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 60714 Advanced Numerical Methods
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 60541 Finite Element Methods
AME 60614 Numerical Methods
AME 60613 Finite Elements in Engineering
AME 60617 Bayesian Data Assimilation and Parameter-State Estimation in Scientific Computing
AME 60631 Experimental Methods in Fluids
AME 60644 Finite Elements in Structural Mechanics
AME 60714 Advanced Numerical 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.

**Fluid Mechanics and Aerodynamics**

*AME 60635 Intermediate 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 40470 Numerical Methods for Bioengineering (to be renumbered as 60000)
*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 60691 Ultrasound Imaging and Signal Processing
*AME 60770 Stem Cell Engineering

**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 60541 Finite Element Methods
*AME 60614 Numerical Methods
*AME 60714 Advanced Numerical Methods
*AME 60741 Computational Nonlinear Solid Mechanics
*AME 70779 Statistical Computing Methods for Scientists & Engineers
*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  Additive Manufacturing
*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
*CBE 60547  Modern Methods in Computational Molecular Thermodynamics and Kinetics
*CBE 60561  Structure of Solids
*CBE 60577  Nanoscience and Technology
*CBE 60642  Molecular Thermodynamics
*CBE 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