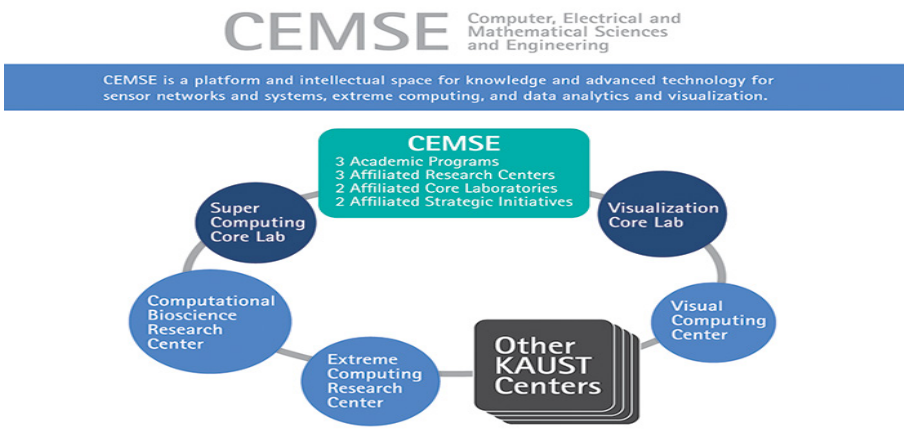
Computer, Electrical, and Mathematical Science and Engineering Division

Applied Mathematics & Computational Sciences Program Guide 2015-2016

Smart man-engineered environment is no longer the realm of science fiction. We are surrounded by intelligent machines that follow our algorithms and improve the quality of our life. We predict highly complex natural phenomena, such as climate, with mathematical models of ever increasing accuracy. We use our understanding, translated in the form of mathematical computations, to design novel materials and to optimize important processes that help us resolve big issues such as availability of clean water and energy. Computer, Electrical and Mathematical Sciences and Engineering (CEMSE) are cornerstones of modern life, they help us ensure the continuity and sufficiency of the supply of water, food, energy in a sustainable environment; they drive our industrial production lines, they give us new materials for upcoming technologies and better healthcare. This is what the CEMSE division is for and in this context this division aims to drive frontier science and train the next generation of scientists as heirs of wisdom and carriers of future progress.

The CEMSE division is the home of three (3) degree-granting programs: Applied Mathematics & Computational Science, Computer Science, and Electrical Engineering. Besides attending lectures and seminars, the students in the CEMSE division have the opportunity to conduct research in the framework of directed research, MS Thesis, and PhD dissertation.



Research at CEMSE takes advantage of the superb KAUST resources and facilities to bring students, research staff, and faculty together to push the frontiers of science through collaborative inquiry into issues of regional and global significance. More specifically, the CEMSE division is associated with three (3) of KAUST's Research Centers: the Computational Bioscience Research Center, the Extreme Computing Center, and the Visual Computing Research Center.In addition, the CEMSE students, researchers, and faculty have unparalleled access to a large collection of best-in-class research laboratories and cutting-edge facilities hosted in the Shaheen Supercomputer, the CORNEA Visualization Center, and the Advanced Nanofabrication Imaging and Characterization.

In summary, the CEMSE division plays a central role in the research, teaching, and outreach of KAUST both because its intellectual domains are evolving rapidly and powerfully at their frontiers.

Mootaz Elnozahy, Dean

Computer, Electrical, and Mathematical Science and Engineering (CEMSE) Division

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1. Aims and Scope

The Applied Mathematics and Computational Sciences (AMCS) program educates students to construct and solve Mathematical and Computational models of real-world problems. Two (2) degree programs are offered: the M.S. degree (under either a Thesis or a Non-Thesis option) and the Ph.D.. degree. Admission to one (1) degree program does not guarantee transfer to another.

The Applied Math and Computational Science program offers specializations in three (3) distinct directions (called"Tracks"):Applied Mathematics (AM),Computational Science and Engineering, Statistics(ST).

The requirements for the different specializations may vary and are outlined below. All students in the M.S. program are guided by a Faculty advisor to develop their program of study.

2. Assessment Test

Students admitted to the M.S. program in AMCS must hold a B.S. degree, usually in mathematics, physics, statistics, or engineering. Preparation for the program includes satisfactory completion of appropriate undergraduate mathematics courses and demonstration of English proficiency (e.g., through the TOEFL). Minimum preparation in mathematics includes four semesters of calculus (including multivariate), and one (1) semester each of ordinary differential equations, linear algebra, and an introduction to probability and statistics. Applicants are also strongly recommended to complete a semester-length course in each of the following: partial differential equations, complex analysis, real analysis, numerical analysis, and optimization. Undergraduate research experience is also beneficial.

3. Master's Degree

Students are expected to complete the M.S. degree in three(3) semesters and one (1) summer session.

There are two M.S. degrees in AMCS: (i) M.S. with thesis and (ii) M.S. without thesis. Both options require at least 24 credits of coursework and 36 credits in total. Graduation requires an average GPA of 3.0; Individual courses require a minimum grade of a B- for course credit. Students who wish to complete the M.S. with thesis must secure a member of the regular faculty to supervise the research.

The required 24 credits of coursework from one of the following tracks:

Applied Mathematics (AM track)

- Core Courses:15 credits
- Electives Courses: 9 credits
- Research /Capstone: 12 Credits

Computational Science and Engineering (CSE track)

- Core Courses: 6 credits
- Electives Courses: 18 credits
- Research /Capstone: 12 Credits

Statistics (ST track)

- Core Courses:12 credits
- Electives Courses: 12 credits
- Research /Capstone: 12 Credits

Research

Research/Capstone Experience (12 credits): The details of this portion of the degree program are uniquely determined by the student and his/her advisor and will involve a combination of research and other capstone experiences that build on the knowledge gained in coursework.

Electives:

Elective courses are selected with the approval of the student's academic or research advisor.

Master Seminar Requirement

Graduate Seminar: Students are required to register for and attend the graduate seminar (course AMCS 298) during the first year (Fall and Spring Semesters)
M.S. GPA Requirements

The courses with * are part of the respective Doctoral (Ph.D.) Qualifying Exam. For more information read the "Qualifying Exam"

Satisfactory completion of at least one (1) Winter Enrichment Program (WEP) is required of all M.S. students as part of completion of the degree requirements. Ph.D. students who did not receive their M.S. degree at KAUST are also required to satisfactorily complete at least one (1) WEP.

3.1 Masters Course Requirements

Applied Mathematics (AM track)

Core Courses 15 credits

- AMCS 231: Applied Partial Differential Equations*
- AMCS 243: Probability and Statistics* or AMCS 241: Probability and Random Processes*
- AMCS 251: Numerical Linear Algebra*
- AMCS 252: Numerical Analysis of Differential Equations
- AMCS290 A: Real Analysis

Electives 9 credits

Students in the AM track must take an additional 9 credits of course work

Computational Science and Engineering (CSE track)

Core Courses 6 credits

Students must fulfill at least two of the four core courses below:

- AMCS 231: Applied Partial Differential Equations*
- AMCS 243: Probability and Statistics* or AMCS 241: Probability and Random Processes*

- AMCS 251: Numerical Linear Algebra*
- AMCS 252: Numerical Analysis of Differential Equations

Electives 18 credits

Students in the CSE track must take an additional 18 credits of course work made up of:

- Six credits of Computer Science courses.
- Six credits in applications of modeling. Eligible application courses include AMCS 332 (mathematical modeling) and courses from other programs. At least one of the modeling courses should be from outside AMCS. In case both courses are from outside AMCS, it is recommended that they be drawn from the same application.
- An additional six credits from AMCS courses.
- Broadening experience (0-6 Credits)

Statistics (ST track)

Core Courses 12 credits

- AMCS 211: Optimization I
- AMCS 241: Probability and Random Processes*
- AMCS 243: Probability and Statistics*
- AMCS 245: Linear Models*

Electives 12 credits

Students in the ST track must take an additional 12 credits of course work

3.2 Thesis Option

Students pursuing the M.S. degree with Thesis option must apply by the ninth week of their second semester. The M.S. Thesis option requires 24 credits of coursework with an additional 12 credits of thesis research.

