NEW PROGRAM PROPOSAL FORM

Name of Institution: South Carolina State University

Name of Program (include degree designation and all concentrations, options, or tracks):
BS Mechatronics 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 2020

CIP Code:144201

Delivery Site(s): South Carolina State University, Main Campus, Orangeburg, South Carolina
Orangeburg Calhoun Technical College, Orangeburg, South Carolina
Piedmont Technical College, Greenwood, South Carolina

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)

Other Distance Education: SC State intends to offer this program in partnership with Piedmont Technical College and Orangeburg Calhoun Technical College partly on the campuses of those institutions. Thus, this proposal also seeks approval to offer the program at those sites. SC State has an articulation agreement with the SC Technical College System.

Program Contact Information (name, title, telephone number, and email address):
Dr. Hasanul Basher, Chair
Department of Engineering Technology
Telephone: (803) 536-8474, Email: hbasher@scsu.edu

Institutional Approvals and Dates of Approval (include department through Provost/Chief Academic Officer, President, and Board of Trustees approval):

Chair, Department of Engineering Technology	**February 27, 2019**
Dean, College of Science, Tech., Engineering, Math., and Transportation	**February 27, 2019**
Vice president of Academic Affairs:	**March 27, 2019**
Educational Policies Council:	**May 28, 2019**

Faculty Senate:	**July 08, 2019**
President:	**December 18, 2019**
Board of Trustees:	**December 18, 2019**

Background Information

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

Purpose: South Carolina State University (SCSU) requests approval of a Bachelor of Science degree in Mechatronics Engineering. Mechatronics is an engineering field that is multidisciplinary in nature and encompasses areas such as mechanics, electronics, sensors, actuators, control systems and computing, and utilizes principles of these areas to solutions and systems. Mechatronics Engineers are experts in a variety of engineering fields from mechanical engineering to electrical engineering. They work on the design, testing and manufacturing of smart systems in areas such as robotics, medical and assistive technology, human-machine interaction, manufacturing and unmanned aerial and ground vehicles. With technology being a crucial part of our lives, there will be an increasing number of opportunities in mechatronics engineering in the coming years. A good knowledge base in this field of engineering is required if our engineering graduates are to be relevant to today's industry. With the spread of mechatronics to all kinds of engineered products and systems, it has become imperative that a whole new system of engineering be initiated to impart education and training in its principles and practices.

The primary purpose of this program is to increase the number of engineering graduates trained in mechatronics engineering to address the manpower needs of modern industry that stem from rapid technological growth. The implementation of the proposed Mechatronics Engineering program will serve to ameliorate not only the manpower needs of modern industry in South Carolina and the nation. The program will also provide opportunities for a diverse student population to pursue an undergraduate degree in Mechatronics Engineering.

Very few universities in the United States and none in the State of South Carolina offer a Bachelor of Science degree in Mechatronics Engineering. The implementation of such a program will increase its visibility in the state, nation and around the world. The program will promote the understanding of the multi-disciplinary field of mechatronics engineering, advance knowledge in the field by increasing the number of qualified graduates for the nation's mechatronics engineering needs, and address knowledge skills gaps identified by relevant industry. By addressing needs that have arisen from a changing technological world, SC State University plans to help students stay current, be educated and trained for the technological challenges of tomorrow and be competitive in their professions. This fits well with the university's student-centered mission, which states, in part, "South Carolina State University is a historically Black public 1890 land-grant comprehensive institution. SC State University is committed to providing affordable and accessible quality baccalaureate programs in the areas of business, applied professional sciences, mathematics, natural sciences, engineering, engineering technology, education, arts, and humanities. SC State University prepares highly skilled, competent and socially aware graduates to enable them to work and live productively in a dynamic, global society."

As the University moves more into the 21st century, the focus needs to be on a wider population of students. The project is geared for all STEM majors in South Carolina, especially those who wish to work in the state's growing manufacturing industry that needs engineers with interdisciplinary skills. The broader impacts of the proposed new program include attracting a higher number of minorities, underserved, underrepresented and low-income students to Mechatronics Engineering. The proposed new program will assist them in achieving their educational goals by providing local industry with well-qualified employees, impacting the local region by increasing the number of STEM-knowledgeable citizens.

Target Audience: South Carolina State University has established an MOU with the SC Technical College System. Most of the two-year technical colleges offer an Associate degree in Mechatronics Technology. This program will be attractive to graduates from those programs who wish to earn a BS degree in Mechatronics Engineering.

Centrality of University Mission: The preparation of "highly skilled, competent and socially aware graduates" is at the core of SCSU's mission. The Mechatronics Engineering program will prepare graduates with those attributes. In addition, the program will add to the number of graduates who are well qualified to take their place in the burgeoning manufacturing workforce in South Carolina. Through this proposed program, SC State will prepare undergraduates for the current technological needs of of the workforce. In this regard, the proposed new program strongly reflects the mission of the University.

Assessment of Need

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

Mechatronics is a multidisciplinary program that is in demand by industries to meet their manpower needs. Mechatronics encompasses areas such as mechanics, electronics and advanced control systems. A thorough knowledge base in these areas is required if engineering graduates are to be relevant in today's industry. With the spread of mechatronics to all kinds of engineered products and systems, it has become imperative that a whole new system of engineering be initiated to impart education in its principles and practices. This synergistic approach to solving engineering problems is extremely valuable in the workplace. With the emergence of Mechatronics since 1990, more industries are expanding their implementation of mechatronics systems. There is an increasing demand for engineers with the multidisciplinary training necessary to design these types of systems.

