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Item Name: Request for New Academic Programs for Northern Arizona University

☒ Action Item

Requested Action: Northern Arizona University asks the board to approve the new program requests effective in the 2019-2020 and 2020-2021 academic years.

Background/History of Previous Board Action

- As provided in board policy, Academic Strategic Plans may be modified during the year with the approval of the Academic Affairs and Educational Attainment Committee.

Discussion

Northern Arizona University seeks to amend its Academic Strategic Plan for implementation in the 2019-2020, and 2020-2021 academic years. This request is for the following three new academic programs as described in the attached tables:

- Mechanical Engineering, PhD
- Applied Physics and Materials Science, PhD
- Civil and Environmental Engineering, PhD

All academic degree programs go through multiple review and approval processes to ensure their currency, quality, and relevance. Each year, the Provost initiates the academic planning process. The academic deans, in consultation with the directors of the academic units, submit information on all proposed new degrees, concentrations, minors, and certificates for the ensuing year, as well as changes to existing degree titles, program disestablishments, and creation of new organizations, organizational changes and disestablishments. Once reviewed and approved by the Provost, these initiatives begin the review process, including, as applicable, the curriculum committees in the academic unit, college, Graduate College, and University Senate. At each level, a substantive review of the proposed program is completed to ensure quality and to avoid redundancy with other programs. At any step in the approval process, programs can be tabled and/or returned to the academic unit for further clarification and/or revision.

Committee Review and Recommendation

The Academic Affairs and Educational Attainment Committee reviewed this item at its January 24, 2019 meeting, and recommended forwarding the item to the full board for approval.

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Statutory/Policy Requirements

ABOR Policy 2-223.A – the Academic Strategic Plan

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Table 1 - Proposed New Programs

Name of Proposed Degree (degree type and major), College/School, Location, Anticipated Catalog Year	Program Fee Required? (Yes or No)	Brief Description Justification and Identified Market Need	Learning Outcomes and Assessment Plan	Projected 3rd Year Enrollment
Doctor of Philosophy in Mechanical Engineering College of Engineering, Informatics, and Applied Sciences Department of Mechanical Engineering Flagstaff, AZ 2019-2020	No	**Description and Justification:** This program capitalizes and builds on the successful research and curricular programs currently in place in Mechanical Engineering (ME) at NAU. The curriculum is underpinned by recognized and particular areas of research strength at NAU, including wind energy, energy systems, adaptive structures and intelligent systems, nano-heat transfer, computational fluid mechanics, advanced composites, robotics, and tools/devices for scientific discovery. Furthermore, these areas are highly aligned with the needs of local partners, most notably W.L. Gore and Associates, and the technological innovations developed by the program's	**Learning Outcome 1 (LO1):** Solve, analyze, evaluate, and interpret results to complex contemporary mechanical engineering problems using advanced mathematics, computational tools, and state-of-the-art methods in mechanical engineering. • **Concepts:** Engineering analysis and advanced mathematics, renewable energy systems, solid mechanics, adaptive materials, and finite element analysis. • **Competencies:** Synthesis of skills that include analysis, evaluation, and interpretation aimed at combining mathematical and computational methods	14

		faculty and students will spur economic development in the region and State. **Market Need:** The critical nature of ME across a wide spectrum of application areas critical to national need, including energy, security and defense, and healthcare, has resulted in significant demand for degree holders in the discipline. According to US News and World Report [2008], mechanical engineering is "the third-most popular discipline among engineering master's and is back in first place among doctorates." More recently, Hanover Research [2017] identified mechanical engineering as the third-highest area of growth in doctoral degrees in the United States and as one of the top-ten fields in Arizona and the Southwest. The National Research Council [2007] found "favorable job prospects and salaries for U.S. Mechanical Engineers" and an 11% increase in employment for holders of mechanical	• **Measures/Assessment:** Assessment for this outcome will focus on the qualifying examination using a multi-part rubric to assess mastery on the analysis of complex data sets and models, evaluation of analytical results, and the ability to interpret and contextualize these results within specific problem areas **Learning Outcome 2 (LO2):** Analyze and critically evaluate information from the scientific literature on mechanical engineering, and synthesizing this information, and identifying and exploring the leading edges of their field in order to expand the understanding and applications within the discipline. • **Concepts:** Identification, assessment, and initial design of solutions to open research questions in a particular area of research	

