

PROGRAM MODIFICATION PROPOSAL FORM

Name of Institution: **Clemson University**

Briefly state the nature of the proposed modification (e.g., adding a new concentration, extending the program to a new site, curriculum change, etc.): **Curriculum modification, request recording of previously declared tracks/concentrations**

Current Name of Program (include degree designation and all concentrations, options, and tracks):
MS Automotive Engineering

Proposed Name of Program (include degree designation and all concentrations, options, and tracks):
MS Automotive Engineering [4 concentrations: Vehicle Manufacturing and Materials; Vehicle Performance; Advanced Powertrains and Drivelines; Vehicle Automation and Electronics]

Program Designation:

- | | |
|---|--|
| <input type="checkbox"/> Associate's Degree | <input checked="" type="checkbox"/> Master's Degree |
| <input type="checkbox"/> Bachelor's Degree: 4 Year | <input type="checkbox"/> Specialist |
| <input type="checkbox"/> Bachelor's Degree: 5 Year | <input type="checkbox"/> Doctoral Degree: Research/Scholarship (e.g., Ph.D. and DMA) |
| <input type="checkbox"/> Doctoral Degree: Professional Practice (e.g., Ed.D., D.N.P., J.D., Pharm.D., and M.D.) | |

Does the program currently qualify for supplemental Palmetto Fellows and LIFE Scholarship awards?

- Yes
 No

If No, should the program be considered for supplemental Palmetto Fellows and LIFE Scholarship awards?

- Yes
 No

Proposed Date of Implementation: **August 2020**

CIP Code: **14.9999 [no change]**

Current delivery site(s) and modes: **50116, Clemson Univ-Campbell Grad Engineer Ctr (CUICAR)**

Proposed delivery site(s) and modes: **50116 [no change]**

Program Contact Information (name, title, telephone number, and email address):

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Institutional Approvals and Dates of Approval:

Curriculum Committee approval: 18 October 2019

Provost approval: 20 October 2019

Board of Trustees approval: 11 October 2019

Background Information

Provide a detailed description of the proposed modification, including target audience, centrality to institutional mission, and relation to strategic plan.

Since its CHE approval in 2005 and initiation in 2007, Clemson's MS Automotive Engineering (AuE) program has grown by leaps and bounds: fall semester enrollment has risen from 66 students in 2010, to 119 in 2015, to 187 in 2019. Over 550 students have completed the MS program, and 77 students have earned their Ph.D. degrees. The original vision to create a world-class program for education, research and innovation in automotive engineering has been realized, and its graduates are now on the path of becoming the next-generation leaders in the automotive industry in SC and nationwide.

The MS curriculum prepares a new generation of engineers to deal with the complex technological, environmental and globalization challenges facing the automotive industry. Some of these challenges lay in the integration of diverse technologies in the automobile itself, and its cost effective and environmentally responsible manufacture. The AuE program equips students with the basis, depth and domain knowledge needed for master's level expertise in systems integration, vehicle systems engineering, and the ability to work globally.

Some of the challenges faced by the automotive industry are also faced in other sectors. While AuE is geared toward the automobile industry, it yields expertise strong linked with needs in the aerospace and other industries within the State, region, and nation. The program has created an exceptionally high positive impact on the reputation of Clemson and the State with its flagship curriculum, including the Deep Orange internship projects that have been supported by original equipment manufacturers (OEMs) like BMW, Toyota, Honda, GM, as well as several Tier I and II suppliers.

Going forward, the AuE program seeks to remain nimble and competitive with peer programs at top-ranked US universities by making program modifications that offer flexible curriculum structures and options to address the needs of a more diverse student body—all while maintaining and enhancing its current proven strengths. The program changes proposed in this modification include: a) initiating fair and flexible professional/internship requirements, b) curricular consolidation of business topics, c) enabling shorter-time-to-completion of course work, d) offering opportunities for student participation in funded research by introducing a thesis as an option to satisfy a professional experience requirement in addition to the extant internship, and e) recording extant concentrations/tracks.