Students are permitted to register for more than 12 credits of M.S. thesis research as necessary and with the permission of the thesis advisor. The evaluation of satisfactory completion of M.S. thesis work is performed by the MS Thesis Defense Committee

The MS Thesis Defense committee, which must be approved by the student's Dean, must consist of at least three members, and typically includes no more than four members. At least two of the required members must be KAUST faculty. The Chair plus one additional faculty member must be affiliated with the student's program. This membership can be summarized as:

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty or Approved Research Scientist	Outside Program
4	Additional Faculty	Inside or outside KAUST

Notes:

- Members 1 – 3 are required. Member 4 are optional
- Co-chairs may serve as Member 2, 3 or 4, but may not be a Research Scientist
- Adjunct Professors and Professor Emeriti may retain their roles on current committees, but may not serve as chair on any new committees
- Professors of Practice and Research Professors may serve as Members 2 , 3 or 4 depending upon their affiliation with the student's program. They may also serve as co-chairs
- Visiting Professors may serve as Member 4

The Evaluation of M.S. Thesis credits is through a pass or fail grade. The Thesis Advisor may require the student to give a public seminar based on the Thesis.

The student is responsible for scheduling the Thesis defense date with his/her supervisor and committee members. It is advisable that the student submit a written copy of the Thesis to the Thesis committee members at least two (2) weeks prior.

3.3 Non-Thesis Option

In addition to the 24 credits of actual mandatory/core/elective coursework, an additional 6 of research (either Directed Research or Internship) and another 6 credits comprised of: Internship: Research-based summer internship (AMCS295). A student may not enrol in more than one (1) internship for credit

4. Doctor of Philosophy

In accordance with KAUST regulations, the Ph.D.program in AMCS includes the following requirements:

- Successful completion of Ph.D.coursework (6 credits of 300 level courses);
- Designating a Research Advisor;
- Passing a qualifying examination;
- Obtaining candidacy status;
- Preparing, submitting, and successfully defending a doctoral dissertation.

The Doctor of Philosophy (Ph.D.) degree is designed to prepare students for careers in research and industry. It is offered exclusively as a full-time program. There is a minimum residency requirement at KAUST of 3.5 years for students entering with a B.S. degree and 2.5 years for students entering with a M.S. degree. A minimum GPA of 3.0 must be achieved on all doctoral coursework. Individual courses require a minimum of a B- to earn course credit.

4.1 Ph.D. Course Requirements

- Four core course
- Four elective courses from AMCS or another program, as agreed upon with the student's academic advisor
- Two (2) courses at the 300 level
- WEP

Students entering with a B.S. degree from another institution may transfer in up to 9 credits of graduate-level coursework to satisfy the above requirements. Transfer coursework must include a minimum B+ grade, not previously used towards a degree, and is contingent on approval of the program. Students entering with a B.S. degree may also earn an M.S. degree by satisfying the M.S. degree requirements (36 credits) as part of the Ph.D.. program.

Students entering the program with a relevant M.S. degree from another institution must complete at least 66 credit hours (60 credits of dissertation research and two (2) 300-level courses). They may transfer coursework toward the requirements of the M.S. degree upon approval of the program.

Students entering the program with an M.S. from KAUST may transfer coursework toward both the M.S. and Ph.D.. requirements listed above upon approval of the program.

4.2 Qualification Phase

The qualifying exam consists of three (3) written subject exams, one (1) in each of the core courses of AM, CSE, or ST marked with an asterisk in the core curriculum above. It is given twice per year: during the final exams of the Fall semester and immediately after the final exams of the Spring semester. The Fall semester qualifying exam is the final exam of each of the above mentione (1)d courses given during the Fall semester. The Spring semester exam is a three (3)-hour exam per subject prepared by the faculty representative. The exams are given over the course of two (2) days in both Spring and Fall.
Students are encouraged to take all three (3) qualifiers in their first semester of the Ph.D.. program. Students have two (2) chances to take each exam and can pass them in any combination. They are required to pass all three (3) qualifying exams within one (1) year. No extension is given except under extenuating circumstances.

Students in the CSE track can replace one (1) of the qualifying exams by a CSE related qualifying exam in another academic program following the rules of that program. The one (1)-year restriction to fulfill the requirement still applies in this case.

Students of the ST track have to pass all three (3) qualifying exams in the same seating. If a ST student at the end of the first year of Ph.D. has only passed 2 out of 3 qualifiers then the case is reviewed by the Qualifying Exam Committee and it is decided if the student can proceed with the Ph.D. For more details related to the Ph.D. qualifying exam, contact the AMCS Program Coordinator.

4.3 Ph.D. Proposal Defense Committee

Each student is expected to identify a Research Advisor by the end of the first year of the program. Optionally, students may select two (2) co-supervisors. The supervisor or at least one (1) of the co-supervisors must have a permanent academic faculty-level appointment.

The research proposal exam must be taken within one (1) year after passing the qualifying exam and is administered by the student's Research Advisory committee.
The research proposal exam tests the student's preparedness to pursue dissertation research. It is a public oral presentation of a research proposal, together with questioning by the advisory committee. The student must submit a written research proposal to the committee at least two (2) weeks prior to the exam. The examination is based on the submitted proposal, but the committee also may ask questions of a more general nature in order to test the adequacy of the student's preparation for the proposed research.

The advisory committee consists of a minimum of three (3) KAUST faculty members, one (1) of whom must be external to the degree program. The candidate must convince the committee that the chosen research area is suitable and demonstrate an appropriate breadth of knowledge in the chosen area. The committee should decide if there is a Thesis topic in the area and whether the candidate is capable of completing such a Thesis. There are four possible outcomes:

- Pass: The student passes the exam and may proceed to undertake study and research for the doctoral degree. The "pass" decision is achieved by the unanimous vote of the committee.
- Conditional Pass: The student's proposal or preparation contains some deficiencies. The student is required by the committee to complete additional preparation (coursework) and/or another individual oral exam. The conditional status is removed when the conditions have been met. A Pass must be obtained by the end of the following semester.
- Failure with retake permitted: If at least one (1) member casts a negative vote, one (1) retake of the examination is permitted if the entire committee agrees. The student must prepare a new research proposal and be examined again within the next six months. Students are allowed no more than one (1) retake.
- Fail: If the committee decides that the student is not capable of completing the degree with an original Thesis in a reasonable amount of time, the student has failed the exam and will be dismissed from the University.

Annual Progress Reports

Progress reports must be filed at the end of each academic semester. They are intended to assist the student to focus

on making timely progress through the program requirements. The standard template for the Progress report is available from the AMCS Graduate Program Coordinator (GPC). Reports are filed with the advisor and the GPC. Student progress is evaluated each semester by the student advisor and at least annually by the Thesis committee.
To be eligible for the Ph.D. degree, students must pass three (3) exams:

- Qualifying Exam
- Research Proposal Exam
- Final Defense

Candidacy Status:
After successfully completing all coursework requirements, passing the qualifying examination, identifying an advisor, and forming a dissertation committee, a student gains candidacy status by presenting a doctoral research proposal and obtaining approval to pursue the proposed research from the dissertation committee.

4.4 Ph.D. Dissertaion Defense
The final defense is taken at least six months (but no later than three (3) years) after the proposal defense and administered by the student's by the Dissertation Deense committee. The student must schedule the final oral defense after completion of the doctoral research (including completion of at least 96 credit hours of course work and dissertation research (AMCS 397) and writing of the dissertation). This exam is a defense of the doctoral dissertation and a test of the candidate's knowledge in the specialized field of research. The format of the exam is a public seminar presented by the candidate, with an open question period, followed by a private examination by the f committee. The only requirement for commonality with the proposal examination committee is the Research Advisor, although it is expected that other members will carry forward to the dissertation committee.
The possible outcomes are:

- Pass: The student passes the exam and the dissertation is accepted as submitted, or with minor revisions. The "pass" decision is achieved by the consensus of the committee with a maximum of one (1) negative vote.
- Failure with retake permitted: If more than one (1) member casts a negative vote, one (1) retake of the examination is permitted if the entire committee agrees. The student must revise the Thesis and be examined again within six months. Students are allowed no more than one (1) retake.
- Failure: If more than one (1) member casts a negative vote, retake of the examination is not permitted. The student will be dismissed from the University.

