

**New Program Proposal  
 Master of Science in Mechanical Engineering  
 The Citadel**

**Summary**

The Citadel requests approval to offer a program leading to the Master of Science in Mechanical Engineering to be implemented in August 2016. The proposed program is to be offered through traditional instruction. The following chart outlines the stages of approval for the proposal; the Advisory Committee on Academic Programs (ACAP) voted to recommend approval of the proposal. The full program proposal is attached.

<b>Stages of Consideration</b>	<b>Date</b>	<b>Comments</b>
Program Proposal Received	8/1/15	Not Applicable
Comments and suggestions from CHE staff sent to the institution	8/21/15	Staff requested the proposal be revised to: <ul style="list-style-type: none"> <li>• Identify the companies requesting the program</li> <li>• Identify the 2+2 program referenced in the Background section.</li> <li>• Revise the Curriculum by Category chart to show the core requirements, electives, and other requirements in addition to the focus area requirements.</li> <li>• Revise the language in the proposal to make it clear that the focus area is a collection of electives, but not an official concentration, option or track.</li> <li>• Explain that if the student is interested in earning a graduate certificate in one of the focus areas, the student will need to complete additional coursework to meet all of the requirements of the certificate program.</li> <li>• Provide a brief explanation and timeline for developing and implementing these new courses.</li> <li>• Provide the total FTE needed to support the program.</li> <li>• Provide an estimated hire date for the new faculty member.</li> <li>• Clarify the amount of funds spent on library resources for engineering.</li> <li>• Explain The Citadel's relationship with the Clemson Restoration Institute.</li> </ul>

Stages of Consideration	Date	Comments
		<ul style="list-style-type: none"> <li>• Provide the implementation date for the new BSME program in the Physical Resources section.</li> <li>• Describe the Taskstream software and provide more detail as programmatic assessment.</li> <li>• Identify the specific courses in which the particular Student Learning Outcome will be assessed.</li> </ul>
ACAP Consideration	9/10/15	<p>ACAP members discussed the need for the proposed program. Representatives from Academic Affairs, Clemson, Coastal Carolina University, USC Aiken, and Winthrop, requested the following explanations:</p> <ul style="list-style-type: none"> <li>• Source of faculty personnel (full-time or part-time via recruitment, re-assignment, or otherwise) needed to teach the new courseload</li> <li>• Total number of new courses and projected budget for new course implementation</li> <li>• Details about collaboration with Clemson</li> <li>• Capability to provide student support</li> <li>• A description of the proposed program certificates</li> </ul>
Revised Program Proposal Received	9/16/15	The revised proposal and appendix satisfactorily addressed the requested revisions.

**Recommendation**

The staff recommends that the Committee on Academic Affairs and Licensing commend favorably to the Commission the program leading to the Master of Science in Mechanical Engineering to be implemented in August 2016.

## NEW PROGRAM PROPOSAL

Name of Institution  
The Citadel

Name of Program (include concentrations, options, and tracks)  
Master of Science Degree in Mechanical 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.)

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

- Yes  
 No

Proposed Date of Implementation  
Aug 2016

CIP Code  
14.1901

### Delivery Site(s)

Courses offered on-site and/or at the Low Country Graduate Center

### Delivery Mode

- Traditional/face-to-face\*  
\*select if less than 50% online
- Distance Education  
 100% online  
 Blended (more than 50% online)  
 Other distance education

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

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### Institutional Approvals and Dates of Approval

Graduate Curriculum Committee: 17 Feb 2015  
Academic Board: 24 Feb 2015  
President: 10 April 2015

## NEW PROGRAM PROPOSAL

### Background Information

State the nature and purpose of the proposed program, including target audience and centrality to institutional mission. (1500 characters)

The MSME is intended to meet the expressed needs of South Carolina industries, especially Charleston based companies. Nationally, Mechanical Engineering is broken out as a separate category by the Department of Labor which shows that Mechanical Engineers are the second most hired group of engineers after civil and before electrical engineers.

The engineering related job market in the Charleston area has exploded in recent years, including a dramatic increase in the need for Mechanical Engineers. Employers include health care, aviation, defense applications, power systems, telecommunications, automotive, manufacturing, testing, data centers, and many others. The MSME supports The Citadel's LEAD 2018 Objective 2 (academic programs of distinction), Objective 4 (expand enrollment in The Citadel Graduate College), and Objective 8 (provide outreach to the region and serve as a resource in its economic development) and is being developed at the request of a number of Charleston based companies such as Boeing, Bosch, UEC Electronics, RFV Rotarian, Daimler, etc. The desire to hire local talent and educate an existing workforce drives the need for a local graduate ME program to complement an existing undergraduate engineering program. Our ability to offer graduate courses within The Citadel MSME is complementary to any other graduate courses being offered in the Lowcountry in providing graduate engineering education. Engineering problem solving is in increased demand and mechanical engineers are a necessary and diverse core engineering skill set that are primarily focused on manufacturing processes and professional services.

List the program objectives. (2000 characters)

Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. Graduates of the Master of Science degree program in Mechanical Engineering will, by the time of graduation:

- **Outcome 1:** Demonstrate breadth of knowledge in complimentary areas of mechanical engineering that promotes an awareness of and skill in interdisciplinary problem solving.
- **Outcome 2:** Demonstrate a depth of knowledge in a chosen focus area of mechanical engineering that allows the student to apply innovative techniques to solve problems.
- **Outcome 3:** Demonstrate knowledge in methods of advanced analysis appropriate for professional use when solving problems.
- **Outcome 4:** Demonstrate knowledge of contemporary issues in their chosen focus area.
- **Outcome 5:** Demonstrate the skills relevant to graduate level work to include the ability to formulate problems, synthesize and integrate information, work collaboratively, and to communicate effectively.
- **Outcome 6:** Demonstrate preparation for successful careers in industry or continued graduate work and an ethic for lifelong learning.