There has been a dramatic increase in mechatronics education at the university level across the globe in the last decade. This is expected to continue as integrated technologies continue to thrive in the marketplace. Mechatronics has become popular and very desirable engineering discipline in Japan and Asian countries. Similar trends are observed in the Australian continent as well.

In response to this anticipated demand, many engineering programs worldwide including the United States have begun offering minors or concentrations in mechatronics. Very few universities in the US and none in the State of South Carolina offer a Bachelor of Science degree in Mechatronics Engineering. This program will certainly help produce engineers with expertise to meet the demand of the industries in the state and the nation.

The undergraduate mechatronics track at the University of South Carolina, Columbia, includes courses from Mechanical and Electrical Engineering programs in addition to twelve (12) credits hours from a mechatronics list of courses and two (2) electives from control and dynamics, design and manufacturing, mechanics and materials, energy systems. A graduate certificate in Mechatronics Engineering can be earned from The Citadel in Charleston. The students in this program must complete 12 credit hours within a three-year period.

Only a few other universities in the US offer a degree in Mechatronics Engineering. These include California State University Chico, North Carolina State University (in conjunction with the University of North Carolina at Ashville), Southern Polytechnic State University, Middle Tennessee State University, University of Detroit Mercy, Vaughn College, and Lawrence Technological University

Mechatronics Engineering graduates can select from a wide spectrum of industries for career choices and can also serve in a variety of roles such as design engineers, software engineers, project planner, product designers, and project managers. Opportunities are also available to graduates in smaller companies that need generalists who can perform both mechanical and electrical engineering functions. The skills that students will acquire in this program will be valuable to employers from a variety of industrial sectors including aerospace, automotive, manufacturing, communications, defense, electronics, healthcare, and others. The employment opportunity data is given below in the Table 1.

Table I: Employment Opportunities

Occupation	State		National		Data Type and Source
	Expected Number of Jobs	Employment Projection	Expected Number of Jobs	Employment Projection	
Mechatronics Engineering	*In 2019, South Carolina employed 530 Mechatronics Engineers	The job market is expected to grow at the same rate as that of the whole nation (5%)	55,790 new Mechatronics jobs filled by 2018.	Annual increase of 5% over the next 10 years (2028)	www.recruiter.com www.ziprecruiter.com

*https://www.careerexplorer.com/careers/mechatronics-engineer/job-market/

Alan S. Brown, associate editor of *Society of Mechanical Engineers*, in an article entitled "Mechatronics and the Role of Engineers" stated in 2011, manufacturing companies desire "students trained to integrate electronics, controls, computers, and moving parts. For them, this is not where engineering is going, it is where engineering has arrived" (https://www.asme.org/topics-resources/content/mechatronics-and-the-role-of-engineers).

Note:

a. As more businesses advance their technologies and turn to sophisticated intelligent systems and robotics, mechatronics engineering will continue to grow in demand. Even manufacturing businesses considering a technology upgrade turn to mechatronics engineers in order to evaluate assembly line efficiency and costs (https://www.calu.edu/academics/undergraduate/bachelors/mechatronics-engineering-technology/what-can-you-do-with-a-mechatronics-degree.aspx).

b. According to *Composite Manufacturing*, "Most of the economic growth, around 91.5 percent, of the surrounding Greenville, S.C., metropolitan area is driven by the manufacturing industry. Three of the cities on the top 10 list of growing manufacturing cities are in South Carolina: Greenville, Summerville and Columbia." (http://compositesmanufacturingmagazine.com/2012/03/top-5-cities-growing manufacturing/2/).

c. Since mechatronics is a relatively new field, the Bureau of Labor Statistics (BLS) does not have any data on salary or job projection specifically for mechatronics engineers. While the BLS does not cite a specific employment outlook for mechatronics engineers, it predicts that the employment of all mechanical engineers would likely grow by 4% from 2018-2028, which is average (www.study.com).

d. Mechatronics engineers earn an average yearly salary of $101,980. Wages typically start from $51,830 and go up to $154,720 (www.recruiter.com).

Transfer and Articulation

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

SC State University signed a Partnership Agreement with the South Carolina Technical College System in January 2019. This agreement provides for seamless transfer of graduates from the two-year technical colleges to South Carolina State University (see attached). Most of these colleges offer Associate degrees in Mechatronics Technology.

SC State is specifically working with Piedmont Technical College and Orangeburg Calhoun Technical College to offer this degree to their graduates and to utilize the equipment on their campuses for this program.

Supporting Evidence of Anticipated Employment Opportunities

Provide supporting evidence of anticipated employment opportunities for graduates.

The State of South Carolina is home to major corporations such as Boeing, Flour Corporation, EATON, BMW, Michelin and Volvo. SCSU is proud to have engineering alumni at most of these companies; yet, the need for more engineering graduates is steadily increasing. A report generated by Avalanche Consulting indicates that strong job growth in the Charleston, South Carolina region is making it increasingly difficult to fill open positions from the existing workforce (www.AvalanceConsulting.com). As a result, the region is overly dependent on recruiting workers from out-of-state to fill jobs.

Most of the economic growth, around 91.5 percent, of the surrounding Greenville, S.C., metropolitan area is driven by the manufacturing industry. "Three of the cities on the top 10 list of growing manufacturing cities are in South Carolina: Greenville, Summerville and Columbia" (http://compositesmanufacturingmagazine.com/2012/03/top-5-cities-growing manufacturing/2/).

