NEW PROGRAM PROPOSAL FORM

Name of Institution: **Clemson University**

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

Program Designation:

- ☐ Associate's Degree
- ☐ Master's Degree
- ☒ Bachelor's Degree: 4 Year
- ☐ Specialist
- ☐ Bachelor's Degree: 5 Year
- ☐ Doctoral Degree: Research/Scholarship (e.g., Ph.D. and DMA)
- ☐ Doctoral Degree: Professional Practice (e.g., Ed.D., D.N.P., J.D., Pharm.D., and M.D.)

Consider the program for supplemental Palmetto Fellows and LIFE Scholarship awards?

- ☒ Yes
- ☐ No

Proposed Date of Implementation: **Fall 2023**

CIP Code: **14.9999**

Delivery Site(s): **Clemson University Main Campus (50104) and Clemson University - Int'l Ctr. for Auto Research-iCAR (50115)**

Delivery Mode:

- ☒ Traditional/face-to-face
  *select if less than 25% online
- ☐ Distance Education
  - ☐ 100% online
  - ☐ Blended/hybrid (50% or more online)
  - ☐ Blended/hybrid (25-49% online)
  - ☐ Other distance education (explain if selected)

Program Contact Information (name, title, telephone number, and email address):
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Institutional Approvals and Dates of Approval (include department through Provost/Chief Academic Officer, President, and Board of Trustees approval):
University Curriculum Committee: 1 April 2022
Provost: 6 April 2022
Clemson University Board of Trustees: 27 April 2022

Background Information

State the nature and purpose of the proposed program, including target audience, centrality to institutional mission, and relation to the strategic plan.

Nature, Purpose and Background

The next generation of automotive engineers will be expected to work in a new landscape, a world shaped by new technologies and business models. While having a strong foundation in mechanical engineering, the proposed automotive engineering baccalaureate program focuses on the knowledge and skills needed in the new world of mobility. The automotive engineer of the future will need expertise not only in mechanical components but also in such disciplines as computing, automation, advanced manufacturing and materials, and electrical and human-factors engineering, among others. Concomitantly, the engineers in the automotive industry will need to think and work like systems engineers.

Indeed, by better integrating multi-disciplinary engineering tools and exploiting technologies like Artificial Intelligence (AI) to help analyze and automate the generation of design concepts, automotive engineers enhance the capabilities of automotive systems, and thereby help to empower the future of the mobility industry. The BS Automotive Engineering program prepares graduates to be independent thinkers in these domains while ensuring they have a broader understanding of systems integration through our practice-based training approach that culminates in a vehicle development capstone project. This new 124 credit hour degree program is aptly suited for college freshmen and associate degree holders that are enthusiastic about applying interdisciplinary skills to excel in the mobility industry. The credit load is comparable, albeit slightly smaller, than two similar BS programs currently offered at Clemson: Mechanical Engineering and Electrical Engineering.

Building on the foundations of humanities, social sciences, communication, physical and engineering sciences, and practice-based vehicle development training and laboratory experience, the BS Automotive Engineering program will prepare students for a dedicated professional career that requires innovating in response to dynamic changes within the mobility world. The program's graduates will have expertise across multiple disciplines, ranging from mechanical engineering to electronics, computer science, human factors, materials science, and manufacturing and systems engineering. This expanded skill set is emphasized by the ten clusters McKinsey & Company identify as relevant technologies shaping the future of the industry: e-hailing, semiconductors, autonomous vehicle sensors and advanced driver-assistance system components, connectivity/infotainment, electric vehicles and charging, batteries, autonomous vehicle software and mapping, telematics and intelligent traffic, backend/cybersecurity, and human-machine interface and voice recognition.

Alignment with Mission and Strategic Plan

Clemson University is uniquely positioned to be a leader, both nationally and globally, in supplying automotive engineers to skilled workforce in the automotive industry in response to growing demand. Leveraging the auto industry's shift to the Southeast and our success in offering MS, PhD, and certificate programs in automotive engineering, the new BS will provide a new educational path serving the institution's land grant mission and the State's need for an expanded, enhanced, and skilled workforce. Further, the new BS program will leverage the over $50 Million in public and private sector investments in the 250-acre CUICAR campus to increasingly support the state economic development efforts, graduating domestic students to fill workforce gaps. This program also supports two key elements of the University's strategic plan, Clemson*FORWARD*: strengthening our academic core, and supporting engagement of the University with external constituents, communities, and workforce partners.

Assessment of Need

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

The automotive industry is at a critical point, similar to the transitions that consumers made from typewriters to computers in the early 1990s, and from landlines to mobile phones in the early 2000s. This shift in transportation technology, however, will be even more far-reaching, changing how we commute and travel, build cities and roadways, reduce emissions linked to climate change, and create new opportunities for those currently unable to drive. To capitalize on these opportunities, multinational corporations as well as the industry as a whole are investing billions of dollars into new strategies and infrastructure in the next decade. They will need automotive engineers with relevant skill sets across multiple disciplines, and Clemson University is uniquely positioned to be a leader, both nationally and globally, in supplying them.

