New AST Ph.D. Curriculum Guide Effective 2022-2023

Applied Science and Technology, Ph.D.
College of Science and Technology

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The mission of the Applied Science & Technology Ph.D. program is to prepare students for high-level science and technology careers in industry, research, and government. Graduates will be able to conceive, develop, and conduct original research that applies physical, mathematical, and technological methods to provide solutions to a broad range of emerging local, national, and global problems related to Atmospheric, Environmental and Energy Science; Applied Physics; Bioscience; Applied Chemistry; Data Science and Analytics; Applied Engineering Technology; Information Technology; Technology Management; Geomatics; and STEM Education.

Admission Requirements
- B.S. degree in a science, technology, engineering, math (STEM) or related discipline with a GPA≥3.25/4.0 or a M.S. degree in a science, technology, engineering, math (STEM) or related discipline with a GPA≥3.0/4.0 from a college or university recognized by a regional or general accrediting agency
- GRE verbal and quantitative scores, no minimum score requirement

Program Outcomes
- Communication Skills – Students completing the Applied Science & Technology Ph.D. program will exhibit effective oral communication skills in terms of customizing presentations to the audience, displaying information, and delivering the presentations.
- Critical Thinking Skills - Students completing the Applied Science & Technology Ph.D. program will effectively use quantitative and qualitative analytical problem-solving skills in terms of defining hypotheses/research questions, reviewing research literature, developing a research plan, identifying the broader impacts of research, and developing a research timetable.
- Disciplinary Expertise - Students completing the Applied Science & Technology Ph.D. program will demonstrate discipline specific expertise in terms of the scientific method, applying technical knowledge to answer research questions, experimental plans and data analysis, analytical methods, and research ethics.
- Research/Creative Engagement - Students completing the Applied Science & Technology Ph.D. program will demonstrate ability to engage productively in the review and conduct of disciplinary research in terms of making conference presentations and publishing refereed journal publications.

Degree Requirements
Total credit hours: 66 (post B.S.), 42 (post M.S.)
- Core courses (9 credits):
  - AST 830 Foundations of Scientific Research
  - AST 831 Math and Computational Modeling (or other graduate analytical modeling course that builds upon a student’s previous background)
  - MATH 721 Multivariate Statistical Analysis (or other graduate statistics course that builds upon a student’s previous background)
- Seminar (6 credits post B.S., 3 credits post M.S.): AST 992 Doctoral Seminar
- Dissertation (21 credits post B.S., 15 credits post M.S.): AST 997 Doctoral Dissertation
- Pass qualifying exam, preliminary exam, and dissertation defense
• In consultation with advisor, take 18 credit hours (15 credits post M.S.) within one of the following concentrations:
  o Applied Chemistry
  o Applied Physics
  o Atmospheric, Environmental and Energy Science
  o Bioscience
  o Data Science and Analytics
  o Information Technology
  o Technology Management
  o STEM Education
  o General – no specified concentration
• In consultation with advisor, take 12 credit hours (post B.S.) of additional courses relevant to research area

Concentration Courses
For each program concentration, students will typically take courses that are included in the following lists with additional courses possible with approval of research adviser and program director:

Applied Chemistry
CHEM 611 Advanced Inorganic Chemistry
CHEM 621 Intermediate Organic Chemistry
CHEM 624 Qualitative Organic Chemistry
CHEM 631 Electroanalytical Chemistry
CHEM 641 Instrumentation of the Modern Sciences
CHEM 642 Techniques in X-ray Crystallography
CHEM 643 Introduction to Quantum Mechanics
CHEM 651 General Biochemistry
CHEM 652 General Biochemistry Lab
CHEM 673 Introduction to Computational Chemistry
CHEM 674 Computational Methods/Protein Modeling Drug Design
CHEM 716 Selected Topics in Inorganic Chemistry
CHEM 722 Advanced Organic Chemistry
CHEM 732 Advanced Analytical Chemistry
CHEM 743 Chemical Thermodynamics
AST 812 Environmental Chemistry
BMEN 711 Biomaterials and Biocompatibility
ECEN 701 Electronic Ceramics
NANO 701 Simulation Modeling Methods in Nanoscience and Nanoengineering
NANO 702 Fundamentals of Nanoengineering Physical Principles
NANO 703 Fundamentals of Nanoengineering Chemical and Biochemical Principles
NANO 704 Fundamentals of Nanomaterials
NANO 705 Nano Safety
NANO 711 Introduction to Nanoprocessing
NANO 721 Nanobioelectronics
NANO 731 Introduction to Nanomodeling and Applications
NANO 811 Polymeric Materials Engineering
NANO 812 Process Modeling in Composites
NANO 821 Advanced Nanosystems
NANO 851 Computational Nano Modeling Lab
NANO 852 Nanoelectronics Laboratory
NANO 853 Nano-Bio Electronics Lab
NANO 854  Nanomaterials Laboratory
NAN 601  Nanochemistry
CHEM 811  Physical Methods for Inorganic Chemistry
CHEM 812  Inorganic Chemical Kinetics and Mechanisms
CHEM 818  Introduction to Soft Matter
CHEM 823  Integrative Medicinal Chemistry
CHEM 827  Organic Structural Spectroscopy
CHEM 833  Biosensors and Bioanalytical Technologies
CHEM 841  Advanced Mass Spectrometry Instrumentation
CHEM 856  Protein Structure and Function
CHEM 885  Special Topics
NAN 615  Intro Spectroscopy Methods in Nanoscience
NAN 630  Advances in Nano-biosensors
NAN 705  Macromolecular and Supramolecular Chemistry Nanoscience
NAN 730  Nanoscale Reactions
NAN 771  Computational Quantum Nanochemistry

Applied Physics
PHYS 600  Classical Mechanics
PHYS 605  Mathematical Methods
PHYS 615  Fundamentals of Electromagnetic Theory
PHYS 620  Quantum Mechanics I
PHYS 630  Statistical Mechanics
PHYS 715  Advanced Electromagnetic Theory
PHYS 720  Quantum Mechanics II
PHYS 730  Optical Properties of Matter
PHYS 737  Physics of Solids
PHYS 738  Nuclear Physics
PHYS 745  Computational Physics
PHYS 746  Methods in Radiation Detection and Measurement
PHYS 843  Experimental Methods
PHYS 850  Quantitative Analysis in Biophysics
PHYS 885  Special Topics
NAN 603  Nanophysics

Atmospheric, Environmental and Energy Science
AST 812  Environmental Chemistry
AST 813  Sustainable Energy Systems
AST 814  Life Cycle Analysis
AST 821  Environmental Energy Econometrics I
AST 841  Biomaterials Characterization
AST 842  Biomass Thermal Conversion Processes
AST 843  Biomass Biological Conversion Processes
AST 844  Environmental and Policy Studies of Biomass Use
AST 850  Physical Meteorology
AST 851  Dynamic Meteorology
AST 852  Climatology
AST 853  Numerical Weather Prediction
AST 854  Advanced Synoptic Weather Analysis
AST 855  Principles of Air Quality
AST 856  Atmospheric Aerosols
AST 857  Advanced Remote Sensing
AST 858  Tropical Meteorology
AST 859  Advanced Mesoscale Analysis
AST 885  Special Topics
NANO 761  Introduction to Nano Energy
NANO 861  Advanced Nano Energy Systems
CM 704  Special Topics in Renewable Energy Technology
CM 679  Environmental Issues in Construction Management
EPT 687  Electrical Power Generation using Nuclear Technology