Assessment of Need

Provide an assessment of the need for the program modification for the institution, the state, the region, and beyond, if applicable.

Since Clemson AuE program's inception in 2007 it has grown at a steady pace in terms of both reputation and the number of graduates. As expected, our program's elevated status and visibility has brought about increased competitive pressures, and sensitivity to global economic trends and political backdrops. As an example, applications to the Clemson AuE program declined from 2016 to 2018, and actual enrollment numbers trended downward between 2013 (155 fall enrollment) and 2018 (125 fall enrollment) despite a consistent increase in the number admission offers. Peer institution market data suggests applicants were receiving "better deals" elsewhere in terms of the program duration and related costs and duration.

Our current AuE MS program is a non-thesis degree with a minimum of 42 credits required to graduate. Its internal *premier program* designation brings its tuition on par with institutions such as Ohio State University, Georgia Tech, Virginia Tech, and the University of Wisconsin, whose related graduate engineering degrees require only 30-33 credits that can be completed in 1.5 years or less. In contrast, our current AuE MS program structure, including the course work and required internship, involves a 2-year matriculation. This brings about the perception of a high opportunity cost—particularly among the domestic students. The proposed modifications itemized below address the challenges described above.

The modified new curriculum will shorten the time to degree (at least of completion of all required course work) and can appeal to a more diverse student populations by offering flexibility and a reduced number of required core courses required. Furthermore, the introduction of an MS thesis option allows program faculty to offer funding to high-caliber students via short-term research grants—offering a pathway to recruit those research-oriented students into the Ph.D. program. With these modifications, the department is also addressing two issues that are often cited in the

Clemson Graduate School Survey of Students who reject the AuE department’s admission offers citing “tuition cost” and “availability of funding from other peer programs” as their top reason for going elsewhere.

Transfer and Articulation

Identify any special articulation agreements for the modified proposed program. Provide the articulation agreement or Memorandum of Agreement/Understanding.

None

Description of the Program

<i>Detailed Projected Enrollment Model – MS Automotive Engineering</i>												
Year	Fall Headcount				Spring Headcount				Summer Headcount			
	New	Continuing	Lost	Graduate	New	Continuing	Lost	Graduate	New	Continuing	Lost	Graduate
2019-20	122	58	0	0	0	180	0	0	0	122	0	58
2020-21	70	122	2	0	0	190	0	0	0	68	0	120
2021-22	80	70	1	0	0	149	0	0	0	79	0	69
2022-23	80	80	2	0	0	158	0	0	0	78	0	78
2023-24	80	80	2	0	0	158	0	0	0	78	0	78

Projected Enrollment						
Year	Fall Headcount		Spring Headcount		Summer Headcount	
	New	Total	New	Total	New	Total
AY 2020-2021	70	192	0	190	0	68
AY 2021-2022	80	150	0	149	0	79
AY 2022-2023	80	160	0	158	0	78
AY 2023-2024	80	160	0	158	0	78

Explain how the enrollment projections were calculated.

We start the enrollment model with best available AY19-20 data. In AY1920, the program saw an unusual 60+ student increase in initial enrollment due to an historically anomalously high yield rate. We assume in AY2021 that this yield will return to near normal, and initial enrollment will increase by 10 students in the out years of the model due to the more attractive duration and thesis option. The model assumes quicker graduation in line with the reduced curriculum, and historical attrition numbers. The final two model years reach a steady state enrollment of 160 students—30 less than this current anomalous AY.

Curriculum

Attach a curriculum sheet identifying the courses required for the program.

The current AuE MS Curriculum's concentration areas (technical tracks) will be retained except for a name change for one of the concentration areas.