During the months of January through February 2020, there were 132 job openings in South Carolina in the area of Mechatronics Engineering in companies such as Ageatia Technology Consultancy Services, Tech USA, Röchling, Cooper Standard, Mercedes-Benz USA, Randstad US, Google, State of South Carolina, Michelin, Volvo Car USA, Mercedes-Benz USA, Tech USA, SageBeans, Michelin North America, Scout Engineering Services, Optomec, Randstad US, Stanley Black & Decker, and Electrolux. A full list of these companies can be found at the following link (https://www.glassdoor.com/Job/jobs.htm?suggestCount=0&suggestChosen=false&clickSource=searchBtn&typedKeyword=mechatronics&sc.keyword=mechatronics&locT=S&locId=3411&jobType=).

In addition, the following eleven (11) member companies of the American Composite Members Association (ACMA) are most likely to hire mechatronics engineers in South Carolina:

- CoMar Products in Cayce,
- Alaglas Pools in Saint Matthews,
- CHOMARAT North America in Anderson,
- Flexi-StiX in Anderson,
- Innegra Technologies in Simpsonville,
- Lindau Chemicals in Columbia,
- Milliken & Company in Spartanburg,
- Quality Marble, Inc. in Summerville,
- Shakespeare Composite Structures in Newberry,
- Southern Cultured Marble, Inc. in Ware Shoals,
- Ahlstrom Glass Nonwovens, LLC in Bishop.

As of January 14, 2020, the average annual pay for a mechatronics engineer in South Carolina was $84,954 per year (www.ziprecruiter.com). Based on recent job postings on ZipRecruiter, the mechatronics engineer job market in both South Carolina and the surrounding area is very active. South Carolina ranks number 23 out of 50 states nationwide for the salaries of mechatronics engineers. While ZipRecruiter notes annual salaries as high as $159,523 and as low as $55,692, most mechatronics engineers' salaries currently range between $64,187 (25th percentile) to $94,392 (75th percentile) in South Carolina.

Description of the Program

The four-year Bachelor of Science degree in Mechatronics Engineering is an undergraduate program that is focused on the fundamentals necessary for the design of "intelligent" systems and products in which mechanization and control requiring sensing, actuation, and computation are combined to achieve improved product quality and performance. Such intelligent systems include robots, as well as modern intelligent automobiles, airplanes, defense systems, assistive devices, and a wide variety of other systems, even those that are not as obvious, such as appliances and game and entertainment systems. Modern technological advancements have been able to harness the innovations occurring in a variety of disciplines into designing efficient systems. This program is designed to train undergraduates to be innovative in this multidisciplinary world. The skills that students will acquire in this program will be valuable to employers from a variety of industrial sectors including aerospace, automotive, manufacturing, communications, defense, electronics, and healthcare.

The projected enrollment for the next five years in the BS Mechatronics Engineering program is listed in the chart below.

Projected Enrollment			
Year	Fall Headcount	Spring Headcount	Summer Headcount
2020-2021	15	20	0
2021-2022	32	37	0
2022-2023	49	54	0
2023-2024	66	71	0
2024-2025	71	71	0

Explain how the enrollment projections were calculated.

The program will admit 15 students during the fall of each year and 5 students during the spring of each year. It is estimated that there will be an attrition of 3 students each year. This same pattern will continue in each subsequent year. For Year 5, the count takes into consideration attrition of students due to graduation in spring 2024.

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.

The curriculum of the BS Mechatronics Engineering degree is listed below. Twenty-one (21) new courses have been developed specifically for the program and are described following the curriculum.

Total Credit Hours Required: 131

Curriculum by Year					
Course Name	**Credit Hours**	**Course Name**	**Credit Hours**	**Course Name**	**Credit Hours**
Year 1					
Fall		**Spring**		**Summer**	
E 150 English Composition I	3	E 151 English Composition II	3		
M 158 Calculus I	4	M 168 Calculus II	4		
C 150 General Chemistry I	3	P 254 General Physics I	3		
C 151 General Chemistry I Lab	1	P 251 General Physics I Lab	1		
ENGR 170 Intro. To Engineering	3	ENGR 120 Intr. to Progr. using C++	3		
PE 150/MS 101/HED 151	2	ENGR 150 Mechanical Draw/Basic CAD	3		
UNIV 101 Intro. to Univ. Community	2				
Total Semester Hours	18	Total Semester Hours	17	Total Semester Hours	
Year 2					
Fall		**Spring**		**Summer**	
ENGR 212 Statics	3	ENGR 313 Dynamics	3		
M 278 Calculus III	4	M 403 Differential Equations	3		
P 255 General Physics II	3	M 250 Linear Algebra for Science & Engineering	3		
P 253 General Physics II Lab	1	ENGR 213 Strength of Materials	3		
ENGR 220 Circuit Analysis	3	EE 236 Electronics I	3		
ENGR 250 Technical Communications	3	EE 312 Digital System Design	3		
Total Semester Hours	17	Total Semester Hours	18	Total Semester Hours	