4.5 Ph.D. Dissertation Defense Committee
The final dissertation phase involves acceptance by the PhD Dissertation Defense Committee of a written dissertation and an oral defense.

The PhD Dissertation Defense committee, which must be approved by the student's Dean, must consist of at least four members, and typically includes no more than six members. At least three of the required members must be KAUST faculty and one must be an examiner who is external to KAUST. The Chair plus one additional faculty member must be affiliated with the student's program. The external examiner, is not required to attend the defense, but must write a report on the dissertation and may attend the dissertation defense at the discretion of the Program. This membership can be summarized as:

Member Role Program Status:

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty	Outside Program
4	External Examiner	Outside KAUST
5	Approved Research Scientist	Inside KAUST
6	Additional Faculty	Inside or outside KAUST

Notes

- Members 1 – 4 are required. Members 5 and 6 are optional
- Co-chairs may serve as either Member 2, 3 or 6
- Adjunct Professors and Professor Emeriti may retain their roles on current committees, but may not serve as chair on any new committees
- Professors of Practice and Research Professors may serve as Members 2 , 3 or 6 depending upon their affiliation with the student's program. They may also serve as co-chairs
- Visiting Professors may serve as Member 6, but not as the external examiner

Once constituted, the composition of the dissertation examination committee can only be changed upon approval by both the research supervisor and the division Dean.

5. Program Courses and Descriptions

AMCS 101. Engineering Mathematics (3-0-0)
Coordinates, Lines, Circles, Functions and their graphs, Polynomials, trigonometric functions, limits, derivatives, numerical approximation of derivatives, indefinite integrals, the definite integral, the fundamental theorem of calculus, applications of the integral: areas, volumes, numerical integration, transcendental functions, techniques of integration: integration by parts,
partial fraction decomposition, substitutions, differential equations of first order, separable equations, numerical integration of differential equations, Euler method, solution of linear differential equations of second order with constant coefficients, Infinite sequences and series, geometric series, convergence tests for series, power series and radius of convergence, Taylor series,

approximation of functions by polynomials, expone intial, cosine and sine expansions,error bounds. The plane and three (3)-dimensional space, vectors, parametric equations for curves, lines, planes, dot and cross product, functions of several variables, partial derivatives, tangent planes and normals, linear approximation, gradient and the differential

AMCS 102. Vector Calculus (3-0-0)

This course covers differential, integral and vector calculus for functions of more than one (1) variable. These mathematical tools and methods are used extensively in the physical sciences, engineering, economics and computer graphics. The course covers triple integrals, cylindrical and spherical polar coordinates. Line and surface integrals. Divergence and curl applications, conservative vector fields. Green's, Gauss' and Stokes' theorems applications.

AMCS 107. Introduction to Programming with Matlab and Mathematica (3-0-0)

This course gives an introduction to MATLAB® and Mathematica. It is designed to give students fluency in these two (2) mathematical software. The course consists of interactive lectures with students doing sample programming problems in real time.

AMCS 131. Vector Analysis and Ordinary Differential Equations (3-0-0)

The course is concentrated mostly on Multivariate Calculus and basic ODEs and contains some necessary preliminaries from Single Variable Calculus and Complex Analysis.

AMCS 143. Introduction to Probability and Statistics (3-0-0)

This course provides an elementary introduction to probability and statistics with applications. Topics include: basic probability models; combinatorics; random variables; discrete and continuous probability distributions; statistical estimation and testing; confidence intervals; and an introduction to linear regression.

AMCS 151. Linear Algebra (3-0-0)

This is a basic subject on matrix theory and linear algebra. Emphasis is given to topics that will be useful in other disciplines, including systems of equations, introduction to vector spaces, basis and dimension, rank of a matrix, determinants, eigenvalues and diagonalization, similarity, and positive definite matrices. Applications. Orthogonal and unitary matrices and transformations. Orthogonal projections, Gram-Schmidt procedure.

AMCS 162. Discrete Mathematics (3-0-0)

This course covers elementary discrete mathematics for computer science and engineering. It emphasizes mathematical definitions and proofs as well as applicable methods. Topics include formal logic notation, proof methods; induction, well-ordering; sets, relations; elementary graph theory; integer congruences; asymptotic notation and growth of functions; permutations and combinations, and counting principles.

CS 199. Directed Study in CS (3-0-0)

This course is a self-study in a particular topic directed by a faculty. Students do not register for this course. They may be required to enroll in it based on the recommendation of a faculty and approval of the program.

AMCS 201. Applied Mathematics I (3-0-3) (Equivalent to AMCS 132)

Prerequisites: Advanced and multivariate calculus and elementary complex variables. AMCS 201 and 202 may be taken separately or in either order. Part of a fast-paced two (2)-course sequence in graduate applied mathematics for engineers and scientists, with an emphasis on analytical technique. A review of practical aspects of linear operators (superposition, Green's functions, and eigenanalysis) in the context of ordinary differential equations, followed by extension to linear partial differential equations (PDEs) of parabolic, hyperbolic, and elliptic type through separation of variables and special functions. Integral transforms of Laplace and Fourier type. Self-similarity. Method of characteristics for first-order PDEs. Introduction to perturbation methods for nonlinear PDEs, asymptotic analysis, and singular perturbations. No degree credit for AMCS majors.

AMCS 202. Applied Mathematics II (3-0-3) (Equivalent to AMCS 153)

Prerequisites: Advanced and multivariate calculus and elementary complex variables. AMCS 201 and 202 may be taken separately or in either order. Part of a fast-paced two (2)-course sequence in graduate applied mathematics for engineers and scientists, with an emphasis on analytical technique. A review of linear spaces (basis, independence, null space and rank, condition number, inner product, norm, and Gram-Schmidt orthogonalization) in the context of direct and iterative methods for the solution of linear systems of equations arising in engineering applications. Projections and least squares. Eigenanalysis, diagonalization, and functions of matrices. Complex analysis, Cauchy-Riemann conditions, Cauchy integral theorem, residue theorem, Taylor and Laurent series, contour integration, and conformal mapping. No degree credit for AMCS majors.

AMCS 206. Applied Numerical Methods (3-0-3) (Equivalent to AMCS 152)

Prerequisites: Advanced and multivariate calculus. No degree credit for AMCS majors. A fast-paced one (1)-semester survey of numerical methods for engineers and scientists, with an emphasis on technique and software. Computer representation of numbers and floating point errors. Numerical solution of systems of linear and nonlinear algebraic equations, interpolation, least squares, quadrature, optimization, nonlinear equations, approximation of solutions of ordinary and partial differential equations. Truncation error, numerical stability, stiffness, and operation and storage complexity of numerical algorithms.

CS 207. Programming Methodology and Abstractions (3-0-3)

Computer programming and the use of abstractions. Object-oriented programming, fundamental data structures (such as stacks, queues, sets) and data-directed design. Recursion and recursive data structures (linked lists, trees, graphs). Introduction to basic time and space complexity analysis. The course teaches the mechanics of the C, C++ or Java language as well as an example of media library.

AMCS 210. Applied Statistics and Data Analysis (3-0-3)
(Equivalent to AMCS 110)

Prerequisites: Advanced and multivariate calculus. For students outside AMCS wishing to obtain an introduction to statistical method. Provides fundamentals of probability and statistics for data analysis in research. Topics include data collection, exploratory data analysis, random variables, common discrete and continuous distributions, sampling distributions, estimation, confidence intervals, hypoThesis tests, linear regression, analysis of variance, two (2)-way tables, and data analysis using statistical software. No degree credits for AMCS majors.

