Appendix D.1 Mathematics Courses

Students must complete one Mathematics Fundamentals course from the list below and one Mathematics Specialization course from the list below for the Ph.D. degree. No other Notre Dame courses will be accepted. Mathematics courses taken at another University as part of an awarded M.S. degree and transferred to Notre Dame may fulfill the mathematics elective requirement.

Mathematics Fundamentals
(one course from list below)

Department of Aerospace and Mechanical Engineering
AME 60611 Mathematical Methods I

Department of Mathematics
MATH 60210 Basic Algebra I
MATH 60330 Basic Geometry And Topology
MATH 60350 Basic Real Analysis I
MATH 60370 Basic Complex Analysis I

Mathematics Specialization
(one course from list below or any additional course from the Mathematics Fundamentals list)

Department of Aerospace and Mechanical Engineering
AME 60611 Mathematical Methods II
AME 60617 Bayesian Data Assimilation and Parameter-State Estimation in Scientific Computing
AME 60624 Continuum Mechanics
AME 70779 Applied Probability and Statistical Computing Methods for Scientists and Engineers

Department of Mathematics
MATH 60610 Basic Discrete Mathematics
MATH 60620 Optimization
MATH 60650 Basic Partial Differential Equations I
MATH 60670 Differential Geometry I
MATH 60850 Probability

Department of Applied and Computational Mathematics and Statistics
ACMS 60395 Numerical Linear Algebra
ACMS 60630 Nonlinear Dynamical Systems
ACMS 60650 Applied Partial Diff Equations
ACMS 60786 Applied Linear Models
ACMS 60790 Numerical Analysis II
ACMS 60850 Applied Probability
ACMS 60852 Advanced Biostatistical Methods
ACMS 60885 Applied Bayesian Statistics

Department of Civil & Environmental Engineering & Earth Sciences
CE 60123 Probabilistic Methods for Engineers and Scientists
Appendix D.2 Techniques Courses

The following courses are accepted to meet the techniques course requirement for the Ph.D. degree. No other Notre Dame courses will be accepted. Techniques courses taken at another University as part of an awarded M.S. degree and transferred to Notre Dame may fulfill the techniques course requirement with approval by the DGS.

**Department of Aerospace and Mechanical Engineering**
AME 60614  Numerical Methods  
AME 60613  Finite Elements in Engineering  
AME 60631  Experimental Methods in Fluids  
AME 60644  Finite Elements in Structural Mechanics  
**AME 60541  Finite Element Methods**  
AME 60735  Advanced Data Analysis Techniques  

**Department of Computer Science and Engineering**
CSE 60113  Numerical Methods and Computation  

**Department of Mathematics**
MATH 60620  Optimization  
MATH 60690  Numerical Analysis I  
MATH 60790  Numerical Analysis II  
MATH 60850  Probability  
MATH 60860  Stochastic Modeling  
MATH 60920  Probabilistic Aspects of Linear Control and Optimization  

**Department of Applied and Computational Mathematics and Statistics**
ACMS 50051  Numerical PDE Techniques for Scientists and Engineers  
ACMS 60395  Numerical Linear Algebra  
ACMS 60590  Finite Elements in Engineering  
ACMS 60690  Numerical Analysis I  
ACMS 60790  Numerical Analysis II  
ACMS 60852  Statistical Methods in the Biological and Health Sciences  
ACMS 60885  Bayesian Statistics  

**Department of Civil & Environmental Engineering & Earth Sciences**
CE 60123  Probabilistic Methods for Engineers and Scientists  
CE 60130  Finite Elements in Engineering  
CE 60140  Applied/Computational Probability for Engineers  

**Department of Electrical Engineering**
EE 60563  Probability and Random Processes  
EE 60573  Detection and Estimation  
EE 80603  Transmission Electron Microscopy  

**Department of Chemical and Biomolecular Engineering**
CBE 60727  Ambient Methods of Surface Characterization
Appendix D.3 Pillar and Core Courses

All non-mathematics graduate courses in AME are organized along five research pillars as outlined below. Courses with an asterisk (*) are considered core courses. Students must complete at least three core courses in a single pillar plus any additional restrictions as listed for that pillar.

Note that some courses are still using 40000-level or 50000-level numbering designations. While 40000-level and 50000-level courses are nominally not supposed to count toward Ph.D. degree requirements, during the transition year of 2019/2020 (only), they will be allowed if they appear on these lists. Only two (2) 40000-level/50000-level courses may be counted, as permitted by the graduate school. Some 60000-level courses will also be renumbered as 70000-level courses in future years.