The proposed program leverages the auto industry's shift to the Southeast, new investments in new electrical and autonomous technologies, and our historical success in offering graduate degree programs and certificates as well as nondegree certificates in automotive engineering in order to launch an undergraduate degree program in the same field. Our recognized success and prominence in the automotive field coupled with the current mobility climate and increasing demand for automotive engineers make this a propitious time to launch an undergraduate automotive engineering degree. The program will offer increased educational opportunities for SC citizens, training them to think deeply and engage in social, scientific, and economic challenges of our time. Graduates will be entering one of the fastest growth sectors, and support South Carolina's automotive companies who employ 72,000 workers and make an annual economic impact of $27 billion according to the SC Department of Commerce. The State's auto industry has quadrupled over the past 20 years with capital investments reaching $9.2 billion in 2020, and 22,900 automotive jobs added from 2011 to 2020, making South Carolina's auto industry among the top 10 fastest-growing labor forces in the nation.

Transfer and Articulation

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

The new degree program does not have any specific agreements or memoranda related to transfer and articulation. However, it will provides opportunities for both 4-year students enrolled elsewhere and associate degree graduates to advance their knowledge and skills in an interdisciplinary program using the foundations of humanities, social sciences, communication, physical and engineering sciences, and practice-based vehicle development training and laboratory experience. Transfer students will be handled per existing transfer policies and processes.

Employment Opportunities

Graduates of this program will be in high demand, and prepared to make significant strides in the transformation of the automotive industry over the next quarter century. This program is not an additional option to the current market of technology-focused automotive programs which are geared toward technical jobs. The Automotive Engineering undergraduate degree will feed efforts such as design, analysis, and

long-term planning, and be one of the first undergraduate programs to enter the market. The program will seek ABET accreditation as quickly as possible.

A wide spectrum of career opportunities is open to the students in the mobility industry (land, air, and sea), as well as government and academia. Many graduates could continue their formal education in the department's renowned graduate programs, which produced the country's first PhD graduates (both male and female) in Automotive Engineering.

	State		National		Data Type and Source
Occupation	Expected Number of Jobs	Employment Projection	Expected Number of Jobs	Employment Projection	
Mechanical Engineer (Design Engineer, Process Engineer, Product Engineer, Test Engineer also included)	**7,100** (6,150 current + 950 new)	**15%**	**320,100** 299,200 current + 20,900 new	**7%**	https://www.careeronestop.org/Toolkit/Careers/Occupations/occupation-profile.aspx?keyword=Mechanical%20Engineers&onetcode=17-2141.00&location=South%20Carolina https://www.bls.gov/ooh/architecture-and-engineering/mechanical-engineers.htm
Quality Assurance Director / Industrial Production Managers	**3,560** (3,070 current + 490 new)	**16%**	**199,300** 189,300 current + 10,000 new	**5%**	https://www.careeronestop.org/Toolkit/Careers/Occupations/occupation-profile.aspx?keyword=Quality%20Control%20Systems%20Managers&onetcode=11-3051.01&location=south%20carolina
Industrial Designers Design Engineer	**610** (550 current + 60 new)	**11%**	**33,300** 31,500 current + 1,800 new	**6%**	https://www.bls.gov/ooh/arts-and-design/industrial-designers.htm
Materials Engineer	**710** (580 current + 130 new)	**22%**	**27,200** 25,100 current + 2,100 new	**8%**	https://www.careeronestop.org/Toolkit/Careers/Occupations/occupation-profile.aspx?keyword=Materials%20Engineers&onetcode=17-2131.00&location=South%20Carolina https://www.bls.gov/ooh/architecture-and-engineering/materials-engineers.htm
Electrical and Electronics Engineer	**2,870** (2,510 + 360 new)	**14%**	**333,600** 313,200 current + 20,400 new	**7%**	https://www.bls.gov/ooh/architecture-and-engineering/electrical-and-electronics-engineers.htm

Supporting Evidence of Anticipated Employment Opportunities

Provide supporting evidence of anticipated employment opportunities for graduates.

The table above is a limited snapshot of the countless federally-coded occupational opportunities open to our graduates. Our engineering undergraduates currently interning provide an indication of how sought after their diverse skill sets are. In Summer 2022, there are Clemson undergraduate students working in engineering positions at BMW Manufacturing, Tesla, Mercedes Benz Vans, Robert Bosch, FEV, Cummins, Magna Drive, Los Alamos National Lab, and Proterra just to name a few. Our graduates are located at many of those companies as well as Ford Motor Company, GM, Honda R&D, Toyota, Rivian, and more. These job sectors are diverse, ranging from manufacturing, to cybersecurity, to racing– and everything in between. The multidisciplinary nature of automotive engineering allows graduates to explore opportunities related to the auto industry, as well as similar applications outside the automotive sector.