AMCS 211. Numerical Optimization (3-0-3)

Prerequisites: Advanced and multivariate calculus and elementary real analysis. Solution of nonlinear equations. Optimality conditions for smooth optimization problems. Theory and algorithms to solve unconstrained optimization; linear programming; quadratic programming; global optimization; general linearly and nonlinearly constrained optimization problems.

AMCS 212. Linear and Nonlinear Optimization (3-0-3)

Prerequisites: Advanced and multivariate calculus. The role of duality, optimality conditions and algorithms in finding and recognizing solutions. Perspectives: problem formulation, analytical theory, computational methods and recent applications in engineering, finance and economics. Theories: finite dimensional derivatives, convexity, optimality, duality and sensitivity. Methods: simplex and interior-point, gradient, Newton and barrier.

CS 229. Machine Learning (3-0-3

Prerequisites: linear algebra and basic probability and statistics. Familiarity with artificial intelligence recommended. Topics: statistical pattern recognition, linear and non-linear regression, non-parametric methods, exponential family, GLIMs, support vector machines, kernel methods, model/feature selection, learning theory, VC dimension, clustering, density estimation, EM, dimensionality reduction, ICA, PCA, reinforcement learning and adaptive control, Markov decision processes, approximate dynamic programming and policy search.

AMCS 231. Applied Partial Differential Equations I (3-0-3)

Prerequisites: Advanced and multivariate calculus and elementary complex variables. First part of a sequence of courses on partial differential equations (PDE) emphasizing theory and solution techniques for linear equations. Origin of PDE in science and engineering. Equations of diffusion, heat conduction, and wave propagation. The method of characteristics. Classification of PDE. Separation of variables, theory of the Fourier series and Fourier transform. The method of Green's functions. Sturm-Liouville problem, special functions, eigenfunction expansions. Higher dimensional PDE and their solution by separation of variables, transform methods, and Green's functions. Introduction to quasi-linear PDE and shock waves.

AMCS 241. Probability and Random Processes (3-0-3)

Prerequisites: Advanced and multivariate calculus. Introduction to probability and random processes. Topics include probability axioms, sigma algebras, random vectors, expectation, probability distributions and densities, Poisson and Wiener processes, stationary processes, autocorrelation, spectral density, effects of filtering, linear least-squares estimation and convergence of random sequences.

AMCS 243. Probability and Statistics (3-0-3)

Prerequisites: Advanced and multivariable calculus. This course is an introduction to probability and statistic for students in statistics, applied mathematics, electrical engineering and computer science. This core course is intended to provide a solid general background in probability and statistics that will form the basis of more advanced courses in statistics. Content: (1) – Probability: Axioms of probability, Conditional probability and independence, Conditional probability and independence, Random variables, expectation, and moments, discrete random variables, Continuous random variables, Pairs of random variables, Limit theorems. (2) – Theory of Statistics: Estimators and properties, Optimality, Maximum likelihood, HypoThesis tests, Confidence intervals, Bayesian statistics. (3) – Methods of Statistics: Graphics and exploratory data analysis, Simple/multiple regression and least squares, Logistic regression, Analysis of variance, Robust and nonparametric statistics.

AMCS 245. Linear Models (3-0-3)

Prerequisites: Advanced and multivariable calculus, linear algebra. This course is an introduction to the formulation and use of the general linear model, including parameter estimation, inference and the use of such models in a variety of settings. Emphasis will be split between understanding the theoretical formulation of the models and the ability to apply the models to answer scientific questions.

CS 247. Scientific Visualization (3-0-3)

Prerequisites: Advanced and multivariate calculus, and linear algebra, computer graphics, and programming experience. Techniques for generating images of various types of experimentally measured, computer generated, or gathered data. Grid structures. Scalar field visualization. Vector field visualization. Particle visualization. Graph visualization. Animation. Applications in science, engineering, and medicine.

CS 248. Computer Graphics (3-0-3)

Prerequisites: solid programming skills and linear algebra. Input and display devices, scan conversion of geometric primitives, 2D and 3D geometric transformations, clipping and windowing, scene modelling and animation, algorithms for visible surface determination, local and global shading models, color and real-time rendering methods.

AMCS 251. Numerical Linear Algebra (3-0-3)

Prerequisites: Programming skills (MATLAB preferred) and linear algebra. Linear algebra from a numerical solution perspective. Singular Value Decomposition, matrix factorizations, linear least squares, Gram-Schmidt orthogonalization, conditioning and stability, eigenanalysis, Krylov subspace methods and preconditioning, and optimization and conjugate gradient methods.

AMCS 252. Numerical Analysis of Differential Equations (3-0-3)

Prerequisites: Familiarity with Taylor series, norms, orthogonal polynomials, matrix analysis, linear systems of equations, eigenvalues, differential equations, and

programming in MATLAB or a similar language.
The course covers theory and algorithms for the numerical solution of ODEs and of PDEs of parabolic, hyperbolic, and elliptic type. Theoretical concepts include: accuracy, zero-stability, absolute stability, convergence, order of accuracy, stiffness, conservation, and the CFL condition. Algorithms covered include: finite differences, steady and unsteady discretization in one (1)and two (2) dimensions, Newton methods, Runge-Kutta methods, linear multistep methods, multigrid, implicit methods for stiff problems, centered and upwind methods for wave equations, dimensional splitting and operator splitting

AMCS 253. Iterative Methods of Linear and Nonlinear Algebra (3-0-3)

Prerequisites: Programming skills (MATLAB preferred) and linear algebra. Classical stationary iterative methods of linear algebra, Chebyshev, multilevel, and Krylov subspace iterative methods, preconditioners from approximate factorizations, hierarchical solvers, and domain decomposition; Classical nonlinear iterative methods, fixed-point, Newton and its variants, nonlinear Schwarz methods.

CS 260. Design and Analysis of Algorithms (3-0-3)

Prerequisite: computer programming skills, probability, basic data structures, basic discrete mathematics. Review of algorithm analysis (search in ordered array, binary insertion sort, merge sort, 2-3 trees, asymptotic notation). Divide and conquer algorithms (master theorem, integer multiplication, matrix multiplication, fast Fourier transform). Graphs (breadth-first search, connected components, topological ordering, depth-first search). Dynamic programming (chain matrix multiplication, shortest paths, edit distance, sequence alignment). Greedy algorithms (binary heaps, Dijkstra's algorithm, minimum spanning tree, Huffman codes). Randomized algorithms (selection, quick sort, global minimum cut, hushing). P and NP (Cook's theorem, examples of NP-complete problems). Approximate algorithms for NP-hard problems (set cover, vertex cover, maximum independent set). Partial recursive functions (theorem of Post, Diophantine equations). Computations and undecidable problems (undecidability of halting problem, theorem of Rice, semantic and syntactical properties of programs).

CS 261. Combinatorial Optimization (3-0-3)

Prerequisite: Familiarity with discrete algorithms at the level of AMCS 260. Topics: algorithms for optimization problems such as matching, maxflow, min-cut and load balancing. Using linear programming, emphasis is on LP duality for design and analysis of approximation algorithms. Approximation algorithms for NP-complete problems such as Steiner trees, traveling salesman and scheduling problems. Randomized algorithms.

AMCS 271. Applied Geometry (3-0-3)

Differential Geometry: selected topics from the classical theory of curves and surfaces, geometric variational problems, robust computation of differential invariants, discrete differential geometry. Projective Geometry: computing with homogeneous coordinates, projective maps, quadrics and polarity. Algebraic Geometry: algebraic curves and surfaces, rational parameterizations, basic elimination theory. Kinematical Geometry: geometry of motions, kinematic mappings. The practical use of these topics is illustrated at hand of sample problems from Geometric Modelling, Computer Vision, Robotics and related areas of Geometric Computing.

AMCS 272 Geometric Modelling (3-0-3)

Prerequisites: Advanced and multivariate calculus and linear algebra, computer graphics, and programming experience. Terminology, coordinate systems, and implicit forms. Parametric and spline representations of curves and surfaces and their uses. Basic differential geometry of curves and surfaces. Subdivision surfaces. Solid modelling paradigms and operations. Robustness and accuracy in geometric computations. Applications.