Course Name	Credit Hours	Course Name	Credit Hours	Course Name	Credit Hours
Year 3					
Fall		**Spring**		**Summer**	
EE 234 Electrical Network Analysis	3	MTRE 350 Mechatronics Engineering Fundamentals	3		
ENGR 235 Circuits Laboratory	1	MTRE 351 Mech. Engg. Fund. Lab	1		
EE 302 Electronics II	3	ENGR 425 Fluid Dynamics	3		
EE 303 Electronics Lab	1	ENGR 255 Engineering Economics Analysis	3		
EE 324 Signals, Systems and Transforms	3	ETS 250 African American in Technology & Science	3		
EE 342 Microcontrollers and Embedded Systems	3	EE 326 Introduction to PLC and Virtual Instruments	3		
EE 343 Micr. & Embed. Syst. Lab	1	EE 327 PLC and Virtual Instr. Lab	1		
Total Semester Hours	15	Total Semester Hours	17	Total Semester Hours	
Year 4					
Fall		**Spring**		**Summer**	
ARTS 250/MU 250/D 254	3	MTRE 460 Senior Project	3		
MTRE 459 Senior Project Proposal	1	MTRE 490 Computer Modeling of Mechatronics Systems	3		
EE 426 Linear Control Systems	3	EE 428 Robotics Analysis & Synthesis.	3		
EAET 410 Engineering Ethics	3	EE 429 Control & Robotics Lab	1		
E 250 or E 251 World Literature	3	H 250/251 World History	3		
SOC 250/PSY 250	3				
Total Semester Hours	16	Total Semester Hours	13	Total Semester Hours	

New Courses

List and provide course descriptions for new courses.

ENGR 120. Introduction to Programming using C++ 3(3,0)
This course introduces the C++ programming language. Students will create, document, run and debug programs using computer. Key topics include fundamentals of algorithms, flowcharts, programming concepts, variables, classes, objects, selection, iteration, control structures, strings, arrays, pointers and functions. Throughout the semester, problem solving skills will be stressed and applied.

ENGR 220. Circuit Analysis 3(3,0)
Study of DC resistive circuits; volt-ampere characteristics for circuit elements; independent and dependent sources; Kirchhoff's laws and circuit equations. Source transformations; Thevenin's and Norton's theorems; superposition. Phasor analysis, impedance calculations, and computation of sinusoidal steady state responses.

EE 234. Electrical Network Analysis 3(3,0)
Continuation of the study of electric circuits including analysis of the RL, RC and RLC, balanced three-phase circuits complex frequency and network functions, frequency response and filter design, two-port parameters, magnetically coupled circuits, use of Laplace transforms techniques to analyze linear circuits with and without initial conditions.

ENGR 235. Circuits Laboratory 1(0,2)
This laboratory course stresses laboratory procedures; learning use of common laboratory equipment such as power supplies, multimeters, signal generators, and oscilloscopes; making measurements; This is a course to expose basic circuit concepts, circuit modeling and methods of circuit analysis in time domain and frequency domain for solving simple and multi-dimensional circuits including DC and AC circuit theory and network theorems. The laboratory exercises are designed to give students ability to design and verify circuit characteristics through computer simulations using PSpice, build and implement basic AC and DC circuits and verify the theory using electronic test equipment. Also, this course provides familiarization with basics of laboratory report writing.

EE 236. Electronics I 3(3,0)
Introduction to electronic materials and devices; principles and applications of PN junctions, diodes, bipolar junction transistors, field-effect transistors, and design of DC and AC circuits using those including the use of transistors in digital circuits.

EE 302. Electronics II 3(3,0)
Analysis and design of amplifier circuits at low and high frequencies; operational amplifiers, frequency response, feedback, stability, and applications of linear and digital integrated circuits.

EE 303. Electronics Lab 1(0,2)
This course is an introductory experimental laboratory that explores the design, construction, and debugging of analog electronic circuits. Laboratory experiments include investigation of the performance characteristics of diodes, transistors, JFETs, and op-amps, including the construction of a small audio amplifier and preamplifier.

EE 312. Digital System Design 3(3,0)
This course is a study of digital circuit fundamentals with an emphasis on combinational and sequential logic design. Topics include number systems and representation of information; Boolean operators and algebra; expression minimization; combinational circuits, including adders, comparators, decoders and multiplexors; sequential logic, including flip-flops, shift registers, counters and memory.

EE 324 Signals, Systems and Transforms 3(3,0)
Comprehensive introduction to analysis of continuous and discrete-time signals and systems; Linear time-invariant systems and convolution; Fourier series representations of periodic signals; Continuous time and discrete time Fourier transforms; Laplace transform; z-transform.

EE 342. Microcontrollers and Embedded Systems 3(3,0)
This course discusses the assembly and C language programming and interfacing of microcontrollers in order to control integrated devices and external peripherals. Topics include memory and I/O port interfacing; interrupts, counters and timers; ADCs and DACs; PWMs; parallel and serial communication, and microprocessor-based controller design.

EE 343. Microcontrollers and Embedded Systems Lab 1(0,2)
Emphasizes microcontroller programming and interfacing for controlling various types of hardware. Topics include reading and writing to RAM, applications of a digital latch, keypad interfacing, interrupts, clock pulse generation, pulse width modulation, serial interfaces, and A-to- D and D-to-A conversion.

EE 326. Introduction to PLC and Virtual Instruments 3(3,0)
An introductory course to Programmable Logic Controller (PLC) and Virtual Instruments (VI) , focusing on the underlying principles of how PLCs work and providing practical information and skills about programming, and troubleshooting a PLC system, multipurpose personal-computer- based approach to real-time instrumentation. Interfacing using Laboratory Virtual Instrument Engineering Workbench (LabVIEW) for data acquisition (DAQ), transmission and analysis.

EE 327. PLC and Virtual Instruments lab 1(0,2)
An introductory course in programmable logic controllers (PLCs) and basic applications in which they are used. Topics include an overview of PLCs, PLC hardware components, basics of PLC programming, development of fundamental PLC ladder programs, programming timers and counters, advanced programming techniques, PLC control of motors and processes using Allen Bradley SLC 500 PLC or equivalent unit; develop virtual instruments and data acquisition techniques using LabVIEW from National Instruments.