Description of the Program

Detailed Enrollment Model

Projected Enrollment												
Year	***Fall Headcount***				***Spring Headcount***				***Summer Headcount***			
	New	***Continuing***	***Lost***	***Graduate***	***New***	***Continuing***	***Lost***	***Graduate***	***New***	***Continuing***	***Lost***	***Graduate***
2023-24	*5*	*0*	*0*	*0*	*0*	*5*	*0*	*0*	*0*	*0*	*0*	*0*
2024-25	*25*	*5*	*2*	*0*	*0*	*28*	*0*	*0*	*0*	*0*	*0*	*0*
2025-26	*45*	*28*	*3*	*0*	*0*	*70*	*0*	*0*	*0*	*0*	*0*	*0*
2026-27	*72*	*70*	*5*	*0*	*0*	*137*	*0*	*3*	*0*	*0*	*0*	*0*
2027-28	*90*	*134*	*6*	*0*	*0*	*218*	*0*	*22*	*0*	*0*	*0*	*0*

Projected Enrollment			
Year	Fall Headcount	Spring Headcount	Summer Headcount
2023-24	5	5	0
2024-25	30	28	0
2025-26	73	70	0
2026-27	142	137	0
2027-28	224	218	0

Explain how the enrollment projections were calculated.

Enrollment projection numbers are based on multiple internal and external sources to provide the total peak enrollment. In this instance, it is expected between years 6 and 7. Peak enrollment was calculated by taking peer institutions' enrollment data (*e.g.*, Purdue and Ferris State) and finding the ratio of students enrolled in these programs compared to the school's total engineering population. The enrollment ratios in automotive engineering technology and motorsports engineering programs ranged between 5% to 10% of the enrolled engineering/ engineering technology population. An automotive population that is 7% of the total enrolled student engineering population would lead to a peak cohort size of 103 students.

Due to the differences in the proposed program from current peers in conjunction with industry demand in SC, it is expected the program will exceed this figure. In particular, industry will demand students with an industry-defined required skillset, which will drive enrollment into programs with an aligned curriculum. Based on South Carolina Commission on Higher Education data, CECAS is the leader in SC's engineering workforce, enrolling more students than all other SC 4-year colleges combined. The U.S. Department of Labor predicts automotive engineers will rise by 15% from 2018 to 2028 in SC, GA, and Alabama, far outpacing the 4% growth predicted for the country—this suggests peak program enrollment could be 3-4 times that of the peer estimate made above. Indeed, automotive companies employ 72,000 workers in S.C. alone and account for an annual economic impact of $27 billion according to the SC Department of Commerce. Between 2024 and 2028, the SC Automotive Engineer Workforce Projection anticipates an average of 1,037 additional jobs per year. The college believes a realistic, best-case enrollment scenario for the program is about 12% of the additional jobs per year, or 125 new students per year, based on these numbers.

Due to enrollment management at Clemson University, we also had to consider the organic growth of this program—*i.e.*, how many students would be truly new to the program and how many students would "melt" from our other engineering programs. Working with Clemson's Office of Admissions to understand their enrollment management practices and priorities, we developed conservative projections. When determining the scale-up of the cohort sizes, trends from the automotive engineering undergraduate certificate were utilized to conclude that it would take four to six years to build momentum and reach a steady cohort size.

The program will operate primarily in a standard undergraduate cohort model, with students enrolling in the fall and subsequently graduating in a spring semester. As with our other undergraduate engineering programs, students will spend their first year in the General Engineering curricular cohort before spending their final 3 years enrolled in the BS program. The withdrawal rate was calculated using based on historical withdrawal rates. As noted above, the program anticipates reaching the maximum new cohort size of 125 students by year 6, at which point it will remain relatively static. This will lead to a maximum total enrollment of approximately 470 students by year 10.

Besides the general institutional admission requirements, are there any separate or additional admission requirements for the proposed program? If yes, explain.

☐ Yes

☒ No

Curriculum

New Courses

List and provide course descriptions for new courses.

- AUE 2010 Human Factors and Fundamentals of Vehicle Design (3 cr)
    - Introduction to vehicle design from the end users' perspective (e.g. market segments, user studies, cognition, perception, ethics). These principles which apply widely across engineering disciplines will be exemplified in the automotive context.

- AUE 2020 Introduction to Automotive Systems (3 cr)
    - Introduction to systems thinking as applied to the description, modeling and control of vehicle systems. Theory and function of the most common vehicle systems, including the engine, fuel, exhaust, lubrication, cooling, power electronics, controls, transmission, steering, braking, suspension, tires, chassis and vehicle body systems.

- AUE 3010 Energy for Mobility (3 cr)
    - This course is designed to help students understand the energy transfer process within a single vehicle and between a vehicle and its surrounding environment such as electric charging infrastructure, renewable energy sources, and the power grid. Basic energy components will be introduced along with an overview of vehicle charging, grid integration, fossil fuels versus renewable low-carbon fuels. The concept of life-cycle CO_2 emissions and the impact of each energy carrier on life-cycle CO_2 will be discussed.

- AUE 3020 Propulsion Systems Design (3 cr)
    - This course covers a deeper analysis of the vehicle's powertrain components and the energy conversion processes including combustion engines, batteries, electric motors, fuel cells, etc. The details of energy conversion and storage in hybrids and EVs and propulsion systems and sub-system design is discussed. Powertrain operational requirements are discussed in the context of vehicle-level performance, fuel economy, and emissions.