AMCS 290 B: Real Analysis (3-0-3)

Prerequisites: Advanced and Multi-variable calculus: This course is an introduction to measure and integration theory, the elementary theory of metric spaces, and applications to the approximation of real valued functions. It is intended as an introductory graduate level course for the Applied Mathematics program and will be of interest to Statistics and students from the Electrical Engineering and possibly other programs. The course has been introduced to be one (1)of the 5 core courses of the AMCS-Applied Mathematics program

CS 291. Scientific Software Engineering (3-0-3)

Prerequisites: Programming experience and familiarity with basic discrete and numerical algorithms. Practical aspects of application development for high performance computing. Programming language choice; compilers; compiler usage. Build management using make and other tools. Library development and usage. Portability and the GNU autoconf system. Correctness and performance debugging, performance analysis. Group development practices and version control. Use of third-party libraries and software licensing.

CS 292. Parallel Programming Paradigms (3-0-3)

Prerequisites: Programming experience and familiarity with basic discrete and numerical algorithms. Distributed and shared memory programming models and frameworks. Thread programming and OpenMP. Message passing and MPI. Parallel Global Address Space (PGAS) languages. Emerging languages for many-core programming. Elements to be covered will include syntax and semantics, performance issues, thread safety and hybrid programming paradigms.

AMCS 297. MS Thesis (variable credit)

AMCS 298. Graduate Seminar (variable credit)

Master-level seminar focusing on special topics within the field.

AMCS 299. Directed Research (variable credit)

Prerequisite: Sponsorship of advisor and approved prospectus. Master-level supervised research.

AMCS 303. Numerical Methods of Geophysics (3-0-3)

Prerequisite: ErSE 203 or consent of instructor. Built on the modelling and simulation foundation developed in ErSE203, this specialized course will discuss advanced ideas of multi-scale modelling, linear and non-linear finite element methods, investigate modern approaches to numerical simulations of hydrodynamic and geophysical turbulence, problems of theoretical glaciology and material science of ice for the prediction of ice sheet evolution, and wave propagation in linear and non-linear media.

AMCS 307. Advanced Statistical Inference (3-0-3)

Prerequisite: AMCS 241, 243, 245. Statistical inference in a wide range of problems at an advanced level. It covers the general theory of estimation, tests and confidence intervals by deriving in particular the asymptotic properties of the maximum likelihood estimator and the likelihood ratio, Wald, and scores tests (and their generalizations) and the calculus of M-estimation. Selected modern topics such as Bayesian and permutation inference, rank tests, the jackknife, and the bootstrap.

AMCS 308. Stochastic Methods in Engineering (3-0-3)

Prerequisites: Basic probability, numerical analysis, and programming. Review of basic probability; Monte Carlo simulation; state space models and time series; parameter estimation, prediction and filtering; Markov chains and processes; stochastic control; Markov chain Monte Carlo. Examples from various engineering disciplines.

AMCS 309. Computational Multivariate Statistics (3-0-3)

Prerequisite: AMCS 245. An introduction to multivariate statistical models, well balancing three (3) equally important elements: the mathematical theory, applications to real data, and computational techniques. Traditional multivariate models and their recent generalizations to tackle regression, data reduction and dimensionality reduction, classification, predictor and classifier instability problems. Tools for analyzing unstructured multivariate data.

AMCS 310. Environmental Statistics (3-0-3)

Prerequisites: AMCS 2101 and 243. This course is an introduction to statistical methods for environmental data, with a focus on applications. Learn, discuss and apply statistical methods to important problems in environmental sciences. Topics include sampling, capture-recapture methods, regression, toxicology, risk analysis, time series, spatial statistics, and environmental extremes

AMCS 312. High Performance Computing (3-0-3)

Prerequisites: Programming experience and familiarity with basic discrete and numerical algorithms. One (1)of a pair of topics courses in high performance computing technology, with an emphasis on using KAUST's research computing systems, focusing primarily on hardware architectures with an emphasis on distributed computing. Theoretical and achievable performance for processor, memory system, netwo (2)rk, and I/O, primarily for large-scale scientific applications. Future architecture directions and limitations. This course focuses on the stresses put on scientific applications and their underlying mathematical algorithms by real-world architecture – not the abstract PRAM. It is intended to develop understanding of high performance computing architectures on which the student will develop and deploy applications. Students will meet some state-of-the-art discretization, solver, and execution frameworks.

CS 321. Applications of AI in Bioinformatics (3-0-3)

Prerequisite: C/C++, HPC (parallel computing) programming experience

Recommended additional prerequisites: Course consists of selected projects. These projects cover application of AI to some of the relevant problems of analysis of large biological data and generally deal with complex information. Each year problems change. Students get assigned one (1)project and they work either alone or in groups of 2. Students in the interactive discussions with the whole class and the instructor solve the project problems. Students regularly present their progress and defend their approach and results in front of the whole class. During one (1)semester several types of topics are dealt with. Students get direct experience in research methodology, report writing, presentations and, most importantly, different ways of approaching solving AI problems

AMCS 329. Finite Element Methods (3-0-3)

An introduction to the mathematical theory of finite element methods and their applications to the solution of initial and boundary-value problems. A major component of the course will focus on the development of FE applications using the commercial software COMSOL Multiphysics to illustrate the fundamental features of the method. Topics of interest will cover classical problems in engineering and science.

AMCS 330. Computational Science and Engineering (3-0-3)

Prerequisites: Programming experience and familiarity with basic discrete and numerical algorithms and experience with one (1)or more computational applications. Case studies of representative and prototype applications in partial differential equations and mesh-based methods, particle methods, ray-tracing methods, and transactional methods.

AMCS 331. Applied Partial Differential Equations II (3-0-3)

Prerequisites: Multivariate calculus, elementary complex variables, ordinary differential equations. Recommended: AMCS 231 or AMCS 201. Second part of a sequence of courses on partial differential equations (PDE) emphasizing theory and solution techniques for nonlinear equations. Quasi-linear and nonlinear PDE in applications. Conservation laws, first-order equations, the method of characteristics. Burgers' equation and wave breaking. Weak solutions, shocks, jump conditions, and entropy conditions. Hyperbolic systems of gas dynamics, shallow-water flow, traffic flow, and bio-fluid flow. Variational principles, dispersive waves, solitons. Nonlinear diffusion and reaction-diffusion equations in combustion and biology. Traveling waves and their stability. Dimensional analysis and similarity solutions. Perturbation methods. Turing instability and pattern formation. Eigenvalue problems. Stability and bifurcation.

AMCS 332. Introduction to Mathematical Modelling (3-0-3)

An introduction to mathematical modelling through a combination of practical problem-solving experience and applied mathematics techniques, including dimensional analysis, non-dimensionalization, asymptotic expansions, perturbation analysis, boundary layers, computing and other topics.

AMCS 333. Hyperbolic Conservation Laws and Godunov-type Methods (3-0-3)

Prerequisites: Analysis of PDEs (AMCS 231) and Numerical analysis of PDEs (AMCS 252).

The course covers theory and algorithms for the numerical solution of linear and nonlinear hyperbolic PDEs, with applications including fluid dynamics, elasticity, acoustics, electromagnetics, shallow water waves, and traffic flow. The main concepts include: characteristics; shock and rarefaction waves; weak solutions; entropy; the Riemann problem; finite volume methods; Godunov's method; TVD methods; and high order methods; stability, accuracy, and convergence of numerical solutions.

AMCS 334. Mathematical Fluid Dynamics (3-0-3)

Prerequisites: AMCS 231 or AMCS 201. Recommended: AMCS 331. Equations of fluid dynamics; inviscid flow and Euler equations; vorticity dynamics; viscous incompressible flow and Navier-Stokes equations; existence, uniqueness, and regularity of solutions of Navier-Stokes equations; Stokes flow; free-surface flows; linear and nonlinear instability and transition to turbulence; rotating flows; compressible flow and shock dynamics; detonation waves.

