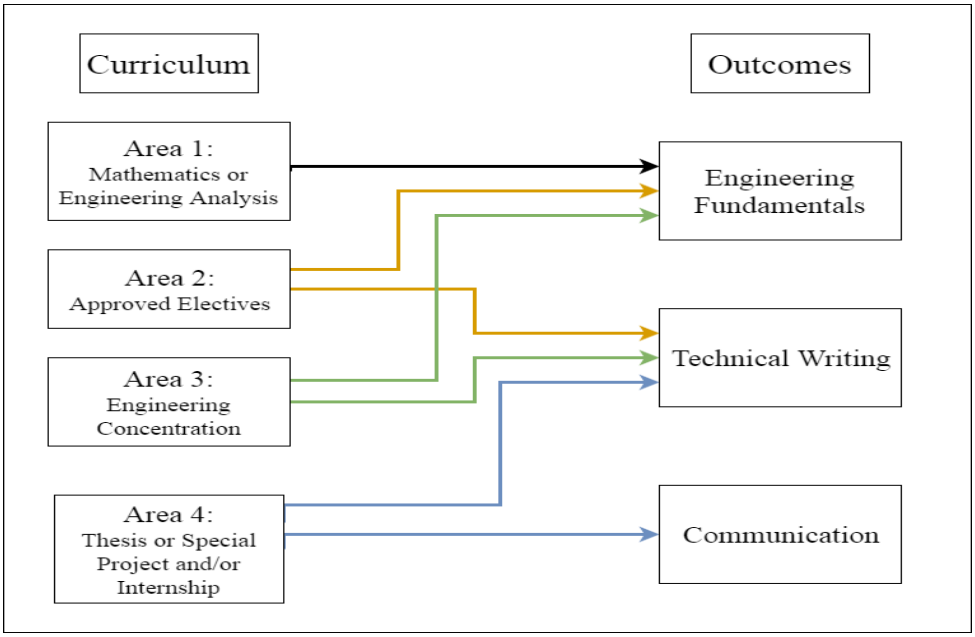

Figure 2. MS Engineering Curriculum Alignment with Program Outcomes

2.5. Curricula Structure

Below are the graduate program curricula for the Engineering concentrations. Additional requirements, selection of courses, and course descriptions can be found in the Graduate Catalog at https://catalog.utc.edu/content.php?catoid=39&navoid=1461.

The MS Engineering program aims to ensure that knowledge of the literature of the discipline is incorporated in its curriculum, as can be seen from course syllabi, shown in Appendix C.

Engineering: Chemical: Chemical Science, M.S.

Area I: Mathematics Component* (3 hours)

- Math 5140 – Mathematical Statistics
- Math 5160 – Applied Statistical Methods
- Math 5190 – Design of Experiments
- Math 5470 – Applied Mathematics for Science and Engineering I
- Math 5600 – Numerical Analysis I
- Math 5610 – Numerical Analysis II

Area II: Approved Electives* (6-9 hours)

- ENCE 5910R – Special Topics in Engineering
- ENCE 5997R – Individual Studies
- ENCH 5260 – Water and Wastewater Treatment Systems
- ENCM 5380/ENME 5300 – Introduction to Continuum Mechanics
- ENGM 5540 – Technical Project Management
- ENGM 5580 – Advanced Engineering Economy
- ENME 5032 – Mechanics of Composite Materials
- ESC 5610 – Advanced Applications of Remote Sensing and Geographic Information Systems
- ESC 5660 – Geographic Information Systems

  *With approval of the graduate program coordinator/thesis advisor, students may take a 5000-level course related to the students' research

Area III: Approved Engineering (12-16 hours)

- ENCE 5031 - Advanced Strength and Applied Stress Analysis
- ENCE 5420 - Finite Element Analysis
- ENCE 5600 - Statically Indeterminate Structures
- ENCE 5640 - Advanced Structural Analysis and Design
- ENCE 5660 - Advanced Civil Engineering Materials

- ENCE 5670 - Advanced Pavement Design
- ENCE 5680 - Infrastructure Systems Analysis and Design
- ENCE 5700 - Advanced Statistics and Design of Experiments

Area IV: Thesis (6 hours) or Project + Additional Coursework (9 hours)

Thesis option:

- Two or more semesters of ENCE 5999r - Thesis (6 hours total)

OR

Project + Coursework option:

- Two additional approved graduate courses (6 hours)
- ENCH 5900r – Engineering Project (3 hours)
- ENCH 5920r – Graduate Internship in Engineering (3 hours)

Program Total: 30 hours (Thesis), 33 hours (Project + Coursework)

Engineering: Civil, M.S.

Area I: Mathematics Component* (3-6 hours)

- MATH 5470 - Applied Mathematics for Science and Engineering I
- MATH 5480 - Applied Mathematics for Science and Engineering II
- MATH 5600 - Numerical Analysis I
- MATH 5610 - Numerical Analysis II

Additional Information and Notes

*With approval of the graduate adviser, students can take an equivalent course in this area.

Area II: Approved Electives (6-9 hours)

- ENCE 5910R – Special Topics in Engineering
- ENCE 5997R – Individual Studies
- ENCH 5260 – Water and Wastewater Treatment Systems
- ENME 5300 – Introduction to Continuum Mechanics
- ENGM 5540 – Technical Project Management
- ENGM 5580 – Advanced Engineering Economy
- ENME 5032 – Mechanics of Composite Materials
- ESC 5610 – Advanced Applications of Remote Sensing and Geographic

Information Systems

- ESC 5660 – Geographic Information Systems

Area III: Approved Engineering (12-16 hours)

- ENCE 5420 - Finite Element Analysis
- ENCE 5600 - Statically Indeterminate Structures
- ENCE 5640 - Advanced Structural Analysis and Design
- ENCE 5660 – Advanced Civil Engineering Materials
- ENCE 5670 – Advanced Pavement Design
- ENCE 5680 – Infrastructure Systems Analysis and Design
- ENCE 5700 – Advanced Statistics and Design of Experiments

Area IV: Thesis (6 hours) or Project + Additional Coursework (9 hours)

Thesis option:

- Two or more semesters of ENCE 5999r - Thesis (6 hours total)

OR

Project + Coursework option:

- Two additional approved graduate courses (6 hours)
- ENCE 5900 - Project (3 hours)

Program Total: 30 hours (Thesis), 33 hours (Project + Coursework)

Engineering: Electrical, M.S.

Area I: General Hours (16 hours)

- ENEE 5000r – Graduate Seminar
- A total of up to 6 hours of Individual Studies (ENEE 5997r) may be substituted for either Engineering Analysis hours or Breadth hours.

Additional Information and Notes

*With approval of the graduate adviser, students can take an equivalent course in this area.

Engineering Analysis (9 hours)

- ENEE 5020 - Linear Systems

- Two of the following or faculty advisor approved courses:
  - ENCE 5700 - Advanced Statistics and Design of Experiments
  - MATH 5130 - Introduction to Probability and Statistics

- ENGM 5520 - Reliability Engineering

Breadth Courses (6 hours)

- Course selection is at the discretion of the student and faculty advisor selected from any discipline in and/or out of the department.

Area II: Focus Area Hours (9 semester hours)

- **Select three (3) courses from one (1) of the following focus areas:**

Power and Energy

- ENEE 5160 - Introduction to the Smart Grid
- ENEE 5520 - Power System Operations
- ENEE 5610 - Power Electronics and Drives
- ENEE 5620 - Power System Protection
- ENEE 5630 - Setting and Testing Digital Relays
- ENEE 5650 - Sustainable Electric Energy Systems
- ENEE 5660 - Smart Distribution Systems
- ENEE 5720 - Power System Analysis and Design

Communications and Signal Processing

- ENEE 5010 - Stochastic Processes
- ENEE 5030 - Digital Signal Processing
- ENEE 5110 - Digital Communications

Microelectronics and Computer Systems

- ENEE 5030 - Digital Signal Processing
- ENEE 5150 - Advanced Digital Design
- ENEE 5700 - Microcomputer Applications
- CPSC 5560 - Computer Data Communications
- CPSC 5700 - Advanced Computer Architecture

Power Systems Management

- ENEE 5160 - Introduction to the Smart Grid
- ENEE 5520 - Power System Operations
- ENEE 5610 - Power Electronics and Drives
- ENEE 5620 - Power System Protection
- ENEE 5630 - Setting and Testing Digital Relays
- ENEE 5640 - Transients in Power Systems
- ENEE 5650 - Sustainable Electric Energy Systems
- ENEE 5660 - Smart Distribution Systems
- ENEE 5720 - Power System Analysis and Design
- ENGM 5500 - Concepts in Engineering Management

- ENGM 5540 - Technical Project Management
- ENGM 5550 - Technical Entrepreneurship and Leadership
- ENGM 5580 - Advanced Engineering Economy
- ENGM 5830 - Strategic Management and Technology
- ENGM 5960 - Capstone Project II

Area III: Specialty (6 semester hours)

- **Select one of the following options:**
  Thesis Research Hours
  Non-Thesis Specialty Hours
  - Two (2) additional focus area courses

Program Total: 31 hours

Engineering: Mechanical: Energy, M.S.

Area I: Mathematics Component* (3-6 hours)

- MATH 5470 - Applied Mathematics for Science and Engineering I
- MATH 5480 - Applied Mathematics for Science and Engineering II
- MATH 5600 - Numerical Analysis I
- MATH 5610 - Numerical Analysis II

Additional Information and Notes

*With approval of the graduate adviser, students can take an equivalent course in this area.

Area II: Approved Electives (6-9 hours)

Area III: Specialty (12-16 hours)

- ENME 5320 - Advanced Thermodynamics
- ENME 5340 - Transport Phenomena
- 5000-level approved elective 3-4 hours

- ENME 5360 - Mass Transfer Operations or
- ENME 5380 - Heat Conduction and Radiation

Area IV: Thesis (6 hours) or Project + Additional Coursework (9 hours)

Thesis option:
- Two or more semesters of ENME 5999r - Thesis (6 hours total)

OR

Project + Coursework option:

- Two additional approved graduate courses (6 hours)
- ENME 5900r – Engineering Project (3 hours)

Program Total: 30 hours (Thesis), 33 hours (Project + Coursework)

2.6. Professional Practice

The MS Engineering program engages students in professional practices and training experiences by offering a variety of seminars, local internship opportunities, and job fairs throughout the year. Students are informed of these via email, social media, bulletin boards, and e-boards. In addition, theses and projects also act as professional practice resources where students get to engage in solving real-world industrial problems as an integral step in their professional preparation towards providing cutting-edge technological solutions.

CECS career and professional development programs administered by the Center for Student Success provide comprehensive services and resources that enable students to take active responsibility for their career development and decision-making in their professional practice. They equip students to make career plans by facilitating awareness of their work-related strengths, interests, values, and understanding of the world of work. They prepare students for finding suitable employment by enhancing their job search skills and express the relevance of their strengths to employers. Through these programs, relationships with members of the University community including students, faculty, and staff are fostered to facilitate the development of professional skills, the integration of learning with work, and the identification of a strong referral base or network.

Mechanisms in place to ensure students receive career and professional development services:

- Assist students with creating a career development plan including components of career assessment, definition of career and internship/co-op goals, job search, resume preparation, and interviewing; following-up with students to discuss progression, to track milestones, and to modify short- and long-term goals. Individual career counseling options are also available from the Career Counselor in our Center for Student Success.
- Connect student with businesses and recruiters to build relationships and increase career opportunities for students.
- Provide advice and tools to assist students through drop-in and scheduled appointments with the Career Counselor in our Center for Student Success in order to achieve their career goals; inform students of activities/steps related to the career planning process and how various UTC Community resources and programs can be used in that process; integrate specific examples to illustrate or suggest next steps while providing or collaborating with students to develop reasonable action plans; and convey information in a clear, encouraging, helpful, and understandable manner.
- Workshops are available on career assessment, resume and professional document preparation, interviewing, and other topics as indicated above. Faculty and staff participate to develop and refine workshop content.
- Cultivation of a formal network across the campus community to identify, evaluate, and share best practices in career advising by the Career Counselor and Graduate Program Coordinators. These activities include regular and active participation in professional associations, continuous training and development, and robust engagement in cross-functional workgroups to include, but not limited to, the Career Development Alliance and the Advisor's Council.

- CECS Career Launch is a platform used to ensure all students are notified about events, programs, industry tours, career fairs, employer networking opportunities, workshops, full-time, co-op, and job or internship postings. It also houses targeted career and professional development resources for students to access. This may include resources to assist with resume preparation, cover letters, mock interviews, LinkedIn or Handshake profiles. It is designed to add support and tools to empower students to navigate to their successful future.
- Students are encouraged to use Handshake, which is a modern career platform that empowers them to find the best roles for their unique goals and equips them to show their potential to employers while enjoying a personalized experience based on interests and feedback. CECS students use Handshake's simple yet powerful search tools and alerts to find the ideal fit for the criteria set from local employers or companies nationwide seeking to hire. Students are able to register career related events, apply for internships, co-ops, and full-time roles, connect with employers, request job/internship search assistance, attend virtual career fairs, request 1:1 career counseling appointments, and also conduct career exploration. Students build online profiles using their own information and list their academic and professional goals.

Professional Development and Career Development Opportunities/Workshops offered each semester for CECS students:

Industry Tours: Provide an opportunity for students to network with companies related to their field of interest. They allow students to see a workplace environment so they can start thinking about the kind of company that would be a good fit for them. Students tour the facilities, speak to current employees of the company, and observe a company presentation/outline. They are encouraged to observe different processes, work culture, and the types of roles that might

resonate with them.

Virtual or in-person informational employer sessions: Benefits for students attending info sessions include: Learning more about employers of interest, networking and developing professional contacts, learning about internships, co-ops and job opportunities, industry roles, learning about company structure, fit and potential, and potential of obtaining interviews directly from company reps.

Career Fair: We host a career fair in the fall and spring - options can vary between in-person or virtual. This is an opportunity to help students prepare for their job search, learn outcomes of their major and connect with employers.

- In-person fairs are held in the EMCS building on the 3rd and 4th floors.
- We partner with Handshake to run our career fair in a virtual format.

Resume Review Day: Opportunity to network with hiring managers and recruiters. Students will have the opportunity to meet with professionals who will review their resume and offer advice on updates and improvements for the career fair.

LinkedIn/Handshake Workshop: Students learn how to leverage the tools and strategies on both platforms to develop a personal plan to maximize their online presence. This workshop assists in developing or updating LinkedIn and Handshake profiles and provide an overview of how to best utilize them when searching for an internship, co-op, or full-time employment.

Mock Interviews: The goal of this event is to help students gain interviewing experience by meeting face-to-face with real employers. During the interview, the employers will provide

students with feedback on their resume, interview responses, and overall impression. We encourage employers to use their own interview format to make mock interviews as close to a real interview as possible.

LinkedIn Reviews: This event allows students to receive feedback from local employers on ways to improve their LinkedIn profile score and discoverability. LinkedIn is a premier networking tool, providing job seekers and potential employers with the ability to connect. Hiring managers and recruiters will provide their insights, offering an opportunity to network with them.

2.7. Online and In-Class Parity

As mentioned earlier, all MS engineering courses in the Electrical Engineering concentration area, and several courses in the concentration areas of Chemical, Civil and Mechanical Engineering are offered online. Students in these courses are monitored and evaluated actively through the Canvas Learning Management System (LMS) to ensure progress and that their achievements are on-par with students attending the same courses on campus.

Online students are required to participate in discussion forums regularly to fulfil their class participation goals and make sure they keep up with the lectures. Normally, both in-class and online students share assignments and exams.

2.8. Pedagogical Methods

Graduate courses are usually offered in the evenings or late afternoons to accommodate working students. Each course uses the Canvas LMS to display class materials, create discussion boards, and post assignments. This system helps students keep up with coursework if they are

unable to attend class due to work or illness.

Online offerings are supported by virtual platforms such as Mediasite, Studio, and Camtasia to record and store lectures both synchronously and asynchronously. UTC has technical support personnel who are responsible for maintaining these platforms. Such virtual platforms offer the opportunities to embed modern instructional methods and pedagogical approaches such as blended learning, synchronous and asynchronous delivery, learner-centric delivery, simulations, flipped-classroom learning, etc.

Part III. Student Experience

3.1. MS Engineering Program Enrollment and Peer Identification

It is important for students to identify with peers during their studies as it contributes to a positive learning experience and promotes team building skills. Peer study groups facilitate understanding of course materials and assignments. The integrated nature of UTC's MS Engineering program is designed to create an appropriate environment for peer interaction through a variety of activities, such as group projects, engineering clubs, and professional student chapters. Within most courses, students are arranged into groups to complete assignments and projects, collaboratively. In addition, students are encouraged to join on-campus clubs, professional student chapters and student bodies such as the Graduate Student Association (GSA). These activities will help students connect with peers outside their discipline.

The MS Engineering program and concentrations provide online-accessible education in the theory and applications of engineering and prepare students for successful careers in industry, government, and academia. The diverse concentrations help students apply tools and techniques in engineering through individual and team- based projects and promote life-long learning and service to the engineering profession.The program objectives are to produce graduates who:

- Function as successful professionals in a variety of engineering disciplines
- Function effectively in multidisciplinary environments
- Adapt to various environments
- Participate in further knowledge building opportunities

- Are progressing towards Professional Registration (e.g., Professional Engineering certificate)

A. Admission Requirements

Applicants must meet the requirements below to be admitted to the Engineering master's program at UTC:

- Hold a baccalaureate degree from a regionally accredited college or university; GRE scores may be required. The GRE is waived for domestic students who have a baccalaureate degree from a regionally ABET accredited college. All other domestic and international students applying for admission are required to submit their GRE scores taken within five years of application.
- Have a minimum grade point average (GPA) of 2.7 on a 4.0 scale for all undergraduate work taken for the baccalaureate degree.
- Students whose native language is not English are required to provide scores for the Test of English as a Foreign Language (TOEFL), International English Language Testing System (IELTS), or Duolingo English Test. An official TOEFL score of 550 or above is required. A score of 213 or above on the computer-based test, or a score of 79 or above on the Internet-based test is considered equivalent to a score of 550 or above on the paper-based test. IELTS scores must be 6.0 or higher. Duolingo English Test scores must be 100 or higher (160-point scale). Scores must be no more than two years old.
- Submit official transcripts from each institution previously attended.
- Complete the Graduate School application form and pay a non-refundable fee.

B. Recruitment

Students are primarily recruited into the Engineering master's program through marketing efforts directed toward undergraduates at UTC, local and regional colleges, as well

as local and regional companies, including faculty visits. Faculty members visit companies to speak about the program and explore opportunities for partnership. Alumni of the MS Engineering program also participate in the recruitment meetings to answer any questions from prospective students. We organize webinars to share information about the program and the application process with the general public. We also participate in various internal and external recruitment and career fairs to attract prospective students.

In 2019, we partnered with Focus EduSolutions, an education e-solutions company that offers online program management including marketing, recruitment, enrollment and retention, and building online courses. With their assistance, we are building the needed platforms to grow our MS Engineering Program for online delivery.

The College of Engineering and Computer Science website (http://www.utc.edu/CECS) is updated regularly, and publications related to the MS Engineering program, such as brochures, flyers, posters, etc., are distributed at recruitment meetings. The publications are also sent to universities across the United States at least once a year. Alumni of the MS Engineering program also play a crucial role in recruitment efforts by informing their colleagues, friends, and family members about the program and the availability of courses online.

Recruitment related links:

- 2020-2021 Year in Review: https://issuu.com/utchattanooga/docs/2020-21_-_annual_review-_v3_-_web?fr=sNDJjYjQzOTYxMTU
- University information website: http://www.utc.edu/about/
- Graduate School website: http://www.utc.edu/graduate-school/
- CECS Graduate Programs website: https://www.utc.edu/engineering-and-computer-science/graduate-programs

C. Enrollment

Figure 3 below shows the Graduate engineering program enrollment data over the past six years.

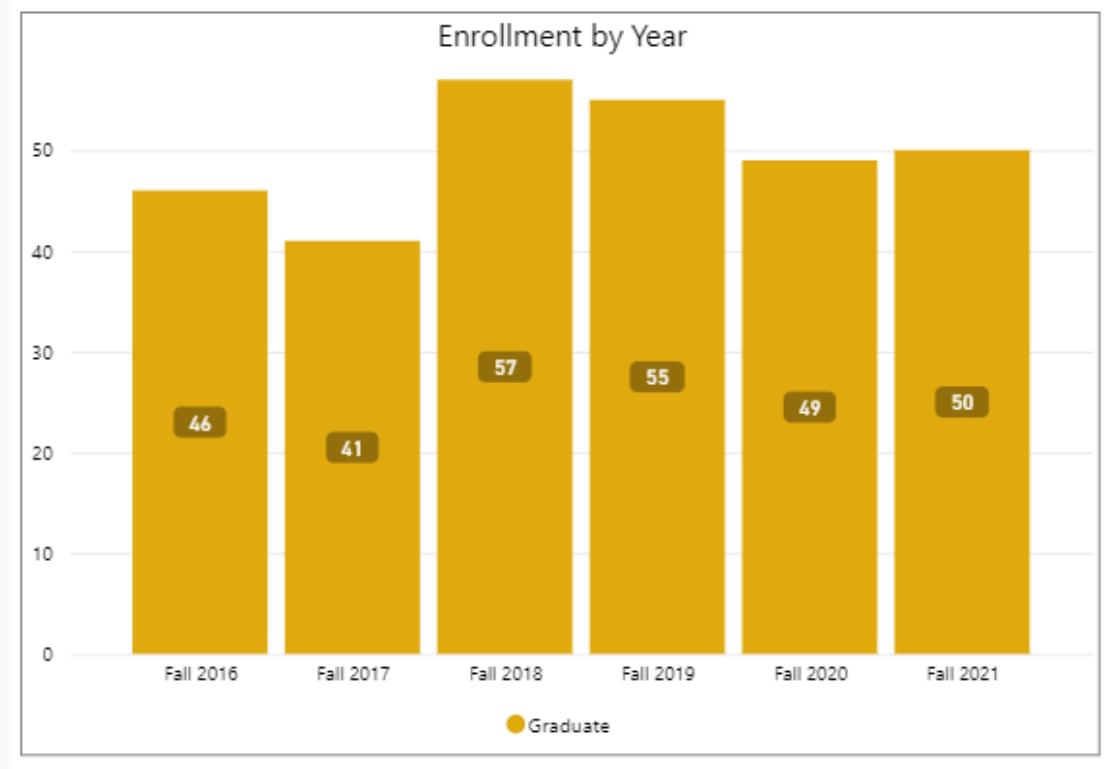

Figure 3. Graduate Engineering Program Enrollment Data*

**Source: Office of Planning, Evaluation, and Institutional Research*

Table 6 shows the enrollment data in detail for each graduate engineering concentration between 2016 and 2021.