- AUE 3110 Introduction to Automotive Manufacturing (3 cr)
    - A course which covers the automotive order-to-delivery process, beginning at the system level to include supply chain and factory organization overview, then coverage of the critical manufacturing technologies and support systems. The course relates the system requirements to major materials and design architectures, with special emphasis on the evolution of vehicle designs in recent years and how they have driven changes in automotive manufacturing strategy. Key performance indicators are reviewed, including details of modeling cost for manufacturing operations.

- AUE 4210 Automotive Multibody Systems Design (3 cr)
    - Theoretical and practical foundation for design/analysis of articulated mechanical systems in automotive applications (e.g. Ackerman steering, Suspension systems). Vector and matrix methods are employed for formulation with an emphasis on developing and cross-validating analytical, hand-coded computational and CAE simulation models.

- AUE 4220 Automotive Electronics Integration (3 cr)
    - A fundamental automotive electronics course to cover the automotive electronic systems, automotive sensors, automotive actuators, automotive batteries and buses, automotive controllers, automotive sensing signal processing technologies, automotive control technologies, and hands-on embedded automotive electronics practice.

- AUE 4310 Automotive Engineering Design Project (3 cr)
    - Project-based application of engineering concepts to address real-world, open-ended, multidisciplinary automotive-focused opportunities. Students work in small teams to design, analyze, prototype, and validate their solutions with the guidance of faculty mentors. Regular technical documentation and professional communication of results is required. The course contains a combination of lectures and weekly mentoring sessions.

Total Credit Hours Required: **124**

Curriculum by Year					
Course Name	**Credit Hours**	**Course Name**	**Credit Hours**	**Course Name**	**Credit Hours**
Year 1					
Fall		**Spring**		**Summer**	
CH 1010 General Chemistry	4	ENGR 1410 Programming and Problem Solving	3		
ENGL 1030 Composition and Rhetoric	3	ENGR 2080 Engineering Graphics and Machine Design	2		
ENGR 1020 Engineering Disciplines and Skills	3	MATH 1080 Calculus of One Variable II	4		
MATH 1060 Calculus of One Variable I	4	PHYS 1220 Physics with Calculus I	3		
TBD Arts and Humanities Requirement or Social Science Requirement[1]	3	PHYS 1240 Physics Laboratory I	1		
		TBD Arts and Humanities Requirement or Social Science Requirement[1]	3		
Total Semester Hours	17	Total Semester Hours	16	Total Semester Hours	
Year 2					
Fall		**Spring**		**Summer**	
MATH 2060 Calculus of Several Variables	4	MATH 2080 Intro to Ordinary Differential Equations	4		
PHYS 2210 Physics with Calculus II	3	ME 2060 Dynamics	3		
ME 2050 Statics for Mechanical Engineers	3	ME 2030 Foundations of Thermal and Fluid Systems	3		
AUE 2010 Human Factors and Fundamentals of Vehicle Design	3	ME 2220 Mechanical Engineering Lab I	2		
AUE 2020 Introduction to Automotive Systems	3	ECE 2070 Basic Electrical Engineering	2		
		ECE 2080 Electrical Engineering Laboratory	1		
Total Semester Hours	16	Total Semester Hours	15	Total Semester Hours	

Course Name	Credit Hours	Course Name	Credit Hours	Course Name	Credit Hours
Year 3					
Fall		**Spring**		**Summer**	
MATH 3650 Numerical Methods for Engineers	3	ME 3050 Modeling and Analysis of Dynamic Systems	3		
ME 2040 Mechanics of Materials	3	AUE 3020 Propulsion Systems Design	3		
AUE 3010 Energy for Mobility	3	AUE 4210 Automotive Multibody Systems Design	3		
AUE 3110 Introduction to Automotive Manufacturing	3	AUE 4220 Automotive Electronics Integration	3		
MSE 2100 Introduction to Materials Science-	3	TBD Technical Elective	3		
Total Semester Hours	15	Total Semester Hours	15	Total Semester Hours	
Year 4					
Fall		**Spring**		**Summer**	
AUE 4080 Vehicle Testing and Characterization	3	AUE 4310 Automotive Engineering Design Project	3		
AUE 4600 Dynamic Performance of Vehicles	3	TBD Arts and Humanities Requirement or Social Science Requirement[1]	3		
TBD Technical Elective	3	TBD Arts and Humanities Requirement or Social Science Requirement[1]	3		
TBD Technical Elective	3	TBD Global Challenges Requirement	3		
TBD Oral Communication Requirement	3	TBD Ethics and Professional Practice Requirement	3		
Total Semester Hours	15	Total Semester Hours	15	Total Semester Hours	

[1]One of the Social Science requirement courses should be utilized to fulfill the REACH Act graduation requirement (current options are HIST 1010, POSC 1010, and POSC 1030)

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.