		engineering doctorates from 1999 to 2003. The Bureau of Labor Statistics places the job outlook for mechanical engineers in the U.S. at 9% growth for 2016-2026 and notes that "job prospects may be best for those who stay abreast of the most recent advances in technology", which again highlights the need for mechanical engineers with advanced doctoral degrees trained in research-active institutions. The National Research Council [2007] also suggested favorable prospects for ME doctoral graduates with the Department of Defense, NASA, NSF, Department of Energy, industry, and state and local governments.	• **Competencies:** Reviewing related work within a specific area of mechanical engineering research, identifying open research questions, and outlining research directions that advance the state-of-the-art • **Measures/Assessment:** Outcome will be primarily assessed during the qualifying examination and the advancement to candidacy examinations assessing mastery of core topics and ability to distill and evaluate insights **Learning Outcome 3 (LO3):** Design, plan and conduct mechanical engineering research, apply advanced mechanical engineering concepts and tools to research problems, and interpret results of mechanical engineering research. • **Concepts:** Discipline-specific topics, such as continuum mechanics and plasticity, in addition to	

			effective trade-off analysis in designing solutions to open problems and the assessment of these solutions • **Competencies:** Developing a concrete research plan aimed at open research questions, selecting and applying appropriate research methods, assessing results • **Measures/Assessment:** Outcome will be assessed during advancement to candidacy examination, the dissertation defense, and the publication required of all students in the program using independent rubrics measuring key competencies **Learning Outcome 4 (LO4):** Demonstrate the ability to communicate effectively complex mechanical engineering theories and methodologies and the results of a comprehensive research study.	

			• **Concepts:** Effective strategies for clear and effective scientific communication (i.e. story-telling structures such as OCAR) • **Competencies:** Communicating in both written and oral form, for audiences that include both experts and non-experts, addressing an open research question, and describing a solution at multiple levels of detail • **Measures/Assessment:** Outcome will be assessed at multiple points, including the qualifying exam, the advancement to candidacy exam, the dissertation defense, and the required publication using dedicated rubrics to assess each key competency	
Doctor of Philosophy in Applied Physics - and Materials Science	No	**Description and Justification:** This first-of-its-kind in Arizona transdisciplinary program in Applied Physics and Materials	**Learning Outcome 1 (LO1):** Evaluate the major theories, research methods and approaches to inquiry in Applied Physics and	13

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College of Engineering, Informatics, and Applied Sciences Applied Physics and Materials Science Program Flagstaff, AZ 2019-2020		Science (APMS) will position NAU to build research capacity and attract high-caliber students to a distinctive degree program. The two emphases of the program, namely Applied Physics and Materials Science, are intrinsically connected and jointly support applications of physical phenomena to technology design and the discovery of advanced functional materials using methods from areas such as condensed matter physics, applications of quantum phenomena to materials, materials synthesis, and analytical method development. This transdisciplinary fusion of areas and methods is highly sought after by employers and funding agencies (e.g. the recent Q-AMASE-i call by NSF), thus providing new opportunities for funding and workforce development in the region and State. **Market Need:** Research areas within Applied Physics and Materials Science (APMS) have	Materials Science, articulate significant challenges involved in practicing the field of study, elucidate its leading edges, and explore the current limits of theory, knowledge and practice. **Concepts:** Foundational theories and methods in applied physics and materials science, including condensed matter physics, thermodynamics, and quantitative research methods **Competencies:** Ability to evaluate and articulate open research questions in the field and identify open research questions and promising research directions **Measures/Assessment:** Outcome will be assessed during the qualifying exam through separate rubrics, one assessing level of mastery of core topics and one emphasis-specific assessment targeting breadth topics **Learning Outcome 2 (LO2):** Create, design and execute experiments (theoretical or experimental) and develop necessary analytical skills for interpretation and analysis of data	

		become the foundational disciplines for next generation technologies in nano-, meso-, and quantum science. The APMS program is aimed to be at the forefront of preparing the next generation of scientists in these areas, which reflects an understanding of the centrality of APMS in modern materials engineering [Workshop on Materials Science and Materials Engineering Education: National Science Foundation, 2008]. There is significant demand for graduates with the transdisciplinary skillset the APMS curriculum supports across many organizations, including federally-funded research centers such as Los Alamos National Laboratory [Balatsky; letter of support 2018]. A recent global economic assessment report identified "Innovation in materials … particularly new products and processes enabled by advanced and lightweight composites, [and] nanotechnologies", as 1 of 8 potential game changers to impact US productivity, jobs,	to create data-supported conclusions. **Concepts:** Experimental design methods, data collection and analysis methods and tools **Competencies:** Designing experiments using problem-appropriate methods and interpreting the results within the larger context of an open research area **Measures/Assessment:** Outcome will be assessed during the advancement to candidacy examination through research synthesis rubric examining the selection and application of research methods and the interpretation of results **Learning Outcome 3 (LO3):** Evaluate and formulate new ideas and recognize unsolved opportunities in their field to demonstrate independent and critical thinking: (a) Recognize the best paths toward publication and (b) Design experiments (theoretical or experimental) around those ideas for pursuit of meaningful publication.	