Table 6. Graduate Engineering Program Enrollment Data

Major	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020	Fall 2021
Chemical: Chemical Science	7	6	10	6	2	3
Civil	3	4	7	9	5	8
Electrical	25	22	25	18	25	28
Industrial	1	0	0	0	0	0
Mechanical: Energy	4	5	8	15	13	8
Mechanical: Mechanics	4	3	2	0	0	0
Automotive Systems	2	1	3	4	4	2
Electrical: Power Systems Mgmt	0	0	2	3	0	1
Total	**46**	**41**	**57**	**55**	**49**	**50**

D. Degrees Awarded

Figure 4 shows number of degrees awarded between 2016 and 2020.

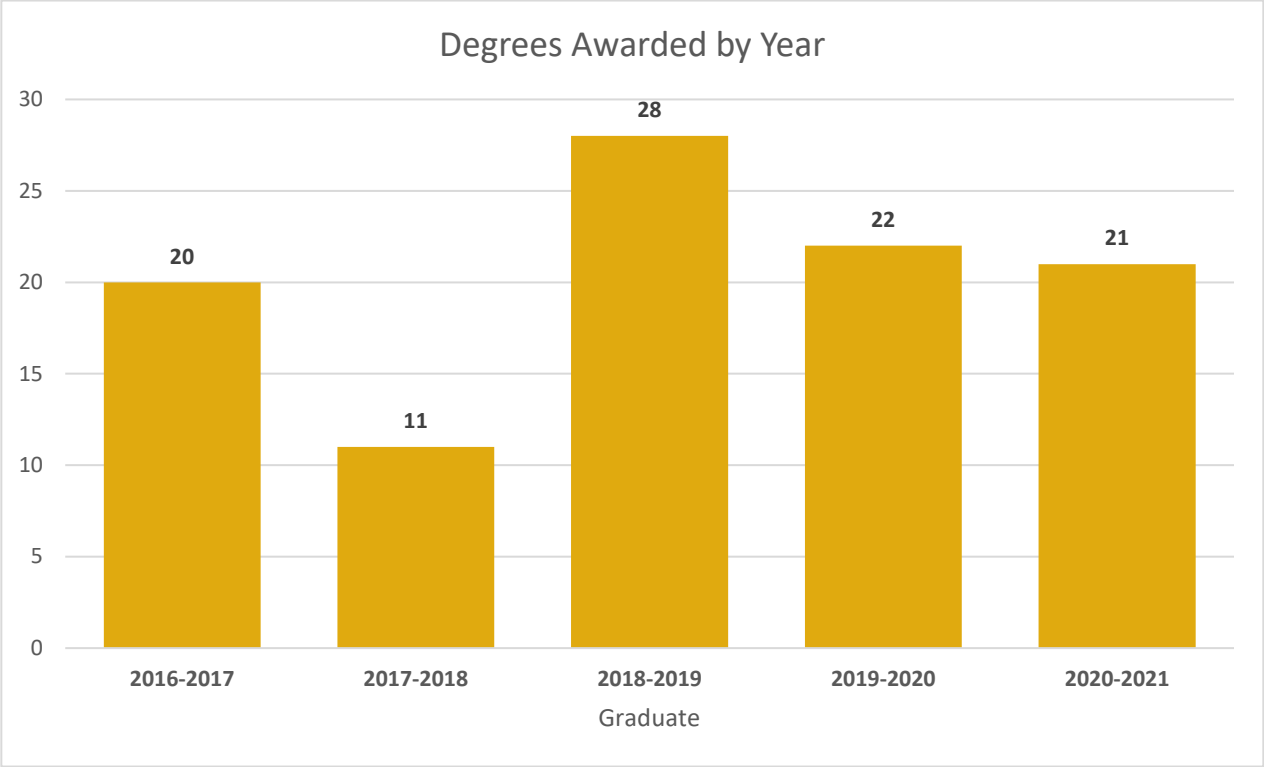

Figure 4. Master of Science in Engineering Degrees Awarded per Academic Year*

**Source: Office of Planning, Evaluation, and Institutional Research.*

3.2. Quality Evaluation

Students have the opportunity to provide feedback on the program and evaluate faculty's teaching effectiveness through surveys conducted online prior to final exams each semester. Students are routinely notified through e-mail and by the instructors in class to log on and complete the survey. As an example, Course Learning Evaluation results for Fall 2020 and Spring 2021 are provided in Appendix D.

3.3. Professional Development Opportunities

The MS Engineering program provides adequate professional development opportunities through membership in professional associations such as Tau Beta Pi,Associated General Contractors (AGC), Graduate Student Association (GSA), American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), National Society of Black Engineers (NSBE), and the Society of Woman Engineers (SWE). These organizations encourage students to attend conferences and workshops, help students network and find jobs, and provide students with opportunities for publication. Below are examples of such student publications.

1. Rua Taha, Noman Saied, Abdelrahman Karrar "Implementation of a Real-Time Decoupling Approach for Power Networks on a Personal Computer", Paper accepted for 2022 IEEE PES T&D Conference, New Orleans, April 26-28, 2022.

2. DeBardelaben, C., and Sreenivas, K., "Effect of Farfield Boundary on Simulations of the Inlet in Crossflow," Accepted for presentation at AIAA SciTech 2022, San Diego, CA, January 2022.

3. Qurishee, M. A., Wu, W., Atolagbe, B., Owino, J., Fomunung, I., & Onyango, M. A. (2021). Deep Learning and UAV Based Solution to Real Time Pavement Condition Assessment (No. TRBAM-21-00056), Transportation Research Board Annual Meeting 2021.

The Center for Career and Leadership Development provides free resources to assist students in finding employment opportunities in line with their qualifications. Its mission is to provide students with tools to be successful in their job search and to be prepared with the right documents for an interview. For more information visit https://www.utc.edu/enrollment-management-and-student-affairs/center-for-career-and-leadership-development.).

3.4. Enrichment Opportunities

To provide adequate enrichment opportunities, the MS Engineering program hosts a variety of seminars conducted by local professional speakers from the TennesseeValley Authority (TVA), Volkswagen (VW), Coca Cola, etc. These seminars, offered free and situated

conveniently in UTC auditoriums, create an environment that facilitates student engagement with local industries and enriches students' education. It also provides opportunities for students to learn multi/inter-disciplinary approaches to problem-solving in various industries.

In support of our teaching, research and service missions, the College continues the Speaker Series. The presentations in the Speaker Series provide opportunities for sharing both cutting-edge information from noted researchers in various fields as well as experience and timely insights from community leaders.

https://www.utc.edu/engineering-and-computer-science/center-for-student-success/speaker-series

3.5. Diverse Perspectives

The MS Engineering program aims to expose students to various perspectivesand experiences throughout the program. Field trips to TVA, VW, Electric Power Board (EPB), Amazon, Miller Industries, McKee Foods Corp. and others are held regularly to introduce students to various work environments. Guest speakers from these companies and many others are brought in to the classroom by professors every semester to impart practical knowledge and provide opportunities for discussion. Some of the contents cover aspects relating to industrial operations, new technologies, professional development, soft skills, and/or perspectives relating to ethics, economic, environmental and social sustainability vis-à-vis industry practice. Students in the MS Engineering program have diverse demographic backgrounds, providing opportunities for shared perspectives and experiences towards inclusivity as students participate in classroom discussions and group projects.

3.6. Academic Support

The availability of instructional resources has improved with the opening of the new library building in January 2015. The UTC Library is well-equipped to support the program with a broad collection of diverse materials including 600,000 print and eBooks, over 30,000 digital journals available, 150+ indexes and databases, and interlibrary loan service. The program's instructional equipment and facilities within the College of Engineering and Computer Science are adequate and continually upgraded. CECS maintains a budget for regular upgrade of instructional and laboratory equipment. Most of the classrooms have state-of-the-art technology, and a variety of laboratories in the College increase learning and research opportunities for graduate students, such as Control Systems Lab, Circuits Lab, Bioengineering Lab, Environmental Engineering and Soil Mechanics Lab, Integrated Nanotechnology Lab, Fluid Mechanics Lab, Materials Lab, as well as Research Centers (https://www.utc.edu/engineering-and-computer-science/research/research-centers).

Graduate students also have a study room on the second floor, EMCS 241, which provides a quiet study environment. Technical support is provided by technical personnel staffed by the College of Engineering and Computer Science, along with graduate assistants.

Other academic support services, within the College, that are available to graduate students are Advising, Career Development, Event resources, Peer Tutoring, and Clubs and Organizations. Some support services available through UTC include the Disability Resource Center, Counseling Center, and the Writing Center.

Part IV. Faculty

4.1 Engineering Graduate Coordinators

The College of Engineering and Computer Science has 56 tenured and tenure- track faculty and 32 non-tenured faculty members. Of those, 31 faculty members (tenured & tenure-track) are distributed across the three Engineering departments within the MS Engineering program concentrations, as shown in Table 7. They are all qualified to teach graduate level courses and advise graduate students. The expenditures of the faculty are provided in Appendix E.

Table 7. Graduate Engineering Program Faculty

Department	Number of Faculty	Encompassed Graduate Programs
Civil and Chemical Engineering	10	Chemical Engineering
		Civil Engineering
Mechanical Engineering	12	Mechanical Engineering
		Automotive Systems Engineering
Electrical Engineering	9	Electrical Engineering

Each department has a graduate coordinator who is responsible for the graduate concentration in his/her discipline. The main responsibilities of graduate coordinators are to advise graduate students, review all prospective graduate students' applications, recruit graduate students to their concentrations, write and propose curriculum changes, and teach graduate level courses. In addition, one Graduate Director represents the graduate engineering program on the Graduate Council. All graduate coordinators for the College meet at least once per semester to discuss the curriculum, assistantships, recruitment, resources, and other related issues. Table 8 shows the list of graduate coordinators in each Engineering discipline in the College.

Table 8. List of Graduate Engineering Coordinators	
Graduate Program	**Graduate Coordinator**
Chemical Engineering	Dr. Sungwoo Yang
Civil Engineering	Dr. Weidong Wu
Electrical Engineering	Dr. Raga Ahmed
Mechanical Engineering	Dr. Charles Margraves*
Automotive Systems Engineering	Dr. Charles Margraves

*Graduate Director for MS Engineering

All full-time and part-time faculty meet the high credential standards set by the program and SACSCOC guidelines. Short background information for each graduate coordinator in the graduate engineering programs is as follows:

Dr. Sungwoo Yang is an Assistant Professor in the Department of Chemical Engineering and is responsible for the Chemical Engineering graduate concentration. Dr. Yang has a B.S. in Chemical Engineering from Ajou University, South Korea (2006), and a Ph.D. in Material Chemistry from Duke University, Durham, North Carolina (2011). Dr. Yang joined UTC as a faculty member in 2017. His current areas of interest include porous materials for renewable energy applications including solar thermal energy harvesting, water harvesting, and energy-efficient windows. Dr. Yang is the lead faculty advisor of UTC's Solar Decathlon Team that aims to build an energy-efficient building for DOE's annual competition.

Dr. Weidong Wu is an Associate Professor in the Civil and Chemical Engineering department and is responsible for the Civil Engineering graduate concentration. Dr. Wu has a B.S. in Civil Engineering from the Huazhong University of Science and Technology (1998), along with an M.S. and Ph.D. in Civil Engineering from the University of Mississippi (2008). Dr. Wu joined UTC in 2013. His areas of interest include computational mechanics, computational modeling of materials, finite element method, and intelligent infrastructure.

Dr. Raga Ahmed is an Associate Professor in the Electrical Engineering department and is responsible for the Electrical Engineering graduate concentration. She is the graduate coordinator responsible for the graduate student academic advising and other graduate program

administrative asks. She is the faculty advisor for the UTC Chapter of the National Society of Black Engineers. Dr. Ahmed is the recipient of a National Science Foundation (NSF) Research Experiences for Teachers (RET) Grant titled Engineering and Data Analytics in Smart Cities. Dr. Ahmed has a B.S. in Electrical Engineering from the University of Khartoum, Khartoum, Sudan (1988), an MEE in Electrical and Computer Engineering from Rice University, Houston, Texas (1993), and a Ph.D. in Electrical and Computer Engineering from the Georgia Institute of Technology, Atlanta, Georgia (2013). Dr. Ahmed joined UTC in 2013 as a faculty member, but taught as an adjunct from 2009 to 2012. Her areas of interest include motor design optimization through finite element analysis, and motion control. Her past experience includes designing and implementation of menu-driven data manipulation tools.

Dr. Chuck Margraves is an Associate Professor in the Department of Mechanical Engineering: Energy concentration as well as the Automotive Systems Engineering concentration. Dr. Margraves has a B.S. in Engineering from the University of Tennessee, Chattanooga (1996), an MS in Mechanical from Georgia Institute of Technology, Atlanta, Georgia (2003), and a Ph.D. in Mechanical Engineering from the University of Tennessee, Knoxville, Tennessee (2008). Dr. Margraves joined UTC as a faculty member in 2013. His current areas of interest include conventional and alternative energy systems, and engineering education. His past experience includes conducting CFD analysis on the propulsion systems of solid rocket motors, as well as work in nano-fluidics with a focus on bio-applications.

4.2. Faculty Teaching Load

Most graduate level courses, on-campus and online, are taught by full-time graduate faculty in the College. For the MS Engineering program, faculty teaching loads are aligned with the highly individualized nature of graduate instruction. In the case of graduation projects and dissertations, specialized professors are assigned to guide the student on an individual basis. Figure 5 shows the average Student Credit Hour (SCH) per Total Faculty FTE generated by a university faculty member, a college faculty member, and the engineering program faculty member for each fall semester for four years starting in 2016. Table 9 shows the average SCH production per various FTE faculty categories for each fall semester.

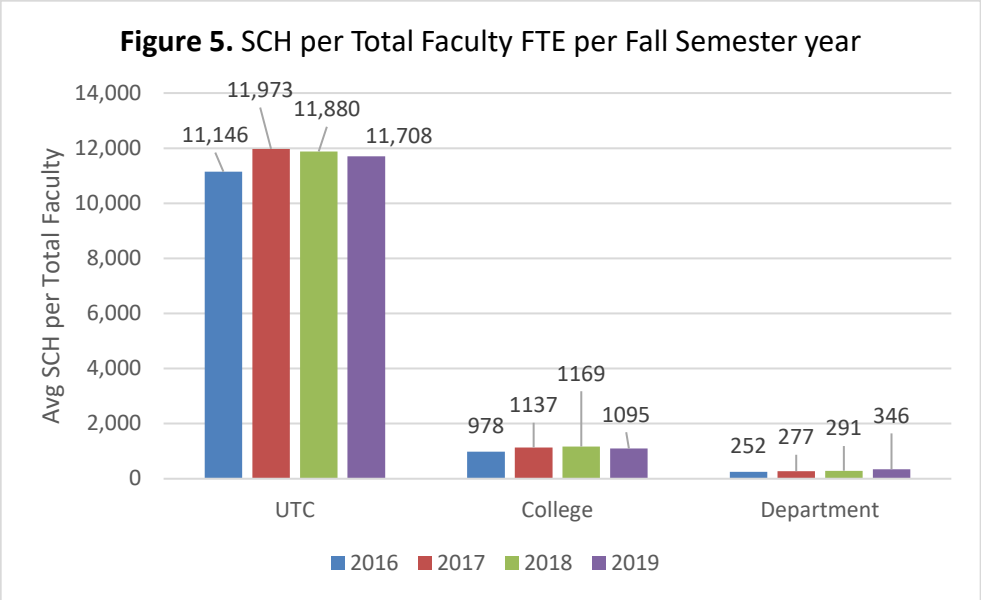

Table 9. SCH/FTE Faculty/Fall Semester/Year				
		UTC	**College**	**Department**
2016	Adjunct	693	84	27
	NTT	1858	202	0
	T/TT	8595	692	225
	Total	**11,146**	**978**	**252**
2017	Adjunct	1412	177	36
	NTT	1697	132	0
	T/TT	8864	828	241
	Total	**11,973**	**1137**	**277**
2018	Adjunct	1286	232	27
	NTT	1472	102	6
	T/TT	9122	835	258
	Total	**11,880**	**1169**	**291**
2019	Adjunct	1224	132	30
	NTT	1637	215	5
	T/TT	8847	748	311
	Total	**11,708**	**1095**	**346**
Key: T: Tenured Faculty / TT: Tenure-Track Faculty / NTT: Non Tenure-Track Faculty				

4.3. Faculty Diversity

Students enrolled in the MS Engineering Program are increasingly diverse. Studies have shown the importance of faculty diversity to enrolling and retaining students from diverse backgrounds. College faculty members have demonstrated a positive impact in shaping campus culture and encouraging students from multiple groups of minorities and genders to enroll and persist through graduation. The diversityof faculty and graduate major enrollment are presented in Appendix F.

4.4. Faculty Professional Development

The MS Engineering faculty strive for continuous professional development, which can advance teaching methods, scholarship and practice. Ongoing, current and past research projects led by faculty members draw external funds such as grants andawards. Annual conferences, workshops, expos, meetings, and a multitude of organizational gatherings are regularly attended by faculty. Examples of professional development include Dr. Ignatius W.

Fomunung's latest refereed and peer-reviewed journals and most recent grant from Texas Department of Transportation of $274,135 (September 2020-September 2022). Dr. Kidambi Sreenivas has several publications in recent years with his latest being accepted for presentation at AIAA SciTech in January 2022. An example Curriculum Vitae of MS Engineering Faculty is shown in Appendix G. Other CVs can be viewed online at http://www.utc.edu/college-engineering-computer-science/profiles/

4.5. Improvement Processes

The faculty actively engages in regular planning, evaluation, and improvement activities that measure and advance student success. To enrich and improve the curriculum, which is maintained at the department level, faculty members may propose changes including curriculum, program goals, and an overall assessment process based on feedback from students and input during departmental meetings. The department reviews the proposal and, if approved, submits it to the graduate coordinator committee.The committee then reviews and approves the proposed changes. Once approved, the university implements the changes in the following academic year. For example, prior to Fall 2021, a GRE score was not required for applicants to the MS Engineering Program. Faculty members proposed adding this requirement for applicants who do not have a baccalaureate degree in Engineering from a regionally ABET accredited college to aid the department in the evaluation of individuals for admission. The proposal was submitted in Fall 2020 and went through the approval process with final approval in Spring 2021. The change took effect as of Fall 2021.

4.6. Faculty Evaluation

The program uses an appropriate process to incorporate the faculty evaluation system explained in detail in Chapter 3 of the Faculty Handbook (http://www.utc.edu/faculty-senate/handbook.php). Generally, supervisors rank their faculty based on overall performance. The annual Evaluation and Development by Objectives (EDO) process is the main tool used to assess faculty at UTC. The processmeasures quality of teaching, research, and service. The annual EDO evaluation consists of objectives, reports and evaluation. The department head's EDO sample format can be found at https://www.utc.edu/sites/default/files/2020-06/department-head-evaluation.pdf.

Please refer to Section 3.2 in this report for Course Learning Evaluation, as they are another assessment used for evaluation. The Course Learning Evaluation process provides feedback to help each individual instructor improve the quality of instruction. The process also helps UTC make decisions about courses and faculty. The Course Learning Evaluations are opened to students three weeks prior to the last day of regular classes. Shortly after final semester grades are turned in, results of the Course Learning Evaluations are made available to faculty. Each department head also is given access to Course Learning Evaluation results for all faculty in his or her department. This link provides information on how faculty can access evaluations and demonstrates what they can view.

Part V. Learning Resources

5.1 Equipment and Facilities Evaluation

The College of Engineering and Computer Science regularly evaluates its facilities and equipment and makes improvements where necessary. For example, the College is committed to creating an environment that places personal safety and health of the students and faculty first by regularly evaluating laboratories. The College's safety manual describes policies and procedures that govern access to labs, including handling of hazardous materials, inspection, and inventory control. Anyone accessing the labs to use equipment or handle materials within the college must receive the needed training and follow accepted procedures and adhere to the published policies, which are easily accessible by students and faculty. See Appendix H, Laboratory Equipment Training and Management Policy for procedures on equipment training, maintenance, and replacement. The Laboratory Safety Manual can be viewed at https://www.utc.edu/sites/default/files/2021-10/laboratorysafetymanual-v16-Fall-21-10-5-21.pdf.