## NEW PROGRAM PROPOSAL

### Assessment of Need

Provide an assessment of the need for the program for the institution, the state, the region, and beyond, if applicable. (1500 characters)

The number of students taking engineering courses at The Citadel has increased dramatically over the last few years. For example, the number of undergraduate engineering students within the Corps of Cadets has grown from 318 in 2012 to 379 students in 2014. The number of evening students has grown from 65 to 85 students. All of this growth is prior to the inclusion of the mechanical engineering undergraduate cadet and evening students who began to attend in fall 2014 (90 new students). The number of enrollments in our MS in Project Management has grown from 95 in 2011 to over 350 in 2013-2014. Many of the evening students in Project Management have asked when we will begin to offer more technical masters level courses and degrees. The arrival of Boeing and their survey of employee educational needs estimate nearly 1000 employees needing undergraduate degree completion, many in engineering. However, recent discussions with key leaders and news releases at Boeing and other companies in the Lowcountry have noted a desire for their current workforce to complete certificates that will show immediate skill attainment as well as master's level technical degrees.

There are few key technical areas / skills this program will ensure anyone with a MSME who wants to work locally will either "have" or "be exposed" to:

#### Technical Skills / Competencies-

- 1) Advanced Analytic Tools- "product design & mfgs" needing analysis tools and specialized training skills such as: 3D Modeling w/ Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD) and system simulations. More and more of the product design at companies is going to 100% "model based definition"
- 2) Design for Manufacturability and/or Assembly & Advanced Quality Management- Probably over 75% of the companies we are supporting in the Lowcountry area are "manufacturers" and we need MEs with basic Design for Manufacturing / Design for Assembly (DFM/DFA) and QA skills and/or knowledge. Just "exposing" the student to these topics in one course may be the way to go. A multi-subject course that covers DFM, DFA, Lean Mfg, and other advanced quality topics (Six Sigma & design of experiments / Analysis of Variance (DOE/ANOVA), failure modes and effects analysis (FMEA), etc).
- 3) Advanced Materials Science / Engineering- Composites is a must have but we need to address all the other industries' needs that support "metals" (advanced metallurgy class and lab possibly, corrosion, heat treating, etc).
- 4) Machine design or automated manufacturing systems / equipment design- basic robotics course (overview only or maybe a lab), and require exposure to programming
- 5) Product Development and/or Systems Engineering skills / competencies- product development "stage-gate" or life cycle models and the systems engineering "V" model to manage large complex product or system designs. This could go under "management" but can be technical.

The Charleston Regional Competitiveness Center forecasts there will be a 16.4% growth (7200 new jobs) in the engineering field in the area by 2018. This information follows closely to the Department of Labor statistics that show a 12 month growth rate for construction in South Carolina as 7.2% while in Charleston it was 16.2%, growth rate for manufacturing in South Carolina as 2.0% while in Charleston it was 25.4%, and the growth rate for trade, transportation, and utilities in South Carolina as 2.5% while in Charleston it was 3.1%. Many other areas were growing at a faster rate in Charleston than the state as a whole.

## NEW PROGRAM PROPOSAL

### Employment Opportunities

Is specific employment/workforce data available to support the proposed program?

Yes

No

If yes, complete the table and the component that follows the table on page 4. If no, complete the single narrative response component on page 5 beginning with "Provide supporting evidence."

Employment Opportunities			
Occupation	Expected Number of Jobs	Employment Projection	Data Source
Based on industry input noted above, a majority of students will be fully employed and part-time students. In-depth discussion in next section.			

Provide additional information regarding anticipated employment opportunities for graduates.  
(1000 characters)

## NEW PROGRAM PROPOSAL

Provide supporting evidence of anticipated employment opportunities for graduates, including a statement that clearly articulates what the program prepares graduates to do, any documented citations that suggests a correlation between this program and future employment, and other relevant information. Please cite specific resources, as appropriate. (3000 characters)

**Note: Only complete this if the Employment Opportunities table and the section that follows the table on page 4 have not previously been completed.**

There is not specific employment data beyond the fact that there is documented growth of current and new companies providing engineering support and/or products for the rapidly expanding manufacturing hub here in the Lowcountry. One example; Boeing has expanded its workforce to 7500 employees within the last year (many desiring additional skills through graduate certificates and MS degrees) and is currently bringing in a design center, a research center, and expanding the plant footprint. This only scratches the surface of the numerous newspaper articles noting companies moving production of required aeronautical parts to decrease the shipping costs from Washington State. Each of these companies require an engineering team to support design and production. The future deepening of the harbor heightens the desire for more companies to locate their production efforts here in the Lowcountry such as Continental Tire, Daimler (1300 jobs), etc. Charleston County is the only county in the US that manufactures planes, boats, and now automobiles. Most of the students that will be taking the courses within the MSME and its associated certificates will be existing mid-level employees with Lowcountry companies working to improve their current skill set. Some local industries need advanced degrees in their workforce and offer flexible work hours and pay for the employees' degrees / certificates. The availability of the Mechanical Engineering advance degree and/or certificates is a huge benefit for local employees, military, and veterans who are unable to travel to the nearest graduate level campus. The MSME is a logical, natural progression for the local 2+2 program with Trident Technical College in North Charleston. Our industry contacts as well as our robust departmental industry advisory board (list attached in the Appendix) have been asking for a number of years for engineering level master degrees in the Lowcountry to support not only improved technical competence and company advancement, but also promotion opportunities for the current workforce. As noted in many locations to include Forbes Magazine, the master's degree helps distinguish a candidate for promotion and advancement within the company and industry.

The argument within the State House for many years is the need for a comprehensive university in the Lowcountry to be able to offer those already here the ability to obtain PhD level degrees. To support the long-term goal to offer engineering PhD's in the Lowcountry, The Citadel is positioned with its all PhD faculty team to offer an MSME degree. The new mechanical engineering graduate program will closely resemble course offerings at Clemson University and USC to ensure ease of transfer for students desiring to transfer for a MS Thesis option or PhD.. An MSME degree at The Citadel will support the needs of local students unable to fully attend Clemson or USC for an MS degree, courses needed by PhD students conducting research in the Lowcountry, employees of local companies, and the current students already taking a BSME at The Citadel whether as a cadet or an evening student.