- Vehicle Manufacturing and Materials
- Advanced Powertrains and Drivelines
- Vehicle Performance
- Vehicle Automation and Electronics (formerly: Vehicle Electronic/Electrical Systems)

These have been previously declared in CHE paperwork, but never recorded as concentrations. Because the revised curriculum dispenses with the current curriculum's course coverage in multiple technical tracks (breadth), and focuses students in a single technical track (depth), we request that these be recorded.

Under the proposed changes, for any one of these concentration areas, a student is required to complete the following depending on the new flexible choice for satisfying a professional experience requirement either by Internship or Thesis:

1. **Core courses** (Required to be taken by all students):
 - AuE 8700: Automotive Business Concepts
 - AuE 8810, AuE 8811(lab): Automotive Systems Overview
2. **Technical electives:** See listing of current technical elective courses by concentration area (technical tracks) on the next page.
 - Internship-based professional experience: students choose any 9 of the technical electives for the chosen concentration area
OR
 - Thesis-based professional experience: students choose any 7 of the technical electives for the chosen concentration area
3. **Professional Experience requirement:**
 - Internship: Six months of internship, internally in Clemson's Deep Orange project or externally at industrial location.
 - INT8010: Graduate Internship (zero credits) during the semesters of the internship.
 - Thesis: Complete and defend a research thesis.
 - Register for at least 6 credits for AuE 8910: Master's Thesis Research (new thesis course)

Total minimum credit requirements: **33 credits**

Sequencing: The following is a typical schedule for a student. Except for the two core courses, all others electives may be taken in any order. See elective list on next page.

Prof Exper Choice	1 st Fall	1 st Spring	Summer	2 nd Fall	2 nd Spring	Summer	Total Credits
Internship Option	AuE 8700, AuE 8810) + any 2 electives)	Four electives	Internship: INT8010	Three electives	Internship: INT8010	Internship: INT8010	
	12 credits	12 credits	0 credit	9 credits	0 credit	0 credit	33 credits
Thesis Option	AuE 8700, AuE 8810) + any 2 electives	Three electives		Two electives+ AuE 8910 (Thesis Research, 6cr)			
	12 credits	9 credits		12 credits			33 credits

Curriculum Changes

Courses Eliminated from Program	Courses Added to Program	Core Courses Modified
AuE 8900: Automotive Engineering Project	AuE 8700: Automotive Business Concepts	
AuE 8950: External Internship	AuE 8910: Master's Thesis Research	
AuE 8800: Automotive Design Manufacture Project Management	INT 8010: Graduate Student Internship	
8030: Autovation for Intrapreneurs		
8040: Autovation for Entrepreneurs		

The above change table applies for all concentration areas/tracks

AuE 8900 and AuE 8950 will be eliminated upon approval of proposed MS degree program changes.

AuE 8800: Automotive Design Manufacture Project Management will be phased out upon the program modification approval.

AuE 8030: Autovation for Intrapreneurs will be phased out upon program modification approval.

AuE 8040: Autovation for Entrepreneurs will be phased out upon the program modification approval.

New Courses

List and provide course descriptions for new courses.

AuE 8700: Automotive Business Concepts (3cr; New approved course): This course explores concepts relevant to the global automotive domain including business principles, economic principles, product development, project management, marketing, human factors, future trends, professionalism and ethics

AuE 8910: Master's Thesis Research (3cr; New approved course): Students choosing to do an Automotive Engineering Master's thesis work register for this course. Students will work with a faculty advisor and a thesis committee to define a research topic, conduct a thorough research, generate a thesis and defend their work to the advisory committee.

INT 8010: Graduate Student Internship (zero credits). A graduate internship for which students agree to complete a minimum of 320 hours during a regular term. Internships must provide meaningful, intentional experiential education opportunities and should allow graduate students to apply knowledge, theories and skills learned in the classroom. This is an off-main campus internship course offered by the Michelin Career Center at Clemson that students can take while on internship to maintain a full-time status.