Below are examples of major equipment in various CECS and UTC labs/facilities that are available to support the program.

1. Major equipment in the Chemical Engineering Bioengineering lab:
    - Laminar flow biosafety cabinet
    - Temperature-adjustable incubator shaker
    - Automated 5.0 L bioreactor system
    - UV-Vis spectrophotometer
    - Biacore SPR system (BC X100)
    - AKTA Start Chromatographic System

2. Major equipment in the Chemical Engineering Integrated Nanobiomaterials lab:
    - Digital electrophoretic imaging system
    - Zeta potential analyzer
    - Nanodrop spectroscopy
    - FTIR spectroscopy
    - RO water system
    - Fume hood

3. Major equipment in the Chemical Engineering Renewable Solar Energy Harvesting lab:
    - Critical Point Dryer (CPD): A CPD uses CO_2 liquid as medium to generate the continuity of state for which there is no apparent difference between the liquid and gas state of a medium. As a result, the surface tension between this interface reducing to zero.
    - GloveBox: A glovebox with inert-gas allows researchers to handle oxygen-sensitive chemicals.
    - Digital Convention Oven: The temperature of a digital convention oven can be precisely controlled to keep regulated reaction environment for chemicals.
    - Chemical vapor deposition (CVD): In CVD, the substrate is exposed to one or more volatile precursors, which react and/or decompose on the substrate surface to produce the desired deposit.
    - Hydrothermal autoclave reactor: A hydrothermal autoclave reactor is used for hydrothermal reactions at high pressure and high temperature.
    - UV-vis NIR spectrometer: UV/VIS/NIR spectroscopy is an analytical technique for determining the optical properties (transmittance, reflectance and absorbance) of liquids and solids.

- Fourier-transform infrared spectroscopy (FTIR): A FTIR is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas.
- Dynamic Vapor Sorption (DVS): A DVS is a gravimetric sorption technique that measures how quickly and how much of a solvent is absorbed by a sample.
- Gas Sorption (LX2, Quantachrome): A LX2 gas sorption system can measure the surface area and pore size distribution of porous materials, such as aerogel, zeolite, and metal organic framework.
- Raman spectroscopy: A Raman spectroscopy is a spectroscopic technique typically used to determine vibrational modes of molecules, although rotational and other low-frequency modes of systems may also be observed.

4. The Chemical Engineering Unit Operations lab houses various unit operations such as pilot-scale absorption and distillation columns, heat exchanger, and a serialized continuous stirred tank system as process stations for pilot operations such as absorption, distillation, heat transfer, fluid flow, and reaction kinetics.

5. Major equipment in the Civil Engineering labs
   - Environmental Engineering and Soil Mechanics Laboratory: This laboratory contains 3 Humboldt Lab Ovens, a Humboldt Flexpan and Loader, a Tinius Olsen Impact tester, an Instron 8502 tester, four sets of standard and modified Proctor hammers and molds, a falling head permeability apparatus, a dual-mast dynamic core penetrometer, soil and fine aggregate sieve shaker, coarse aggregate sieve shaker, consolidation test frames with weights, Cassagrande cups for Atterberg limits, a direct shear apparatus, and a soil sample extractor, Dekaport

sample splitter, HACH filter funnel with vacuum for water solids analysis, HACH (2100Q01) turbidity meter, and HACH (CDC40101) conductivity meter.

- Asphalt Laboratory: This laboratory contains a load frame for Marshall stability and flow, a hot water bath, a Marshall hammer cabinet, a SuperPave Gyratory compactor, an asphalt extraction vacuum apparatus, an ignition oven, an aggregate drying oven, an asphalt mixer, an asphalt sample extractor, capping equipment for sulfur capping concrete specimens, sand equivalency test equipment, pulse velocity equipment, and a surface resistivity meter.
- Biomechanics Laboratory: This laboratory contains a Tinius Olsen Load Testing Machine, LECO Hardness Tester, an Olympus Stereo Microscope, and a Fisher Hamilton fume hood.
- Advanced Engineering Materials Laboratory: This laboratory contains two compression machines, an LA Abrasion Machine, a curing tank, slump cones air meters, sample preparation equipment, steel beam molds, a small sample lapidary saw, and three mixers.
- Mechanics of Materials Laboratory: This laboratory contains two Instron 5566 testers, an Ametek torsion tester, a TecQuipment torsion tester, and a Tinius Olsen beam strength and deflection tester as well as multiple PC's.
- Long Term Durability Research Laboratory: This laboratory contains a stereo zoom microscope, a polarizing light microscope, a Taber abrasion wheel, one set of rapid chloride permeability testing (RCPT) equipment, a half-cell corrosion potential test apparatus, a trip-stimulus colorimeter, a chloride titration kit, a pull-off tester (tensile bond strength), and an infiltration ring (ASTM C1702 pervious concrete infiltration rate).

- SMITS LAB: Smart Simulation, Analytics, and Modeling in Intelligent Transportation Systems (SIMITS) lab. The research lab contains driving simulator with three degrees of freedom motion base motion base that enables heave, roll, and pitch movements while driving for an immersive experience in the virtual reality environment.
- Intelligent transportation system and connected autonomous vehicles (CAV): Driving simulator; A Head Mount Display for VR research; A 1/10th scale car for automation research; An automation enabler for full-scale cars; and 10,000 sq. ft. advanced vehicle test facility and a one-mile vehicle test track for Intelligent Transportation System and CAV related research. Moreover, the department devotes to intelligent infrastructure research equipped with unmanned aerial vehicle, thermal camera, shake table, 3D printer and other essential facilities.

6. Major equipment in the Mechanical Engineering labs:
   - Fluid Mechanics Laboratory: This lab contains a three Transition Flow TQH215, AC duct heat pipe, Armfield Water Tunnel, a LabVIEW Closed Flow Loop, a Reynolds Number and Transitional Flow Demonstration Apparatus and a supersonic tunnel.
   - Engineering Shop: The shop contains a Trump CNC mill, a Colchester manual lathe, a Clausing milling machine, a sheet metal shear and bender, two drill presses, a Kiln, a table saw, a Haas CNC mill and CNC lathe, and a ShopBot CNC cutter as well as many power tools, hand tools, and benches.
   - Automotive lab: This lab contains a Grizzly Mill and Lathe, two Fisher Hamilton fume hoods, and two welders.

7. The SimCenter computing facility includes state-of-the-art computer servers and storage infrastructure to support computational aspects of the program. SimCenter major equipment includes:

Computational Clusters

- **tennessine** – 924 CPU core/59,136 GPU core (33 node) diskless cluster (Dell)
    - Two 14-core Intel Xeon E5-2680 v4 processors
    - 128 GB RAM per node
    - EDR InfiniBand (100 Gb/s) interconnect
    - 1 Nvidia P100 GPU (16 GB) with 1792 double precision cores
    - 400 GB SSD per node (pending installation)
- **papertape** – 640 core (40 node) diskless cluster (Dell)
    - Two Eight-core Intel Xeon E5-2670 processors
    - 32 GB RAM per node
    - FDR InfiniBand interconnect (2:1 blocking)
- **qbert** – 192 core (12 node) cluster (Dell)
    - Two eight-core Intel Xeon E5-2650v2 processors
    - 32 GB RAM per node
    - 10 Gigabit Ethernet interconnect
    - 216 TB reconfigurable 10 Gigabit iSCSI storage
    - Head node has 256 GB RAM, an NVIDIA K20 and Xeon Phi 5110P co-processors
    - Currently configurable for data analytics type (hadoop) applications
- **bluetick** – 32 core compute server (IBM)
    - Four eight-core IBM POWER7 3.55GHz processors

    - 256 GB RAM
- **blueprint** – 32 core compute server (IBM)
    - Four eight-core IBM POWER7 3.55GHz processors
    - 128 GB RAM
- **cerberus** – 32 core compute server (Dell)
    - Four eight-core Intel Xeon X7560 2.27 GHz processors
    - 256 GB RAM
- **Lookout** – 160 core/640 thread (4 node) Power9 IBM cluster
    - Dual Power9 20 core/80 thread CPUs
    - 4 Nvidia Volta GPUs
    - 256 GB RAM
    - InfiniBand EDR interconnect

Infrastructure

- 10 GbE network backbone
- Force10 E1200 director class switch for server room 1-10 GbE infrastructure
- Dell R730 VMWARE cluster which runs all system critical services
    - Three node cluster
    - Highly redundant hardware
    - Important services configured ‘highly available’ so they never crash
    - Dynamic load balancing

Data Storage

- Highly scalable DDN 14KX GPFS storage system
    - 113 TB (10K SAS) of high speed, tier 1 storage

    - 1 PB of high capacity, lower tier storage
    - Connects to the HPC infrastructure at EDR InfiniBand speeds (100 Gb/s)
    - Scalable up to over 1700 hard drives and 60 GB/s bandwidth
    - Available (via NFS) to all desktops in the SimCenter
- Expandable Dell PowerVault LTO7 tape backup system
    - LTO7 tape media can store between 6 and 15 TB (based on compression). Can backup/archive between 240 and 600 TB of data without expansion

Additional facilities and equipment supporting the MS Engineering program are included in Appendix I.

5.2 Learning and Information Resources

Students and faculty have access to information resources to support teaching and learning primarily through the UTC library. Additionally, theWalker Center for Teaching and Learning supports faculty by offering development sessions and other teaching resources. Section 5.3 provides more information on the Walker Center for Teaching and Learning, and the following subsections provide information on the new UTC Library.

A. UTC Library General Information

The mission of the UTC Library is to support the teaching and research of faculty and students of the University of Tennessee at Chattanooga through the development of collections and services to promote and enhance the university's curriculum and research endeavors. The UTC Library offers a comprehensive suite of materials, services, and programming to help the UTC community succeed. Students, faculty, and staff benefit from a number of critical resources, including:

- Books, journals, databases, and audio-visual materials available online and physical formats

- Technology, a vast array of equipment and support tools for use in the library and remotely
- Research, writing, communication, media production, and archival support
- Digital and physical spaces to pursue scholarship and research activities

The UTC Library employs 26 Librarians and 14 full-time staff members to support the students, staff, faculty, alumni, and campus community as evidenced by the following snapshot of yearly activity:

UTC Library Materials, Expenditures & Services	FY 2021
Physical Books	328,907
E-books	446,812
Audio-Visual Materials	265,738
Journals	103,559
Digital databases	275
Total Holdings	**1,145,291**
One-Time Library Materials Expenditures	$453,870
Ongoing Library Materials Expenditures	$1,219,371
Collection Support Expenditures	$198,252
Total Material Expenditures	**$1,871,493**
Information Services to Individuals	8,023
Total Presentations to Groups	689
Total Participants in Group Presentations	9,977
Room Rentals for Private Study, Group Meetings & Media Production	**7,508**
Employment Hours Staffed by UTC Students	**11,435**
Visits to the UTC Library Website	403,814
Visits to the UTC Library (Physical Building)	137,474
Total Library Visits	**541,288**

More information about the UTC Library can be found online at utc.edu/library and in Appendix J which includes a list of strategic campus partnerships and services.

B. Library Collections

Databases, Serials, and Ongoing Expenditures

As of June 30, 2021, the Library makes available **103,559** journal titles, including open access titles, through subscriptions to full-text resources, databases, journal packages, and individual journals. In support of the Engineering programs within the College of Engineering and Computer Science (CECS), the library makes available **5,520** related print and electronic journals and **503** electronic conference proceedings.

Engineering students and faculty have access to several large, multidisciplinary full-text journal packages and databases to support their scholarship. For CECS, the Library spent **$218,020** in FY2021 for ongoing serial and subscription resource purchases. In total, the library spent **$1,219,371** on all ongoing serial and database subscriptions in FY2021. In total, the UTC community used these electronic resources **398,239** times in FY2021.

FY2021	**Engineering**	**UTC Library Total (including multidisciplinary)**
# of Journals – Print + Digital	5,520	103,559
$ Spent on ongoing serial and database subscriptions	$218,020 (includes all college-level purchases for CECS)	$1,219,371

Publishers

The majority of journal content is current and online via journal packages from publishers including:

- ACM Digital Library,
- EBSCOhost,
- Emerald,
- Highwire Press,
- Institute of Physics,
- Oxford University Press,
- Cambridge University Press,
- Elsevier ScienceDirect,
- Gale Group,
- IEEE Xplore,
- JSTOR,
- Portico,

- ProQuest,
- SIAM Society for Industrial and Applied Mathematics,
- Taylor and Francis Online, and
- SAGE,
- Springer Link,
- Wiley Online Library

Journal Titles

The majority of journals are available online and can be accessed through the UTC Library Journals Search feature. A selected list of electronic journals supporting Engineering students and faculty is available by clicking here.

Databases

The UTC Library database subscriptions include the following that support Engineering:

- ABI/Inform
- Building Green
- Business Source Premier
- Elsevier ScienceDirect e-journals
- IEEE Electronic Library *(journals, conference proceedings and standards)*
- LEED User
- ProQuest SciTech Premium Collection *(contains numerous subset abstracting and databases relevant to engineering)*
- SciFinder,
- Springer ebooks, journals, and protocols,
- Web of Science

Monographs, Audio-Visuals, and One-Time Expenditures

As of June 30, 2021, the Library's collection consisted of **328,907** print monographs and **446,812** electronic books for a total of **775,719** titles. Of those, **71,594** bear the call numbers (HE; Q; QB; QC; QD; QE; T; TA; TC; TD; TE; TF; TG; TH; TJ; TK; TL; TN; TP; TS; U; UC; UF; UG; V; VC; VF; VK; VM) which are specifically related the study of Engineering.

The library holds a collection of **19,614** physical audio/visual materials and **246,124** online streaming AV materials for a total of **265,738**. Of those, **519** titles are specifically related to

Engineering.

Each year, a portion of the Library's materials budget is allocated to purchase books, audio-visual materials, and other one-time resources. The FY2021 Library allocation for one-time expenditures for the College of Engineering and Computer Science was **$68,860** from a total amount of **$453,870** spent supporting all academic departments.

FY2021	**Engineering**	**UTC Library Total**
# of Monographs – Print + Digital	71,594	775,719
$ Spent on one-time purchases	$68,860 (includes all college-level purchases for CECS)	$453,870

C. Library Services

Interlibrary Loan and Course Reserves

The Library offers interlibrary loan (ILL) and Document Delivery services at no cost to students and faculty who need materials that are not owned or accessible through the UTC Library. Patrons can submit and track progress of requests, receive email notification when materials arrive, and obtain articles electronically through the ILL management system, ILLiad. In FY2021, **2,171** ILL borrowing and document delivery requests were filled for the UTC community; of those, **47** were filled for Engineering faculty and students.

Circulation of Physical Materials

The library has generous circulation policies and allows semester-long borrowing of monographs for students and year-long borrowing for faculty members. In FY2021, physical monographs and audio-visual materials circulated **4,594** times; at least **793** of these were Engineering materials. The library also circulates laptop computers, other tech equipment (cameras, calculators, digital recorders, external hard drives, etc.), and group study rooms to patrons. In FY2021, these resources circulated **9,191** times.

Research and Instructional Services

The Library boasts a busy, well-respected, and growing instruction program that combines traditional information literacy and research skills instruction sessions with skills-based workshops on topics ranging from preparing powerful presentations to improving skills with Microsoft Office, Adobe, and statistical software. Course-specific instruction sessions are tailored specifically to the curriculum and include information literacy and research skills tied to assignment objectives. The Library's Research and Instruction department develops and teaches both general and course-specific instructional sessions tailored to specific research needs or library resources. Partnering with UTC Faculty, the Instruction Team teaches students the necessary skills to be effective 21st Century researchers.

In FY2021, Instruction Librarians taught **431** (in-person + online) instruction sessions and workshops that reached **7,327** participants across all academic disciplines. **Sixteen** of these presentations were delivered for Engineering classes, reaching **248** Engineering students.

Focus of Engineering Presentations	Engineering Presentations Offered	# of Participants in the Presentation
General	7	95
Chemical	3	66
Civil	1	28
Electrical	3	34
Management and Technology	2	25
Total	**16**	**248**

Instruction Librarians also dedicate time to providing one-on-one individualized attention to students, faculty, and staff seeking research assistance in a particular area. In FY2021, Instruction Librarians participated in **311** individual research consultations.

Studio

The UTC Library Studio provides a creative space for the campus community to learn innovative technology and media creation. This well-used space provides access (in-person and from remote locations) to 24 workstations with specialized software including the Adobe Creative Suite, the AutoDesk Suite, Camtasia, and other digital design programs. In addition, the Studio circulates cameras and other high-end production equipment as well as reservable spaces for students to use as they complete media projects. In FY2021, these resources circulated **3,707** times.

The Studio is staffed by expert Librarians and Staff who provide one-on-one consultations, small group and course-specific instruction, curriculum development, as well as a fully-staffed service point to answer point-of-need questions. In FY2021, the Studio offered **118** individual consultations and taught **165** classes (in-person + online) that reached **1,692** students across campus.

Writing and Communication Center

The Writing & Communication Center (WCC) supports writers of all backgrounds and proficiency levels with any kind of writing or communication project at any stage in the process. Peer consultants help writers brainstorm, organize ideas, develop or revise arguments, practice speeches, learn citation styles, become better self-editors, and more. In addition to in-person and online consultations, the WCC also offers workshops, a library of writers' resources, and a supportive environment for working independently.

In FY2021, the WCC conducted **15** individual consultations with Engineering students related to a course for their major. The WCC also taught **93** classes (in-person + online) reaching **1,692** students across campus.

Information Commons

The Information Commons provides students, faculty, staff, and community users with the tools and services needed to complete assignments and research. The Information Commons was staffed 81 hours each week and fielded **1,238** research questions by chat, and SMS text in FY2021.

Within the Information Commons patrons can get individualized research help at the Information Desk, complete research and assignments by utilizing one of 142 Windows and 36 Macintosh computers (in-person and from remote locations) loaded with a variety of software programs supporting all university disciplines, scan important documents, or simply print out an assignment. Comfortable open seating also makes the Information Commons a popular spot to complete work within the Library.

Special Collections and University Archives

The Special Collections unit of the Library at the University of Tennessee at Chattanooga is the repository for university's collections of manuscripts, university records and publications, rare books and maps, theses and dissertations, and other archival material. The digital repository holds **92,059** artifacts and was accessed **755,864** times in FY2021 to support a wide range of researchers including undergraduate and graduate students, faculty, members of the community, and other scholars whose work relies on primary source materials.

Departmental Liaisons

A Library Liaison program is in place where a librarian is assigned to each academic department to enhance communication and offer custom support. Librarians are matched with departments based on educational background, work experience, and subject expertise.
The liaison for Engineering disciplines is Bo Baker who works with Engineering faculty and volunteered for the College's FY2021 Technology Symposium and Backpack to Briefcase events.

5.3 Library Technology and Spaces

Classrooms, Meeting Spaces, and Instructional/Learning Technologies

The UTC Library is a state-of-the-art facility that provides students, faculty, and staff with access to private and group study rooms, practice presentation rooms, conference meeting rooms, a theater classroom, and computer classrooms.

As well, the library offers the necessary technology to support the teaching, learning, and research needs of faculty and students.

- Conference rooms are set up for hosting and attending online events; these rooms are equipped with overhead projection, podiums with Windows computers, HDMI cables for use with laptops, and white boards.
- Study rooms contain LCD monitors (HDMI and other cables are available to borrow) and whiteboards to aid in group assignments and quiet study.
- Computer classrooms contain desktop or laptop computers, presentation podiums, and built-in speakers.

Students, faculty, and staff can borrow Windows laptops, Chromebooks, high-end A/V equipment, scientific calculators, and a variety of cables, chargers, and other accessories. Multifunctional machines, which offer printing, copying, and scanning, are available throughout the library.

Additionally, the library in coordination with the Disability Resource Center, offers a dedicated space for adaptive technology with the following specialized resources:

- Dragon NaturallySpeaking
- Echo Desktop
- Optelec (CCTV) printed material magnifier
- JAWS speech synthesizer

- Kurzweil 1000/3000
- ZoomText screen magnification program
- ZoomText keyboard

All computers in the library (including circulating laptops) are loaded with a variety of software programs needed by students across the University to support their research endeavors.

Part VI. Support

6.1. Operating Budget

The MS Engineering program's internal and external support are consistent withthe budget needs of the program. Table 10 shows the internal awards/grants received by the faculty in the department. Appendix E shows the operating budget for the College.