**Bioscience**
BIOL 615  Principles of Virology
BIOL 630  Molecular Genetics
BIOL 640  Introduction to Bioinformatics and Genomic Research
BIOL 651  Principles and Practice of Immunology
BIOL 700  Environmental Biology
BIOL 703  Experimental Methods Biology
BIOL 704  Cell and Molecular Biology
BIOL 720  Environmental Influences on Human Diseases
BIOL 749  Recent Advances in Cell Biology
BIOL 762  Molecular Pathogenesis of Cancer
AST 843  Biomass Biological Conversion Processes
ANSC 771  Bioinformatics Genome Analysis
ANSC 782  Cellular Pathobiology
BMEN 713  Biotechnology Entrepreneurship
BIOL 830  Advanced Techniques in Integrative Biosciences
BIOL 831  Cellular and Molecular Biology of Disease
BIOL 832  Microbial Pathogenesis
BIOL 833  Recent Advances in Immunology
BIOL 834  General Physiology I
BIOL 835  General Physiology II
BIOL 855  Advances in Systems Biology
BIOL 885  Special Topics
STAT 824  Biostatistics Health Analytics
NAN 602  Nanobiology
NAN 620  Immunology Nanoscience
NAN 625  Molecular Biology in Nanosciences
NAN 626  Introduction to Stem Cell Biology and Ethics
NAN 745  Nanoimaging
NAN 750  Nanomedicine

**Data Science and Analytics**
MATH 612  Advanced Linear Algebra
MATH 623  Probability Theory and Applications
MATH 624  Theory and Methods of Statistics
MATH 665  Principles of Optimizations
MATH 675  Graph Theory
MATH 690  Scientific Programming for Mathematical Scientists
MATH 706  Categorical Data Analysis
STAT 707  Introduction to Data Science
STAT 708  Linear Models for Data Science
<table>
<thead>
<tr>
<th>Code</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>MATH 709</td>
<td>Disc and Combi Math for Data Sci</td>
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<tr>
<td>STAT 710</td>
<td>Statistical and Deep Learning</td>
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<tr>
<td>STAT 711</td>
<td>Stat Comp &amp; Algorithm Analysis</td>
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<tr>
<td>MATH 712</td>
<td>Numerical Linear Algebra</td>
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<td>STAT 719</td>
<td>Statistical Computing and Algorithm Design &amp; Analysis</td>
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<td>MATH 721</td>
<td>Multivariate Statistical Analysis</td>
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<td>MATH 723</td>
<td>Advanced Topics Stochastic Modeling</td>
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<tr>
<td>MATH 733</td>
<td>Advanced Probability and Stochastic Processes</td>
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<td>MATH 782</td>
<td>Statistical Data Analytics and Visualization</td>
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<tr>
<td>CST 764</td>
<td>Advanced Big Data Analytics</td>
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<tr>
<td>COMP 751</td>
<td>Data Analytics Tools and Techniques</td>
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<tr>
<td>COMP 765</td>
<td>Data Mining</td>
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<tr>
<td>STAT 777</td>
<td>The Practice of Stat Consulting</td>
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<tr>
<td>STAT 808</td>
<td>Advanced Regression Methods for Data Science</td>
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<tr>
<td>STAT 823</td>
<td>Time Series Analysis Business Analytics</td>
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<tr>
<td>STAT 824</td>
<td>Biostatistics Health Analytics</td>
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<tr>
<td>MATH 885</td>
<td>Special Topics</td>
</tr>
<tr>
<td>NAN 605</td>
<td>Mathematical Methods</td>
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**Information Technology**

| CST 700 | Project Management for IT Professionals                           |
| CST 702 | Statistical Methods                                               |
| CST 714 | Reconfigurable Computing                                          |
| CST 717 | Health Informatics System Architecture                            |
| CST 725 | Wide Area Networks                                                |
| CST 729 | Data Warehousing                                                  |
| CST 731 | Knowledge Discovery Systems                                       |
| CST 732 | Text Mining                                                       |
| CST 733 | Data Visualizations                                               |
| CST 735 | Telecom Management Issues                                         |
| CST 745 | Network Services for the Enterprise                               |
| CST 750 | Computer System Security                                          |
| CST 752 | Advanced Computer Forensics                                       |
| CST 755 | Enterprise Management Systems                                     |
| CST 760 | Intermediate Enterprise Systems                                   |
| CST 764 | Advanced Big Data Analytics                                       |
| CST 765 | Advanced Enterprise System Operation                               |
| CST 770 | Survey of Virtualization Technology                               |
| CST 850 | Advanced Wireless Communication Systems                           |
| CST 855 | Advanced Optical Communication Systems                            |
| CST 885 | Special Topics                                                     |
| COMP 727 | Secure Software Engineering                                       |
| COMP 823 | Secure Social Computing                                           |
| CSE 703  | Data Structure Software Principles & Programming                  |
| CSE 806  | Computational System Theory                                       |