		and the economy GDP and "advanced materials" as 1 of 12 disruptive technologies that will transform life, business and the global economy." (Manyika et al., 2013).	**Concepts:** Discipline-specific research methods, experimental design, and publication strategies **Competencies:** Selecting appropriate publication and other scholarly dissemination venues and successfully publishing scholarly results **Measures/Assessment:** Outcome will be assessed during advancement to candidacy examination assessing ability to execute on research methods and during the dissertation defense exam with a focus on assessing scholarly output and quality **Learning Outcome 4 (LO4):** Compose and engage in highly-effective oral and written communication in Applied Physics and Materials Science; demonstrate clear argumentation and logical cohesion for all avenues of scholarly and lay-person dissemination of results. **Concepts:** Effective strategies for communication and scientific story-telling and best-practices for communication based on audience expertise	

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			Competencies: Communicating effectively and with clear and coherent argumentation across a variety of audience stakeholders, including expert and non-expert **Measures/Assessment:** Outcome will be assessed during advancement to candidacy and during dissertation defense exams as well as through an assessment of individual student job placement immediately after graduation **(Materials Science emphasis only) Learning Outcome 5 (LO5):** Elucidate the fundamental concepts of phenomena-based science and apply these to solve problems in materials science: (a) Apply mathematical and computational tools to quantitatively describe and understand a wide range of materials systems. (b) Develop new methodology to create new materials and describe their physical phenomena. (c) Examine or develop modern analytical instrumentation and techniques in order to identify materials and elucidate their functional properties.	

			Concepts: Foundational scientific topics in materials science, including supramolecular chemistry, kinetics, statistical thermodynamics, and nanotechnologies **Competencies:** Developing new methodologies for materials creation and applying analytical techniques for assessing functional properties and potential applications of materials **Measures/Assessment:** Outcome will be assessed during qualifying and advancement to candidacy exams through emphasis-specific rubrics assessing mastery of foundational topics **(Applied Physics emphasis only) Learning Outcome 6 (LO6):** Elucidate the fundamental concepts for the application of the physical phenomena and apply concepts to solve applied physics problems: (a) Elucidate modern problems in physics with molecular dynamics, computation or predictive methodology. (b) Examine how concepts from macroscopic observations are related to the description of	

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			microscopic states that fluctuate around an average state. (c) Develop new analytical tools, through the synthesis of the fundamental understandings of physics phenomena. **Concepts:** Foundational scientific topics in applied physics, including quantum mechanics, electromagnetics, quantum field theory, and solid state physics **Competencies:** Developing new methodologies for molecular dynamics and microscopic states for the analysis of physical phenomena **Measures/Assessment:** Outcome will be assessed during qualifying and advancement to candidacy exams through emphasis-specific rubrics assessing mastery of foundational topics.	
Doctor of Philosophy in Civil and Environmental Engineering College of Engineering, Informatics, and Applied Sciences	No	**Description and Justification:** This program, emphasizing infrastructure resilience, addresses key societal issues and builds upon existing departmental expertise in four focus areas of Civil Engineering: Transportation, Structures, Environmental, and Water Resources. The targeted focus	**Learning Outcome 1 (LO1):** Explain major theories, research methods, and technical approaches within Civil and Environmental Engineering (CENE) and interpret their effect on infrastructure and society. • **Concepts:** Foundational areas of expertise, including	11

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Department of Civil Engineering, Construction Management, and Environmental Engineering Flagstaff, AZ 2020-2021		of infrastructure resilience is unique within the state of Arizona and in the west, joining only a handful of these types of programs in the country. Advanced by its very nature, infrastructure resilience is the design, operation, monitoring, management, security and decommission of any system that supports or enables quality of human life through a changing environment. This program will foster the development of research capacity and scientific discovery in a high-growth area that is critical to Arizona and the Nation. **Market Need:** The U.S. has demonstrated moderate to severe infrastructure problems. High-profile failures of this type include the I-35 bridge collapse in Minnesota; the Oroville Dam crisis; and the Flint, MI water crisis. The American Society of Civil Engineers (ASCE) gave the infrastructure in the United States a grade of 'D+' on its last infrastructure report card.	infrastructure planning, resilience, public policy, and regulatory issues. • **Competencies:** Identify key research methods within areas of expertise in civil and environmental engineering and interpret the impact of their application. • **Measures/Assessment:** Assessment will be conducted using a multi-part rubric deployed during the qualifying examine, which will be focused on measuring the mastery of key discipline-specific concepts across key areas and the extent of analysis addressing societal impact. **Learning Outcome 2 (LO2):** Identify, explain, synthesize, and apply the fundamental concepts of infrastructure and CENE, including the inter-relationships between various infrastructure systems, the impact of changing environmental	