MTRE 350. Mechatronics Engineering Fundamentals 3(3,0)
This course is an introduction to designing mechatronic systems, which require integration of the mechanical and electrical engineering disciplines within a unified framework. Topics include foundational concepts in mechatronics including analog and digital electronics, sensors, actuators, microprocessors and microprocessor interfacing to electromechanical systems.

MTRE 351. Mechatronics Engineering Fundamentals Lab 1(0,2)
This laboratory course offers exercises to give guided hands-on experience with many of the topics covered in the theory. Topics covered in the course include low-level interfacing of software with hardware; use of high-level graphical programming tools to implement real-time computation tasks; digital logic; analog interfacing and power amplifiers; measurement and sensing; electromagnetic and optical transducers; control of mechatronic systems.

MTRE 459. Senior Project Proposal 1(1,0)
During the first semester of the two-sequence senior project courses the student teams gain understanding of the project scope, formulate engineering specifications, develop conceptual solutions and designs, go through a concept analysis and selection process, carry out the necessary engineering analyses and arrive at a final proposed prototype design complete with drawings. This proposed prototype design is presented to the instructor who provides assessment and critique, and the student team submits a final report at the close of the semester.

MTRE 460. Senior Project 3(3,0)
In the second semester of the two-sequence senior project courses the student teams proceed with physical realization and testing of their designs and at the end *they deliver an engineered, tested and validated product* in

class. A final comprehensive report is then submitted by each team documenting their built and tested prototype along with the associated design, realization and testing processes. Failure to deliver a finished prototype adhering to specifications by the end of the cycle may result in failing the course. In order to avoid this, any non-compliance with specifications must be explained and viable solutions to address its root causes must be proposed.

MTRE 490. Computer Modeling of Mechatronics Systems 3(3,0)
This course covers two main areas: modeling and simulation. Topics include, study modelling methodologies both mathematical and graphical that can be used for mechatronics systems, simulation and analysis of systems responses using software tools, such as MATLAB/Simulink and/or LABVIEW.

EE 426. Linear Control Systems 3(3,0)
Fundamentals of control systems. Analysis and design of control systems using physical system models. State variables, steady-state error, time- and frequency-responses, control system stability using root-locus analysis, Bode diagram and Nyquist stability criterion and controller design - PI, PD, PID, lead-lag compensator.

EE 428. Robotics Analysis and Synthesis 3(3,0)
This course will introduce the students to the mathematical foundations for modern robotics. Topics include rigid body motion, forward and inverse kinematics, trajectory generation, robot dynamics and control.

EE 429. Control and Robotics Lab 1(0,2)
A one semester laboratory course to accompany Linear Control Systems and Robotics Analysis and Synthesis. The students will be engaged in a series of hands-on and simulation experiences in control systems and robotics.

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
BS Mechanical Engineering with Concentration in Mechatronics	Total Program Credits = 126 Number of credits in Conc. = 12	University of South Carolina, Columbia (USC)	The study of mechatronics involves the integration of mechanical systems and electronics. USC as well as the SCSU program integrate, to large extent, mechanical systems and electronics such as electromechanical systems with embedded sensors, microcontrollers, actuation, and process control; robots and autonomous vehicles; and automotive systems.	Not a complete program in Mechatronics Engineering but a concentration in the field of the larger bachelor's degree in Mechanical Engineering.
Graduate Certificate in Mechatronics Engineering	12	The Citadel	Similar only in the academic discipline.	The Citadel is offering graduate level courses and SCSU's program is an undergraduate degree.
Mechatronics Technology	63-72	The following two-year Technical Colleges in South Carolina offer Mechatronics Technology programs: Orangeburg-Calhoun Tech, Midlands Tech, Trident Tech, Piedmont Tech, Greenville Tech, Horry-Georgetown Tech, Tri-County Tech, York Tech, and Spartanburg Community College.	These institutions offer courses such as electric circuits, electronics, digital circuits, programmable controllers, and microprocessors similar to the courses offered in the 1st and 2nd Year of the BS Mechatronics Engineering program.	The Technical Colleges offer associate degrees in Mechatronics Technology while SC State's program is a BS in Mechatronics Engineering.

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.)
Assistant Professor (Full-time)	ENGR 212 Statics	PhD Applied Science, Idaho State University; MS Archaeometry, University of Science and Technology of China	
Professor (Full-time)	ENGR 213 Strength of Materials ENGR 313 Dynamics	PhD Nuclear Engineering, Ohio State University; MSNE Nuclear Engineering Georgia Institute of Technology	
Professor (Full-time)	ENGR 425 Fluid Dynamics	PhD Nuclear Engineering, University of Illinois, Urbana-Champaign; MS Nuclear Engineering, University of Illinois, Urbana-Champaign; M.Sc. Physics, Ahmadu Bello University, Nigeria	
Professor (Full-time)	EAET 410 Engineering Ethics	Ph.D. Material Engineering South Dakota School of Mine and Technology; MS Engineering Management South Dakota School of Mine and Technology	
Assistant Professor (Full-time)	ET 170 Introduction to Engineering Technology ET 255 Engineering Economic Analysis	MS Industrial Engineering, Clemson University	
Assistant Professor (Full-time)	ET Mechanical Drawing/Basic CAD	PhD Mechanical Engineering, Missouri University of Science and Technology MS Geological Engineering, Missouri University of Science and Technology MS Mechanical Engineering, Tripoli University, Libya	
Professor (full-time)	ET 250 Technical Communication	ScD Electrical Engineering, New Mexico State University;	