Technical Requirement Electives:

Concentration: Vehicle Manufacturing, Structures and Materials

AuE 8330 Automotive Manufacturing Systems Overview
 AuE 8550 Structural Analysis Methods for Automotive Systems and Components
 AuE 8570 Applied Optimization for Light-Weight Automotive Design
 AuE 8660 Materials for Automotive Applications
 AuE 8670 Vehicle Manufacturing Processes
 AuE 8690 Quality Control for Automotive Systems
 AuE 8650* Advanced Composite Manufacturing Processes
 AuE 8651- Accompanying Lab
 AuE 8930* Fundamentals of Injection Molding
 AUE 8770 - Light-Weight Vehicle Systems Design

Concentration: Vehicle Performance

AuE 8260 Vehicle Diagnostics
AuE 8270 Automotive Control Systems
AuE 8290 Tire Behavior and Performance
AuE 8500 Stability and Safety Systems
AuE 8860 Vehicle NVH
AuE 8861- Accompanying Lab
AuE 8870 Methods for Vehicle Testing
AuE 8871- Accompanying Lab
AuE 8930 Advanced Dynamics
AuE 4010/6010 Vehicle Dynamics
AuE 8930 Robotic Mobility and Manipulation

Concentration: Advanced Powertrains and Drivelines

AuE 8160 Fundamentals of Engine Combustion and Emissions
AuE 8161- Accompanying lab
AuE 8170 Hybrid Propulsion Systems
AuE 8180 Engine System Analysis, Design and Experimentation
AuE 8181- Accompanying lab
AuE 8190 Advanced Internal Combustion Engine Concepts
AuE 8260 Vehicle Diagnostics
AuE 8270 Automotive Control Systems
AuE 8280 Fundamentals of Vehicle Drivelines and Powertrain Integration
AuE 8930* Hybrid Vehicle Powertrain Control

Concentration: Vehicle Automation and Electronics

AuE 8350 Automotive Electronics Overview
AuE 8270 Automotive Control Systems
AuE 8260 Vehicle Diagnostics
AuE 8240 Autonomous Driving Technologies
AuE 8930* Robotic Mobility and Manipulation
AuE 8930* Autonomy: Science and Systems
AuE 8930* High Performance Computing for Vehicle Autonomy Modeling and Simulation
AuE 8930* Computational Methods for Automotive Engineering
AuE 8930* Perception and Intelligence

NOTE: AuE 8930 courses are temporary Special Topics courses that have not yet been given a permanent course number.

Similar Programs in South Carolina offered by Public and Independent Institutions

Identify the similar programs offered and describe the similarities and differences for each program.

There are no other similar programs to the Clemson Graduate Automotive Engineering Program in South Carolina.

Program Name and Designation	Total Credit Hours	Institution	Similarities	Differences
NONE				

Faculty

State whether new faculty, staff or administrative personnel are needed to implement the program modification; if so, discuss the plan and timeline for hiring the personnel. Provide a brief explanation of any personnel reassignment as a result of the proposed program modification.

The proposed changes will require minimal, if any, personnel changes. The program modification requires an overall reduction of course credit hours, but will reallocate workload to support other program curriculum needs such as advising MS theses for students selecting this option instead of an internship. Additionally, the curriculum reform is well aligned with the long-term strategic plans. The number of credit hours will decrease, but the enrollments will increase from recent 2013-2018 levels. Additional staff is already on-board to develop programs for recruiting high-quality incoming student talent, and improving the diversity of the student body. In sum, the Automotive Engineering department and the College of Engineering, Computing and Applied Science have taken steps that will provide the necessary depth and flexibility to handle the proposed changes.

Resources

Identify new library, instructional equipment and facilities needed to support the modified program.