## NEW PROGRAM PROPOSAL

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

Yes

No

If yes, explain. (500 characters)

n/a

## NEW PROGRAM PROPOSAL

### List of Similar Programs in South Carolina

Program Name	Institution	Similarities	Differences
MSME	Clemson University	Offering of courses in composites, mechatronics, manufacturing, aeronautics, power and energy	The Citadel MSME will only be a no thesis MS degree, only requires 6 ME courses and the other 4 courses can be Technical (ME, CE, EE, other) or non-technical (accounting, business, leadership, project management, etc.)
MSME	The University of South Carolina	Offering of courses in composites, mechatronics, manufacturing, aeronautics, power and energy	The Citadel MSME will only be a no thesis MS degree, only requires 6 ME courses and the other 4 courses can be Technical (ME, CE, EE, other) or non-technical (accounting, business, leadership, project management, etc.)

**Notes:**

There are no Masters of Science in Mechanical Engineering programs in the Low Country of South Carolina. There are MSME programs at Clemson University and The University of South Carolina, but limited opportunity for local students in the heavily populated area of Charleston to attend face-to-face a Mechanical Engineering program without leaving the area as well as limited opportunity for local employees to further their education face-to-face in Mechanical Engineering. The Citadel has a Bachelor of Science in Mechanical Engineering. Trident Technical College has an Associate in Science, Mechanical Engineering Transfer. Many students in the Associate in Science, Mechanical Engineering Transfer program at Trident Technical College matriculate into The Citadel's evening undergraduate Mechanical Engineering program. Many of these students desire to continue living in the Lowcountry and eventually obtain a MSME degree face-to-face.

**NEW PROGRAM PROPOSAL**

**Description of the Program**

<b>Projected Enrollment</b>						
<b>Year</b>	<b>Fall</b>		<b>Spring</b>		<b>Summer</b>	
	Headcount	Credit Hours	Headcount	Credit Hours	Headcount	Credit Hours
2016-2017	5	45	5	45	3	15
2017-2018	12	108	12	108	6	18
2018-2019	19	171	19	171	10	30
2019-2020	29	261	29	261	15	45
2020-2021	39	351	39	351	20	60

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

Yes

No

If yes, explain. (1000 characters)

n/a

Are there any special articulation agreements for the proposed program?

Yes

No

If yes, identify. (1000 characters)

n/a

## NEW PROGRAM PROPOSAL

### Curriculum

Select one of the following charts to complete: Curriculum by Year **or** Curriculum by Category

The categories listed in the following table represent courses in the focus areas of the proposed MSME program. Focus areas are a collection of courses that are interrelated. They will not be recorded on a student's transcript, but they allow the student depth in a particular area of mechanical engineering and to build on previous knowledge. Specific requirements for the courses are listed in a subsequent table in this section.

The Citadel MSME will require 30 credit hours where 18 credit hours will be technical while 12 credit hours can be non-technical (finance, accounting, leadership, program management, etc.). Of the 18 credit hours of technical courses, 12 must be from one of the five categories listed in the following table. The other 6 technical hours can be from the same or a different category.

Requirements - Citadel MS in Mechanical Engineering:

- 30 credit hours, non-thesis
- Require at least 6 courses (18 hours) in technical classes; 4 courses (12 hours) in one focus area / category
- 4 courses (12 hours) in technical or non-technical classes (Mechanical, Electrical, Civil, Program Management, Business)

<b>Curriculum by Category*</b>			
<b>Composites</b>	<b>Credit hours</b>	<b>Aeronautical</b> (Recommended sequence is MECH 611, 670, 771, and 772)	<b>Credit Hours</b>
MECH 604: Advanced Mechanics of Materials	3	MECH 631: Advanced Engineering Mathematics	3
MECH 605: Materials and Process Selection	3	MECH 611: Advanced Fluid Mechanics	3
MECH 606: Fatigue and Fracture	3	MECH 670: Applied Aerodynamics	3
MECH 702: Theory of Elasticity	3	MECH 771: Compressible Flow	3
MECH 703: Theory of Plasticity Note: Recommend MECH 702 before 703	3	MECH 772: Computational Methods in Thermal Sciences	3
MECH 708: Mechanics of Composite Materials	3		
<b>Manufacturing</b> (Courses can be taken in any sequence)		<b>Power and Energy</b> (Courses can be taken in any sequence)	
MECH 625: Computer-Aided Design and Analysis	3	MECH 615: Applied Heat Transfer	3
MECH 635: Computer-Aided Design and Analysis Laboratory	0	MECH 617: Advanced Topics in Renewable Energy Systems	3
MECH 640: Manufacturing Process and Design	3	MECH 618: Energy Sources, Technology, and Policy	3

**NEW PROGRAM PROPOSAL**

MECH 645: Machine Design	3	MECH 619: Power Systems Engineering	3
MECH 660: Advanced Design	3		
<b>Mechatronics</b> (Courses can be taken in any sequence except MECH 755)			
MECH 650: Modeling, Analysis, and Control Systems	3		
MECH 655: Advanced Mechatronics	3		
MECH 750: Introduction to Modern Control Engineering	3		
MECH 755: Nonlinear Control Engineering	3		

\* Add category titles to the table (e.g., major, core, general education, concentration, electives, etc.)

Total Credit Hours Required 30

## NEW PROGRAM PROPOSAL

### Course Descriptions for New Courses

New courses will be developed during 2016 - 2018. Most 600-699 courses will be developed in the 2016-2017 academic year. 700-799 courses will be developed 2017 – 2018. Priority will be to courses and focus areas requested by enrolling students and in demand by employers through an employer survey.