		M.S. Electrical Engineering, New Mexico State University	
Associate Professor (Full-time)	ETS 250 African Americans in Technology and Science	EdD Technology Education, North Carolina State University; MS Computer Graphics, Purdue University	
*Faculty 1 Full-Time	ENGR 220 ENGR 235 ENGR 250 ENGR 120 EE 326 EE 327	PhD in Electrical Engineering or related field	
*Faculty 2 Full Time	EE 324 EE 342 EE 343 EE 426 MTRE 459 EE 428 EE 429 MTRE 460 MTRE 490	PhD in Mechanical Engineering or related field	
*Faculty Full-Time	ENGR 220 EE 234 EE 302 ENGR 235 EE 236 EE 312 MTRE 350 MTRE 351	PhD in Electrical Engineering or related field	

*New faculty

Total FTE needed to support the proposed program:

Faculty: Three additional faculty will be needed to support the program from Year 2 onward as enrollment grows. The current faculty from the disciplines of Electrical Engineering Technology, Mechanical Engineering Technology, Industrial Engineering, Civil Engineering and Nuclear Engineering will provide instruction when the program begins.

Staff: The program will be served by the current staff in the Department of Engineering Technology

Administration: The current Chair of the Department of Engineering Technology will serve as the Coordinator of the Program

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

Since this is an interdisciplinary program, faculty members from Electrical Engineering Technology, Mechanical Engineering Technology, Civil Engineering, Industrial Engineering, and Nuclear Engineering programs will be involved in teaching courses in this program. Therefore, no new faculty costs are associated with the program in the first year. It is anticipated that three full-time faculty will be needed as the enrollment in the program grows; two Electrical Engineering faculty and one Mechanical Engineering faculty.

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.

Library holdings in print and digital formats are adequate to support the proposed new interdisciplinary program which draws on the academic disciplines already present at the University. Besides resources available in the Miller F. Whitaker Library, students at SC State have access to millions of library and learning resources available through various interlibrary borrowing services such as: 1) PASCAL Delivers, a South Carolina network among universities and colleges; 2) OCLC WorldCat via LYRASIS, a nationwide and international network; 3) CHEC (Claflin, OC-Tech, SC State), an agreement among the college and universities in Orangeburg; 4) articulation agreements with various other libraries in SC; and 5) the statewide library borrowing card.

PASCAL – **P**artnership **A**mong **S**outh **C**arolina **A**cademic **L**ibraries
CHEC – Community Higher Education Council
LYRASIS – 1,200 member Libraries and Cultural Institutions Network

In addition to the resources above, $10,000 will be allocated to purchase books and reference materials specific to Mechatronics Engineering.

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.

The establishment of this new degree program will not require any changes or addition to the current academic support services at the University. Some of many student support services units include, the Student Success and Retention Program which provides tutoring an scholarship information; the Career Center, the Push Writing Center, the Counseling and Self-Development Center, Brooks Health Center, the Office of Student Disability Services, and the Office of Student Life and Leadership (http://www.scsu.edu/academics.aspx). In addition, the Mechatronics Engineering program will provide tutorials to students, assist them with identifying internship opportunities and provide them with interviewing skills from industrial partners through the College's Industrial Advisory Council.

Physical Resources/Facilities

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

The program will be housed in the Engineering and Computer Science Complex, which is a state-of-the-art building completed in 2012. The complex has a total of 85,337 sq. ft. of area, with a 215-seat auditorium, 81 faculty offices, 28 laboratories, 10 classrooms, and 5 storage rooms. This building houses the offices of the Dean of the College of Science, Technology, Engineering, Mathematics and Transportation; as well as the Department of Engineering, the Department of Engineering Technology, and the Department Computer Science and Mathematics. The faculty and supporting staff offices, classrooms and laboratories of all programs in the three departments are also housed in this building. The classrooms are shared among all programs of the three departments. The faculty and staff offices and laboratories of the Electrical Engineering Technology program are located on the 3rd floor of this complex. In addition, this building has three (3) conference rooms, one (1) faculty lounge and two (2) student lounges. In

addition, student organizations such as IEEE, NSBE, ASCE, Tau Alpha Pi, etc. have their offices located on the first floor of the building.

The lab facilities dedicated to the programs of the three departments and those that are available to students in the programs are the EET Computing Laboratory, the Circuits and Electronics Laboratory, the Machines and Power System Laboratory, the Control and Robotics Laboratory, the Microprocessor and Virtual Instruments Laboratory, the CADD Laboratory, the Rapid Prototyping Laboratory, the Machine Tool Laboratory, the Material Testing Laboratory, the Fluid Mechanics Laboratory, and the Computer Numerical Control Laboratory. The current facilities are adequate to support the program and no new facilities will be required.

Equipment
Identify new instructional equipment needed for the proposed program.

Engineering and Engineering Technology programs in the College have several laboratories that support the existing programs. Currently, hands-on mechatronics activities take place in the labs serving the control, robotics and numerical machines courses. All these labs will be available for use in relevant courses of the proposed program. However, MPS 202 equipment for a Mechatronics laboratory will be purchased in the second year. This equipment will expose students to instrumentation and real-time control using elements such as pneumatics, electronics, sensors, control systems, and programmable controllers. The MPS 202 stations can also be networked via I/O ports. In addition, OC-Technical College and Piedmont Technical College have agreed to make their labs and equipment available to students in the program.