AMCS 335. Multiscale Modelling and Simulation for PDEs (3-0-3)

The course will cover some basic multiscale methods as well as some advanced methods for solving partial differential equations with multiple scales. The topics will include: Background, Problems with multiple scales; Difficulties in solving multiscale problems; Homogenization techniques for partial differential equations (PDEs) (with periodic micro-structure); Formal asymptotic analysis; Homogenized media properties. Applications to various PDEs: Effective medium theory (based on homogenization); Simplified theories; Bounds for homogenized coefficients: Numerical homogenization (upscaling) techniques; Slowly varying and non-periodic microstructures; Estimating errors of numerical homogenization: Homogenization for nonlinear operators; Numerical homogenization for nonlinear operators; Multiscale finite element methods; Differences from homogenization/numerical homogenization; Simplified multiscale basis functions.

AMCS 336. Numerical Methods for Stochastic Differential Equations (3-0-3)

Prerequisites: knowledge of basic probability, numerical analysis, and programming. Brownian motion, stochastic integrals and diffusions as solutions of stochastic differential equations. Functionals of diffusions and their connection with partial differential equations. Weak and strong approximation, efficient numerical methods and error estimates. Jump diffusions.

CS 337. Information Netwo (2)rks (3-0-3)

Prerequisite: probability. 1. Define the course prerequisites as follows: Prerequisite: probability, stochastic systems, netwo (2)rk architecture of the Internet and the systems performance 2.Slightly rewrite the course content as follows: modelling, experimental design, performance measurement, model development, analytic modelling, single queue facility, netwo (2)rks of queues, stochastic systems, deterministic systems, birth-death model analysis, closed netwo (2)rk model, bottleneck, interactive netwo (2)rks, M/M/m queues, M/G/1 priority queues, Markovian queuing model, random numbers, discrete event simulation, verification and validation of simulation models, workload characterization and benchmarks. Also, advanced research papers on using queuing theory for netwo (2)rking systems. The course consists of a final modelling and simulation project on a novel idea that leads to publication.

AMCS 338. Applied Real and Functional Analysis with Applications (3-0-3):

Prerequisites: advanced calculus and linear algebra and basic familiarity with PDE. Students taking this course are recommended to also take AMCS 231. An introduction to the principles of measure and integration theory, the elements of functional analysis in Banach spaces, and spectral theory in Hilbert spaces, to discuss two (2) classical areas of applications, integral and differential equations. Additional topics will include differential and integral calculus in Banach spaces, fundamental results of distribution theory and Sobolev spaces.

CS 340. Computational Methods in Data Mining (3-0-3)

Prerequisites: Probability and scientific computing. Focus is on very-large-scale data mining. Topics include computational methods in supervised and unsupervised learning, association mining and collaborative filtering. Individual or group applications-oriented programming project. 1 credit without project; 3 credits requires final project

EE 341. Information Theory (3-0-3)

Prerequisite: EE 241 or consent of an instructor. The concepts of source, channel, rate of transmission of information. Entropy and mutual information. The noiseless coding theorem. Noisy channels, the coding theorem for finite state zero memory channels. Channel capacity. Error bounds. Parity check codes. Source encoding.

AMCS 350. Spectral Methods for Uncertainty Quantification (3-0-3)

This course is an advanced introduction to uncertainty propagation and quantification in model-based simulations. Examples are drawn from a variety of engineering and science applications, emphasizing systems governed by ordinary or partial differential equations. The course will emphasize a probabilitic framework, and will survey classical and modern approaches, including sampling methods and techniques based on functional approximations.

AMCS 353. Advanced Topics in Wave Propagation (3-0-3)

Prerequisites: AMCS 201,202 or equivalent knowledge on eigenvalue problem, Fourier transform, linear algebra. This course starts from the basic linearized theory of wave phenomena: examples are chosen from electromagnetics, acoustics, elastics and other subjects, and expores the recent developments in wave propagation. The topics include: basic concepts in wave propagation; waves in layered media; scattering, transmission and reflection; waves in random media, effective medium properties, resolution analysis; applications in wave functional materials and imaging; and numerical techniques in solving wave euqations in heterogeneous media. Basic knowledge on eigenvalue problem, Fourier transform, linear algebra, vector analysis is required.

AMCS 354. Asymptotic Methods of Applied Mathematics (3-0-3)

Prerequisite: Basic courses in complex analysis, ODE, and PDE. Asymptotic approximations, regular and singular asymptotics, approximation of integrals (methods of stationary phase and steepest descents), asymptotic analysis of ODE at regular/irregular singular points, parameter asymptotics for initial/boundary value problems, matched asymptotic expansions, the method of multiple scales, WKB method, weakly nonlinear oscillations and waves, bifurcation and stability.

CS 361. Combinatorial Machine Learning (3-0-3)

Prerequisites: AMCS/CS 260. Lower and upper bounds on complexity and algorithms for construction (optimization) of decision trees, decision rules and tests. Decision tables with one-valued decisions and decision tables with many-valued decisions. Approximate decision trees, rules and tests. Global and local approaches to the study of problems over infinite sets of attributes. Applications to discrete optimization, fault diagnosis, pattern recognition, analysis of acyclic programs, data mining and knowledge discovery. Current results of research.

AMCS 370. Inverse Problems (3-0-3)
Prerequisites: Linear algebra, multi-variable calculus. The aim of the course is to introduce the basic notions and difficulties encountered with ill-posed inverse problems, to present methods for analyzing these problems and to give some tools that enable to solve such problems. The course will show what a regularization method is and introduce different kind of regularization techniques and the basic properties of these methods for linear ill-posed problems. Non-linear inverse problems are also studied through some examples: inverse spectral problem, inverse problem of electrical impedance tomography and the inverse scattering problem. The course will introduce numerical tools for analyzing inverse problems, with a focus on the adjoint state method. The Bayesian estimation is also considered. Examples of inverse problems are provided especially in medical imaging.

CS 380. GPU and GPGPU Programming (3-0-3)
Prerequisite: CS 280. Recommended optional prerequisites: CS 248, CS 292. Architecture and programming of GPUs (Graphics Processing Units). Covers both the traditional use of GPUs for graphics and visualization, as well as their use for general purpose computations (GPGPU). GPU many-core hardware architecture, shading and compute programming languages and APIs, programming vertex, geometry, and fragment shaders, programming with CUDA, Brook, Open CL, stream computing, approaches to massively parallel computations, memory subsystems and caches, rasterization, texture mapping, linear algebra computations, alternative and future architectures

AMCS 313. Spatial Statistics (3-0-3)
Prerequisite: AMCS 241, 243, 245. Recommended optional prerequisites: AMCS 307. This course is an introduction to the concepts and applications of spatial statistics. It covers the following topics. Geostatistical data: Random Fields; Variograms; Covariances; Stationarity; Non-stationarity; Kriging; Simulations. Lattice data: Spatial regression; SAR, CAR, QAR, MA models; Geary/Moran indices. Point patterns: Point processes; K-function; Complete spatial randomness; Homogeneous/inhomogeneous processes; Marked point processes.

AMCS 390 A: Statistics of Extremes (3-0-3)
Prerequisites: AMCS 241, 243, 245. This course is an introduction to Extreme-Value Theory and Statistics, and its application to real problems. Topics covered include (a) Univariate Extreme-Value Theory: Extremal-Types Theorem; GEV distribution; return levels; Domains of attraction; Threshold-based methods; GPD distribution; Point process representation; r-largest order statistics approach; Likelihood inference; Modelling of non-stationarity; Dependent time series; Clustering and declustering approaches. (b) Multivariate Extreme-Value Theory: Modelling of componentwise maxima; Spectral representation; Parametric models; Dependence measures; Asymptotic dependence/independence; Threshold methods; Likelihood-based inference. (c) Spatial Extremes: Gaussian processes; correlation functions; Max-stable processes and models.

AMCS 396. Mathematical Modelling in Computer Vision (3-0-3)
Prerequisites: multivariable calculus, and basic probability theory. A research course that covers topics of interest in computer vision, including image denoising/debluring, image segmentation/object detection, and image registration / matching. The emphasis will be on creating mathematical models via the framework of Bayesian estimation theory, analyzing these models, and constructing computational algorithms to realize these models. Techniques from calculus of variations, differential geometry, and partial differential equations will be built up as the need arises.