Course Name	Description
MECH 604: Advanced Mechanics of Materials	Advanced topics in mechanics of materials, including three-dimensional stress and strain transformations, torsion of non-circular prismatic bars, shear center, unsymmetrical bending, curved beams, flat plates, elastic strain energy, and theories of failure and application to machine and structural design. <i>Prerequisites:</i> CIVL 304 or consent of program director.
MECH 605: Materials and Process Selection	Engineering application of materials. Material, shape, and process selection for mechanical designs based on function, constraints, objectives, and free variables. Materials and the environment. <i>Prerequisites:</i> CIVL 304 or consent of program director.
MECH 606: Fatigue and Fracture	Stationary crack under static loading, energy balance, crack initiation and growth, dynamic crack growth, and fatigue of metals, ceramics, polymers, and composites. <i>Prerequisite:</i> MECH 304 Engineering Materials or equivalent.
MECH 702: Theory of Elasticity	Plane stress and plane strain; two-dimensional problems in rectangular and polar coordinates; strain energy methods; complex variables in two-dimensional problems; the general equations of three-dimensional elasticity. <i>Prerequisites:</i> MECH 604 (Advanced Mechanics of Materials) or consent of program director.
MECH 703: Theory of Plasticity	Stress and strain tensors; elastic stress-strain relations, criteria of yielding; plastic stress-strain relations; elastoplastic problems of spheres and cylinders; the plane elastoplastic problem; the slip-line field. <i>Prerequisites:</i> MECH 604 (Advanced Mechanics of Materials) or consent of program director.
MECH 708: Mechanics of Composite Materials	Analysis of stress, strain, and strength of fiber reinforced composite laminates and structures. Topics include laminated plate theory, stress analysis of orthotropic plates, damage mechanisms, fatigue, impact, thermal and environmental effects. <i>Prerequisite:</i> MECH 604 (Advanced Mechanics of Materials) or consent of program director.
MECH 631: Advanced Engineering Mathematics	Classification and solution of partial differential equations; includes linear superposition, separation of variables, Fourier and Laplace transform methods, Green's functions, similarity solution, and spectral methods; introduction to solution of nonlinear partial differential equations, including both exact and approximate techniques, with a strong emphasis on physical systems. <i>Prerequisite:</i> MATH 335 (or equivalent undergraduate Applied Mathematics II course) or consent of program director.
MECH 611: Advanced Fluid Mechanics	Advanced Fluid Mechanics is a continuation of concepts presented in a typical undergraduate course in fluid mechanics. The course introduces vector, tensor, and indicial notation. Topics in incompressible fluid dynamics are explored at depth including viscous flows, the Navier-Stokes

## NEW PROGRAM PROPOSAL

	equations, and boundary layer theory. Basic concepts in turbulent flow are also covered. <i>Prerequisites:</i> MATH 231 and MECH 311 or consent of program director.
MECH 670: Applied Aerodynamics	Applied Aerodynamics introduces the basic theories for analyzing the aerodynamic forces on a vehicle in flight. Topics include incompressible flow over airfoils and finite wings, laminar and turbulent boundary layers in airfoil analysis, and boundary layer transition. <i>Prerequisites:</i> MATH 231 and MECH 311 or consent of program director.
MECH 771: Compressible Flow	Compressible Flow combines aspects of classical thermodynamics and equilibrium mixtures with compressible fluid flow. Chemical thermodynamics and real gases are explored. One-dimensional flows through nozzles and diffusers are analyzed. Normal and oblique shock relations, Prandtl-Meyer flow, and method of characteristics are also introduced. <i>Prerequisites:</i> MATH 231 and MECH 611 or consent of program director.
MECH 772: Computational Methods in Thermal Sciences	Computational Methods in Thermal Sciences is an introduction to the field of Computational Fluid Dynamics (CFD). Finite difference methods for the solution of fluid dynamics and heat transfer problems are utilized. Students will gain a general understanding of numerical methods, computer programming, and fluid dynamics and heat transfer through project-based assignments. Finite volume methods are also introduced. <i>Prerequisites:</i> MATH 231, MECH 611, MATLAB experience or consent of program director.
MECH 625: Computer-Aided Design and Analysis	Geometric and solid modeling, finite element analysis, optimization, rapid prototyping. Emphasizes practical utilization of computer-based design tools. <i>Prerequisites:</i> MECH102 and MECH 325 or consent of program director. <i>Corequisite:</i> MECH 635.
MECH 635: Computer-Aided Design and Analysis Laboratory	Non-credit laboratory to accompany MECH 625. <i>Corequisite:</i> MECH 625.
MECH 640: Manufacturing Process and Design	Selection and analysis of manufacturing processes. Product and process design for automated manufacturing. Economic analysis of manufacturing. Automated manufacturing, knowledge-based systems, and flexible product manufacture. <i>Prerequisites:</i> MECH 340 or consent of program director.
MECH 645: Machine Design	Selection, design, assembly, and analysis of common machine elements including springs, shafts, gears, clutches, brakes, and bearings. Computer-based methods of optimization employed when appropriate. <i>Prerequisites:</i> MECH 345 or consent of program director.
MECH 660: Advanced Design	Creative decision-making processes for design. In-depth study of design in mechanical engineering. Quality functions, robust design, axiomatic design, and design for assembly.
MECH 615: Applied Heat Transfer	Fundamentals of conduction, convective heat transfer, diffusive and convective mass transfer, heat-exchanger design; tradeoff associated with heat transfer systems, workable and optimal system. <i>Prerequisites:</i> MECH 415 or consent of program director.
MECH 617: Advanced Topics in Renewable Energy Systems	Advanced topics in renewable energy sources to include solar heating and cooling, wind resource characteristics and assessments; wind turbine technologies (fixed and variable-speed turbines); wind power transmission; integration and interconnection issues; and photovoltaic energy. Surveys