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. The Chairman of the Department of Engineering Technology has shared the prospect of the new program with current students and based on his assessment, approximately 10 students in the existing Electrical Engineering Technology and Mechanical Engineering Technology programs will likely transfer to the Mechatronics Engineering program.

☒Yes

☐No

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	$0	$193,550	$0	$381,570	$0	$569,590	$0	$757,610	$0	$785,260	$0	$2,654.400
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	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Federal, Grant, or Other Funding: **Title III**	$0	$0	$0	$50,000	$0	$0	$0	$0	$0	$0	$0	$50,000
Total	$0	$193,550	$0	$431,570	$0	$569,590	$0	$757,610	$0	$785,260	$0	$2,737,580
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	$0	$0	$0	$70,000	$0	$140,000	$0	$210,000	$0	$210,000	$0	$630,000
Facilities, Equipment, Supplies, and Materials	$0	$5,000	$0	$55,000	$0	$5,000	$0	$5,000	$0	$5,000	$0	$75,000
Library Resources	$0	$5,000	$0	$2,000	$0	$2,000	$0	$1,000	$0	$0	$0	$10,000
Other (specify)	$0		$0		$0		$0		$0	$0	$0	
Total	$0	$10,000	$0	$127,000	$0	$147,000	$0	$216,000	$0	$215,000	$0	$715,000
Net Total (Sources of Financing Minus Estimated Costs)	$0	$183,550	$0	$304,570	$0	$422,590	$0	$541,610	$0	$570,260	$0	$2,022,580

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 revenue and expenditure of the BS Mechatronics Engineering program are explained below.

Revenue

- Year 1 Revenue: 35 students X $5,530 (per semester tuition) = $193,550
- Year 2 Revenue: 69 students X $5,530 (per semester tuition) + $50,000 Title Funding = $431,570
- Year 3 Revenue: = 103 students X $5,530 (per semester tuition) = $569,590
- Year 4 Revenue: = 137 students X $5,530 (per semester tuition) =$757,610
- Year 5 Revenue: = 142 students X $5,530 (per semester tuition) = $785,260
- Total Revenue: =$2,737,580

Expenditure

- Year 1: $5,000 supplies + $5,000 library resources = $10,000
- Year 2: $70,000 salary Asst Prof. + $50,000 equipment + $5,000 supplies + $2,000 library resources = $127,000
- Year 3: $140,000 for 2 Asst Profs. + $5,000 supplies + $2,000 library resources = $147,000
- Year 4: $210,000 for 3 Asst Profs. + $5,000 supplies + $1,000 library resources = $216,000
- Year 5: $210,000 for 3 Asst Profs. + $5,000 supplies = $215,000

Evaluation and Assessment

Program Objectives	Student Learning Outcomes Aligned to Program Objectives	Methods of Assessment
1. Students will be successful and excel in chosen career. Students will meet requirements to pursue positions that require design, development, analysis, control and automation of systems and processes.	1. Demonstrate the ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	Students will be expected to achieve a required score of 70% or higher on selected assignments in EE 302.
	2. Demonstrate the 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.	Students will be expected to achieve a required score of 70% or higher on design assignments in MTRE 460.
	3. Demonstrate the ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	Students will be expected to achieve a required score of 70% or higher on selected laboratory exercises in EE 303.
2. Students will possess effective research and development skills	4. Demonstrate the ability to	Students will be expected to achieve a required score of 70% or

that will enable engagement in graduate education and professional development in Mechatronics Engineering or related field.	communicate effectively with a range of audiences. 5. Demonstrate the ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives 6. Demonstrate the ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	higher on selected laboratory exercises in ENGR 250. Students will be expected to achieve a required score of 70% or higher on project management in MTRE 460. Students will be expected to achieve a required score of 70% or higher on selected assignment in MTRE 490.
3. Students will be responsible members of society through involvement in community and professional engagement.	7. Demonstrate the 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	Students will be expected to achieve a required score of 70% or higher on select representative questions in exams in EAET 410.

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.

Assessment of this program will be conducted in accordance with the guidelines developed by the Continuous Improvement Committee (CIC) of the College of Science, Technology, Engineering, Mathematics and Transportation at South Carolina State University. The program objectives will be reviewed by the members of the Industrial Advisory Council of the College every two years. This body meets once every semester. Student Learning Outcomes are established for all the individual courses associated with the program and these outcomes will be assessed each year. Continuous Improvement at the program level will be done based on the results of the assessments of student learning outcomes at the course level and assessment of the program outcomes at the program level. Results of the assessments will be reviewed each year and decisions about program improvement will be made annually based on those results. The continuous improvement process will also consider input from the CIC. The program will also undergo a standard program review every six years, as do all other ABET-accredited degree programs of the College. An additional assessment of the program success would be provided via survey of the graduates who are employed.

The employment of graduates will be tracked using the following:
1) Senior Exit Survey
2) Records from the Office of Alumni Relations
3) Locating alumni via Social Media

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

The BS in Mechatronics Engineering program is expected to be EAC (Engineering Accreditation Commission) of ABET (Accreditation Board for Engineering and Technology) accredited within next four years.

Will the proposed program 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

PARTNERSHIP AGREEMENT
between
SOUTH CAROLINA STATE UNIVERSITY
and the
SOUTH CAROLINA TECHNICAL COLLEGE SYSTEM

I. PURPOSE

The following agreement between South Carolina State University and the South Carolina Technical College System (SCTCS) is designed to increase access to higher education across the state and to enhance the seamless transfer of students and graduates from the 16 technical colleges in South Carolina to South Carolina State University. By closely examining and improving the transfer function, South Carolina State University and SCTCS seek to expand and encourage access to baccalaureate education.