**Technology Management**

| AET 710 | Manufacturing Materials                                          |
| AET 720 | Industrial Economics                                             |
| AET 721 | Industrial Operational Management                               |
| AET 735 | Manufacturing Organization and Management                        |
### STEM Education
The STEM Education PhD course requirements are:

**STEM Education Foundations** (9 credit hours) The purpose of the Foundation requirements is to provide a bridge into this interdisciplinary field by integrating STEM and education concepts:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>AST 801</td>
<td>History and Philosophy of STEM Education</td>
</tr>
<tr>
<td>AST 802</td>
<td>Theories of Development and STEM Thinking</td>
</tr>
<tr>
<td>AST 803</td>
<td>STEM Education Methods</td>
</tr>
</tbody>
</table>

**STEM Expertise** (3 credit hours)
Students are required to complete a coherent sequence of graduate courses in a STEM field other than STEM Education. The purpose of this requirement is to provide depth of understanding of STEM concepts, in particular, STEM concepts that may be the focus of STEM Education research activities.

**STEM Education Research Specialization** (3 credit hours)
The purpose of the Specialization requirement is to develop depth of knowledge in one area of STEM Education.

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<tbody>
<tr>
<td>AST 804</td>
<td>Cognitive Devices in STEM Learning Environments</td>
</tr>
<tr>
<td>TECH 719</td>
<td>Technology Education: Design in Construction</td>
</tr>
<tr>
<td>TECH 720</td>
<td>Technology Education: Design in Manufacturing</td>
</tr>
<tr>
<td>TECH 722</td>
<td>Technology Education: Design in Transportation</td>
</tr>
</tbody>
</table>
Dissertation Research
A student may not register for dissertation credits before passing the Qualifying Examination.

Qualifying Examination
The Qualifying Examination with both written and oral components is given to assess the student’s competence in a broad range of relevant subject areas. Only students with unconditional status and in good academic standing may take the Qualifying Examination. No student is permitted to take the Qualifying Examination without passing the Qualifying Examination.
Examination more than twice. A student not recommended for re-examination or who fails the exam on a second attempt may be dismissed from the doctoral program.

**Preliminary Oral Examination**
The Preliminary Oral Examination is conducted by the student's dissertation committee and is a written and oral defense of the student’s dissertation proposal. Failure on the examination may result in dismissal from the doctoral program. The student's Dissertation Committee may permit one re-examination. At least one full semester must elapse before the re-examination. Failure on the second attempt will result in dismissal from the doctoral program.

**Admission to Candidacy**
Student will be admitted to candidacy upon successful completion of the Qualifying Exam and the Preliminary Exam. After admission to candidacy and before Final Oral Examination, a student may be dismissed from the doctoral program if the student’s dissertation committee determines that the student is not making satisfactory progress.

**Final Oral Examination**
The Final Oral Examination is conducted by the student's dissertation committee. This examination is the final dissertation defense presentation that is scheduled after a dissertation is completed. The examination may be held no earlier than one semester (or four months) after admission to candidacy. Failure on the examination may result in dismissal from the doctoral program. The student's Dissertation Committee may permit one re-examination. At least one full semester must elapse before the re-examination. Failure on the second attempt will result in dismissal from the doctoral program.

**Submission of Dissertation**
Upon passing the Ph.D. Final Oral Examination, the Ph.D. student must have the dissertation approved by each member of the student's Dissertation Committee. The approved dissertation must be submitted to The Graduate College by the deadline given in the academic calendar and must conform to the Graduate College’s guidelines for theses and dissertations.