## NEW PROGRAM PROPOSAL

	the life cycle cost and present value to evaluate systems. Same as MECH 417 but includes graduate student project / report. <i>Prerequisites:</i> MECH 415 or consent of program director.
MECH 618: Energy Sources, Technology, and Policy	Multidisciplinary overview of energy technologies, fuels, environmental impacts, and public policies. Quantitative engineering analysis in energy, including the differences among fuels and energy technologies, the electricity sector, liquid fuels, conventional fuels, renewable fuels, impacts on the environment, basics of atmospheric chemistry, and water use for power plant cooling. Energy policy and the societal aspects of energy, such as culture, economics, war, and international affairs, are covered. <i>Prerequisites:</i> MECH 415 or consent of program director.
MECH 619: Power Systems Engineering	Physical features, operational characteristics, and analytical models for major electric power systems and components; advanced techniques for solving large power networks; load flow, symmetrical components, short circuit analysis. <i>Prerequisites:</i> MECH 415 or consent of program director.
MECH 650: Modeling, Analysis, and Control Systems	Methods for analytical modeling, analysis, prediction, and control of linear, stationary time series of multidisciplinary dynamic systems, including mechanical, electrical, electro-mechanical, hydraulic and pneumatic systems; includes examples of advanced research in nonstationary time-series modeling and applications in manufacturing and other areas. Students complete a project on a topic of their choice. <i>Prerequisite:</i> MECH 350 and MECH 450 or consent of program director.
MECH 655: Advanced Mechatronics	Integrated use of mechanical, electrical, and computer systems for information processing and control of machines and devices. System modeling, electro- mechanics, sensors and actuators, basic electronics design, signal processing and conditioning, noise and its abatement, grounding and shielding, filters, and system interfacing techniques. <i>Prerequisite:</i> MECH 350 and MECH 450 or consent of program director.
MECH 750: Introduction to Modern Control Engineering	State variable methods, eigenvalues, and response modes; controllability, observability, and stability; calculus of variations; optimal control; control of regulator and tracking servomechanisms; Hamilton-Jacobi, dynamic programming; deterministic observers, Kalman filter; discrete and continuous time. <i>Prerequisite:</i> MECH 350 and MECH 450 or consent of program director.
MECH 755: Nonlinear Control Engineering	Characteristics of nonlinear systems; State space formulation; stability criteria; Liapunov functions; describing functions; signal stabilization; Popov and circle criteria for design; adaptive control-systems. <i>Prerequisite:</i> MECH 350 and MECH 650 or consent of program director.

The new mechanical engineering graduate program will closely resemble course offerings at Clemson University and USC to ensure ease of transfer for students desiring to transfer for a MS Thesis option or PhD. A comparison of the degree with those at Clemson University and the University of South Carolina is provided below in Table 1. The Citadel MSME will require 30 credit hours where 18 credit hours will be technical while 12 credit hours can be non-technical (finance, accounting, leadership, program management, etc.). As shown in Table 1, there will be the opportunity to complete individual graduate certificates in five main focus areas to meet the needs of the local industry in South Carolina: Manufacturing, Materials, Mechatronics, Power and Energy, and Aeronautics. If the student is interested in earning a graduate certificate in one of the focus areas, the student will need to complete the necessary coursework to meet all of the requirements of the certificate program.

## NEW PROGRAM PROPOSAL

Table 1: MS Mechanical Engineering Comparison to Other Institutions

	<b>Citadel</b>	<b>Clemson</b>		<b>USC</b>	
	MS Non Thesis	MS Thesis	MS Non Thesis	MS Thesis	ME Non Thesis
Total Hrs	30	30	33	30	30
Core / Focus Area	Comp. – 12 Aero – 12 Manf – 12 Pwr&En – 12 Mechatron – 12	Eng Mech –12 TherFluid – 15 Dynamics – 9 DsgnManf -9	Eng Mech –12 TherFluid – 15 Dynamics – 9 DsgnManf -9	12	12
Other Tech	6 minimum	0 → 6 (50% min tech)	0 → 9 (50% min tech)	advisor	advisor
Other	12 maximum	15	15	advisor	advisor

**Citadel MS in Mechanical Engineering:**

- 30 credit hours, non-thesis
- Require at least 6 courses (18 hours) in technical classes
- 4 courses (12 hours) in technical or non-technical classes (Mechanical, Electrical, Civil, Program Management, Business)

**Example Course Plan:**

If a student, for example, has a focus in Composites, he/she must take the 4 Composite courses. The remaining technical courses must be a minimum combination of 2 from the Other Technical Courses (from available focus areas such as Aero). The Other 4 courses can be from non-technical (Business, Leadership, Program Management) or from technical programs (Mechanical, Electrical, or Civil). See example in Table 2, below.

**NEW PROGRAM PROPOSAL**

Table 2: Sample Course Plan for Composite Focus in MS ME Program

	Course # and Title	30 Credit Hours
MS ME Focus Area (Composites)	MECH 604: Advanced Mechanics of Materials	3
	MECH 606: Fatigue and Fracture	3
	MECH 702: Theory of Elasticity	3
	MECH 708: Mechanics of Composite Materials	3
Other Tech Courses	MECH 605: Advanced Engineering Mathematics	3
	MECH 670: Applied Aerodynamics	3
Other Courses	PMGT 650: Overview of Technical Project Mgmt	3
	PMGT 651: Tech Project Planning and Scheduling	3
	PMGT 652: Applications in Quality Management	3
	PMGT 653: Technical Project Support and Operations	3

**NEW PROGRAM PROPOSAL**

**Faculty**

<b>Faculty and Administrative Personnel</b>				
<b>Rank</b>	<b>Full- or Part-time</b>	<b>Courses Taught or To be Taught, Including Term, Course Number &amp; Title, Credit Hours</b>	<b>Academic Degrees and Coursework Relevant to Courses Taught, Including Institution and Major</b>	<b>Other Qualifications and Comments (i.e., explain role and/or changes in assignment)</b>
*Professor	Full-time	To be hired		
Associate Professor	Full-time	MECH 650 MECH 655 MECH 750 MECH 755	PhD, MSE: ME Univ TX at Austin; Model & Simul, Sys Dynamics, Cntrl Sys Dsgn, Veh Sys Dyn, Mechatronics	Professional Engineer, PE
Associate Professor	Full-time	MECH 604 MECH 605 MECH 606 MECH 702 MECH 703 MECH 708	PhD, University of New Orleans: Plasticity, Elasticity, Aerospace Composites, Advanced Composite Materials, Fracture Mechanics ; ME, Poznan University of Technology: Solid-state Physics, Production Technology	
Assistant Professor	Full-time	MECH 625 MECH 635 MECH 640 MECH 645 MECH 660	PhD, ME Georgia Tech; Computer Aided Design, Mfg Processes and Systems, Mfg Systems, Micro Mfg, Eng Economy, Fracture Mechanics, Structural Vibrations	
Assistant Professor	Full-time	MECH 631 MECH 611 MECH 670 MECH 771 MECH 772	MS, MAE, Univ of Virginia; PhD, Univ. of Tenn-Knoxville Comp Flow, Fluid Mech, Adv Engr Math, Num Methods, CFD, Conduction, Convection, Radiation, Stat Mech, Non-Eq. Thermo, Combustion	Fundamentals of Engineering, EIT
*Assistant Professor	Full-time	MECH 615 MECH 617 MECH 618 MECH 619	Howison, MS, MAE – UVA; PhD, Univ. of Tenn-Knoxville Conduction, Convection, Radiation, Combustion Rabb, PhD, ME – UT Austin; Radiation Heat Transfer, Combustion, Sys Dynamics	These two individuals can be covered until assistant professor is hired.
*Assistant Professor	Full-time	To be hired		
*Assistant Professor	Full-time	To be hired		

Note: Individuals should be listed with program supervisor positions listed first. Identify any new faculty with an asterisk next to their rank.