II. TERMS OF THE AGREEMENT

SCTCS and South Carolina State University will engage in transfer efforts to create course and program articulation between the Associate in Arts (AA), the Associate in Science (AS) degrees, and the Associate in Applied Science (AAS) provided by the SCTCS and the approved baccalaureate programs offered at South Carolina State University. This agreement should also facilitate collaborative partnerships and the development of detailed articulation guides between South Carolina State University and the individual technical colleges within the system.

This agreement does not preclude any existing or forthcoming bridge agreements, nor any other transfer efforts between South Carolina State University and an individual technical college.

III. TARGET STUDENTS

Students entering South Carolina State University under this agreement will be referred to as a "Transfer Student" and will be defined as a student who has:

A. Earned an AA or AS or AAS from one of the 16 technical colleges within SCTCS,

B. Earned a grade of "C" or higher in each course applicable to the AA, AS, and AAS degrees,

C. Intends to transfer to South Carolina State University, and

D. Meets all other requirements contained in this Agreement.

IV. ACADEMIC ADMISISONS AGREEMENT

A. Graduates from a South Carolina technical college may be granted admission to South Carolina State University and may expect the following subject to the admissions policies and procedures of South Carolina State University:

1. Students who have completed the AA, AS, or AAS may enter South Carolina State University with Junior standing and will have satisfied the South Carolina State University General Education Program Requirements.

2. All transfer courses that are accepted by South Carolina State University will be applied to the attainment of the baccalaureate degree as appropriate to the student's major.

3. Although a course may be transferable into a baccalaureate program at South Carolina State University, it may not be applied to a specific major in all instances. In such cases, these credits will transfer as elective credits.

V. RESPONSIBILITIES

A. SCTCS students will:

1. Assume primary responsibility for understanding and following the requirements for their technical college AA, AS, and AAS degrees and the specific requirements for their intended major at South Carolina State University.

2. Follow all South Carolina State University requirements for admission processes and timelines published in the Undergraduate Catalog in effect at the time the application is submitted.

3. Submit all college and university transcripts with an admission application.

B. SCTCS Colleges will:

1. Advise students regarding courses needed to complete the AA, AS, and AAS degrees.

2. Notify students of transfer opportunities to South Carolina State University under this agreement.

3. Promote agreement and degree programs available at South Carolina State University among faculty, staff, and students to include the college and SCTCS websites.

4. Participate in relevant engagement and training opportunities offered to enhance college partnerships and the development of programmatic articulation guides.

C. South Carolina State University will:

1. Upon student's application to South Carolina State University, treat SCTCS students on an equal basis with other transfer students with regard to award and distribution of financial aid and other scholarships, campus housing, parking, selection of courses, and other student services.

2. Facilitate a Reverse Transfer option for SCTCS students who enroll at South Carolina State University without having attained their AA, AS, or AAS degree. Upon successful completion of coursework and hours at South Carolina State University, credits earned at South Carolina State University may be transferred back to the SCTCS institution and may be applied toward an associate degree at the originating technical college.

D. SCTCS and South Carolina State University will:

1. Collaborate to develop articulation guides and related materials for use in advisement and recruitment.

2. Monitor changes in the curriculum. When applicable, notify the other and update articulation guides on a mutually agreed upon schedule.

3. Work collaboratively to ensure consistency in student advising as it relates to the terms of this agreement.

4. Partner to conduct assessment and evaluation of this agreement.

VI. REVIEW OF AGREEMENT

Review of this agreement will take place annually beginning one year after approval by representatives of SCTCS and South Carolina State University. Any revisions or new program elements will be implemented when mutually agreed upon by both parties. South Carolina State University shall ensure its ongoing compliance with *The Principles of Accreditation* as issued and amended by the Southern Association of Colleges and Schools Commission on Colleges.

SCTCS and South Carolina State University agree to the terms of this agreement as indicated by signing below and will remain in effect until additional recommendations for modifications are approved by both signatory entities or otherwise terminated as stated below.

This agreement is effective until such time that either party officially terminates the agreement in writing. The termination shall be effective six months after receipt of written notification or upon a mutually agreed upon termination date as provided in writing.

VII. SIGNATURES

James E. Clark, M.S.
President
South Carolina State University

1/8/19
Date

Tim Hardee, Ph.D.
President
South Carolina Technical College System

1/8/19
Date

Hope Rivers, Ph.D.
Executive Vice President
South Carolina Technical College System

1/8/19
Date

PIEDMONT TECHNICAL COLLEGE

Dr. Keli Fewox • Vice President for Academic Affairs
Phone: (864) 941-8307 • Email: fewox.k@ptc.edu

February 7, 2020

Dr. Sanley N. Ihekweazu
Dean of the College of Science, Mathematics, Engineering & Technology
South Carolina State University
300 College Street, NE
Orangeburg, South Carolina 29117

Dear Recipient,

On behalf of Piedmont Technical College, it is our pleasure to write a letter of support for the establishment of a new BS degree in Mechatronics Engineering with South Carolina State University. We have had a notable transfer partnership for 20 plus years with South Carolina State University. Through these partnerships, our graduates of Electronic Engineering Technology and Mechanical Engineering Technology are provided the opportunity to receive bachelor's degrees from SCSU and increased opportunities in the workforce.

We fully support the establishment of the BS degree in Mechatronics Engineering and look forward to the possibility of partnering with SCSU to empower our students to succeed both in their education and future careers.

Sincerely,

Keli Fewox

Dr. Keli Fewox
Vice President for Academic Affairs