Table 10. Internal (UC Foundation) Support

10.1 Internal (UC Foundation) Support			
NAME OF AWARD/GRANT	DEPT. AWARDS	TOTAL AWARDS	DEPT. AWARDS AS % OF TOTAL AWARDS
SEARCH (previously Provost Student Research Award (joint faculty/student grants))[1] (AY16-17 through AY20-21)	15	125	12.00%
Faculty Development and Research Grants [1] (FY16-17 through FY20-21)	28	388	7.22%
Faculty Sabbaticals and Study Leaves[1] (AY16-17 through AY20-21)	1	42	2.38%
Faculty Summer Fellowships[2] (Sum16)	0	9	0.00%
HIP (High Impact Practice) (formerly QEP Grant Awards) (AY16-17 through AY20-21)	5	103	4.85%
QEP Faculty Awards (AY16-17 through AY20-21)	1	5	20.00%

[1]Unable to break apart undergraduate from graduate

[2] 2016 was last year for Faculty Summer Fellowships

AY - Academic Year (August through May)

FY - Fiscal Year (July through June)

6.2 Enrollment and Effectiveness

Enrollment and graduation rates are key components of accountability at UTC. A high-quality experience has been integrated throughout the graduate program in order to maintain high enrollment rates. The program has been progressively self-sustaining over the years and even more so after the introduction of the online offerings. Faculty builds strong relationships with students through smaller classes and one-on-one meetings, and serves as primary mentors of students. The faculty also encourages local industries to hire MS program students, enabling the maintenance of a high student enrollment and retention rates. Please see Section 3.1 for recruitment details and enrollment numbers.

6.3 Program Responsiveness

The MS Engineering program is responsive to changing local, state, regional and national needs. As mentioned in Section 2.1, the curriculum contents are reviewed regularly, partly to respond to changing regional needs. With growing interests in the areas of renewable energy, sustainable infrastructure, data analytics, artificial intelligence, smart transportation, environmental sustainability, biomedical devices, etc., in the region, state, and nationally, the college has the capacity to grow its MS program offerings in response to these needs by providing the relevant training through new programs and/or modification to existing programs to support workforce demands in these areas.

The strategic plan for the College of Engineering and Computer Science can be seen at https://www.utc.edu/sites/default/files/2020-09/cecs-strategic-plan-approved-09082016.pdf.

6.4 Graduate Student Data Collection and Placement Evaluation

Graduate students are connected to the College's LinkedIn page (https://www.linkedin.com/groups/6715787) upon graduation. The LinkedIn page helps the College stay connected with alumni and where they currently work. Since 2015, theCollege

has also completed an Annual Review, which is distributed to all alumni in addition to the local and regional businesses. The latest review can be found at http://www.utc.edu/college-engineering-computer-science/about-us/annual-review.php.

See Appendix K, Employment and Placement for additional information from University, College, and Department/Program graduates.

6.5 Procedure Review

The MS Engineering program's procedures are regularly reviewed to ensure alignment to institutional policies and mission. This is done every year to comply with and maintain the standards contained in the guidelines of the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC), the recognized regional accrediting body in the eleven U.S. southern states, as well as other institutions such as THEC, UT System, and BOT.

Appendix A. Rubric

College of Engineering and Computer Science
University of Tennessee at Chattanooga

Course:_____ Course Title:_____

Instructor:_____

Learning Outcome Assessed:

Effective Technical Writing Skills - The student will be able to write an effective thesis or project

Measure: _____

Rubric:

Criteria / Evaluation	Needs Significant	Needs Improvement	Satisfactory	Very Good	Excellent
Individual Score	<=6	7	8	9	10
1. **Problem Definition:** Stated the research problem clearly, providing motivation for undertaking the research.					
2. **Literature and Previous Work:** Demonstrated sound knowledge of literature in the area, and of prior work on the specific research problem.					
3. **Impact of Proposed Research:** Demonstrated the potential value of solution to the research problem in advancing knowledge within the area of study.					
4. **Solution Plan:** Provided a sound plan for applying state-of-the-field research methodologies/tools to solving the defined problem and shows a good understanding of how to use methods/tools effectively.					
5. **Results:** Analyzed and interpreted research results effectively.					
6. **Quality of Written Communication:** Communicated contents of thesis/dissertation clearly and professionally in written form					
7. **Critical Thinking:** Demonstrated capability for independent research in the area of study, preparedness in core competencies relevant to the research, and ability to complete the research.					
8. **Broader Impact:** Demonstrated awareness of broader implications of the research. Broader implications may include aspects associated with economics, technical, ethics, business, etc.					
9. **References and Citations:** Properly and explicitly cited. Reference list matches citations					
10. **Publications:** Journal or conference publications have resulted, or are anticipated, from this research.					
Total					

Overall Assessment:

The assessment of the overall performance of the student based on the evidence provided in theabove items.

Overall Performance Rating				
QUALITY of Thesis UNACCEPTABLE	**QUALITY of Thesis ACCEPTABLE**			
Needs Significant Improvement	**Needs Improvement**	**Satisfactory**	**Very Good**	**Excellent**

Target:

Based on the performance on selected Measure a target of **(Very Good)** has been agreed upon by theCurriculum Committee.

Instructor Signature

_____

If applicable, please provide additional comments below or on the backside of this page.

Appendix B. Undergraduate Syllabi Examples

THE UNIVERSITY OF TENNESSEE CHATTANOOGA
College of Engineering and Computer Science

Thermodynamics

Fall 2021
ENME 3030, CRN 41374, 3 Credit Hours

Instructor: Dr. Reetesh Ranjan

Email and Phone Number: reetesh-ranjan@utc.edu, 423-425-4017

Office Hours and Location: T 2:30 PM – 3:30 PM, EMCS 417B. You can also request to meet me at an alternate time by contacting me through email.

Course Meeting Days, Times, and Location: TR, 8:00 AM – 9:15 PM, EMCS 401.

Course Catalog Description: Classical thermodynamics with emphasis on first and second laws of thermodynamics. Property relationships, chemical equilibrium, and cycle analysis. Fall semester and summer. Lecture 3 hours. Prerequisites: May be registered as ENCH 3030. No credit in both ENME 3030 and ENCH 3030.

Course Pre/Co Requisites: ENCE 1040 with a minimum grade of C and MATH 1920 or MATH 1960 or department head approval.

Course Student Learning Outcomes: At the completion of the course, students will have demonstrated the ability to

- Use both the English and SI systems of units, including conversions between them.
- Perform first and second law analysis.
- Calculate work and power absorbed or generated by thermodynamic systems.
- Understand and determine phase-change processes and diagrams.
- Determine properties using lookup tables.
- Perform constant specific heat analysis and prove reversibility.
- Analyze gas power cycles.
- Calculate heat losses/gains.

This course supports the following ABET student outcomes:

- (1) An ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science, and mathematics.

Required Course Materials: "Thermodynamics An Engineering Approach", 9th Edition, by Cengel & Boles, McGraw Hill Publishing, ISBN # (1259822672)

Technology Requirements for Course: A Canvas course web site is used to disseminate course materials: schedule, announcements, homework assignments, class lectures, corrections/revisions to this syllabus. http://www.utc.edu/learn (use UTC id and password).

Technology Skills Required for Course: Students must be able to use a scientific calculator.

Technology Support: If you have problems with your UTC email account or with UTC Learn (Canvas), contact IT Help Desk at 423-425-4000 or email helpdesk@utc.edu.

Course Assessments and Requirements: Assessment will be based on performance in exams, quizzes and homework using the current ABET student-learning outcome 1.

Course Grading: Your final grade will be weighted as follows

Exams (3)	70%
Quizzes (3)	30%
Homework	0%

The final letter grades will be based on the statistics, such as mean, median, and standard deviation of the score of the class. However, you can consider the following range as a guideline for the final letter grades

A 90 – 100
B 80 – 89
C 70 – 79
D 60 – 69
F 0 – 59

Instructor Grading and Feedback Response Time: Quizzes and exams will be graded and returned within 1 week of being submitted. Final exams will not be returned. Homework problems will not be graded, but they will complement the content of the lecture for quizzes and exams. Solution to selected homework problems will be posted for you to verify your solution to selected problems as well as to provide you a guidance on expected approach for solution to the problems. I will attempt to answer all emails within 24 hours.

Course and Institutional Policies

Late/Missing Work Policy: Make up quizzes and exams will be given only with prior approval.

Student Conduct Policy: UTC's Academic Integrity Policy is stated in the Student Handbook (https://www.utc.edu/dean-students/student-handbook.php).

Honor Code Pledge: I pledge that I will neither give nor receive unauthorized aid on any test or assignment. I understand that plagiarism constitutes a serious instance of unauthorized aid. I further

pledge that I exert every effort to ensure that the Honor Code is upheld by others and that I will actively support the establishment and continuance of a campus-wide climate of honor and integrity.

Course Attendance Policy: Attendance is expected. If you know you will miss a class, please send me an email before the class if possible.

Course Learning Evaluation: Course evaluations are an important part of our efforts to continuously improve learning experiences at UTC. Toward the end of the semester, you will be emailed links to course evaluations and you are expected to complete them. We value your feedback and appreciate you taking time to complete the anonymous evaluations.

UTC Bookstore: The UTC Bookstore will price match Amazon and BN.com prices of the exact textbook - same edition, ISBN, new to new format, used to used format, and used rental to used rental format, with the same rental term. For more information, go to the Bookstore Price Match Program webpage, visit the bookstore, email sm430@bncollege.com or call 423-425-2184.

Course Calendar/Schedule: Posted online on Canvas.

CECS peer to peer tutoring: It can be accessed from UTC.EDU/CECSTUTOR

COVID-19 Absences:

Students **must complete the** COVID-19 Notification form if they are positive for COVID-19; symptomatic for COVID-19; exposed (close contact) to a known case of COVID-19 / someone positive for COVID-19; or potentially exposed to a known case of COVID-19 / someone positive for COVID-19. Documentation will be provided to me by the Office of Student Outreach & Support.

If you are instructed by university administration to stay home due to your responses, you are not to come to campus or attend face to face classes. If you are cleared to be on campus and attend class you are required to attend face-to-face class sessions.

You will not be penalized for COVID-19 related absences or late course assessments due to a COVID-19 related concern unless you are unable to complete course learning outcomes. I will work reasonably with you to identify ways to complete course requirements.

You must, if you are asymptomatic or if your symptoms do not interfere with your ability to participate in the course, **continue to participate in the course using the online assets and tools that I may make available through UTCLearn including**: course related information, lecture notes, and homework problems.

If COVID-19 related illness results in any missed course work (face-to-face or online), **you must contact me within 48 hours of recovering to plan make-up work.** Makeup work must be completed according to the plan devised by me in coordination with you. It remains your responsibility to complete any missed work such as assignments, tests, quizzes, labs, or projects outside of scheduled class time. But please realize that class will continue, and you may find yourself in the situation where you are unable to complete all work by the end of the semester. In such a case, you should consider a late withdrawal or an incomplete grade. Please contact the Records Office (423-425-4416) to learn more about the late withdrawal process.

If you have COVID-19 disability related risk factors that may affect attendance, you are strongly encouraged to register with the Disability Resource Center (423-425-4006) in order to receive necessary accommodations.

If you believe I have not made reasonable and appropriate accommodations for absences, or makeup assignments, projects, labs, or exams due to COVID-19, you have the right to appeal according to UTC's General Student Grievance (Complaint) Procedure by filling out the Student Complaint Form and submitting to the Office of the Dean of Students.

THE UNIVERSITY OF TENNESSEE CHATTANOOGA
College of Engineering and Computer Science

Protective Relaying

Fall 2021
ENEE, 4620, 40915, Blended/Hybrid, 3 credit hours

Instructor: Gary L. Kobet, P.E.

Email and Phone Number: gary-kobet@utc.edu, 423-883-4769

Office Hours and Location: I work full-time for TVA but have a temporary office at EMCS 338, planned office hours 3:30pm-4:45pm Tuesday and Thursday.

Course Meeting Days, Times, and Location: Tuesday-Thursday, 5:15pm-6:30pm, EMCS 202

Course Catalog Description: Protection fundamentals. Generator protection, transformer, reactor and shunt capacitor protection bus, motor, line protection and pilot protection. On demand. Lecture 3 hours.

Course Pre/Co Requisites: ENEE 4720 (Power System Analysis and Design) or equivalent with minimum grade of C or department head approval.

Course Student Learning Outcomes: Demonstrate an understanding of power system protection through correct solution methods of homework problems and exam problems.

Required Course Materials: J. Lewis Blackburn and Thomas A. Domin, Protective Relaying Principles & Applications, 4th edition, CRC, Inc., 2014. PowerPoint slides based on the course textbook will be made available on the UTC Learn course website.

Technology Requirements for Course: You need access to a computer with a reliable internet connection to complete this course. Test your computer set up and browser for compatibility with UTC Learn at http://www.utc.edu/learn/getting-help/system-requirements.php. You should also have an updated version of Adobe Acrobat Reader, available free from https://get.adobe.com/reader/.

Technology Skills Required for Course: These include using Microsoft Word and Excel, using the learning management system (UTC Learn), using MOCSNet email, creating and submitting files to UTC Learn, copying and pasting, and downloading and installing software.

Campus Safety Policy: Due to COVID-19, there is a campus safety policy

(https://blog.utc.edu/coronavirus/covid-19-information/policies-and-protocols/covid-policies/) for classes that meet on campus; please review this policy.

COVID-19 Absence Policy: Due to COVID-19, there is an absence policy for Fall 2021.

Students **must complete the** COVID-19 Notification form if they are positive for COVID-19; symptomatic for COVID-19; exposed (close contact) to a known case of COVID-19 / someone positive for COVID-19; or potentially exposed to a known case of COVID-19 / someone positive for COVID-19. Documentation will be provided to the instructor by the Office of Student Outreach & Support.

Students who are instructed by university administration to stay home due to their responses are not to come to campus or attend face-to-face classes. Students who are cleared to be on campus and attend class are required to attend face-to-face class sessions. Students will not be penalized for COVID-19 related absences or late course assessments due to a COVID-19 related concerns unless they are unable to complete course learning outcomes. Faculty will work reasonably with students to identify ways to complete course requirements.

Students must, if they are asymptomatic or if their symptoms do not interfere withtheir ability to participate in the course, continue to participate in the course usingthe online assets and tools that the instructor may make available through UTCLearn including lectures via Zoom and assignments posted to Canvas.

If COVID-19 related illness results in any missed course work (face-to-face or online), **students must contact the instructor within 48 hours of recovering to plan make-up work**. Makeup work must be completed according to the plan devised by the instructor in coordination with the student. It remains the student's responsibility to complete any missed work such as assignments, tests, quizzes, labs, or projects outside of scheduled class time. But please realize that class will continue, and students may find themselves in the situation where they are unable to complete all work by the end of the semester. In such a case, students should consider a late withdrawal or an incomplete grade. Please contact the Records Office (423-425-4416) to learn more about the late withdrawal process.

If students have COVID-19 disability related risk factors that may affect attendance, students are strongly encouraged to register with the Disability Resource Center (423-425-4006) in order to receive necessary accommodations.

If students believe the instructor has not made reasonable and appropriate accommodations for absences, or makeup assignments, projects, labs, or exams due to COVID-19, students have the right to appeal according to UTC's General Student Grievance (Complaint) Procedure by filling out the Student Complaint Form and

submitting to the Office of the Dean of Students.

Technology Support: If you have problems with your UTC email account or with UTC Learn (Canvas), contact IT Help Desk at 423-425-4000 or email helpdesk@utc.edu.

Student Technology: If you have technology needs to access your courses and/or complete course requirements in Canvas, submit a request (https://new.utc.edu/information-technology/learning-from-home) with Information Technology.

Student Accommodations: If you have accessibility and accommodation requests, contact the Disability Resource Center (https://www.utc.edu/disability-resource-center/index.php) at 423-425-4006 or email DRC@utc.edu.

Course Assessments and Requirements: Assessments include weekly homework assignments,a midterm exam, and a final exam. All homework and exam assignments are accepted by uploadto UTC Learn only, as a legible scanned .pdf. No pictures of assignments taken by cell phone, etc. will be accepted or graded.

Course methods include classroom lectures using PowerPoint presentation slides which will be posted to UTC Canvas prior to class. Example problems worked on dry-erase board in the classroom. Homework problems in the textbook to be submitted for grade; solution posted on UTC Canvas after homework submitted. Mid-term and final exam problems to demonstrate understanding of the subject matter. Additional problems not-for-grade posted on UTC Canvasto aid in mastery of the principles presented.

One field trip to a utility substation is planned.

Group study sessions for understanding and solving homework problems are strongly encouraged. I am glad to make myself available as needed during these sessions at a mutually convenient time. However, each student is responsible for his/her own work and turning in the assignment.

Homework Format: Writing on only one side of the page; draw a box around the final answer. Each completed assignment should be clearly presented so that others can follow the solution process. The solution method is just as important to the grade as the final numerical solution. Unreadable work will not be graded or credited.

Course Grading

Course Grading Policy: 90-100% = A; 80-89% = B; 70-79% = C, 60-69% = D; <60% = F. Final grades will be rounded precisely. If you have an 89.4% final average, this is a B. If you have a 69.5%, this is a C.

Homework	50%
Mid-term	25%
Final	25%

Instructor Grading and Feedback Response Time: All assignments and exams are graded by a graduate teaching assistant who will try to grade all assignments within one week ofthe due date and provide written feedback when necessary. I will review grading as needed.

Course and Institutional Policies

Late/Missing Work Policy: Homework assignments submitted after 5pm on the due date will result in an automatic penalty of 10% per day. Homework assignments submitted morethan one week after the due date will not be accepted or graded and result in a grade of zero.

Student Conduct Policy: UTC's Student Code of Conduct and Honor Code (Academic Integrity Policy) can be found on the Student Conduct Policy page (https://www.utc.edu/student-conduct/codes.php).

Honor Code Pledge: As a student of the University of Tennessee at Chattanooga, I pledge that I will not give or receive any unauthorized assistance with academic work or engage in any academic dishonesty in order to gain an academic advantage. I will exert every effort to insure that the Honor Code is upheld by myself and others, affirming my commitment to a campus-wide climate of honesty and integrity

Course Attendance Policy: Due to the COVID-19 pandemic, this course has a rotating face-to-face (F2F) format. The class will be arbitrarily divided into two groups, a Tuesday group and a Thursday group. You will need to attend in-person only one day per week per your assigned group. The other day of the week you will attend via internet (Kaltura or Zoom). If you would like to attend a different day than your initial assignment, please let me know and I will do my best to accommodate. Finally, note that each student is expected to attend and/or view every class lecture and participate, maintaining an environment conducive to learning. This means being respectful to fellow classmates, the instructor, and any visitors who may be present.

Course Participation/Contribution: Class attendance and participation are very important to learning the material and are required. Class discussions will involve novel solution techniques, modeling helps, and problem solving. It is recommended that a full scientific calculator be used during classes to follow along as the instructor works sample problems.

Course Learning Evaluation: Course evaluations are an important part of our efforts to continuously improve learning experiences at UTC. Toward the end of the semester, you will be emailed links to course evaluations and you are expected to complete them. We value your feedback and appreciate you taking time to complete the anonymous evaluations.

UTC Bookstore: The UTC Bookstore will price match Amazon and Barnes and Noble (https://www.barnesandnoble.com/) prices of the exact textbook - same edition, ISBN, new to new format, used to used format, and used rental to used rental format, with the same rental

term. For more information, go to the Bookstore Price Match Program (https://bnc.pgtb.me/MMt77F), visit the bookstore, email sm430@bncollege.com or call 423-425-2184.

Course Zoom link/info:
When: Aug 17, 2021 05:00 PM Eastern Time (US and Canada)
Register in advance for this meeting:
https://tennessee.zoom.us/meeting/register/tJApf-usqTssHtOwV4w0pvtcM2aaXfV_cZH3
After registering, you will receive a confirmation email containing information about joining the meeting.

Course Calendar/Schedule: A tentative class-by-class topical outline is as follows:

Date	Topic	Chapter/Section(s)
8/17/2021	Introductions	Syllabus
8/19/2021	General protection philosophy	1.1-1.13
8/24/2021	Fundamental units: Per-unit & percent	2.1-2.10
8/26/2021	Fundamental units: Per-unit & percent	2.1-2.10
8/31/2021	Phasors & polarity	3.1-3.11
9/2/2021	Phasors & polarity	3.1-3.11
9/7/2021	Symmetrical components	4.1-4.9
9/9/2021	Symmetrical components	4.10-4.17
9/14/2021	Relay input sources	5.1-5.7
9/16/2021	Relay input sources	5.7-5.15
9/21/2021	Substation visit	
9/23/2021	Protection fundamentals/basic design principles	6.1-6.4
9/28/2021	Protection fundamentals/basic design principles	6.5-6.8
9/30/2021	Review	Mid-term posted by 10/3, due 10/10
10/5/2021	Bus protection	10.1-10.10
10/7/2021	Bus protection	10.11-10.15
10/12/2021	FALL BREAK	
10/14/2021	Line protection	12.1-12.10
10/19/2021	Circuit breakers	Matt Schebler
10/21/2021	Protection & control design, fuses, etc.	Robert Frye
10/26/2021	Tour of TVA wiring shop	Robert Frye/Jason Eames
10/28/2021	Line protection	12.11-12.18
11/2/2021	Line protection	12.11-12.18
11/4/2021	Transformer protection	9.1-9.15
11/9/2021	Transformer protection	9.16-9.24
11/11/2021	Generator protection	8.1-8.10

11/16/2021	Generator protection	8.11-8.20
11/18/2021	Capacitor/reactor protection	9.25-9.34
11/23/2021	Review – LAST DAY OF CLASS	
12/7/2021	FINAL EXAM	6-8pm

Appendix C. Graduate Syllabi Examples

THE UNIVERSITY OF TENNESSEE CHATTANOOGA
College of Engineering and Computer Science

Advanced Thermodynamics

Fall 2020
Mechanical Engineering, 5320, 43520, Hybrid Lecture, 4 credit hours

Instructor: Chuck Margraves, PhD, UC Foundation Associate Professor

Email and Phone Number: Charles-Margraves@utc.edu, (423)425-4010

Office Hours and Location: See Schedule on Office Door, EMCS430F. For online students office hours will be by appointment.