## NEW PROGRAM PROPOSAL

Total FTE needed to support the proposed program (i.e., the total FTE devoted just to the new program for all faculty, staff, and program administrators):

Faculty	1	Staff	0	Administration	0
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Expect to hire the new FTE in 2016-2017. Request position within 2016-2017 budget build.

### Faculty /Administrative Personnel Changes

Provide a brief explanation of any additional institutional changes in faculty and/or administrative assignment that may result from implementing the proposed program. (1000 characters)

Faculty are required to teach a full load – 12 credit hours each semester. Each faculty member may consult one day per week and can gain teaching release time for successful research proposals. Additionally, The Citadel has a foundation grant that provides funding (\$2500 each area/year) in the following three areas: research seed funding, result presentations at conferences, and/or participate in faculty development opportunities. The new MSME program will start with current faculty teaching courses as an add pay in the summer while leveraging the ability for students to take up to 4 non-technical courses already being offered throughout the year. As the demand increases beyond the ability for faculty to cover courses with add pay, faculty positions will be requested or reallocated. Current estimates would allow the program to cover 6 graduate courses per semester when the full complement of faculty are hired based on the BSME program approved 3 October 2013 and one additional FTE faculty member (2017). The staff and administration positions supporting the BSME will also support the MSME program.

### Library and Learning Resources

Identify current library/learning collections, resources, and services necessary to support the proposed program and any additional library resources needed. (1000 characters)

The 2011 Standards for College Libraries does not address Mechanical Engineering specifically beyond recommending that a comparison of our holdings should occur with a group of peer institutions. The Citadel's holdings were compared with those of Clemson and USC (PASCAL members), VMI, UT-Chattanooga, Western Carolina, and University of North Florida. The Citadel library catalog holdings are small for mechanical engineering; however, the current ebook package, Academic Complete from ebrary, yields 3,521 hits from the same phrase search. These ebooks are available from on and off campus to currently-enrolled students.

The top 5 U.S. journals in mechanical engineering are *IEEE/ASME Transactions on Mechatronics* (access *IEEE*), *Precision Engineering* (access *ScienceDirect*), *Journal of Fluids and Structures* (access *ScienceDirect*), *Journal of Sound and Vibration* (access *ScienceDirect*), *Tribology Letters* (access *ScienceDirect*), and *Tribology International* (access *ScienceDirect*). The Citadel has access to all of them.

The new BSME program has purchased a print version of the entire ASTM package. We expect many fully employed students will be using company resources to complete assignments. The Citadel currently spends approximately \$40,000 per year on library resources for engineering.

## **NEW PROGRAM PROPOSAL**

### **Student Support Services**

Identify academic support services needed for the proposed program and any additional estimated costs associated with these services. (500 characters)

The Citadel currently has strong student support services for existing undergraduate programs, graduate programs and veterans. These same services would provide support for the evening students who would be taking courses within the MSME degree or associated certificates. It is expected that a majority of the students will be either full time employed or completing research degrees through Clemson's Restoration Institute. The Citadel and Clemson support credit (up to five courses) for each other's masters programs and The Citadel courses and faculty could support the research and associated courses at Clemson's Restoration Institute.

### **Physical Resources**

Identify any new instructional equipment needed for the proposed program. (500 characters)

The equipment being purchased as part of the new BSME program as well as the equipment used within the BSCE and BSEE programs will support any physical demonstrations needed within MSME level courses. Since the MSME degree requires only 10 courses and no thesis, the lab equipment needs will be limited to support for showing theoretical concepts within a given course. The five focus areas: composites, mechatronics, manufacturing, aeronautics, and power and energy are the same as the five focus areas within the BSME and associated equipment being purchased.

Will any extraordinary physical facilities be needed to support the proposed program?

Yes

No

Identify the physical facilities needed to support the program and the institution's plan for meeting the requirements, including new facilities or modifications to existing facilities. (1000 characters)

n/a

**NEW PROGRAM PROPOSAL**

**Financial Support**

<b>Estimated New Costs by Year</b>						
<b>Category</b>	<b>1<sup>st</sup></b>	<b>2<sup>nd</sup></b>	<b>3<sup>rd</sup></b>	<b>4<sup>th</sup></b>	<b>5<sup>th</sup></b>	<b>Total</b>
Program Administration	0	0	0	0	0	0
Faculty and Staff Salaries	6,000	12,000	105,000	105,000	117,000	345,000
Graduate Assistants	0	0	0	0	0	0
Equipment	0	0	0	0	0	0
Facilities	0	0	0	0	0	0
Supplies and materials	500	500	500	500	500	2500
Library Resources	0	0	0	0	0	0
Other*	0	0	0	0	0	0
<b>Total</b>	<b>6,500</b>	<b>12,500</b>	<b>105,500</b>	<b>105,500</b>	<b>117,500</b>	<b>347,500</b>
<b>Sources of Financing</b>						
<b>Category</b>	<b>1<sup>st</sup></b>	<b>2<sup>nd</sup></b>	<b>3<sup>rd</sup></b>	<b>4<sup>th</sup></b>	<b>5<sup>th</sup></b>	<b>Total</b>
Tuition Funding	19,500	45,000	72,000	109,500	147,000	393,000
Program-Specific Fees	0	0	0	0	0	0
State Funding (i.e., Special State Appropriation)*	0	0	0	0	0	0
Reallocation of Existing Funds*	0	0	0	0	0	0
Federal Funding*	0	0	0	0	0	0
Other Funding*	0	0	0	0	0	0
<b>Total</b>	<b>19,500</b>	<b>45,000</b>	<b>72,000</b>	<b>109,500</b>	<b>147,000</b>	<b>393,000</b>
<b>Net Total (i.e., Estimated New Costs Minus Sources of Financing)</b>	<b>13,000</b>	<b>32,500</b>	<b>(33,500)</b>	<b>4,000</b>	<b>29,500</b>	<b>45,500</b>

\*Provide an explanation for these costs and sources of financing in the budget justification.