Program Name and Designation	Total Credit Hours	Institution	Similarities	Differences
Mechanical Engineering, BS	125	Clemson University	-Many of the same introduction level courses during freshman and sophomore year -Some overlap between content in the disciplines -Similar credit hour count	-AuE is a more specialized, focused, cross disciplinary field that aligns with overall automotive growth within South Carolina -More direct automotive-applicable classes for AuE than ME -Capstone will be oriented towards the systems integration of a vehicle vs ME capstone
Electrical Engineering, BS	127	Clemson University	-Some common basic electrical engineering courses in both majors -Students in EE can focus on cybersecurity, which is also a growing part of Automotive Engineering -Many of the disciplines in Automotive Engineering, such as robotics, autonomy, manufacturing, *etc* rely on basic knowledge of EE	-AuE is a more specialized, focused, cross-disciplinary field that aligns with overall automotive growth within South Carolina -AuE allows for deeper exploration of electrical components in the automotive sector, such as electrification, autonomous vehicles, robots on an assembly line, etc. -Capstone will be oriented towards the systems integration of a vehicle vs EE capstone
Mechanical Engineering, BS	134	The Citadel	-Overlap of some course descriptions, disciplines -Some interest areas are common, like power and energy, and composites.	--AuE is a more specialized, focused, cross-disciplinary field that aligns with overall automotive growth within South Carolina -Clemson program is fewer credit hours -The Citadel ME program can focus on Power and Energy, Manufacturing, Aeronautical Systems, Composites, or Mechatronics, whereas the Clemson AUE degree focuses on Materials and Manufacturing, Powertrains and Drivelines, Vehicle Performance, or Vehicle Autonomy
Mechanical Engineering, BSE	125	University of South Carolina	-Similar credit hour requirements -Some content overlap between the disciplines	-AuE is a more specialized, focused, cross-disciplinary field that aligns with overall automotive growth within South Carolina -Capstone will be oriented toward the systems integration of a vehicle than the final project for the USC degree

Faculty

Rank and Full- or Part-time	Courses Taught for the Program	Academic Degrees and Coursework Relevant to Courses Taught, Including Institution and Major	Other Qualifications and Relevant Professional Experience (e.g., licensures, certifications, years in industry, etc.)
Associate Professor, Full Time	AuE 2010 Human Factors and Fundamentals of Vehicle Design	Ph.D. in Industrial and Organizational Psychology, Clemson University, 2005 MS in Applied Psychology – Human Factors Engineering, Clemson University, 2002	-Clinical Research Faculty at Prisma Health since 2009 -Institute for Advancement of Health Care Scholar
McQueen Quattlebaum Assistant Professor, Full Time	AuE 4220 Automotive Electronics Integration	Ph.D. in Electrical Engineering, Michigan State University, 2014 MS in Control Theory and Control Engineering, South China University of Technology, 2008	-Director, Collaborative Robotics and Automations (CRA) Lab -CECAS College Faculty Collaboration Award (2020) -SAE Ralph R. Teetor Educational Award (2020) -NSF Faculty Early Career Development (CAREER) Award (2019) -NSF CISE Research Initiation Initiative (CRII) Award (2018) -SAE Trevor O. Jones Outstanding Paper Award (2017) -IEEE Senior Member -ASME Member -SAE Member
Michelin Endowed Chair in Vehicle Automation, Full Time	AuE 4210 Automotive Multibody Systems Design	Ph.D. in Mechanical Engineering and Applied Mechanics, University of Pennsylvania, 1998	-Connected and Automated Vehicles (CAV) Lab Founder -Editor-in-Chief, ASME Journal of Mechanisms and Robotics -NSF CAREER Award -Petro-Canada Young Innovator Award -ASME Design Materials and Manufacturing Segment Leadership -Chair of ASME Mechanisms and Robotics Committee -Executive Committee of IEEE Robotics and Automation Society

Associate Professor, Full Time	AUE 3020 Propulsion Systems Design	Ph.D. in Mechanical Engineering, University of Michigan, 2013 MS in Mechanical Engineering, University of Michigan, 2011	-ASME Member -SAE World Congress Organizer -SAE Ralph R. Teetor Award (2022)
Acting Department Chair, BMW Endowed Chair in Automotive Manufacturing, Full Time	AuE 3110 Introduction to Automotive Manufacturing	Ph.D. in Mechanical Engineering, Georgia Tech, 2006 MS in Mechanical Engineering, Georgia Tech, 2003	-Professional Engineer (2006) -SME Certified Manufacturing Engineer (2014) -ASQ Certified Quality Engineer (1996) -PI, Clemson THINKER program -Director, Clemson University Vehicle Assembly Center (VAC) -Institution of Mechanical Engineers George Stevenson Gold Medal (2013) -Society of Automotive Engineers Ralph R. Teetor Educational Award (2011) -South Carolina Governor's Young Researcher Award for Excellence in Scientific Research (2011) -ASME Manufacturing Engineering Division Award for Best Organizer of -Symposium and Sessions (BOSS) (2011) -National Science Foundation CAREER Award (2010) -General Motors Manufacturing Scholar (2005-2006) -Best Presentation Award, International Conference on Agility, Helsinki (2005) -American Society for Quality Joe D. Simmons Scholar (2004) -CECAS Dean's Professorship (2015 - 2018) -McQueen Quattlebaum Faculty Achievement Award (2013) -Clemson University Board of Trustees Award for Faculty Excellence (2011) -Clemson University College of Engineering, Computing and Applied Sciences Collaboration Award (2010)
BMW Endowed Chair in Systems Integration, Full Time	AuE 2010 Introduction to Automotive Systems	TBD	
Kulwicki Endowed Professor, Full Time	AuE 4310 Automotive Engineering Design Project	Ph.D. in Mechanical Engineering, University of Michigan, 2008	-Deputy Director, Clemson VIPR-GS -SAE Ralph R. Teetor Educational Award (2017) -Murray Stokely Award for Excellence in Teaching (2015)