Course Meeting Days, Times, and Location: Monday and Wednesday, 3:25-5:05 EMCS 402.

Course Catalog Description: A study of the principles of thermodynamics, involving a review of the fundamental concepts and introduction of the analytical treatments of the first, second and combined first and second laws of thermodynamics. Topics include irreversibility, availability (exergy), thermodynamic relations, mixtures, chemical reactions, and chemical equilibrium.

Course Pre/Co Requisites: Prerequisites ENME 3030 or equivalent or department head approval.

Course Student Learning Outcomes: Course outcomes: After completion of the course students are expected to be able to: complete an exergy analysis of a system using the control volume approach, conduct a first and second law analysis of both non-reacting and reacting mixtures, apply equilibrium principals to a reacting flow, analyze thermodynamic property relations.

Course Fees: Differential course fee, $58/credit hour.

Required Course Materials: Thermodynamics An Engineering Approach, 9th Edition, by Cengel & Boles, McGraw Hill Publishing

Technology Requirements for Course: Microsoft office software, Access to reliable internet service, a webcam and microphone, the ability to scan documents into PDF format.

Technology Skills Required for Course: Knowledge of Microsoft office software.

Technology Support: If you have problems with your UTC email account or with UTC Learn, contact IT Solutions Center at 423-425-4000 or email itsolutions@utc.edu.

Campus Safety Policy: Due to COVID-19, there is a campus safety policy (https://www.utc.edu/walker-center-teaching-learning/covid-19-safety-policy.php) for classes that meet on campus; please review this policy.

COVID-19 Absence Policy: Due to COVID-19, there is an absence policy (https://www.utc.edu/walker-center-teaching-learning/covid-19-absence-policy.php) for Fall 2020.

Class Adjustments due to Campus Shutdown: In anticipation of a possible campus shutdown this course will be conducted both face to face and online throughout the duration. If a shutdown is to occur the course will continue with the online option only. All students are required to have access to a device capable of attending meetings through Zoom and a functioning microphone and camera as well as reliable internet service. You will also need a way to scan all documents in PDF form.

Course Assessments and Requirements: Grades will be assessed as shown below.

Course Grading

Grading System

Letter Grade	***Percentage***
A	90% & above
B	80% – 89%
C	70% – 79%
D	60% - 69%
F	59% and below

Exams (3)	70%
Project – Written Portion	20%
Project - Presentation	5%
HW	5%

Instructor Grading and Feedback Response Time: Instructor will try to return graded work 1 week after the due date.

Course and Institutional Policies

Late/Missing Work Policy: Homework is due at the time of each exam. It will not be accepted late.

NOTE: All exams must be taken at the same time as the in-class students and you must be logged into a Zoom meeting during this time for monitoring purposes. There will also be a presentation required at the end of the course during class time.

Student Conduct Policy: UTC's Academic Integrity Policy is stated in the Student Handbook.

> **Honor Code Pledge:** I pledge that I will neither give nor receive unauthorized aid on any test or assignment. I understand that plagiarism constitutes a serious instance of unauthorized aid. I further pledge that I exert every effort to ensure that the Honor Code is upheld by others and that I will actively support the establishment and continuance of a campus-wide climate of honor and integrity.
>
> **Cheating:** The first time a student is caught cheating they will receive a grade of 0 for that assignment. They will lose a letter grade for the course and will be "unofficially reported" to the dean of students. The second time they are caught cheating a student will receive an F for the course and be "officially" reported to the dean of students.
>
> **Course Attendance Policy:** All students are expected to attend each class. If you must miss please inform your instructor beforehand if possible.

Course Participation/Contribution: All students are expected to be on time to class and participate in class discussion.

Course Learning Evaluation: Course evaluations are an important part of our efforts to continuously improve the learning experience at UTC. Toward the end of the semester, you will receive a link to evaluations and are expected to complete them. We value your feedback and appreciate you taking time to complete the anonymous evaluations.

Course Calendar/Schedule: Final Exam: Monday, December 7: 3:30-5:30

Tentative Course Outline

Chapter	Topic	Time
4-7	Thermo 1 Review • Specific Heat • Control Mass/Control Volumes • Cons. Of mass • Cons. Of Energy • 2nd Law / Entropy	1-2 Weeks
8	Exergy/Availability • Work Potential • 2nd Law Efficiencies • Exergy transfer, destruction, and balance	2 Weeks
	EXAM - 1	
12	Thermodynamic Property Relations • Partial Derivatives • Maxwell Relations • Clapeyron Equation • Determining relationships for internal energy, enthalpy, entropy, and specific heats • Joule Thompson • Real Gas relationships	2 Weeks
13	Gas Mixtures	2 Weeks

	• Determining Mass and Mole concentrations • Differences between Real and Ideal Gasses	
	EXAM-2	
15	Chemical Reactions • Theoretical and Actual Combustion • Enthalpy of formation and combustion • 1st Law for reacting systems • Adiabatic flame temperature • Entropy calculations for reacting systems • 2nd Law for reacting systems	3 Weeks
16	Chemical Equilibrium • Criterion for Equilibrium • Equilibrium for single reactions • Equilibrium constants for ideal gasses • Equilibrium for simultaneous reactions • Variation of equilibrium with temperature	2 Week

The University of Tennessee at Chattanooga

THE UNIVERSITY OF TENNESSEE CHATTANOOGA
College of Engineering and Computer Science

Advanced Protective Relaying Concepts

Spring 2021

ENEE, 5910R, 23544, Blended/HybridRotating, 3 credit hours

Instructor: Gary L. Kobet, P.E.

Email and Phone Number: gary-kobet@utc.edu, 423-883-4769

Office Hours and Location: I work full-time for TVA but have a temporary office at EMCS338, planned office hours 3:30pm-4:45pm Tuesday and Thursday.

Course Meeting Days, Times, and Location: Tuesday-Thursday, 5:15pm-6:30pm, EMCS 202

Course Catalog Description: Selected advanced problems of current interest. Ordinarily, topics will cover those not available in other graduate courses. May be repeated. Builds on ENEE 4620/5620 Protective Relaying/Power System Protection. Topics may include advanced transmission line protection topics including mutual coupling, weak infeed, source impedance ratio, stub bus, close-into-fault, loadability, loss-of-potential, multi-terminal lines, distance element theory, current reversal, directional ground polarizing; transformer protection topics including inrush, overcurrent settings, damage curves; generator protection topics including fault protection, abnormal operating condition protection, system backup; bus protection topics including high impedance, percentage/restrained differential, fast-bus trip, bus configuration impacts; apparent impedance and infeed; zero-sequence infeed; capacitor bank protection; shunt reactor protection; short circuit software; system grounding; load shedding; distribution system coordination; NERC and IEEE standards. On demand. Lecture 3 hours.

Course Pre/Co Requisites: Department head approval. ENEE 4620/5620 strongly recommended.

Course Student Learning Outcomes: Demonstrate an understanding of power system protection through correct solution methods of homework problems and exam problems. A research paper or laboratory project are also required to demonstrate further in-depth understanding of a particular power system protection problem/concept.

Required Course Materials: J. Lewis Blackburn and Thomas A. Domin, Protective Relaying Principles & Applications, 4th edition, CRC, Inc., 2014. PowerPoint slides based on the course textbook will be made available on the UTC Learn course website. Various IEEE PSRC

technical papers and tutorials as assigned.

Technology Requirements for Course: You need access to a computer with a reliable internet connection to complete this course. Test your computer set up and browser for compatibility with UTC Learn at http://www.utc.edu/learn/getting-help/system-requirements.php. You should also have an updated version of Adobe Acrobat Reader, available free from https://get.adobe.com/reader/.

Technology Skills Required for Course: These include using Microsoft Word and Excel, using the learning management system (UTC Learn), using MOCSNet email, creating and submitting files to UTC Learn, copying and pasting, and downloading and installing software.

Campus Safety Policy: Due to COVID-19, there is a campus safety policy (https://www.utc.edu/walker-center-teaching-learning/covid-19-safety-policy.php) for classes that meet on campus; please review this policy.

COVID-19 Absence Policy: Due to COVID-19, there is an absence policy (https://www.utc.edu/walker-center-teaching-learning/covid-19-absence-policy.php) for Fall 2020.

> Prior to arriving on campus each day or attending a face-to-face class, you are to complete the daily self-check through the university approved application. If you are instructed to stay home due to your responses, you are not to come to campus or attend face to face classes and instead follow up as directed through the self-check instructions.
>
> You **must notify me of your absence by email within 48 hours, if possible.** You are not required to provide me with documentation of COVID-19 symptoms. You will not be penalized for absences or late course assessments unless you are unable to complete course learning outcomes. I will work with you to identify ways to complete course requirements.
>
> You must, if you are asymptomatic or if your symptoms do not interfere with your ability to participate in the course, **continue to participate in the course using the online assets and tools that I make available through UTCLearn including** recorded lectures, posted lecture slides, other posted materials, problem assignments, reading assignments, and other materials which I mention in lectures.
>
> If COVID-19 related illness results in any missed course work (face-to-face or online), you should **proactively work with me to plan make-up work.** It remains your responsibility to complete any missed work such as assignments, tests, quizzes, labs, or projects outside of scheduled class time. But please realize that class will continue, and you may find yourself in the situation where you are unable to complete all work by the end of the semester. In such a case, you should consider a late withdrawal or an

incomplete grade. Please contact the Records Office (423-425-4416) to learn more about the late withdrawal process.

If you have COVID-19 disability related risk factors that may affect attendance, you are strongly encouraged to register with the Disability Resource Center (423-425-4006) in order to receive necessary accommodations.

If you believe I have not made reasonable and appropriate accommodations for absences, or makeup assignments, projects, labs, or exams due to COVID-19, you have the right to appeal according to UTC's Policies and Procedures for Student Complaints by filling out the Student Complaint Form and submitting to the Office of the Dean of Students.

Technology Support: If you have problems with your UTC email account or with UTC Learn (Canvas), contact IT Help Desk at 423-425-4000 or email helpdesk@utc.edu.

Student Technology: If you have technology needs to access your courses and/or complete course requirements in Canvas, submit a request (https://new.utc.edu/information-technology/learning-from-home) with Information Technology.

Student Accommodations: If you have accessibility and accommodation requests, contact the Disability Resource Center (https://www.utc.edu/disability-resource-center/index.php) at 423-425-4006 or email DRC@utc.edu.

Course Assessments and Requirements: Assessments include weekly homework assignments,a midterm exam, and a final exam. All homework and exam assignments are accepted by uploadto UTC Learn only, as a legible scanned .pdf. No pictures of assignments taken by cell phone, etc. will be accepted or graded.

Course methods include classroom lectures using PowerPoint presentation slides which will be posted to UTC Canvas prior to class. Example problems worked on dry-erase board in the classroom. Homework problems in the textbook to be submitted for grade; solution posted on UTC Canvas after homework submitted. Mid-term and final exam problems to demonstrate understanding of the subject matter. Additional problems not-for-grade posted on UTC Canvas to aid in mastery of the principles presented.

One field trip to a utility substation is planned (Raccoon Mountain switchyard).

Group study sessions for understanding and solving homework problems are strongly encouraged. I am glad to make myself available as needed during these sessions at a mutually convenient time. However, each student is responsible for his/her own work and turning in the assignment.

Homework Format: Writing on only one side of the page; draw a box around the final answer. Each completed assignment should be clearly presented so that others can follow the solution process. The solution method is just as important to the grade as the final numerical solution.

Unreadable work will not be graded or credited.

Graduate students are expected to complete either a design project or a research paper.

The design project should consist of a protection scheme for a power system element (transmission line, transformer, or generator), and should be tested in the laboratory. Students are encouraged to come up with their own design projects. They are also encouraged to start on their project early in the semester. Milestone assignments will be posted in UTC Learn.

Given that off-campus students may not have access to the UTC Relay Lab, a research paper may also be developed. The paper will require the reading of journal and conference papers. Several excellent references are provided at the end of many chapters of the course text. The IEEE Xplore database is an excellent search engine for finding papers along with downloadable .pdf files of most papers. The database is accessible through the UTC library. Professor Chapel Cowden (Chapel-Cowden@utc.edu) at the UTC library may help you with your research. Validation of solution methodologies must be performed on Standard Test Systems, which are provided by the IEEE Power Engineering Society on the IEEE website (www.ieee.org).

Whether research paper or project, students will report the results and methodologies used in a term paper. The paper shall be written in IEEE Transaction paper format, professional engineering style as if submitting to a professional conference or journal. The length of the paper (including all written materials, i.e., appendices and endnotes) shall have a minimum of 10pages of meaningful substance, not to exceed 16 pages. The IEEE Transactions paper template has been uploaded to UTC Canvas; no other formats will be accepted (double-column, single- spaced, 10 pt. Times-Roman font, etc.). The paper shall include an abstract, conclusions, and references per the template.

Projects can be worked in teams of two maximum as long as both demonstrate participation and understanding of the work. NOTE: EACH MEMBER OF THE TEAM MUST POST SOMETHING TO UTC CANVAS FOR EACH GRADING MILESTONE BELOW. DO NOT DEPEND ON YOUR PARTNER FOR THIS.

Research papers are individual only.

The timeline/grading milestones for the research paper/project are:

- Project/research paper topic selection, due 2/18/2021 (10%)
- Weekly updates, due 2/25, 3/4, 3/11, 3/18, 4/1, 4/8, 4/15, 4/22 (10%)
- Status/rough draft, due 3/25/2021 (40%)
- Final project report/research paper, due 5/2/2020

Course Grading

Course Grading Policy: 90-100% = A; 80-89% = B; 70-79% = C, 60-69% = D; <60% = F. Final grades will be rounded precisely. If you have an 89.4% final average, this is a B. If

you have a 69.5%, this is a C.

Homework	40%
Design project/research paper	20%
Mid-term	20%
Final	20%

Instructor Grading and Feedback Response Time: All assignments and exams are graded by a graduate teaching assistant who will try to grade all assignments within one week of the due date and provide written feedback when necessary. I will review grading as needed.

Course and Institutional Policies

Late/Missing Work Policy: Homework assignments submitted after 5pm on the due date will result in an automatic penalty of 10% per day. Homework assignments submitted morethan one week after the due date will not be accepted or graded and result in a grade of zero.

Student Conduct Policy: UTC's Student Code of Conduct and Honor Code (Academic Integrity Policy) can be found on the Student Conduct Policy page (https://www.utc.edu/student-conduct/codes.php).

Honor Code Pledge: As a student of the University of Tennessee at Chattanooga, I pledge that I will not give or receive any unauthorized assistance with academic work or engage in any academic dishonesty in order to gain an academic advantage. I will exert every effort to insure that the Honor Code is upheld by myself and others, affirming my commitment to a campus-wide climate of honesty and integrity

Course Attendance Policy: Note that each student is expected to attend and/or view every class lecture and participate, maintaining an environment conducive to learning. This means being respectful to fellow classmates, the instructor, and any visitors who may be present.

Course Participation/Contribution: Class attendance and participation are very important to learning the material and are required. Class discussions will involve novel solution techniques, modeling helps, and problem solving. It is recommended that a full scientific calculator be used during classes to follow along as the instructor works example problems.

Course Learning Evaluation: Course evaluations are an important part of our efforts to continuously improve learning experiences at UTC. Toward the end of the semester, you will be emailed links to course evaluations and you are expected to complete them. We value your feedback and appreciate you taking time to complete the anonymous evaluations.

UTC Bookstore: The UTC Bookstore will price match Amazon and Barnes and Noble (https://www.barnesandnoble.com/) prices of the exact textbook - same edition, ISBN, new to new format, used to used format, and used rental to used rental format, with the same rental

term. For more information, go to the Bookstore Price Match Program (https://bnc.pgtb.me/MMt77F), visit the bookstore, email sm430@bncollege.com or call 423-425-2184.

Course Zoom link/info:
When: Jan 19, 2021 05:00 PM Eastern Time (US and Canada)
Register in advance for this meeting:
https://tennessee.zoom.us/meeting/register/tJAocuGqpzgtH9XZQm12rOGVlqPwYB6BRufb
After registering, you will receive a confirmation email containing information about joining the meeting.

Course Calendar/Schedule: A tentative class-by-class topical outline is as follows:

Date	Topic	Chapter/Section(s)	79EH0148-7-PWR	88EH0269-1 PWR
1/19/2021	Introductions	Syllabus		
1/21/2021	Review of basic protection principles	Chapters 1-5		
1/26/2021	Transmission line protection – review	6.3, 12.1-12.4	Chapters I-IIf	
1/28/2021	TL protection – distance elements	6.5.5-6.6		
2/2/2021	TL protection – ground directional polarizing	12.19-12.25	Chapter III	
2/4/2021	TL protection – infeed, apparent impedance	-		
2/9/2021	TL protection – backup protection	12.27	Chapter IV	
2/11/2021	TL pilot protection – weak infeed/echo-keying, current reversal	12.8-12.10		
2/16/2021	TL protection – SIR, stub bus, CIF/SOTF, LOP	12.12	Chapter V	
2/18/2021	TL protection – loadability, load encroachment	W. Hakim		
2/23/2021	Circuit breaker concepts	Matt Schebler	Chapter VI	
2/25/2021	Review	-		
3/2/2021	MID-TERM	-	Chapter VII	
3/4/2021	Generator protection – fault protection	8.1-8.9		
3/9/2021	Generator protection – fault protection	8.1-8.9	Chapter VIII	
3/11/2021	Generator protection – abnormal operating conditions	8.10-8.13		
3/16/2021	Generator protection – system backup, generator breaker failure, etc.	8.14-8.17		Chapters 1,2
3/18/2021	Switchyard arrangements	10.1-10.10		
3/23/2021	Bus protection – summation TOC, restrained percentage differential	10.11-10.12, W Hakim		Chapter 3
3/25/2021	Bus protection – high impedance	10.11-10.12, W. Hakim		

3/30/3021	Transformer protection – inrush, damage curves, sudden pressure	9.15, 9.19-9.22, W. Hakim		Chapter 4
4/1/2021	Transformer protection – differential protection with zero sequence sources in-zone	-		
4/6/2021	Capacitor/reactor bank protection	9.25-9.34		Chapter 5
4/8/2021	Capacitor/reactor bank protection	9.25-9.34, W. Hakim		
4/13/2021	Capacitor/reactor bank protection	9.25-9.34, W. Hakim		Chapter 6
4/15/2021	System grounding	Chapter 7		
4/20/2021	Load shedding, reclosing	14.7-14.24		Chapters 7-8
4/22/2021	Last day of classes – Review	-		
5/4/2021	FINAL EXAM	6-8pm		

Appendix D. Course Learning Evaluation

Table 13. Student Ratings of Courses (next 8 pages)

Course Learning Evaluation

Fall 2020

Engineering

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	766	57	383	28	115	9	30	2	21	2	14	1	15	1
The course content addresses the learning outcomes of this course.	755	56	379	28	111	8	36	3	31	2	11	1	21	2
The course structure assists me in achieving the learning outcomes of this course.	670	50	313	23	165	12	51	4	59	4	42	3	44	3
I am achieving the learning outcomes of this course.	658	49	331	25	174	13	65	5	46	3	40	3	30	2
I keep up with all course readings and assigned work.	737	55	379	28	144	11	38	3	19	1	12	1	15	1
The course encourages my use of critical thinking skills.	778	58	329	24	140	10	38	3	25	2	8	1	26	2
The way this course is delivered encourages me to be actively engaged.	671	50	264	20	165	12	97	7	50	4	50	4	53	4
The instructor is willing to assist me with achieving the course learning outcomes.	797	60	288	22	108	8	69	5	19	1	18	1	31	2
The instructor provides constructive feedback on my coursework.	692	52	263	20	152	11	69	5	58	4	43	3	54	4
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	762	57	291	22	93	7	87	7	32	2	15	1	49	4

Course Learning Evaluation

Fall 2020

College of Engineering and Computer Science

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	1002	59	466	27	138	8	36	2	25	1	22	1	20	1
The course content addresses the learning outcomes of this course.	978	57	457	27	143	8	46	3	40	2	15	1	30	2
The course structure assists me in achieving the learning outcomes of this course.	862	50	385	23	196	11	72	4	77	5	52	3	65	4
I am achieving the learning outcomes of this course.	857	50	411	24	213	12	85	5	57	3	47	3	39	2
I keep up with all course readings and assigned work.	956	56	472	28	179	10	45	3	27	2	13	1	17	1
The course encourages my use of critical thinking skills.	1008	59	400	23	171	10	501	3	32	2	14	1	34	2
The way this course is delivered encourages me to be actively engaged.	850	50	327	19	201	12	121	7	77	5	60	4	73	4
The instructor is willing to assist me with achieving the course learning outcomes.	1023	60	340	20	133	8	95	6	32	2	26	2	42	2
The instructor provides constructive feedback on my coursework.	882	52	317	19	182	11	103	6	78	5	59	3	70	4
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	980	58	351	21	111	7	116	7	46	3	22	1	61	4