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		Arizona as a state fared better, with an overall grade of 'C,' but that improvement over the national grade is generally attributed to the relative youth of our infrastructure. Given this need, graduates with advanced knowledge in civil engineering are critical and have strong employment prospects. The Bureau of Labor Statistics identifies an expected growth of 11% in civil engineering positions through 2026, while Hanover Research identifies civil engineering among just six areas that are both high-growth and high-completion [*Hanover Research 2018*], emphasizing many opportunities available for graduates of this type of program.	conditions on infrastructure resilience, the relationship between infrastructure management and public policy, and the interdisciplinary nature of infrastructure itself. • **Concepts:** Specialized disciplinary knowledge in infrastructure and infrastructure systems, including topics addressing structures, transportation, and water and environmental resources. • **Competencies:** Identify and select methods and areas of expertise for particular infrastructure problems while synthesizing this expertise into coherent solutions to open CENE research questions. • **Measures/Assessment:** Through the deployment of an infrastructure concepts rubric, assessment will be focused on the ability to meaningfully and coherently combine infrastructure	

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			mastery topics during the qualifying examinations. **Learning Outcome 3 (LO3):** Identify, explain, synthesize, and apply expertise within one of the following CENE technical focus areas: water resources, environmental, transportation, structures, or others as identified. • **Concepts:** Emphasis-specific advanced disciplinary knowledge (e.g. channel flow analysis, flow design, and groundwater engineering for the water resources area). • **Competencies:** Identify, assess, and appropriately apply key research methods and areas of expertise in a specialty area, such as environmental engineering, structures, transportation, and water resources. • **Measures/Assessment:** Assessment will focus on mastery of specialty areas within the discipline during	

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			the qualifying examination by using of an emphasis-specific topics rubric. **Learning Outcome 4 (LO4):** Identify, survey, analyze, organize, and elucidate information and data from the scientific literature within a CENE-specific emphasis area as well as creatively identify open research questions. • **Concepts:** Core disciplinary-specific topics appropriate to a specific research problem as well as analytical methods appropriate to civil and environmental engineering. • **Competencies:** Survey and distill information from scholarly literature and synthesize insights to identify open research questions and promising research directions. • **Measures/Assessment:** Assessment will be focused on key disciplinary methods and the ability to synthesize	

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			knowledge and methods across CENE areas, assessed through a research foundations rubric to be deployed during both the qualifying exam and the advancement to candidacy examinations. **Learning Outcome 5 (LO5):** Independently apply appropriate expertise, methods, and tools to the creative design, execution, and assessment of an investigation that addresses original CENE research questions. • **Concepts:** Experimental design and assessment methods in CENE and data analysis techniques. • **Competencies:** Design appropriate research and experimental design methods to open civil engineering research questions and assess results. • **Measures/Assessment:** Assessment will focus on	

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			measuring student mastery of discipline-specific methods and the ability to coherently combine them within the context of a specific problem area through a research design rubric deployed in the advancement to candidacy examination and dissertation defense. **Learning Outcome 6 (LO6):** Create highly effective written and oral communication in CENE areas; demonstrate clear argumentation and logical cohesion in a variety of written and oral communications, including scholarly dissemination, funding requests, industry, and communication to non-specialist audiences. • **Concepts:** Effective strategies for communication and scientific storytelling paired with best-practices for communication based on	

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			audience expertise and make-up. • **Competencies:** Communicate effectively, with clear and coherent argumentation across a variety of audience stakeholders, including experts and intelligent, non-specialists. **Measures/Assessment:** Through separate oral and written communication rubrics, assessment will be focused on the quality of the oral and written portion of the qualifying, advancement to candidacy, and dissertation examinations, including the public portions that are open to non-specialist audiences.	

NAU
NORTHERN ARIZONA UNIVERSITY

REQUEST FOR NEW ACADEMIC PROGRAMS FOR NORTHERN ARIZONA UNIVERSITY

ARIZONA BOARD OF REGENTS
FEBRUARY 7, 2019

DIANE STEARNS, INTERIM DEAN; GABRIEL MONTAÑO, PROFESSOR; CONSTANTIN CIOCANEL, ASSOCIATE PROFESSOR

COLLEGE OF ENGINEERING, INFORMATICS, AND APPLIED SCIENCES