## NEW PROGRAM PROPOSAL

### Budget Justification

Provide a brief explanation for the other new costs and any special sources of financing (state funding, reallocation of existing funds, federal funding, or other funding) identified in the Financial Support table. (1000 characters)

**Note: Institutions need to complete this budget justification *only* if any other new costs, state funding, reallocation of existing funds, federal funding, or other funding are included in the Financial Support table.**

n/a

### Evaluation and Assessment

**Programmatic Assessment:** Provide an outline of how the proposed program will be evaluated, including any plans to track employment. Identify assessment tools or software used in the evaluation. Explain how assessment data will be used. (3000 characters)

The Citadel is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools. The undergraduate engineering programs are accredited by ABET (ME will request initial accreditation in June 2016). The MS in Project Management has requested accreditation through the Project Management Institute Global Accreditation Center. The MSME program will track accomplishment of Program Outcomes through the Taskstream software. Taskstream's platforms provide a centralized information and communication hub for assessment, accreditation, and planning activities across an institution. These include academic and non-academic outcomes assessment, planning, and program review. Taskstream offers specialized tools that enable users to document learning outcomes, align outcomes to institutional goals and standards, develop assessment plans, create curriculum maps, manage faculty credentials, and improve education based on findings. Taskstream's suite of tools facilitates the collection of student work, student reflections on the learning process, and faculty or peer rubric-based assessment. Rubrics, which are used to clarify expectations and scoring criteria, may also be aligned with established learning outcomes, standards, and competencies. The software provides reporting capabilities to support the aggregation and analysis of student performance data for the review of program and institutional effectiveness, as well as for reporting to accrediting agencies and other external stakeholders.

All programs within the School of Engineering track employment or employment changes after completion of each degree. The MSME will track employment data in a similar way, but will also track from where students are initiating their MSME (full-time employment, research, full-time schooling by continuing their education after a BSME, etc.). Surveys from employers and continuing education institutions will be part of the post-graduation assessment data. Additionally, Professional Registration (PE) success rates will be used to assess the program.

**NEW PROGRAM PROPOSAL**

**Student Learning Assessment**

<b>Expected Student Learning Outcomes</b>	<b>Methods of/Criteria for Assessment</b>
Demonstrate breadth of knowledge in complimentary areas of mechanical engineering that promotes an awareness of and skill in interdisciplinary problem solving	Exams, design projects Courses: MECH 605, MECH 708, MECH 611, MECH 631, MECH 625, MECH 660, MECH 615, MECH 618, MECH 650, MECH 750
Demonstrate a depth of knowledge in a chosen focus area of mechanical engineering that allows the student to apply innovative techniques to solve problems	Exams, design projects and graduate certificates in focus areas Courses: MECH 604, MECH 606, MECH 611, MECH 671, MECH 640, MECH 645, MECH 617, MECH 619, MECH 655, MECH 755
Demonstrate knowledge in methods of advanced analysis appropriate for professional use when solving problems	Exams, design projects, homework Courses: MECH 605, MECH 772, MECH 635, MECH 617, MECH 655
Demonstrate knowledge of contemporary issues in their chosen focus area	Papers, presentations Courses: MECH 708, MECH 772, MECH 660, MECH 617, MECH 655
Demonstrate the skills relevant to graduate level work to include the ability to formulate problems, synthesize and integrate information, work collaboratively, and to communicate effectively	Exams, design projects, homework, presentations Courses: MECH 702, MECH 703, MECH 670, MECH 640, MECH 617, MECH 655
Demonstrate preparation for successful careers in industry or continued graduate work and an ethic for lifelong learning	Surveys, work placement tracking, and graduate certificates in focus areas of the MSME program Courses: MECH 708, MECH 772, MECH 660, MECH 618, MECH 755

## NEW PROGRAM PROPOSAL

Will the proposed program seek program-specific accreditation?

Yes

No

If yes, provide the institution's plans to seek accreditation, including the expected timeline for accreditation. (500 characters)

n/a

Will the proposed program lead to licensure or certification?

Yes

No

If yes, explain how the program will prepare students for licensure or certification. (500 characters)

n/a

## Teacher or School Professional Preparation Programs

Is the proposed program a teacher or school professional preparation program?

Yes

No

If yes, complete the following components.

Area of Certification

n/a

Please attach a document addressing the South Carolina Department of Education Requirements and SPA or Other National Specialized and/or Professional Association Standards.

Mechanical Engineering  
Appendix – Additional Questions from CHE

**1. How are we going to fund the new degree when we have asked for no money and placed none in the table.**

The new mechanical engineering (ME) degree will start slowly allowing the administration to gauge interest and demand, and at the same time, not strain any existing resources. We anticipate the majority of the initial students to be part-time since they will be full-time employed within the Low Country. The new degree requires no new infrastructure, laboratory facilities, or services since the new master's degree is an evening program and a majority of our undergraduate courses and laboratories are completed by 5 PM each day; therefore, we have the infrastructure to support the new MS degree which begins after 5 PM.

Initially, full time PhDs at The Citadel will teach the MS ME courses and will be compensated with add pay. In subsequent years, adjuncts will be used to fill teaching opportunities within the undergraduate degree to allow PhD credentialed faculty to teach within the graduate degree as the demand increases. Currently the program utilizes no adjuncts to support the undergraduate program. A full time faculty member will be hired when the demand for full time graduate courses grows to justify a full time position. The administration of the program will initially be handled by the Department Head with the addition of a program director (course reduction for an existing faculty member) once the work load and revenue generation allow for that increase.