Course Learning Evaluation

Fall 2020

Total University

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	12495	69	3793	21	1001	6	269	1	187	1	126	1	130	1
The course content addresses the learning outcomes of this course.	12271	68	3805	21	1009	6	363	2	233	1	159	1	161	1
The course structure assists me in achieving the learning outcomes of this course.	11277	63	3297	18	1424	8	496	3	608	3	392	2	507	3
I am achieving the learning outcomes of this course.	10881	60	3753	21	1592	9	559	3	478	3	347	2	391	2
I keep up with all course readings and assigned work.	11326	63	4211	23	1665	9	320	2	272	2	114	1	93	1
The course encourages my use of critical thinking skills.	11165	62	3877	22	1634	9	549	3	332	2	212	1	232	1
The way this course is delivered encourages me to be actively engaged.	101211	57	3353	19	1810	10	729	4	731	4	540	3	627	3
The instructor is willing to assist me with achieving the course learning outcomes.	11999	67	3010	17	1104	6	722	4	352	2	294	2	362	2

continued

Course Learning Evaluation

Fall 2020

Total University (continued)

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
The instructor provides constructive feedback on my coursework.	10905	61	2839	16	1365	8	1028	6	601	3	526	3	576	3
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	11766	66	2976	17	888	5	1149	6	352	2	219	1	461	3

Course Learning Evaluation

Spring 2021

Engineering

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	789	60	370	28	93	7	19	1	16	1	10	1	10	1
The course content addresses the learning outcomes of this course.	783	60	370	28	79	6	23	2	25	2	13	1	14	1
The course structure assists me in achieving the learning outcomes of this course.	733	56	317	24	120	9	31	2	42	3	23	2	41	3
I am achieving the learning outcomes of this course.	671	51	362	28	137	10	52	4	38	3	20	2	27	2
I keep up with all course readings and assigned work.	743	57	382	29	130	10	26	2	14	1	7	1	0	0
The course encourages my use of critical thinking skills.	777	59	358	27	100	8	30	2	18	1	14	1	10	1
The way this course is delivered encourages me to be actively engaged.	702	54	281	21	130	10	56	4	55	4	42	3	41	3
The instructor is willing to assist me with achieving the course learning outcomes.	835	64	279	21	87	7	38	3	19	1	18	1	23	2
The instructor provides constructive feedback on my coursework.	724	56	276	21	123	9	62	5	41	3	31	2	41	3
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	804	62	273	21	71	5	84	6	22	2	14	1	30	2

Course Learning Evaluation

Spring 2021

College of Engineering and Computer Science

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	1035	61	456	27	124	7	25	1	20	1	20	1	15	1
The course content addresses the learning outcomes of this course.	1019	60	449	26	117	7	35	2	32	2	21	1	22	1
The course structure assists me in achieving the learning outcomes of this course.	939	55	381	22	156	9	47	3	59	3	39	2	74	4
I am achieving the learning outcomes of this course.	868	51	452	27	180	11	66	4	51	3	33	2	45	3
I keep up with all course readings and assigned work.	970	57	474	28	178	11	32	2	21	1	10	1	10	1
The course encourages my use of critical thinking skills.	1012	60	434	26	135	8	39	2	30	2	26	2	19	1
The way this course is delivered encourages me to be actively engaged.	888	52	341	20	173	10	76	4	75	4	68	4	74	4
The instructor is willing to assist me with achieving the course learning outcomes.	1062	63	349	21	113	7	61	4	29	2	26	2	43	3
The instructor provides constructive feedback on my coursework.	916	54	332	20	156	9	101	6	57	3	46	3	74	4
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	1029	61	352	21	93	6	111	7	27	2	22	1	47	3

Course Learning Evaluation

Spring 2021

Total University

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
I am aware of the learning outcomes of this course, as stated in the syllabus	12571	71	3569	20	978	6	219	1	168	1	113	1	131	1
The course content addresses the learning outcomes of this course.	12396	70	3578	20	945	5	305	2	244	1	126	1	155	1
The course structure assists me in achieving the learning outcomes of this course.	11451	65	3139	18	1346	8	419	2	559	3	338	2	497	3
I am achieving the learning outcomes of this course.	11002	62	3679	21	1483	8	530	3	408	2	271	2	376	2
I keep up with all course readings and assigned work.	11125	63	4181	24	1630	9	321	2	273	2	142	1	0	0
The course encourages my use of critical thinking skills.	11443	64	3703	21	1443	8	487	3	252	1	232	1	189	1
The way this course is delivered encourages me to be actively engaged.	10541	59	3130	18	1691	10	597	3	674	4	510	3	606	3
The instructor is willing to assist me with achieving the course learning outcomes.	12191	69	2928	17	985	6	632	4	305	2	228	1	347	2

continued

Course Learning Evaluation

Spring 2021

Total University (continued)

	N	Strongly Agree (%)	N	Agree (%)	N	Somewhat Agree (%)	N	Neither Agree nor Disagree (%)	N	Somewhat Disagree (%)	N	Disagree (%)	N	Strongly Disagree (%)
The instructor provides constructive feedback on my coursework.	11137	63	2768	16	1301	7	911	5	511	3	457	3	517	3
The instructor responds to my questions and emails within the time-frame indicated in the syllabus.	11972	68	2938	17	760	4	1106	6	257	1	201	1	345	2

Appendix E. Expenditures

Table 11. Expenditures					
	2016-17[1]	2017-18[1]	2018-19[1]	2019-20[1]	2020-21[1]
Actual Expenditures[2,4]	$1,698,687	$1,847,664	$1,767,784	$1,848,085	$1,906,226
Fall Adjunct Salaries[2]	$72,000	$75,000	$73,400	$87,000	$81,600
Spring Adjunct Salaries[2]	$94,750	$91,557	$93,100	$106,000	$127,400
FT Faculty FTE[2,4]	38.0	30.0	33.0	35.0	34.0
PT Faculty FTE[2,4]	3.9	4.8	4.9	6.3	4.7
Total Major Enrollment	111	108	113	111	104
Degrees Awarded[3]	18	11	28	22	21
FT Faculty Fall SCH	225	241	264	316	286
FT Faculty Spring SCH	202	236	314	290	292
PT Faculty Fall SCH	27	36	27	30	27.0
PT Faculty Spring SCH	60.0	60	69	34	30.0
Fall SCH	252	277	291	346	313
Spring SCH	262	296	383	324	322
Total SCH	514	573	674	670	635
Expenditures per FT Faculty FTE	$49,090	$67,141	$58,615	$58,317	$62,213
Expenditures per Student Major	$16,806	$18,650	$17,118	$18,388	$20,339
Expenditures per SCH	$3,629	$3,515	$2,870	$3,046	$3,331

[1]FY data is July 1 - June 30

[2]data contains total department (graduate and undergraduate) results

[3]Calculated using preceding Summer, Fall and Spring terms

[4]Salaries and Expenditures amounts come from all the Engineering accounts.

Appendix F. Diversity

Graduate Major Enrollment[1]

	2018-2019		2019-2020		2020-2021	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**
Multiple Races		1		1		
Unknown		4	1	1	1	2
American Indian						
Asian	3	11	1	8	1	5
Hispanic		4		2	1	3
Native Hawaiian or Other Pacific Islander				1		1
African American	2	10	1	12	2	10
White	2	25	5	26	5	29
Total	**7**	**55**	**8**	**51**	**10**	**50**

Faculty[2]

	2018-2019		2019-2020		2020-2021	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**
Multiple Races						
Unknown						
American Indian						
Asian	1	6	1	7	2	7
Hispanic						
African American	4	11	3	11	4	9
White	3	34	3	29	3	27
Total	**8**	**51**	**7**	**47**	**9**	**43**

[1]Includes primary and secondary majors

[2]Includes all faculty paid from the engineering accounts, excluding computer science and engineering management technology.

Appendix G. Example Curriculum Vitae

A. Resume of Ignatius W. Fomunung, Ph.D.

EDUCATION

Ph.D.	2000	*Georgia Institute of Technology*	Civil & Environmental Engineering
M.S.	1996	*Georgia Institute of Technology*	Civil Engineering (Transportation)
M.S.	1995	*Clark Atlanta University*	Physics
B.S.	1987	*Nanjing Institute of Technology, PRC*	Civil Engineering

EMPLOYMENT

Professor	*University of Tennessee at Chattanooga, TN*		Fall 2016 - …
Visiting Professor	*Changsha University of Science and Technology*		Fall 2015 - …
Associate Professor	*University of Tennessee at Chattanooga, TN*		7/2005 – 6/2016
Assistant Professor	*Clark Atlanta University-(CAU)*	Atlanta, GA	8/2000 – 5/ 2005
Post-Doctoral Research Scientist	*CTSPS-CAU*	Atlanta, GA	Summer 2000
Adjunct Professor of Physics	*Spelman College*	Atlanta, GA	Spring 2000
Graduate Teaching Assistant	*Georgia Institute of Technology*	Atlanta, GA	Fall 1999
Graduate Research Assistant	*Georgia Institute of Technology*	Atlanta, GA	1995-1999
Graduate Research Assistant	*CTSPS - CAU*	Atlanta, GA	1993-1995
Graduate Teaching Assistant	*Clark Atlanta University*	Atlanta, GA	1993-1995
Civil Engineer	*Del Monte Corporation*	Tiko, Cameroon	1991-1993
Civil/Hydraulic Engineer	*Cameroon Development Corp*.	Limbe, Cameroon	1988-1991

HONORS AND AWARDS

- 2015 ASCE Faculty Advisor of the Year Award
- 2015 Sustainable Transportation Award: Shaping a Future of Transportation Without Petroleum by the TN Department of Environment and Conservation (TDEC)
- Best Faculty Teaching Award, Dept. of Civil, Chemical & General Engineering, 2014-15 AY
- Faculty Honors Day Award, Office of Grants and Program Review, December 2007
- EXCEED Teaching Fellowship, *American Society of Civil Engineers Excellence in Civil Engineering Education Fellowship*, 2003
- Sigma Pi Sigma National Physics Honor Society, 1995
- San Hao Xuecheng (Model Student), Nanjing Institute of Technology, PRC 1986

Thesis Advisor/Project Supervision/Committee Member

Kelvin Msechu – Spring 2021: committee member

Atolagbe Babatunde – December 2019: Advisor

Murad Qureshi – May 2019

Mowazu Fortunatus – August 2018: committee member

Abubakr Ziedan – December 2017: committee member

Weiran Yang, Implementation of XFEM and Concrete Damage Plasticity for Recycled Aggregate Concrete Crack modeling, December 2015, MS Civ Eng – committee member

Asritha Batchu, Thermal Analysis of Pre-stressed Double Tee Canopy Beam, December 2015, MS Civ Eng – committee member

Drew Loiseaux, A Quantified Approach to the Functional Longevity of Geosynthetic Rolled Erosion Control Products (GRECPs), September 2015, MS Civ Eng –committee member

Daniel Malyuta, Analysis of Factors Affecting Pavement Markings and Pavement Marking Retroreflectivity in Tennessee Highways, May 2015, MS Civ Eng –committee member

Amour Saliha, Pavement Management Analysis of Arterial Roads in the City of Chattanooga using Micropaver, May 2015, MS Civ Eng – committee member

Harry Smithers, Evaluating the Effectiveness of Measures for Improving a University Shuttle Service, December 2014 – Advisor.

Ammar El Hassan, The Effects of Visual Stability Index (VSI) on Fresh Segregation of Self Consolidating Concrete (SCC), July 2014, MS Civ Eng – committee member
Gloria Neal, The Physical and Economic Impacts of Urban Flooding on Critical Infrastructure and Surrounding Communities, May 2014; MS Civ Eng. - Advisor

Refereed and Peer-Reviewed Journals (Last 5 years)

Fomunung et al., "ASSETS: Building a Model to Support Transfer Students in Engineering –Work in Progress," 2020 IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden, 2020, pp. 1-5, doi: 10.1109/FIE44824.2020.9274046.

Fomunung, Ignatius. (2021). UTC ASSETS: Supporting Underprivileged and Underrepresented Engineering Students. *Scientia*. doi:https://doi.org/10.33548/scientia555

Ziedan A., Onyango M., Wu W., Udeh S., Owino J., and Fomunung I. "Comparative Analysis between MERRA and Updated MEPDG Climate Database in the State of Tennessee. Transportation Research Record vol 2673, 6, pp 279-287 May 2019.

Fortunatus M, Onyango M, Fomunung I, McLean A, Owino J. *Use of a Smart Phone based Application to Measure Roughness of Polyurethane Stabilized Concrete Pavement*. Civil Eng Res J. 2018; 4(4): 555645. DOI: 10.19080/CERJ.2018.04.555645

Murad Al Qurishee, Ignatius Fomunung. *Smart Materials in Smart Structural Systems. Imperial Journal of Interdisciplinary Research* (IJIR) vol-3, Issue-7, 2017

Onyango M. A., Merabti S. A., Owino J. Fomunung I.., Wu W. "Analysis of Cost Effective Pavement Treatment and Budget Optimization for Arterial Roads in the City of Chattanooga" Frontiers of Structural and Civil Engineering Journal, 2017.

Rollins, A., Owino, J., I. Fomunung, *Improving Hardened Properties of PCC with Surface-Applied Colloidal Nano-Silica*-**Proceedings of fib Symposium 2016 Performance-Based Approaches for Concrete Structures**, Cape Town South Africa

Onyango, M., Sen, T., Fomunung I., Owino J. "Evaluation of Treatment Choice, User Cost and Fuel Consumption of Two Roadways in Hamilton County TN Using HDM-4" Journal of Urban Planning and Civil Engineering pp 201 - 218, Edited by Virginia P. Sisiopiku and Ossama E. Ramadan, Published by ATINER, ISBN: 978-960-598-009-2, Athens, Greece, 2015.

Benjamin Byard, Ammar El Hassan Joseph Owino, Ignatius Fomunung, Mbakisya Onyango, Alex Brent Rollins *Mixture Parameters, Fresh and Hardened Properties of Self-Consolidating Concrete (SCC)-A Survey of Current Practice in the U.S.* Submitted to **Transportation Research Board (TRB)** 2015

Peer – Reviewed Conference Proceedings (Last 5 years)

*Abubakr Ziedan, Ignatius Fomunung, Joseph Owino, Andrew Ray and Melissa Taylo*r. Assessing the impacts of workforce participation rates in telecommuting programs on VMT and emission reductions in a mid-size city. The 22nd International Conference of the Hong Kong Society for Transportation Studies (HKSTS), Hong Kong December 9 -11, 2017

Ignatius Fomunung, Joseph Owino, Mbaki Onyango, *Safe Routes to School as a Transportation Control Measure: Impacts on the Emission Inventory*, International Symposium on Systematic Approaches to Environmental Sustainability in Transportation (ISSAEST), *Fairbanks, AK, US August 2-5, 2015*

Wu, W., Fomunung, I., Owino, J., Onyango, M., and Al-Ostaz, A. "*Finite Element Modeling for Damage of Recycled Aggregate Concrete*", *ICCEASI 2015, Hong Kong, July 1-3.*

GRANTS AND CONTRACTS

Title: A Framework for Quantitative Assessment of the Environmental, Social, and Economic Benefits of TDOT Infrastructure Projects
Source: TDOT
Project Period: Sept 2020 to Sept 2022
Award Amount: $274,135
Role: PI

Title: Performance Evaluation of Full Depth Reclaimed (FDR) Pavements in Tennessee
Source: TDOT
Project Period: August 2019 to July 2021
Award Amount: $199,274
Role: Co-PI

Title: UTC-ASSETS
Source: National Science Foundation (NSF)
Project Period: April 1, 2018 – March 31, 2023
Award Amount: $993,000
Role: PI

Title: 3-D Drone Delivery Transportation Problem
Source: CEACSE – Internal Seed Grant
Project Period: July1, 2018 to June 30, 2019
Award Amount: $67,568
Role: PI

Title: Traffic Input for Mechanistic Empirical Pavement Design Guide (MEPDG)
Source: TDOT
Project Period: March 2018 – March 2019
Award Amount: $114,809
Role: Co-PI

Title: Improving Rigid Pavement Smoothness using Polylevel
Source: Tennessee Department of Transportation (TDOT)
Project Period: 10/01/2015 – 03/31/2018
Award Amount: $154,457
Role: Co-PI

Title: Traffic Data Input for Mechanistic Empirical Pavement Design Guide (MEPDG)
Source: TDOT and DOT-FHWA- Federal Highway Administration
Project Period: 10/01/2015 – 03/31/2018
Award Amount: $172,054
Role: Co-PI

Title: Development of Class P-SCC (Self Consolidating Concrete) and Class A-
Source: TDOT
Project Period: 06/01/2013 – 05/31/2015
Award Amount: $150,000
Role: Co-PI

Title: Implementation of Green Power Provider Agreement at the AVTF-
Source: Environmental Task Force (ETF), UTC
Project Period: March 2015 – April 2015
Award Amount: $3,898.00
Role: PI

Technical Referee (Paper Reviewer) – Journals

- International Journal of Modern Engineering (IJME)
- International Association of Journals and Conferences (IAJC)
- Journal of Transportation and Statistics (JTS)
- Transportation Research Board, Transportation and Air Quality Committee (ADC20)
- Transportation Research Board, Statistical Methodology and Statistical Computer Software in Transportation Research Committee (ABJ80)
- Transportation Research Board, Bicycle Transportation Committee (ANF20)
- Transportation Research Board, Low Volume Roads Committee (AFB30).

B. Resume of Kidambi Sreenivas, Ph.D.

Education

Ph. D., General Engineering (Computational Fluid Dynamics); Minor: Math — December 1996
Mississippi State University

M.S., Aerospace Engineering — August 1993
Mississippi State University

B. Tech., Aerospace Engineering — June 1991
Indian Institute of Technology, Madras

Employment

Professor — 07/2020 - Present
Mechanical Engineering, University of Tennessee at Chattanooga

Associate Professor — 01/2017 – 06/2020
Mechanical Engineering, University of Tennessee at Chattanooga

Joint Faculty Appointment — 04/2014 – 04/2019
Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN

Research Professor — 07/2011 – 12/2016
SimCenter, University of Tennessee at Chattanooga

Associate Research Professor — 09/2002 - 06/2011
SimCenter, University of Tennessee at Chattanooga

Associate Research Professor — 07/2002 - 09/2002
Computational Simulation & Design Center, Mississippi State University

Assistant Research Professor — 07/1999 - 06/2002
Computational Simulation & Design Center, Mississippi State University

Visiting Researcher — 07/1998 - 06/1999
Computational Fluid Dynamics Laboratory, Mississippi State University

Post-Doctoral Fellow — 01/1997 - 06/1998
Computational Fluid Dynamics Laboratory, Mississippi State University

Graduate Research Assistant — 08/1991 - 12/1996
Computational Fluid Dynamics Laboratory, Mississippi State University

Research Areas

Dr. Sreenivas has been active in the area of unstructured, multi-physics flow solvers since 1996. Prior to this, his focus was in the area of structured flow solver development with applications to acoustics and stability of turbomachines. Dr. Sreenivas pioneered the capability to enable rotating machinery simulations using unstructured meshes. Additionally, he has developed pre-conditioners that enable simulations of fluids with non-ideal equations of state. Dr. Sreenivas has applied these advanced capabilities to solve real-world problems involving complex geometry and complex physics. The range of applications include maneuvering submarines and surface ships, simulations of wind farms, multi-stage turbomachinery, improvement in aerodynamic efficiency of Class 8 trucks, particle deposition within the human respiratory system, contaminant dispersal through urban environments, and embedded propulsion systems. Dr. Sreenivas has worked closely with researchers from NASA, Navy, Department of Energy and various private companies and has transitioned the latest developments to provide them with advanced flow simulation capabilities.

Professional Memberships

American Institute of Aeronautics and Astronautics (AIAA)
American Society of Mechanical Engineers (ASME)
Sigma Xi
Phi Kappa Phi

Reviewer

Archival Journals

AIAA Journal Computers
& FluidsEnergy Reports
International Journal of Aerodynamics
International Journal of Computational Fluid Dynamics
Journal of Aircraft
Journal of Computational Physics
Journal of Fluids Engineering Journal
of Propulsion and Power Journal of
Turbomachinery Shock Waves

Conference Proceedings

ASME Turbo Expo
AIAA Propulsion Conference
ASME IMECE Conference
AIAA Aviation
AIAA SciTech

University Service

Conduct preliminary exams for Computational Fluid Dynamics exam area for the PhD program, 2014 - present
Graduate Coordinator, Computational Science PhD program, 2021 - present
Graduate Council, 2021 – present
Undergraduate Academic Standards Committee, 2021 – presentUndergraduate Petitions Committee, 2020 - 2021
Undergraduate Admissions Committee, 2019 – 2020
Faculty Academic Integrity Investigation Committee, 2019 – 2020
Undergraduate Research and Creative Endeavor (URaCE) advisory committee, 2016 – 2018
Grant Administrator search committee, SimCenter, 2017-18
Member, EE Department Head Search Committee, August 2019 – 2020
Member, Mechanical Engineering (Thermal-Fluids) faculty search committee, 2019 - 2020
Faulty Advisor, AIAA Student Chapter, October 2019 - present
Curriculum Committee, Mechanical Engineering, 2017 - present
Workload Policy Committee, Mechanical Engineering, 2017 – present
Strategic Planning Committee, Mechanical Engineering, 2018 – present
Technical Advisor, Design/Build/Fly Team, Jan 2018 – present
Chair, Mechanical Engineering (Thermal-Fluids) faculty search committee, 2018-19
Member, Mechanical Engineering (Advanced Manufacturing) faculty search committee, 2017-18

Professional Service

Member, AIAA Applied Aerodynamics Technical Committee, June 2017 – present Technical Chair, AIAA Applied Aerodynamics Conference, June 2021 (Virtual)
Technical Co-Chair, AIAA Applied Aerodynamics Conference, Dallas TX, June 2019

Publications

1. DeBardelaben, C., and **Sreenivas, K.**, "Effect of Farfield Boundary on Simulations of the Inlet in

Crossflow," Accepted for presentation at AIAA SciTech 2022, San Diego, CA, January 2022.