			-Select Committee Member, Emerging Trends and Technology Network at SEMA -SAE Combustion Committee Me -Associate Editor, International Journal of Powertrains
Associate Professor, Full Time	AuE 3010 Energy for Mobility	Ph.D. in Electronic and Electrical Engineering, University of Strathclyde Ph.D. in Mathematics, Xi'an Jiaotong University	-IET Fellow -IFAC TC6.3 Member -Chartered Engineer -Associate Editor for IET Renewable Power Generation and IET Smart Grid
Lecturer, Part Time	AuE 4080 Vehicle Testing and Characterization	MS in Science, Structural Dynamics, University of Cincinnati, 1986	-SAE Member
Jenkins Endowed Professor, Full Time	AuE 4930/6930 Lightweight Design Using Composites	Ph.D. in Mechanical Engineering, University of Wisconsin-Milwaukee, 2009 MS in Mechanical Engineering, University of Toledo, 2005	-Founding Director of Clemson Composites Center -Associate Editor of SAE International Journal of Materials and Manufacturing -Series Editor of Polymer Science and Plastics Engineering at Wiley-Scrivener -Editorial Board of Journal of Renewable Materials -Board Member, Injection Molding Division of the Society of Plastics Engineers -NCEES Engineer-in-Training (2007)

Total FTE (full-time equivalent) needed to support the proposed program:
Faculty: 3
Staff: 5
Administration: 0

Faculty, Staff, and Administrative Personnel
Discuss the Faculty, Staff, and Administrative Personnel needs of the program.

Considering the 10 cluster areas described earlier from the McKinsey report, new tenure/tenure track faculty are needed to fill expertise gaps and develop some of the new courses for the program. Three technical staff are needed to support undergraduate capstones, the undergraduate Deep Orange applied training, and expanded research due to the growth of the department. An additional student services staff member will be needed within the department to provide professional advising to the undergraduate students, and additional IT support staff on the CU-ICAR campus will be required to support the undergraduate students. Current staff within the department are at capacity with the graduate program.

These personnel needs are included in the proposal budget. The extant robust administrative structure of the Department of Automotive Engineering will be sufficient to serve the new baccalaureate program.

Resources

Library and Learning Resources

Explain how current library/learning collections, databases, resources, and services specific to the discipline, including those provided by PASCAL, can support the proposed program. Identify additional library resources needed.

Prior to this program's conception and development, Clemson Libraries was already working with the Department of Automotive Engineering to establish an enhanced presence on the CU-ICAR campus for the graduate population. This is scheduled to begin in fall 2022 and will ultimately serve the undergraduate population too.

Student Support Services

Explain how current academic support services will support the proposed program. Identify new services needed and provide any estimated costs associated with these services.

Additional dining options are needed on the CU-ICAR campus with the incorporation of an undergraduate program. However, such options are already in development as part of unrelated plans to expand the CU-ICAR campus for additional industrial partners. This will result in no incremental cost to the academic program.

Additional transportation services will be needed between Clemson's main campus and the CU-ICAR campus. It is predicted that most of the students will continue to live in Clemson and commute to CU-ICAR based on Clemson's nursing program that offers a similar program format of two years on main campus, and two years in Greenville. Additional shuttle routes to nearby Whole Foods and restaurants to further expand the dining options to the entire CU-ICAR community are also planned for. Projected annual, steady state costs are $100,000 for these expanded transportation services.

The program will not affect the existing growth and cost of student health services. The virtual healthcare options from the University are fit to accommodate these students' needs while on the CU-ICAR campus. Students will still be able to access in-person care on the main campus, and educational materials will be developed and shared with the undergraduate students for any in-person care they would need to access in Greenville inasmuch as many undergraduates hold private insurance.

Physical Resources/Facilities

Identify the physical facilities needed to support the program and the institution's plan for meeting the requirements.

Clemson currently leases the 2nd floor of the One Research Drive (ORD) building on the CU-ICAR campus. The floor houses a group of Computer Science faculty, and supports an advanced manufacturing student program. When the BS Automotive Engineering opens, there will be space available to accommodate the program needs in terms of incremental classrooms, offices, student study space, and teaching labs. This space is already secured and can accommodate this program until it grows beyond 100 undergraduate students at the CU-ICAR campus. Considering our enrolment projections, this should be sufficient for the foreseeable future. The long-range planning mechanisms of

Clemson's facilities and operations team are conscious that, should this program exceed enrollment projections, an expansion of space would be required.