**Fluid Mechanics and Aerodynamics**

*AME 60635  Inter. Fluid Mechanics
*AME 70731  Viscous Flow Theory
*AME 90935  Turbulence (to be numbered as 70000 after “Viscous Flow Theory”)
AME 60630  Intermediate Compressible Flows
AME 60632  Physical Gas Dynamics
AME 60638  Turbine Engine Components
AME 60639  Advanced Aerodynamics
AME 60731  Surface Flow Measurement
AME 77103  Geometric & Physical Optics
AME 77104  Aeroacoustics: Theory & Comp
AME 90936  Computational Fluid Mechanics
AME 90937  Hydrodynamic Stability

**Bioengineering**

*AME 50571  Biomaterials (to be renumbered as 60000)
*AME 50572  Biomechanics (to be renumbered as 60000)
*AME 60548  Biofabrication
*AME 60671  Orthopaedic Biomechanics
*AME 60672  Cell Mechanics
*AME 60673  Kinematics of Human Motion
*AME 60677  Biomimetic Tissue Engineering
*AME 60678  Biomedical Imaging Modalities
*AME 60679  Nanoparticles in Biomedicine
*AME 60770  Stem Cell Engineering
AME 40470  Numerical Methods for Bioengineering (to be renumbered as 60000)

**Robotics and Dynamics**

*AME 50551  Introduction to Robotics (to be renumbered as 60000)
*AME 50562  Intermediate Controls (to be renumbered as 60000)
*AME 50650  Applied Nonlinear Analysis and Controls (to be renumbered as 60000)
*AME 60623  Analytical Dynamics
*AME 60627  Computational Mechanism Design
*EE 60550  Linear Systems
*EE 60551  Mathematical Programming
AME 60619  Fractional Calculus for Engineers
AME 60654  Advanced Kinematics

Computational Engineering
*AME 50541  Finite Element Methods (to be renumbered as 60000)
*AME 60614  Numerical Methods
*AME 60741  Computational Nonlinear Solid Mechanics
*AME 70779  Statistical Computing Methods for Scientists & Engineers
*AME 70790  Advanced Topics in Machine Learning
*AME 90936  Computational Fluid Mechanics
*ACMS 60212  Advanced Scientific Computing
*ACMS 60690  Numerical Analysis I
*ACMS 60790  Numerical Analysis II
*ACMS 60395  Numerical Linear Algebra
*ACMS 60650  Applied Partial Differential Equations
*CE 60140  Applied/Computational probability for engineers

Materials & Thermal Science and Manufacturing (1 of the 3 required core courses must be an AME course)
*AME 60624  Continuum Mechanics
*AME 60634  Intermediate Heat Transfer
*AME 60641  Advanced Mechanics of Solids
*AME 60642  Manufacturing Systems
*AME 60643  Mechanics of Sliding Surfaces
*AME 60646  Failure of Materials
*AME 60677  Biomimetic Tissue Engineering
*AME 60679  Nanoparticles in Biomedicine
*AME 60733  Solar Energy: Photovoltaic Systems
*AME 60637  Ionization & Ion Transport (to be renumbered as 70000)
*AME 70791  Molecular Level Modeling for Engineering Applications

*CE 60547  Modern Methods in Computational Molecular Thermodynamics and Kinetics
*CE 60561  Structure of Solids
*CE 60577  Nanoscience and Technology
*CE 60642  Molecular Thermodynamics
*CE 60727  Ambient Methods of Surface Characterization

*CHEM 60435  Electrochemistry and Electrochemical Engineering
*CHEM 60610  Organometallic Chemistry
*CHEM 60618  Chemical Crystallography
*CHEM 60641  Statistical Mechanics I
*CHEM 60642  Statistical Mechanics II
*CHEM 60649  Quantum Mechanics

*EE 60548  Electromagnetic Theory
*EE 60556  Fundamentals of Semiconductor Physics
*EE 60566  Solid State Devices
*EE 60647  Alternative Energy Devices and Materials
*EE 60657 Optoelectronic Devices
*EE 60672 Vacuum and SEM Technology
*EE 67055 Introduction to Biophotonics and Biomedical Optics
*EE 80603 Transmission Electron Microscopy
*EE 87039 Quantum Optics and Nanophotonics