AMCS 397. Doctoral Dissertation (variable credit)

AMCS 398. Graduate Seminar (variable credit)
Doctoral-level seminar focusing on special topics within the field.

AMCS 399. Directed Research (variable credit)
Prerequisite: Sponsorship of advisor. Supervised research.

6. KAUST University Requirements

Office of the Registrars

6.1 Program and Degrees

King Abdullah University of Science and Technology (KAUST) advances science and technology through bold and collaborative research. It educates scientific and technological leaders, catalyzes the diversification of the Saudi economy and addresses challenges of regional and global significance, thereby serving the Kingdom, the region and the world.

Research and education, as well as their transformative potential, are central to KAUST's mission. KAUST has a three (3)-part mission:

Research at KAUST – both basic and goal-oriented – is dedicated to advancing science and technology of regional and global impact. Research excellence inspires teaching and the training of future leaders in science and technology. Research and education at KAUST energize innovation and enterprise to support knowledge-based economic diversification.

Through the synergy of science and technology, and innovation and enterprise, KAUST is a catalyst for transforming people's lives.

In support of this mission, King Abdullah University of Science and Technology offers eleven graduate programs leading to M.S. and Ph.D. degrees.

KAUST Offers the Following two (2) Degrees
The M.S. degree typically takes three (3) semesters and a summer to complete (18 months). The degree allows

flexibility for internships, research, and academics. Learn more about M.S. degree requirements.
The Ph.D. degree is typically a three (3)- to four-year post-master's degree. The Ph.D., involves original research, culminating in a research dissertation. Learn more about Ph.D. degree requirements.
Three (3) academic divisions, these are:

Biological and Environmental Sciences and Engineering (BESE)
Bioscience (B)
Environmental Science and Engineering (EnSE)
Marine Science (MarS)
Plant Science (PS)

Computer, Electrical and Mathematical Sciences and Engineering (CEMSE)
Applied Mathematics and Computational Science (AMCS)
Computer Science (CS)
Electrical Engineering (EE)

Physical Sciences and Engineering Division (PSE)
Chemical and Biological Engineering (CBE)
Chemical Sciences (ChemS)
Earth Science and Engineering (ErSE)
Materials Science and Engineering (MSE)
Mechanical Engineering (ME)

Each program is administered by a Graduate Committee and a Graduate Chair. Courses for each program will be listed at the 100 (non-credit), 200, 300 or 400 level.

7. Master's Program

Admissions

Admission to the M.S. program requires the satisfactory completion of an undergraduate B.S. degree in a relevant or related area, such as Engineering, Mathematics or the Physical, Chemical and Biological Sciences.

Master's Degree requirements
The M.S. degree requires successful completion of 36 credits. Students are expected to complete the M.S. degree in three (3) semesters plus one (1)summer session. Degree requirements are divided into three (3) sections: Core Curriculum; Elective Curriculum; and Research/Capstone Experience.

Core Curriculum (9-15 credits): This portion of the degree program is designed to provide a student with the background needed to establish a solid foundation in the program area over and above that obtained through undergraduate studies.

Elective Curriculum (9-15 credits): This portion of the degree program is designed to allow each student to tailor his/her educational experience to meet individual research and educational objectives. Depending upon the program and the objectives, this may be met by added coursework or by additional research experience.

Research/Capstone Experience (12 credits): The details of this portion of the degree program are uniquely determined by the student and his/her advisor and will involve a combination of research and other capstone experiences that build on the knowledge gained in coursework.

Satisfactory participation in KAUST's Summer Session's and Winter Enrichment Program (WEP) are mandatory.

Summer Session courses are credit bearing and apply toward the degree.

WEP courses do not earn credit towards the degree.

At least thirty-six (36) degree credits must be completed in graduate-level courses and research projects. These courses should be 200-level or above and must be approved by the student's advisor. Additional non-credit bearing activities, such as graduate seminars, may be required by the Program. Details on the specific program expectations, as well as the difference between the Thesis and non-Thesis degree options can be found through the link in the Program Guide http://www.kaust.edu.sa/study.html. For a list of eligible faculty advisors, see: http://www.kaust.edu.sa/faculty-advisors.html

7.1 Thesis Requirements

Students wishing to pursue a Thesis as part of their M.S. degree, must identify a Research Advisor and must file for Thesis status.

The application for the Thesis option is due to the Registrar's Office by the ninth week of the student's second semester at KAUST. Criteria for Acceptance into the Master's Degree with Thesis program.
Students should have a well-constructed Thesis proposal that includes a time-line for completion. The Thesis proposal must be approved by the Research Advisor and the Dean of the Division. In the case of an optional Thesis program, the student should have a minimum GPA of 3.2 and at least 12 credit hours completed at the conclusion of the first semester and be registered in at least 12 credit hours during the second semester.

The Research Advisor must indicate that he/she endorses the Thesis topic and scope of work and that it could reasonably be completed by the end of the third semester. Alternatively, the faculty member agrees to a longer time frame, not to exceed the end the fourth semester, and to cover the student and experimental costs that accrue during this period.

The student's program of study should be structured such that the student may change to the M.S. without Thesis option and finish the degree by the end of the student's third semester.

The MS Thesis Defense committee, which must be approved by the student's Dean, must consist of at least three members, and typically includes no more than four members. At least two of the required members must be KAUST faculty. The Chair plus one additional faculty member must be affiliated with the student's program. This membership can be summarized as:

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty or Approved Research Scientist	Outside Program
4	Additional Faculty	Inside or outside KAUST

Notes:

- Members 1 – 3 are required. Member 4 are optional
- Co-chairs may serve as Member 2, 3 or 4, but may not be a Research Scientist
- Adjunct Professors and Professor Emeriti may retain their roles on current committees, but may not serve as chair on any new committees
- Professors of Practice and Research Professors may serve as Members 2 , 3 or 4 depending upon their affiliation with the student's program. They may also serve as co-chairs
- Visiting Professors may serve as Member 4

The student is responsible for scheduling the Thesis defense date with his/her supervisor and committee members. It is advisable that the student submits a written copy of the Thesis to the Thesis committee members at least two (2) weeks prior the defense date.

7.2 Non-Thesis Option

Students wishing to pursue the Non Thesis options must complete a minimum of 6 credits of directed research credits (299) is required. Summer internship credits may be used to fulfill the research requirement provided that the summer internship is research-based. Summer internships are subject to approval by the student's academic advisor.

Students must complete the remaining credits through one (1)or a combination of the options listed below:

Broadening Experience Courses: Courses that broaden a student's M.S. experience.
Ph.D.-Level Courses: Courses numbered 300 or greater. Any course in the Ph.D. core requirements that is passed with a minimum grade of B– may be used towards meeting the core Ph.D. requirements of the program if the student chooses to continue for a Ph.D. degree in at KAUST.
Internship: Research-based summer internship (295). Students are only allowed to take one (1)internship.

It should be noted that a student may also combine courses to satisfy the six-credit requirement. For example, a student could take one (1)Ph.D.-level course and one (1)graduate-level course in another program. A student may not enrol in two (2) summer internships.Thesis format requirements are described in the KAUST Thesis and Dissertation Guidelines http://libguides.kaust.edu.sa/theses

For a list of eligible faculty advisors, see: http://www.kaust.edu.sa/faculty-advisors.html

Students may select a KAUST faculty member from another program to act as a Research Advisor (for either Thesis or directed research), but must provide a one-page description of the research and an explanation of how such research would be relevant to the degree program. Upon approval by the program and the Dean, the faculty member would be allowed to act as an affiliated faculty member and advisor for the student.

Please Note: Degree Programs may have additional requirement to those listed above.

8. Ph.D. Program

Admissions

Ph.D. students apply for and enter a specific degree program. A faculty advisor is either immediately designated (in the case of a student being recruited by a specific faculty member) or temporarily assigned; in the latter case, the student is expected to identify a Research Advisor by (at the latest) the end of the first year.