2. DeBardelaben, C., DeHay, J., Snuggs, J., Snyder, A., **Sreenivas, K.**, and Newman, J., "Creation of a Powered Trimmed Aerodynamic Database for a Generic Hypersonic Vehicle," Accepted for presentation at AIAA SciTech 2022, San Diego, CA, January 2022.
3. Crawford, A.M., and **Sreenivas, K.**, "Helios and Tenasi Results for the Workshop for Integrated Propeller Prediction," AIAA Paper 2020-2675, AIAA Aviation 2020, Reno, NV, June 2020.
4. Azarnoosh, J., **Sreenivas, K.**, Arabshahi, A., "Numerical Simulation of Tidal Breathing through the Human Respiratory Tract," Journal of Biomechanical Engineering, Available online January 1, 2020.
5. Mittal, A., Sreenivas, K., Hereth, L., and Taylor, L.K., "Numerical Simulation of the Interaction between Tandem Wind Turbines with Offset," under preparation for submission to Journal of Propulsion and Power, 2020.
6. Tanis, C., **Sreenivas, K.**, Newman, J., and Webster, R.S., "Performance Portability of a Multiphysics Finite Element Code," 2018 Aviation Technology, Integration, and Operations Conference, Atlanta GA, June 2018 (AIAA 2018- 2890)
7. **Sreenivas, K.**, Webster, R.S., Collao, D.M., "Computational Simulations of the Low-Noise SDT2-R4 Configuration Using Tenasi," 2018 Applied Aerodynamics Conference, Atlanta, GA, June 2018 (AIAA 2018-4203)
8. **Sreenivas, K.**, Webster, R., and Hereth, E., "Impact of High-Order Spatial Accuracy on Multi-Stage Turbomachinery Simulations", 53rd AIAA/SAE/ASEE Joint Propulsion Conference, AIAA Propulsion and EnergyForum, Atlanta, GA, July 2017. (AIAA 2017-4823).
9. **Sreenivas, K.**, Webster, R., and Hereth, E., "Single and Dual Flow Nozzle Simulations using Tenasi", 53rd AIAA/SAE/ASEE Joint Propulsion Conference, AIAA Propulsion and Energy Forum, Atlanta, GA, July 2017. (AIAA 2017-4656).
10. Collao, M.D., Webster, R., **Sreenivas, K.**, "Testing Protruding Studs as a Form of Casing Treatment on a TransonicTurbofan: A Computational Study," Proceedings of ASME Gas Turbine Technical Congress and Exposition, 2017,Charlotte, NC, June 2017. Paper GT 2017-65257.
11. Hereth, E., **Sreenivas, K.**, Taylor, L.K., and Nichols, D.S., "An Automatic Parallel Octree Grid Generation Software with an Extensible Solver Framework and a Focus on Urban Simulation" AIAA Paper 2017-0587, Grapevine, TX, January 2017.
12. Mittal, A., Briley, W.R., **Sreenivas, K**., and Taylor, L.K., "A Parabolic Velocity-Decomposition Method for WindTurbines," ***Journal of Computational Physics***, Vol. 330, pp 650–667, 2017.
13. Collao, M.D., Webster, R.S., Sreenivas, K., and Lin, W., "Computational Study of the Effects of Protruding Studs Casing Treatment on the Performance of an Axial Transonic Turbofan, " AIAA Paper 2016-4646, 52nd AIAA/SAE/ASEE Joint Propulsion Conference, 2016.
14. **Sreenivas, K**., Mittal, A., Hereth, L., Taylor, L.K., and Hilbert, C.B., "Numerical Simulation of the Interaction between Wind Turbines," ***Journal of Wind Engineering and Industrial Aerodynamics*****,** Vol**.** 157, pp 145–157, 2016.
15. Mittal, A., **Sreenivas, K**., Taylor, L., Hereth, L., Hilbert, C.B., "Blade-Resolved Simulations of a Model Wind Turbine: Effect of Temporal Convergence," ***Wind Energy***, Vol. 19, pp 1761–1783, 2016.
16. Azarnoosh, J., **Sreenivas, K**., Arabshahi, A., "CFD Investigation of Human Tidal Breathing through Human Airway Geometry," ***Procedia Computer Science***, Volume 80, pp 965–97, 2016.
17. **Sreenivas, K**, Webster, R.S., Hereth, E., Key, N.L., and Berdanier, R.A., "Computational Simulations of a Multi- Stage Subsonic Research Compressor," AIAA Paper 2016-0395, 54th AIAA Aerospace Sciences Meeting, January,2016.
18. Mittal, A., **Sreenivas, K**., Briley, W.R., Taylor, L.K., "Towards Wind Farm Layout Design Using Sensitivity Derivatives Obtained from a Parabolic Method," AIAA Paper 2016-2198, 34th Wind Energy Symposium, January, 2016.
19. **Sreenivas, K**., Mittal, A., Taylor, L.K., and Hereth, L., "Higher-Order Accurate Simulations of Wind Turbine Flow Fields: A Poor Man's Approach," AIAA Paper 2016-0749, 34th Wind Energy

Symposium, January, 2016.

20. Mittal, A., Briley, W.R., Taylor, L.K., and **Sreenivas, K**., "A Parabolic Method without Pressure Approximations for a Wind Farm," EWEA Offshore 2015, Copenhagen, Denmark.
21. Hassan, W.E., **Sreenivas, K**., Mittal, A., Taylor, L.K., and Hereth, L. "Blade Resolved Simulation for a Wind Farm," AIAA Paper 2015-2269, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015.
22. Mittal, A., **Sreenivas, K**., Briley, W.R., and Taylor, L.K., "A Parabolic Method for Accurate and Efficient Wind Farm Simulation," AIAA Paper 2015-2268, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015.
23. Mittal, A., Taylor, L.K., **Sreenivas, K**., Briley, W.R., and Nichols, D.S., "Extension of a Parabolic Method withoutPressure Approximations for Wind Turbines in ABL Flows," AIAA Paper 2015-3391, 33rd AIAA Applied Aerodynamics Conference, Dallas, TX, June 2015.
24. Kamali, S., Ahrabi, B.R., Webster, R.S., and **Sreenivas, K**., "Numerical Simulation of Compressible Flow in a Diffusing S-duct with and without Vortex Generators," AIAA Paper 2015-2715, 33rd AIAA Applied AerodynamicsConference, Dallas, TX, June 2015.
25. Gruetzemacher, R., Arabshahi, A., and **Sreenivas, K.**, "Effects of Inhalation Transcience on Flow Structures During Numerical Simulation of Airflow through a CT-Based Airway Geometry," Summer Biomechanics, Bioengineeringand Biotransport Conference (SB3C), Snowbird Resort, Utah, June 2015.
26. Webster, R. S., **Sreenivas, K**., and Hilbert, C. B., "Computational Simulation of the Fan and Low-pressure Compressor Stages of the Energy Efficient Engine," AIAA Paper 2015-1344, January, 2015.
27. **Sreenivas, K**., Mittal, A., Hereth, L., and Taylor, L.K., "Computational Simulation of the Interaction Between Tandem Wind Turbines with Offset," AIAA Paper 2015-0224, 33rd Wind Energy Symposium, AIAA SciTech 2015,January 2015.
28. Mittal, A., Briley, W.R., Taylor, L.K., and **Sreenivas, K**., "A Parabolic Method without Pressure Approximations for Wind Turbines," AIAA Paper 2015-0728, 33rd Wind Energy Symposium, AIAA SciTech 2015, January 2015.
29. Mittal, A., **Sreenivas, K**., Taylor, L.K., and Hereth, L., "Improvements to the Actuator Line Modeling for Wind Turbines," AIAA Paper 2015-0216, 33rd Wind Energy Symposium, AIAA SciTech 2015, January 2015.
30. Gruetzemacher, R., Arabshahi, A., and **Sreenivas, K**., "Numerical Simulation of Airflow in a CT-based Human Airway Model with Physiologically Appropriate Boundary Conditions," Poster Presentation within the RespiratoryBioengineering Track, Biomedical Engineering Society Annual Meeting, San Antonio, Texas, October 2014.
31. **Sreenivas, K**., Mittal, A., Hereth, L., Taylor, L.K., and Hilbert, C.B., "High-Fidelity Computational Simulation of the Interaction between Tandem Wind Turbines," 32nd AIAA Applied Aerodynamics Conference, June 2014, AIAA Paper 2014-2278
32. Mittal, A., **Sreenivas, K**., Taylor, L.K., Hereth, L., Hilbert, C.B., and Hyams, D.G., "Investigation of Rotor Models for Wind Turbine Simulations," 32nd AIAA Applied Aerodynamics Conference, Atlanta, GA, June 2014, AIAA Paper 2014-2280
33. Gupta, A., **Sreenivas, K**., and Taylor, L.K., "Preconditioning Methods for Multiphase Flows," 11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference, Atlanta, GA, June 2014, AIAA Paper 2014-2824
34. Currier, N., and **Sreenivas, K**., "A Preconditioned Non-Singular Eigensystem for the Navier-Stokes Equations with Finite-Rate Chemistry," 7th AIAA Theoretical Fluids Mechanics Conference, Atlanta, GA, June 2013, AIAA Paper2014-3084.
35. Mittal, A., **Sreenivas, K**., and Taylor, L.K., "Exploration of Modal Decomposition Techniques for Wind Turbines,"AIAA Paper 2014-1398, SciTech 2014, National Harbor, MD, January 2014.
36. Ahrabi, B.R., **Sreenivas. K**., and Webster, R.S., "Computational Investigation of Compressible Flow in a Diffusing S-duct," 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference. San Jose, CA,

July 2013, AIAA Paper 2013- 3601.

37. Flynt, G.A., Webster, R.S., and **Sreenivas, K**., "Computation of Heat Transfer in Turbine Rotor Blade Cooling Channels with Angled Rib Turbulators," 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference. San Jose, CA,July 2013, AIAA Paper 2013-3621.
38. Lin, W., **Sreenivas, K**., Webster, R.S., and Hyams, D.G., "Effect of Casing Groove Locations on the Performance of an Axial Flow Stage," 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference. San Jose, CA, July 2013, AIAA Paper 2013-3632.
39. **Sreenivas, K.**, Hilbert, C.B., Mittal, A., Hereth, L., and Taylor, L.K., "High-Fidelity Computational Simulation of the Wake Characteristics of a Model Wind Turbine," 31st AIAA Applied Aerodynamics Conference, San Diego, CA, June 2013, AIAA Paper 2013-2416.
40. Taylor, L.K., **Sreenivas, K**., Webster, R.S., and Kress, J., "An Artificial Compressibility Algorithm for ConvectiveHeat Transfer," 44th AIAA Thermophysics Conference. June 2013, San Diego, CA, AIAA Paper 2013-2894.
41. Webster, R., Whitfield, D., Hilbert, B., **Sreenivas, K**., Hyams, D. and Briley, W., "Demonstration of Sub-System Level Simulations: A Coupled Inlet and Turbofan Stage," AIAA Paper 2012-4282, 48th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Atlanta, GA, 2012.
42. Ghasemi, A., **Sreenivas, K**., and Taylor, L.K., "Unconditionally Stable High-order Picard Iteration Algorithm for Computational Electromagnetics," IEEE Antennas and Propagation Society International Symposium (APSURSI),8 - 14 July 2012, Chicago, IL.
43. Lin, W., **Sreenivas, K**., Webster, R., Hyams, D.G., "Effect of Casing and Tip Modifications on the Performance ofan Axial Flow Stage," AIAA Paper 2012-0475, 50th AIAA Aerospace Sciences Meeting, 9 - 12 January 2012, Nashville, TN.
44. Mittal, A., Taylor, L.K., **Sreenivas, K**., and Arabshahi, A., "Investigation of Two Analytical Wake Models Using Data from Wind Farms," Proceedings of the ASME 2011 International Mechanical Engineering Congress & Exposition, Denver, Co., November 11-17, 2011.
45. Ghasemi, A., and **Sreenivas, K**., "On the Theory of a Novel High-Order Time-Marching Algorithm Based on Picard Iteration," UTC-CECS-SimCenter-2011-02, September 2011.
46. Hyams, D., **Sreenivas, K**., Webster, R., Currier, N., "A Generalized, Unstructured Interpolative Interface method for Rotor-Stator Interactions," AIAA-2011-3700, 20th AIAA Computational Fluid Dynamics Conference, Honolulu, Hawaii, June 27-30, 2011.
47. Hyams, D.G., **Sreenivas, K**., Pankajakshan, R., Nichols, III, D.S., Briley, W.R., and Whitfield, D.L., "Computational simulation of model and full-scale Class 8 trucks with drag reduction devices," ***Computers & Fluids***, Volume 41, Issue 1, February 2011, Pages 27-40.
48. Ji, L., **Sreenivas, K**., Hyams, D., and Wilson, R., "A Parallel Universal Mesh Deformation Scheme for Hydrodynamic Applications," Proceedings of the 28th ONR Symposium on Naval Hydrodynamics, Pasadena, CA, 12-17 Sep. 2010.
49. Hyams, D. G., Webster, R. W., and **Sreenivas, K**., "A Generalized Interpolative Interface for Parallel Unstructured Flow Solvers," 40th Fluid Dynamics Conference and Exhibit, Chicago, Illinois, June, 2010. Paper No. 2010-5097.
50. Hyams, D. G., Webster, R. W., and **Sreenivas, K**., "A Generalized Axisymmetric Boundary Condition Method for Parallel Unstructured Field Solvers," Proceedings of ASME Gas Turbine Technical Congress and Exposition 2010, Glasgow, UK, June 14-18, 2010. ***Paper GT 2010-23414***.
51. Ji, L., Wilson, R., **Sreenivas, K**., and Hyams, D., "A Parallel Universal Mesh Deformation Scheme," 28th AIAA Applied Aerodynamics Conference, June 2010, Chicago, AIAA Paper 2010-4938.
52. Johnson, B. C., Webster, R. S., and **Sreenivas, K**., "A Numerical Investigation of S-Duct Flows with Boundary- Layer Ingestion," 48th AIAA Aerospace Science Meeting, January, 2010, Orlando, Florida, AIAA Paper 2010-841.
53. Webster, R., Hyams, D., **Sreenivas, K**., "Unstructured Grid Technology Applied to Axial-flow Compressors," AIAA Paper 2010-1605, 48th AIAA Aerospace Sciences Meeting Including the New Horizons Forum and AerospaceExposition, Orlando, Florida, January, 2010.

54. **Sreenivas, K**., Mitchell, B., Nichols, D.S., Hyams, D.G., and Whitfield, D.L., "Computational Simulation of the GCM Tractor-Trailer Configuration," ***Aerodynamics of Heavy Vehicles II: Trucks, Buses, and Trains***, Lecture Notes in Applied and Computational Mechanics. Springer Berlin/Heidelberg. 2009.
55. Arabshahi, A., Webster, R., **Sreenivas, K**., Hyams, D.G., and Whitfield, D.L., "Numerical Simulation of Reacting and Non-Reacting Nozzle Flows," AIAA-2009-4858, 45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Denver Colorado, August 2009.
56. **Sreenivas, K**., Taylor, Lafayette K., Briley, W. Roger, "Unsteady Flow Simulations for an Aerotonomy-Designed Synthetic-Jet Airfoil," UTC-CECS-SimCenter-2009-02-R, June 2009.
57. Wilson, R., Lei, J., Karman, Jr., S., Hyams, D., **Sreenivas, K**., Taylor, L., and Whitfield D., 2008, "Simulation of Large Amplitude Ship Motions for Prediction of Fluid-Structure Interaction," Proceedings of the 27th ONR Symposium on Naval Hydrodynamics, Seoul, Korea, 5-10 Oct. 2008.
58. Whitfield, D.L, Pankajakshan, R., **Sreenivas, K**., and, Taylor, L.K. "Numerical Derivatives, Matrix-Vector Product, and Richardson Extrapolation Using Complex Variables," UTC-CECS-SimCenter-2008-01, March 2008.
59. Pankajakshan, R., **Sreenivas, K**., Mitchell, B., and Whitfield, D.L., "CFD Simulations of Class 8 Trucks," SAE 2007-01-4293, SAE 2007 Commercial Vehicle Engineering Congress & Exhibition, October 2007.
60. Wilson, R., Nichols, S., Mitchell, B., Karman, S., Betro, V., Hyams, D., **Sreenivas, K**., Taylor, L., Briley, R., and Whitfield D., "Simulation of a Surface Combatant with Dynamic Ship Maneuvers," 9th Int. Conf. in Num. Ship Hydro., University of Michigan, 5-8 Aug. 2007.
61. Arabshahi, A., **Sreenivas, K**., Nichols, D.S., Mitchell, B., Taylor, L.K., and Whitfield, D.L., "Computational Analysis of Turbulent Internal Flow in Ballistic Rocket Motors," AIAA Paper 2007-1449, 45th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada, Jan. 8-11, 2007.
62. **Sreenivas, K**., Nichols, D.S., Hyams, D.G., Mitchell, B., Sawyer, S., and Whitfield, D.L., "Computational Simulation of Heavy Trucks," AIAA Paper 2007-1087, 45th AIAA Aerospace Sciences Meeting and Exhibit, Reno,Nevada, January 2007.
63. **Sreenivas, K**., Mitchell, B., Sawyer, S., Karman, S., Nichols, D.S., and Hyams, D.G., "Computational Prediction ofForces and Moments for Transport Aircraft," AIAA Paper 2007-1088, 45th AIAA Aerospace Sciences Meeting andExhibit, Reno, Nevada, Jan. 8-11, 2007.
64. Nichols, D.S., **Sreenivas, K**., Karman, S., and Mitchell, B., "Turbulence Modeling for Highly Separated Flows," AIAA Paper 2007-1407, 45th AIAA Aerospace Sciences Meeting and Exhibit, Reno, Nevada, Jan. 8-11, 2007.
65. Wilson, R.V., Nichols, D.S., Mitchell, B., Karman, S.L., Hyams, D.G., **Sreenivas, K**., Taylor, L.K., Briley, W.R., and Whitfield, D.L., "Application of an Unstructured Free Surface Flow Solver for High Speed Transom Stern Ships," 26th Symposium on Naval Hydrodynamics, Rome, Italy, September. 17-22, 2006.
66. **Sreenivas, K**., Taylor, L.K., and Briley, W.R., "A Global Preconditioner for Viscous Flow Simulations at All Mach Numbers," AIAA Paper 2006-3852, June 2006.
67. Hyams, D.G., **Sreenivas, K**., and Whitfield, D.L., "Parallel FAS Multigrid for Arbitrary Mach Number, High Reynolds Number Unstructured Flow Solvers," AIAA Paper 2006-2821, June 2006
68. Nichols, S., Mitchell, B., **Sreenivas, K**., Taylor, L.K., Whitfield D.L., and Briley, W.R., "Aerosol Propagation in anUrban Environment," AIAA Paper 2006-3726, June 2006.
69. Nichols, D.S., Hyams, D.G., **Sreenivas, K**., Mitchell, B., Taylor, L.K., and Whitfield, D.L., "An Unstructured Incompressible Multi-Phase Solution Algorithm", AIAA Paper 2006-1290, 44th AIAA Aerospace Sciences Meetingand Exhibit, January 2006.
70. **Sreenivas, K**., Pankajakshan, R., Nichols, D.S., Mitchell, B., Taylor, L.K., and Whitfield, D.L., "Aerodynamic Simulation of Heavy Trucks with Rotating Wheels", AIAA Paper 2006-1394, 44th AIAA Aerospace Sciences Meeting and Exhibit, January 2006.
71. McCallen, R., Salari, K., Ortega, J., Castellucci, P., Paschkewitz, J., Eastwood, C., Dechant, L.,

Hassan, B., Pointer, W. D., Browand, F., Leonard A., Rubel, M., Ross, J., Heineck, J.T., Walker, S., Storms, B., Roy, C., Whitfield, D.L., Pankajakshan, R., Taylor, L., **Sreenivas, K**., Englar, R., "DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations Leading to Intelligent Design," SAE International, 2005.