Upfit of additional private offices will be required to accommodate the faculty growth, and the student services hire who need appropriate space to advise students.

Expansion of a machine shop will also be required to support undergraduate capstone and Deep Orange vehicle projects. These costs are included in the proposed budget.

Equipment

Identify new instructional equipment needed for the proposed program.

As part of the expansion of the machine shop, a lathe, mill and welder will need to be secured. These costs are included in the proposed budget.

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

In the short term, as the program first initiates admissions and enrollment, we expect some 'melt' of enrollment from other disciplines within the engineering college to this program. Over time, this will even out and refreeze as the Clemson engineering college expects to grow overall enrollment for the foreseeable future. We note that the temporary melt will have no effect on these other programs' viability and sustainability inasmuch as our engineering programs—particularly the mechanical engineering program from which an automotive engineering program would likely initially draw students—are amongst the most highly enrolled at Clemson.

Financial Support

Sources of Financing for the Program by Year												
	1st		2nd		3rd		4th		5th		Grand Total	
Category	**New**	**Total**	**New**	**Total**	**New**	**Total**	**New**	**Total**	**New**	**Total**	**New**	**Total**
Tuition Funding	$81,600	$81,600	$482,746	$482,746	$1,214,022	$1,214,022	$2,415,989	$2,415,989	$3,904,030	$3,904,030	$8,098,386	$8,098,386
Program-Specific Fees	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Special State Appropriation	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reallocation of Existing Funds	$51,450	$51,450	$53,008	$53,008	$54,615	$54,615	$56,271	$56,271	$57,979	$57,979	$273,322	$273,322
Federal, Grant, or Other Funding	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$133,050	$133,050	$535,754	$535,754	$1,268,637	$1,268,637	$2,472,260	$2,472,260	$3,962,008	$3,962,008	$8,371,708	$8,371,708
Estimated Costs Associated with Implementing the Program by Year												
	1st		2nd		3rd		4th		5th		Grand Total	
Category	**New**	**Total**	**New**	**Total**	**New**	**Total**	**New**	**Total**	**New**	**Total**	**New**	**Total**
Program Administration and Faculty/Staff Salaries	$293,010	$293,010	$455,939	$455,939	$843,409	$843,409	$998,978	$998,978	$1,029,294	$1,029,294	$3,620,631	$3,620,631
Facilities, Equipment, Supplies, and Materials	$147,850	$147,850	$1,032,915	$1,032,915	$887,003	$887,003	$992,128	$992,128	$1,133,054	$1,133,054	$4,192,950	$4,192,950
Library Resources	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other (specify)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Total	$440,860	$440,860	$1,488,854	$1,488,854	$1,730,412	$1,730,412	$1,991,106	$1,991,106	$2,162,348	$2,162,348	$7,813,581	$7,813,581
Net Total (Sources of Financing Minus Estimated Costs)	-$307,810	-$307,810	-$953,101	-$953,101	-$461,776	-$461,776	$481,153	$481,153	$1,799,660	$1,799,660	$558,127	$558,127

Note: New costs - costs incurred solely as a result of implementing this program. Total costs - new costs; program's share of costs of existing resources used to support the program; and any other costs redirected to the program.

Budget Justification

Provide an explanation for all costs and sources of financing identified in the Financial Support table. Include an analysis of cost-effectiveness and return on investment and address any impacts to tuition, other programs, services, facilities, and the institution overall.

The new undergraduate degree program will be funded and supported by reallocation of resources within the College of Engineering, Computing, and Applied Science, and tuition revenue. Other funding not shown above is support from central administration, and the exact amount is to be determined. Tuition revenue is calculated using undergraduate tuition, currently set at $544 per credit hour.

Reallocation of Existing Funds represents existing faculty workload within the College. Faculty workload is calculated at $12.5K per course. Program Administration and Faculty and Staff Salary is supported by Reallocation of Existing Funds for current faculty workload and courses already taught within the College. It also includes three, new tenure-track faculty positions beginning in Years 1, 2, and 3 at $105K plus fringe each. New staff members will begin in Years 2, 3, and 4 for technical program support, IT support, and student services. Staff positions are budgeted between $50K and $80K and are subject to change.

Facilities, Equipment, Supplies, and Materials include marketing and advertising, operating supplies, and space and upfit costs. Marketing and advertising expenses are budgeted at $17K in Year 1 and will deescalate to $4.7K annually by Year 6. Operating supplies includes one-time classroom technology upgrades at the instructional site, student engagement support for specialized programs, and instructional technology and equipment. Other operational expenses are designated for administrative supplies and shuttle contracts for free student transportation. The Space and Upfit costs are budgeted for the lease contract of the instructional site beginning in Year 2, as well as facilities upfit for Years 1 and 2.

All impacts on other programs, services, and facilities have been addressed by the inclusion of new staff positions and space and upfit. There will be no impact on institutional tuition. The program is expected to recover start-up costs by Year 4 and will ultimately create additional undergraduate and graduate research and support for the College.