Library Resources: No new resources

Equipment: No new equipment

Facilities: No new facilities

Impact on Existing Programs

Will the proposed program impact existing degree programs or services at the institution (e.g., course offerings or enrollment)? If yes, explain

Yes

No

Financial Support

Estimated Sources of Financing for the New Costs						
Category	1st	2nd	3rd	4th	5th	Total
Tuition Funding	\$4,510,223	\$3,706,766	\$4,060,582	\$4,182,400	\$4,307,871	\$20,767,842
Program-Specific Fees						
Special State Appropriation						
Reallocation of Existing Funds						
Federal, Grant, or Other Funding						
Total	\$4,510,223	\$3,706,766	\$4,060,582	\$4,182,400	\$4,307,871	\$20,767,842
Estimated New Costs by Year						
Category	1st	2nd	3rd	4th	5th	Total
Program Administration and Faculty and Staff Salaries	\$2,861,131	\$2,946,965	\$3,035,373	\$3,126,435	\$3,220,228	\$15,190,132
Facilities, Equipment, Supplies, and Materials	\$5,250	\$5,355	\$5,462	\$5,571	\$5,683	\$27,321
Library Resources						
Other (Admin Overhead)	\$902,045	\$741,353	\$812,116	\$836,480	\$861,574	\$4,153,568
Total	\$3,768,426	\$3,693,673	\$3,852,951	\$3,968,486	\$4,087,485	\$19,371,021
Net Total (i.e., Sources of Financing Minus Estimated New Costs)	\$741,797	\$13,093	\$207,631	\$213,914	\$220,386	\$1,396,821

Budget Justification

Provide a brief explanation for all new costs and sources of financing identified in the Financial Support table.

Tuition and Funding: The AuE MS Program is a premier-priced program and is listed separate from normal tiered graduate programs due to the expensive delivery of the program. In-state students pay per-semester academic fees of \$6,950, while out-of-state students pay \$15,500 as of fall 2019. The AuE M.S degree program has approximately 180 students enrolled in fall of 2019. We calculated the average tuition collected per student is \$11,807/semester based on the mix of full-time, part-time, in-state and out-of-state students. This tuition funding is projected forward based on total enrollment in each year for each of the three semesters: fall, spring and summer. A planned tuition increase of 5% is proposed for the second year of the modified program. Each additional year, 3% average tuition increases are expected.

Program Administration: Automotive Engineering faculty salary market rates average \$116,000 overall for the department, which includes a mix of full, associate, and assistant professors, lecturers and research faculty. Faculty workload per course is projected at 25% per semester based on a 2:2 research productive faculty workload model. The average cost to teach a course is approximate \$29K/course, while the overall average course offerings per semester equal approximately 32 courses/semester for spring, fall and a small portion of courses taught summer due to internship requirements. Average faculty costs are expected to increase 3% each year based on previous compensation increases.

Facilities, Equipment, Supplies and Materials: New materials will be needed to advertise program curriculum changes. Marketing and advertising costs average \$5K each year, escalated 2%. Additional materials are projected at approximately \$250/year escalated 2%.

Other (Admin Overhead – 20% Tuition Revenue): Overhead is based on tuition revenue and supports departmental costs across academic programs at both the College and University level.

Evaluation and Assessment

Program Objectives	Student Learning Outcomes Aligned to Program Objectives	Methods of Assessment
Unchanged, remaining the same		

Will any the proposed modification impact the way the program is evaluated and assessed? If yes, explain.

- Yes
- No

Will the proposed modification affect or result in program-specific accreditation? If yes, explain; and, if the modification will result in the program seeking program-specific accreditation, provide the institution's plans to seek accreditation, including the expected timeline.

- Yes
- No

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Will the proposed modification affect or lead to licensure or certification? If yes, identify the licensure or certification.

Yes

No

Explain how the program will prepare students for this licensure or certification.

N/A

If the program is an Educator Preparation Program, does the proposed certification area require national recognition from a Specialized Professional Association (SPA)? If yes, describe the institution's plans to seek national recognition, including the expected timeline.

Yes

No