72. **Sreenivas, K**., Hyams, D. G., Nichols, D. S., Mitchell, B., Taylor, L. K., Briley, W. R., and Whitfield, D. L., "Development of an Unstructured Parallel Flow Solver for Arbitrary Mach Numbers," AIAA Paper 2005-0325, 43rd Aerospace Sciences Meeting and Exhibit, Reno, NV, January 2005.
73. **Sreenivas, K**., Cash, A.N., Hyams, D.G., and Taylor, L.K., "Computational Study of Propulsor-Hull Interactions," AIAA Paper 2003-1262, 41st Aerospace Sciences Meeting and Exhibit, Reno, NV, January 2003.
74. Blades, E., **Sreenivas, K**., and Hyams, D.G., "Arbitrary Overlapping Interfaces for Unsteady Unstructured Parallel Flow Simulations," AIAA Paper 2003-0276, 41st Aerospace Sciences Meeting and Exhibit, Reno, NV, January 2003.
75. Burg, C.O.E., **Sreenivas, K**., and Hyams, D.G., "Unstructured Nonlinear Free Surface Simulations for the Fully- Appended DTMB Model 5415 Series Hull Including Rotating Propulsors," 24th Symposium on Naval Hydrodynamics, Fukaoka, Japan, July 2002.
76. **Sreenivas, K**., Hyams, D.G., Mitchell, B., Taylor, L.K., Marcum, D.L., and Whitfield, D.L., "Computation of Vortex-Intensive Incompressible Flow Fields,", AIAA Paper 2002-3306, 32nd AIAA Fluid Dynamics Conference and Exhibit, St. Louis, MO, June 2002.
77. Burg, C.O.E., **Sreenivas, K**., and Hyams, D.G., "Unstructured Nonlinear Free Surface Flow Solutions: Validation and Verification", AIAA Paper 2002-2977, 32nd AIAA Fluid Dynamics Conference and Exhibit, St. Louis, MO, June 2002.
78. **Sreenivas, K**., Hyams, D.G., Sheng, C., Jayaraman, B., Wang, X., Mitchell, B., Jiang, M.Y., Pankajakshan, R., Taylor, L.K., Gaither, K.P., Gaither, A., Beeland, H., Marcum, D.L., Briley, W.R., and D. L. Whitfield, "Physics- Based Maneuvering Simulations for Tiltrotor Aircraft," MSU Report No. MSSU-COE-ERC-02-06 (NASA-ARC Grant NAG2-1232), April 2002.
79. **Sreenivas, K**., Hyams, D. G., Burg, C.O.E., Mitchell, B.J., Sheng, C., Jayaraman, B., Pankajakshan, R., Brewer, W.H., Nichols, D.S., Taylor, L.K., Remotigue, M.G., Wang, X., Jiang, M.Y., Gaither, K.P., Gaither, A., Beeland, H.L., Newman III, J.C., Marcum, D.L., Briley, W.R., and Whitfield, D.L., "Computational Engineering Research Supporting the Analysis and Design of Marine and Aerospace Vehicles," *MSSU-COE-ERC-02-09*, Mississippi State University, May 2002.
80. Marcum, D., Mitchell, B., **Sreenivas, K**., and Hyams, D., "Unstructured Grid Generation for Large-Scale CFD Applications," ECCOMAS Computational Fluid Dynamics Conference 2001, University of Wales, Swansea, Wales, UK, September 2001 (**Invited**).
81. Donatello, D., **Sreenivas, K**., and Taylor, L.K., "Computations of Unsteady Forces and Moments for SUBOFF Undergoing Prescribed Maneuvers Using U^{2}NCLE," MSSU-COE-ERC-01-12, Mississippi State University. October 2001.
82. Lorenzo, L., **Sreenivas, K**., Mitchell, B., and Taylor, L.K., "Computation of Forces and Moments for the Airship AKRON and SUBOFF Using U2NCLE," MSSU-COE-ERC-01-11, Mississippi State University, October 2001.
83. Hyams, D.G., **Sreenivas, K**., Taylor, L.K., and Whitfield, D.L., "Incompressible Unstructured RANS Simulations for a Low Speed Centrifugal Compressor using U^{2}NCLE," MSSU-COE-ERC-01-10, Mississippi State University, October 2001.
84. Marcum, D., Mitchell, B., **Sreenivas, K**., and Hyams, D., "Unstructured Grid Generation for Large-Scale CFD Applications," 1st MIT Conference on Computational Fluid and Solid Mechanics, Massachusetts Institute of Technology, Cambridge, MA, June 2001 (**Invited**).
85. **Sreenivas, K**, Hyams, D., Mitchell, B., Taylor, L., Briley, W. R., and Whitfield, D., "Physics Based Simulations of Reynolds Number Effects in Vortex Intensive Incompressible Flows," NATO/RTO Symposium on Advanced Flow Management, Norway, May 2001.
86. Hyams, D.G., **Sreenivas, K**., Sheng, C., Nichols, S., Taylor, L.K., Briley, W.R., and Whitfield, D.L., "An Unstructured Multielement Solution Algorithm for Complex Geometry Hydrodynamic

Simulations," 23rd Symposium on Naval Hydrodynamics, Val de Reuil, France, September 2000.

87. Sheng, C., Hyams, D., **Sreenivas, K**., Gaither, A., Marcum, D., and Whitfield, D., "Three-Dimensional Incompressible Navier-Stokes Flow Computations About Complete Configurations Using a MultiblockUnstructured Grid Approach," MSSU-COE-ERC-00-07, July, 2000.
88. Hyams, D.G., **Sreenivas, K**., Sheng, C., Briley, W.R., Marcum, D.L., and Whitfield, D.L., "An Investigation of Parallel Implicit Solution Algorithms for Incompressible Flows on Multielement Unstructured Topologies," Proc., 38th Aerospace Sciences Meeting & Exhibit, AIAA Paper 2000-0271, Reno, NV, January 2000.
89. Sheng, C., Hyams, D., **Sreenivas, K**., Gaither, J.A., Marcum, D. L., Whitfield, D.L. and Anderson, W.K., "Three- Dimensional Incompressible Navier-Stokes Flow Computations About Complete Configurations Using a Multi- Block Unstructured Grid Approach," AIAA 1999-0778, 37th AIAA Aerospace Sciences Meeting, Reno, NV, January 1999.
90. Arabshahi, A., Beddhu, M., Briley, W.R., Chen, J.P., Gaither, A., Gaither, K., Janus, J.M., Jiang, M., Marcum, D., McGinley, J., Pankajakshan, R., Remotigue, M., Sheng, C., **Sreenivas, K**., Taylor, L.K., and Whitfield, D.L., "A Perspective on Naval Hydrodynamic Flow Simulations," 22nd Symposium on Naval Hydrodynamics, Washington, D.C., August 9-14, 1998.
91. **Sreenivas, K**. and Whitfield, D.L., "Time-and Frequency-domain Numerical Simulation of Linearized Euler Equations," ***AIAA Journal***, Vol. 36, No. 6, June 1998, pp. 968-975.
92. Chen, J. P., Ghosh, A. R., **Sreenivas, K.**, and Whitfield, D. L., "Comparison of Computations Using Navier-Stokes Equations in Rotating and Fixed Coordinates for Flow Through Turbomachinery," AIAA Paper 1997-0878, AIAA35th Aerospace Sciences Meeting and Exhibit, Reno, NV, January, 1997.
93. **Sreenivas, K**., Whitfield, D.L., and Huff, D.L., "High Resolution Numerical Simulation of the Linearized Euler Equations in Conservation Law Form," AIAA Paper 1993-2934, AIAA 24th Fluids Dynamics Conference, Orlando,FL, July, 1993.

Dissertation/Thesis

Linearized Euler Analysis of Turbomachinery, PhD Dissertation
Major Professor: David L. Whitfield, Mississippi State University, Mississippi State, MS
High Resolution Numerical Simulation of the Linearized Euler Equations in Conservation Law Form, MS Thesis
Major Professor: David L. Whitfield, Mississippi State University, Mississippi State, MS

Appendix H. Laboratory Equipment Training and Management Policy

This policy outlines laboratory equipment training and management procedures for the College of Engineering and Computer Science, University of Tennessee at Chattanooga. The main elements covered here are equipment training, maintenance and replacement.

Equipment training

- Faculty, laboratory instructors and laboratory manager shall identify training needs and examine safety records that may be associated with the laboratory equipment and facility.
- Faculty and/or laboratory instructors shall be responsible for organizing safety orientation for students before the commencement of laboratory equipment training
- Faculty and/or laboratory instructors shall be responsible for identifying specific goals and objectives for equipment training.
- Students shall receive adequate training for all required laboratory equipment, software and accessories according to safe working procedures before the commencement of any laboratory work.
- Faculty and/or laboratory instructors shall be responsible for training students on the proper use of laboratory equipment for their courses.
- Faculty and/or laboratory instructors shall be responsible for keeping training records for all students
- Students are responsible for ensuring that they have received adequate safety orientation and equipment training before using any laboratory equipment.

Proactive maintenance

- Faculty, laboratory instructors, and/or laboratory manager shall inspect all laboratory equipment before the start of each semester and before the commencement of each laboratory section to ensure proper working condition.
- Faculty, laboratory instructors, and/or laboratory managers shall ensure that equipment are serviced at least once during the semester.
- The laboratory manager shall be responsible for collecting data and keeping the maintenance records for each equipment in the laboratory.

Equipment replacement

- Faculty, laboratory instructors, and/or laboratory manager shall ensure that all laboratory equipment are repaired, replaced or discarded at the end of its useful life.
- Laboratory manager shall evaluate ongoing maintenance costs, equipment productivity andquality, equipment downtime, safety issues before repairing old equipment for extended use.
- Old equipment in good condition may be donated or sold at a salvage value to partially cover the cost of replacement.
- The laboratory manager shall keep records on the age and performance of each laboratory equipment.

Appendix I. Facilities and Equipment

Laboratory Information

EMCS 102 – Soil Mechanics Laboratory
Master Loader HM-3000 SOILS EQUIPMENT
Gilson Testing Screens
HM-2330D Minilogger 4-Channel Digital, Data Acquisition

EMCS 103 – Civil Engineering Materials Laboratory
Ignition Oven
Compression Machine
Digital Master Loader W/Display
Automatic Triple Marshall Mechanical Compactor
Economy Specific Gravity Tank
Heavy Duty Forced Convection Ovens

EMCS 111 – Engineering Shop
Dynatorch XLE CNC Plasma Cutter
Dayton Fume Extractor
Clausing Colchester 15" Lathe
Clausing Milling Machine - 5HP
Clausing Drill Press - 1.5HP
Edwards 50 Ton Iron Worker
Tennsmith Model H52 Shear
Chicago Metal Bending Brake
Haas VF2 CNC Milling Machine
Haas ST20 CNC Lathe w/ Live Tooling
Strongway 50 Ton Hydraulic Press
Clausing KC1016VS Band Saw
Rockwell Model 20 Vertical Band Saw
Sybron Thermolyte Heat Treating Oven
Bader Belt Sander - 2HP
Powermatic Model 66 Table Saw
Baileigh 24" Drum Sander
Baileigh 12" Jointer/Planer
Shopbot 4'x 8' CNC Router
Miller Dynasty 400 TIG Welder

EMCS 119 – Chemical Engineering Laboratory
AC Controls Equipment
Dead Weight Tester
GC System
Micro Motion Coriolis Elite Sensor

Coriolis MVD flow and density transmitter
Analytical Balance

EMCS 120 - Chemical Engineering Laboratory
12-Stage Web Lab Distillation Column and Packed Column
Fisher Hamilton Fume Hoods
Rotary Evaporator
Continuous Stirred Tank Reactors
12-Stage Web Lab Distillation Column and Packed Column
RU-2100 Fuel Cell Research Unit
Calorimeter
ALPHA II - Platinum FT-IR Spectrometer w/ ATR stage
Nanodrop 3300 Fluorospectrometer
DELL DIMENSION XPS R450MHZ W/21" COLOR MONITOR & K
Series 2500 Loop Powered Percent
Laborota
Microscope
Spectrophotometer -Gensys 10SUV-VIS
Versa Star PH/Logr Kit
Litesizer 500
Auto. Critical Point Dryer C160336 Leica EM

EMCS 122 – Concrete Laboratory
Los Angeles Abrasion Machine
Leica Model TS02 Flexline
Topcon GTS-245NW 5" Total Station
Flexural Beam Test Set
Carlson Explorer II w/SurvCe TS Data Collector
Carlson Surveyor Plus Data Collecting
DT20C Sokkia Electronic Digital Theodolite

EMCS 123 & 124 – Mechanical Engineering Laboratory
X-Stream General Purpose Gas Analyzer
DELL DIMENSION XPS R400MHZ W/17" COLOR MONITOR & K
DELL PRECISION 420 WORKSTATION W/19" MON & KB
SENSOR 25 NPT FEMALE UNION
IFT9701R 85-250AC 3/4" LDO SYSTEM 3
MEASURING SPARK PLUG
PDC-32G (Item 2) PDC-VP: VACUUM PUMP LEYBOLD
Dell Precision Workstation 670 Intel
Journal Bearing Demonstration
DELL DIMENSION XPS T550MHZ W/19" COLOR MONITOR & K
DELL PRECISIONS 420 WORKSTATION W/19" MON & KB
DELL PRECISIONS 420 WORKSTATION W/19" MON & KB
300XL ELECTRONIC FLUE GAS ANALYZER
Dell Precision Workstation 670 Intel
Dell Precision Workstation 670 Intel
Dell Precision Workstation 670 Intel
Dell Precision Workstation 670 Intel

Dell Precision Workstation 670 Intel
Latitude D820 Intel (r) CoreTM Duo T2400

EMCS 213 – Advanced Mechatronics Laboratory
SMC SIF 401 Pallet and Container Feeding
SMC SIF 402 Container Filling Solid
SMC SIF 403 Container Filling Liquid
SMC SIF 405 Capping
SMC SIF 406 Container Warehouse
SMC SIF 407 Container Labelling and Dispatching
Denford Micromill 2000
Festo Mechanical Drives LabVolt System

EMCS 214C – Research Laboratory
Shaking Incubator, 49 liters
Water Purification System; Millipore Sigma; Direct
SimpliAmp Thermal Cycler
Biotek Microplate Reader
Mettler Toledo Analytical Balance
New Brunswick Bioreactor
Yamato Mobile Autoclave
Thermo Scientific Biosafety Cabinet

EMCS 236 & 236A – Strengths of Materials Lab & Research Laboratory
Tinius OlsenH10K-S Benchtop Universal Test Machine
Sharpy MDL84 Pendululm Impact Tester for Metals
5KN Benchtop Universal Test Machine
5KN Benchtop Universal Testing Machine
PROXIMA DP6850+ PROJECTOR
BC X100 Processing Unit Silver
Hitachi S-3400N-II Variable Pressure SEM and EDAX fixed bed EDX unit
AKTA START LC Chromatographic System

EMCS 304 – Power Electronics Laboratory
Tenma 72-1015 True RMS Multimeter
Tektronix TDS 2014C Four Channel Digital Storage Oscilloscope
BK Precisoin 1730A 30V/3A DC Power Supply
Fluke 8012A Digital Multimeter
BK Precision 4010A 2MHz Function Generator

EMCS 307 – Electrical Circuits Laboratory
Tektronix TDS 2002B Two Channel Digital Storage Oscilloscope
Tecktronix CDM250 Digital Multimeter
Tektronix PS280 DC Power Supply
Tektronix CFG280 11MHZ Function Generator
Global Specialties Proto-Board PB-503

EMCS 310 – Instrumentation Advanced Electronics Laboratory

Keithley 2231A-30-3 Triple Channel DC Power Supply
Keithley 2110 5 1/2 Digital Multimeter
Tenma 72-1015 True RMS Multimeter
Tektronix AFG Arbitrary Function Generator
Tektronix TBS 1052B-EDU Digital Oscilloscope

EMCS 322 – Electrical Systems Laboratory
Tenma 72-1015 True RMS Multimeter
Tenma 72-1015 True RMS Multimeter
Tenma 72-7245 Laboratory DC Power Supply
Tenma 72-7210 5MHz Sweep Function Generator
BK Precision 3110 100W Multi Range 60V/5A DC Power Supply
Tektronix TDS 2002B Two Channel Digital Storage Oscilloscope
DSpace ACE1104 Controller board
MotorSolver Dyno-Kit

EMCS 440D – Research Laboratory
Shaking Incubator, 49 liters
NANOFILTRATION UNIT - PALL CORP

EMCS 443 – Research Laboratory
NOVAtouch LX2
VACUUM PUMP to go with NOVAtouch LX2
ATI Mattson Spectrometer
DVS Intrinsic SN 1016

Appendix J. Library Information

UTC Library Facts:

- 180,000 square feet
- 5 floors
- Opened January 2015

Details:

The new LEED-certified library is chock full of strategic campus partnerships and is the premier location for student academic needs outside the classroom. The following partnerships represented in the UTC Library include: Centerfor Academic Support and Advisement, Disability Resource Center Student Room, English Composition Faculty Offices, Fellowship of Southern Writers Room, Graduate Student Lounge, Starbucks, The University's Permanent Art Collection maintained by the Art Department, Walker Center for Teaching and Learning, and the Writing and Communication Center. Designed with a robust technological infrastructure and themes of transparency, collaboration, and flexibility, student access and success were at the center of building planning processes. Current students, faculty and staff are invited to use these wonderful services physically located within the library building:

- Multifunction printers/scanners/copiers located throughout the building
- An enormous computer lounge on the 2nd floor featuring both Windows and Macs
- Group study rooms
- Third floor Studio, a workspace for innovative technology and media creation
- Two silent study lounges
- Classrooms
- Reservable seminar and conference rooms

- Visiting scholar rooms
- The Andrew C. Roth Grand Reading Room

Appendix K. Employment and Placement

University results for all Master's degrees

Primary Status after Graduation	Summer 2018-Spring 2019 (N)	%	Summer 2019-Spring 2020 (N)	%
Employed full time	48	80.0	42	53.2
Employed part time	1	1.7	4	5.1
Actively engaged in pursuing an entrepreneurial activity	0	0.0	0	0.0
Participating in a volunteer or service program	0	0.0	2	2.5
Pursuing another degree	7	11.7	1	1.3
Planning to pursue another degree but not yet enrolled	0	0.0	0	0.0
Seeking employment	3	5.0	28	35.4
Serving in the US military	1	1.7	2	2.5
Unable to seek employment at this time	0	0.0	0	0.0
Not seeking employment or continuing education at this time	0	0.0	0	0.0
	60		79	

Relevance of job to degree	Summer 2018-Spring 2019 (N)	%	Summer 2019-Spring 2020 (N)	%
Yes, my position is directly related to my degree program	27	65.9	20	69.0
Yes, my position is somewhat related to my degree program	10	24.4	5	17.2
Yes, my position is related to my degree program but I do not use anything I learned while earning my degree	0	0.0	1	3.4
Not sure	0	0.0	0	0.0
No, my degree program has little relevance to my current position	2	4.9	3	10.3
No, my degree program is not at all related to my current position.	2	4.9	0	0.0
	41		29	

Did you complete an internship	Summer 2018-Spring 2019 (N)	%	Summer 2019-Spring 2020 (N)	%
Yes	13	30.2	31	51.7
No	30	69.8	29	48.3
	43		60	

Did the internship lead to your job	Summer 2018-Spring 2019 (N)	%	Summer 2019-Spring 2020 (N)	%
Yes	3	27.3	8	28.6
No	8	72.7	20	71.4
	11		28	

Experiential Learning graduates participated in	Summer 2018-Spring 2019 (N)	%	Summer 2019-Spring 2020 (N)	%
Formal research project	20	33.3	27	34.2
International Experience	4	6.7	0	0.0
Internship	13	21.7	31	39.2
Cooperative Education	0	0.0	0	0.0
Practicum	4	6.7	20	25.3
Other	3	5.0	7	8.9

College results for all Master's degrees

Primary Status after Graduation	Summer 2018-	%
Employed full time	8	61.5
Employed part time	0	0.0
Actively engaged in pursuing an entrepreneurial activity	0	0.0
Participating in a volunteer or service program	0	0.0
Pursuing another degree	0	0.0
Planning to pursue another degree but not yet enrolled	0	0.0
Seeking employment	4	30.8
Serving in the US military	1	7.7
Unable to seek employment at this time	0	0.0
Not seeking employment or continuing education at this tin	0	0.0
	13	

Relevance of job to degree	Summer 2018-	%
Yes, my position is directly related to my degree program	5	83.3
Yes, my position is somewhat related to my degree progran	0	0.0
Yes, my position is related to my degree program but I do not use anything I learned while earning my degree	0	0.0
Not sure	0	0.0
No, my degree program has little relevance to my current p	1	16.7
No, my degree program is not at all related to my current po	0	0.0
	6	

Did you complete an internship	Summer 2018-	%
Yes	5	50.0
No	5	50.0
	10	

Did the internship lead to your job*	Summer 2018-	%
Yes		
No		

Experiential Learning graduates participated in	Summer 2018-	%
Formal research project	8	61.5
International Experience	0	0.0
Internship	5	38.5
Cooperative Education	0	0.0
Practicum	0	0.0
Other	0	0.0

*Less than 5 combined responses in this section

Department/Program results*

Primary Status after Graduation	Summer 2018-	%
Employed full time	4	30.8
Employed part time	0	0.0
Actively engaged in pursuing an entrepreneurial activity	0	0.0
Participating in a volunteer or service program	0	0.0
Pursuing another degree	0	0.0
Planning to pursue another degree but not yet enrolled	0	0.0
Seeking employment	2	15.4
Serving in the US military	0	0.0
Unable to seek employment at this time	0	0.0
Not seeking employment or continuing education at this tin	0	0.0
	6	

Relevance of job to degree*	Summer 2018-	%
Yes, my position is directly related to my degree program		
Yes, my position is somewhat related to my degree program		
Yes, my position is related to my degree program but I do not use anything I learned while earning my degree		
Not sure		
No, my degree program has little relevance to my current position.		
No, my degree program is not at all related to my current position.		

Did you complete an internship	Summer 2018-	%
Yes	3	30.0
No	2	20.0
	5	

Did the internship lead to your job*	Summer 2018-	%
Yes		
No		

Experiential Learning graduates participated in	Summer 2018-	%
Formal research project	4	66.7
International Experience	0	0.0
Internship	3	50.0
Cooperative Education	0	0.0
Practicum	0	0.0
Other	0	0.0

*Less than 5 combined responses in this section