Evaluation and Assessment

Graduates of the BS Automotive Engineering program are expected to be able to meet the program objectives listed in the table below. Our student outcomes are required by ABET to prepare graduates to enter professional engineering practice.

Program Objectives	Student Learning Outcomes Aligned to Program Objectives	Methods of Assessment
Our graduates demonstrate expertise in problem-solving through creative and effective application of fundamental knowledge, integral engineering practices, and clear communication.	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys. Direct assessment measures will be determined by the faculty, and at least two direct measures will be used as evidence of student learning for each component of

		the student learning outcomes. These direct measures will be chosen and assessed, with collaboration from the faculty, from test questions, quizzes, reports, etc. Indirect assessments of student learning will be used to assess student attitudes and/or their perceived extent of their learning experience.
Our graduates demonstrate expertise in problem-solving through creative and effective application of fundamental knowledge, integral engineering practices, and clear communication.	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys. Direct assessment measures will be determined by the faculty, and at least two direct measures will be used as evidence of student learning for each component of the student learning outcomes. These direct measures will be chosen and assessed, with collaboration from the faculty, from test questions, quizzes, reports, etc. Indirect assessments of student learning will be used to assess student attitudes and/or their perceived extent of their learning experience.
Our graduates demonstrate expertise in problem-solving through creative and effective application of fundamental knowledge, integral engineering practices, and clear communication.	An ability to communicate effectively with a range of audiences.	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys.
Our graduates will possess world-class knowledge and continuously seek to expand their current knowledge base that will position them at the forefront of their field, whether in industry, government, or higher education.	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys. Direct assessment measures will be determined by the faculty, and at least two direct measures will be used as evidence of student learning for each component of the student learning outcomes. These direct measures will be chosen and assessed, with collaboration from the faculty, from test questions, quizzes, reports, etc. Indirect assessments of student learning will be used to assess student attitudes and/or their perceived extent of their learning experience.
Our graduates will be innovative leaders in their respective fields of engineering and science, leveraging their skills, knowledge, and experience	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys. Direct assessment measures will be determined by the faculty, and at least two

to address engineering grand challenges at a global scale.	goals, plan tasks, and meet objectives.	direct measures will be used as evidence of student learning for each component of the student learning outcomes. These direct measures will be chosen and assessed, with collaboration from the faculty, from test questions, quizzes, reports, etc. Indirect assessments of student learning will be used to assess student attitudes and/or their perceived extent of their learning experience.
Our graduates will be engaged in advanced study, are progressing, and have attained advanced learning.	An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys. Direct assessment measures will be determined by the faculty, and at least two direct measures will be used as evidence of student learning for each component of the student learning outcomes. These direct measures will be chosen and assessed, with collaboration from the faculty, from test questions, quizzes, reports, etc. Indirect assessments of student learning will be used to assess student attitudes and/or their perceived extent of their learning experience.
Our graduates will be engaged in advanced study, are progressing, and have attained advanced learning.	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	Direct assessment in Automotive Engineering courses, indirect assessment via exit interviews and surveys. Direct assessment measures will be determined by the faculty, and at least two direct measures will be used as evidence of student learning for each component of the student learning outcomes. These direct measures will be chosen and assessed, with collaboration from the faculty, from test questions, quizzes, reports, etc. Indirect assessments of student learning will be used to assess student attitudes and/or their perceived extent of their learning experience.

Explain how the proposed program, including all program objectives, will be evaluated, along with plans to track employment. Describe how assessment data will be used.

The proposed program will be evaluated directly via assessment in Automotive Engineering courses, and indirectly via exit interviews and surveys. The assessment data will be used to ensure we are meeting the program objectives and the student outcomes. The University's Office of Institutional Effectiveness utilizes several forms of graduates' employment incomes are trackable at multiple timepoints past graduation using, e.g., Clemson's implementation of the National Association of Colleges and Employers' First Destinations Survey and publicly available data from the federal College Scorecard initiative (which will be available at the program level for this degree program).

Accreditation and Licensure/Certification

Will the institution seek program-specific accreditation (e.g., CAEP, ABET, NASM, etc.)? If yes, describe the institution's plans to seek accreditation, including the expected timeline.

☒Yes

☐No

Clemson will seek ABET accreditation through its engineering college once the program has graduates. This process would be expected to begin in the summer of 2027.

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

☒Yes

☐No

Yes, FE (Fundamentals of Engineering, the first of two examinations required to become licensed as a Professional Engineer (P.E.))

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

The curriculum has a set of courses that will provide relevant knowledge and understanding for the student to successfully compete for the FE exam under General or Mechanical Engineering categories. Some of the course listings are: Mathematics, Chemistry, Instrumentation and Controls, Engineering Ethics and Societal Impacts, Safety, Health, and Environment, Engineering Economics, Statics, Dynamics, Strength of Materials, Materials, Fluid Mechanics, Basic Electrical Engineering, Thermodynamics and Heat Transfer.

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