**2. How we plan to roll-out the new programs.**

Summary: Initially, the mechanical engineering (ME) program will select one or two focus areas (Composites, Aeronautics, Manufacturing, Power and Energy, or Mechatronics) to offer to the first cohort of students. The ME courses will be developed and taught based on interest from prospective students and employers. Surveys will be used to gather this data. In the first cohort (1-2 years), we expect the current faculty to be able to develop and teach two courses over the summer term, and one course each semester in the fall and spring. Students will be able to take two technical courses during the summer term, and one technical course during each long semester. If students wish to take additional courses during the fall and spring terms, they can take existing, non-technical graduate level courses in Program Management, Business, Leadership or technical graduate level courses in other engineering departments such as civil and electrical. Students must complete at least six technical courses. The remaining four courses can be technical or non-technical.

Example: Based from surveys of potential student and local employers, the Aeronautical focus area is selected as the first to be developed. Students would earn a MSME selecting the following sequence of courses:

Table 1: Example MSME Sequence

	Technical Courses	Non-Technical Courses
Summer 2016	MECH 631: Adv Eng Math	
Fall 2016	MECH 611: Adv Fluid Mechanics	PMGT <i>or</i> BADM 600/700 level
		Note: PMGT and BADM courses are currently offered fall, spring, and summer and can support additional enrollment.
Spring 2017	MECH 771: Compressible Flow	PMGT <i>or</i> BADM 600/700 level
Summer 2017	MECH 772: Comp Mthds in Thermal Sci	
Fall 2017	MECH 604: Adv Mech of Matls	PMGT <i>or</i> BADM 600/700 level
Spring 2018	MECH 605: Matls and Process Selection	PMGT <i>or</i> BADM 600/700 level

Priority: The following table lists the initial priority of focus areas with the course development sequence within each.

Table 2: MSME Course Priority for Development

<b>Focus Area</b>	<b>Course</b>	<b>Estimated Development / Offering</b>
<b>Aeronautical</b>	MECH 631: Advanced Engineering Mathematics	Year 1
	MECH 611: Advanced Fluid Mechanics	1
	MECH 771: Compressible Flow	1
	MECH 772: Computational Methods in Thermal Sciences	2
	MECH 670: Applied Aerodynamics	2
<b>Composites</b>	MECH 604: Advanced Mechanics of Materials	Year 2
	MECH 605: Materials and Process Selection	2
	MECH 708: Mechanics of Composite Materials	2
	MECH 606: Fatigue and Fracture	3
	MECH 702: Theory of Elasticity	3
	MECH 703: Theory of Plasticity Note: Recommend MECH 702 before 703	3
<b>Manufacturing</b>	MECH 625: Computer-Aided Design and Analysis	Year 3
	MECH 635: Computer-Aided Design and Analysis Laboratory	3
	MECH 640: Manufacturing Process and Design	3
	MECH 645: Machine Design	4
	MECH 660: Advanced Design	4
	MECH 615: Applied Heat Transfer	Year 3
<b>Power and Energy</b>	MECH 617: Advanced Topics in Renewable Energy Systems	3
	MECH 618: Energy Sources, Technology, and Policy	4
	MECH 619: Power Systems Engineering	4
	MECH 615: Applied Heat Transfer	Year 3
<b>Mechatronics</b>	MECH 650: Modeling, Analysis, and Control Systems	Year 4
	MECH 655: Advanced Mechatronics	4
	MECH 750: Introduction to Modern Control Engineering	5
	MECH 755: Nonlinear Control Engineering	5

**3. How our relationship with Clemson at the restoration center will influence funding and/or roll-out of the new programs.**

An articulation agreement (ref TIGE, The Institute for Graduate Education) between The Citadel and Clemson is in effect for the new MS programs. The Citadel and Clemson support credit (up to five courses) for each other’s masters programs. This is above the typical limit of 9-12 transfer hours or 3-4 courses from another institution. Under the agreement, The Citadel’s courses and faculty could support the research and associated courses (graduate level) at Clemson’s Restoration Institute. This relationship will help to provide additional students and course offering that neither institution would have individually. The Citadel currently has one faculty member and two students working with Clemson’s Restoration Institute.

**4. Complete list of current faculty, adjunct, and staff supporting the program. We are in the process of adding additional adjuncts once the MS program is approved.**

Faculty Name	Highest Degree Earned-Field and Year	Rank <sup>1</sup>	Type of Academic Appointment <sup>2</sup> T, TT, NTT	FT or PT	Years of Experience			Professional Registration/ Certification – Current Employer if not Citadel
					Govt./Ind. Practice	Teaching	This Institution	
Robert J. Rabb	Ph.D., Mechanical 2007	ASC	TT	FT	19	8	2	MO
Monika Bubacz	Ph.D., Mechanical, 2006	ASC	TT	FT	5	8	2	
Kevin Skenes	Ph.D., Mechanical, 2014	AST	TT	FT	1	1	1	
Jason Howison	Ph.D., Aerospace, 2015	AST	TT	FT	2	1	1	EIT
Jeremy Barrows	M.S. Industrial & Systems, 2005	A	NTT	PT	15	0	0	Boeing
Adam Cho	M.S. Mechanical, 2014	A	NTT	PT	1	1	0	EIT / Boeing
Rachel Hannah	M.S. Mechanical, 2009	A	NTT	PT	6	2	0	EIT / Boeing

1. Code: P = Professor Track T = Tenured ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other 2. Code: TT = Tenure NTT = Non Tenure Track

**5. As can be seen below, we have a robust and very active in the lowcountry set of industry advisors for our program. They have been voicing a need for face-to-face MS degrees for years to ensure the continuous improved technical competence, company advancement, and promotion opportunities.**

MECHANICAL ENGINEERING ADVISORY BOARD ROSTER  
The Citadel, 171 Moultrie Street, Charleston, SC 29409

Academic Year 2014-2015

Name	Job Title	Company	Company Address	Email	Phone
Steven Hollingswoth	Director Production Programs : Support Services	BAE Systems	5895 Core Rd North Charleston, 29405	<a href="mailto:steven.hollingsworth@baesystems.com">steven.hollingsworth@baesystems.com</a>	Cell: 843-637-0825  Office: 843-614-5165
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Mike Mayer	787-8/-9 Aft Body Stress Manager	Boeing South Carolina	3455 Airframe Dr. North Charleston, SC 29418	<a href="mailto:Michael.S.Mayer@boeing.com">Michael.S.Mayer@boeing.com</a>	843-743-6913