There are three (3) phases and associated milestones for Ph.D. students:

Passing a qualifying exam;
Passing an oral defence of the dissertation proposal
Dissertation phase with a final defense milestone.

8.1 Ph.D. Degree Requirements

There is a minimum residency requirement (enrolment period at KAUST) of 2.5 years for students entering with an M.S. degree, 3.5 years for students entering with a B.S. degree. Qualification and advancement to candidacy are contingent upon: (i) successfully passing Ph.D. coursework, (ii) designating a Research Advisor, (iii) successfully passing a qualifying exam, and (iii) writing and orally defending a research proposal. Possible outcomes include pass, failure with complete retake, failures with partial retake, and failure with no retake. Students not permitted to retake the exam, or who fail the retake, will be dismissed from the University. The maximum allotted time for advancement to candidacy for a student entering with a M.S. degree is two (2) years; three (3) years for students entering with a B.S.

Satisfactory participation in KAUST's Summer Session and Winter Enrichment Period (WEP) is mandatory. Summer Session courses are credit bearing and apply toward the degree. WEP courses do not earn credit towards the degree.

The required coursework is outlined below and see program for specific program course requirements:

M.S. Degree

- Core courses
- Elective courses
-

Ph.D. Degree

- Two (2) or more courses at the 300 level
- Graduate seminar if required by the program.

Students entering the program with a relevant M.S. from another institution may transfer coursework toward the requirements of the M.S. degree listed above upon approval of the program.

Students entering the program with a M.S. from KAUST may transfer coursework toward both the M.S. and Ph.D. requirements listed above upon approval of the program and based on their program of study at KAUST.

Students entering with a B.S. from another institution may transfer in up to 9 credits of graduate level coursework towards the above requirements upon approval of the program. In addition, students entering with a B.S. may also qualify to earn a M.S. degree by satisfying the M.S. degree requirements as part of the Ph.D. program.

Some degree programs may require a diagnostic entrance exam as a basis for admission, and students may be required to complete additional coursework depending on their degree-granting institution. If the M.S. degree is from a subject other than the Ph.D. degree program, there may be additional courses required and specified by the advisor.

8.2 Candidacy

Achieving Ph.D. candidacy is contingent upon successfully passing a qualifying examination, acceptance by the Research Advisor of a written research proposal and successfully passing an oral examination. Details should be confirmed in the individual degree program material. For a list of eligible faculty advisors for any degree program see: http://www.kaust.edu.sa/faculty-advisors.html

Passing the qualification phase is achieved by acceptance of all committee members of the written proposal and a positive vote of all but, at most, one (1)member of the oral exam committee. If more than one (1)member casts a negative vote, one (1)retake of the oral defense is permitted if the entire committee agrees. A conditional pass involves conditions (e.g., another course in a perceived area of weakness) imposed by the committee, with the conditional status removed when those conditions have been met. Once constituted, the composition of the qualification phase committee can only be changed upon approval by both the faculty Research Advisor and the division dean.

8.3 Dissertation Research Credits

Besides coursework (6 or more credit hours), dissertation research (course number 397) must be earned during the first (proposal preparation and defense) and second phases of the Ph.D. program. A full-time workload for Ph.D. students is considered to be 12 credit hours per semester (courses and 397) and 6 credit hours in summer (397 only). There is a minimum residency requirement (enrolment period at KAUST) of 2.5 years for students entering with an M.S. degree, 3.5 years for students entering with a B.S. degree. Ph.D. students typically complete the degree in 5 years.

8.4 Dissertation and Dissertation Defense

The Dissertation Defense is the final exam of the Ph.D. degree. It involves a public presentation of the results of the dissertation research followed by a question and answer session. The Dissertation Defense committee consists ofPhD

Dissertation Defense Committee

The PhD Dissertation Defense committee, which must be approved by the student's Dean, must consist of at least four members, and typically includes no more than six members. At least three of the required members must be KAUST faculty and one must be an examiner who is external to KAUST. The Chair plus one additional faculty member must be affiliated with the student's program. The external examiner, is not required to attend the defense, but must write a report on the dissertation and may attend the dissertation defense at the discretion of the Program. This membership can be summarized as:

Member	Role	Program Status
1	Chair	Within Program
2	Faculty	Within Program
3	Faculty	Outside Program
4	External Examiner	Outside KAUST
5	Approved Research Scientist	Inside KAUST
6	Additional Faculty	Inside or outside KAUST

Notes

- Members 1 – 4 are required. Members 5 and 6 are optional
- Co-chairs may serve as either Member 2, 3 or 6
- Adjunct Professors and Professor Emeriti may retain their roles on current committees, but may not serve as chair on any new committees
- Professors of Practice and Research Professors may serve as Members 2 , 3 or 6 depending upon their affiliation with the student's program. They may also serve as co-chairs
- Visiting Professors may serve as Member 6, but not as the external examiner

It is the responsibility of the student to inform the dissertation committee of his/her progress and meet deadlines for submitting defense date and graduation forms. It is expected that students will submit their dissertations to their committee six weeks prior to the defense date in order to receive feedback from the committee members in a timely manner. However, the advisor may approve exceptions to this expected timeline. The dissertation format requirements are described in the KAUST Thesis and Dissertation Guidelines. (http://libguides.kaust.edu.sa/theses).

The result of the defense will be made based on the

recommendation of the committee. There are four possible results:
(1) Pass: the student passes the exam and the dissertation is accepted as submitted;
(2) Pass with revisions: the student passes the exam and the student is advised of the revisions that must be made to the text of the dissertation;
(3) Failure with retake: normally this means the student must do more research to complete the dissertation. The student must revise the dissertation and give another oral examination within six months from the date of the first defense;
(4) Failure: the student does not pass the exam, the dissertation is not accepted, the degree is not awarded, and the student is dismissed from the University.

9. Program Descriptions

The Master's and Doctoral degree program requirements listed above represent general university-level expectations. The specific details of each degree requirements are outlined in the descriptions of the individual degree programs.

9.1 Course Notation

Each course is listed prefaced with its unique number and post fixed with (l-c-r) where:
l is the lecture hours, to count toward fulfilling the student workload during a semester.
c is the recitation or laboratory hours.
r is the credit hours toward fulfilling a degree course requirement.

Eg CS 220 Data Analytics (3-0-3) has a total of three (3) hours of lectures per week, has no labs and earns 3 credits for the semester

10. University Guidelines

10.1 Grading

The KAUST grading system is a 4.0 scale utilizing letter grades, and these are the only grades that will be assigned.

A	=	4.00	C	=	2.00
A-	=	3.67	C-	=	1.67
B+	=	3.33	D+	=	1.33
B	=	3.00	D	=	1.00
B-	=	2.67	D-	=	0.67
C+	=	2.33	F	=	0.00

I	=	Incomplete
IP	=	In Progress
W	=	Withdrew
S	=	Satisfactory
U	=	Unsatisfactory
WF	=	Withdrew-Failed

10.2 Incomplete Grades

Students who complete the majority of the requirements for a course but are unable to finish the course may receive an incomplete (I) grade. A grade of Incomplete will be assigned only with the consent of the instructor of the course after the instructor and the student have agreed on the academic work that needs to be completed and the date it is due (but no later than the end of the second week of the following semester or session). When the requirements for the course are completed, the instructor will submit a grade that will replace the incomplete grade on the student's academic record. Incompletes not completed by the end of the second week of the following semester or session will be changed to F (failing) grades.

Grades for students that are due to graduate
Note that any incomplete grades (as well as fail grades) will mean a student will not graduate or receive a diploma during the Commencement ceremony.

Incomplete grades are granted to individual students on a case-by-case basis. Incomplete grades should not be used as a mechanism to extend the course past the end of the semester.

Students are allowed only one (1)incomplete grade while in a degree program at KAUST.

10.3 In Progress grade (IP)

Thesis Research (297) or Dissertation Research (397) should be graded as IP (In Progress), S (satisfactory) or U (unsatisfactory) for each semester.
(These IP grades will be converted by the Registrar's Office to "S" grades for all semesters, once the Office has been notified that the Thesis or dissertation has been submitted to the Library)

10.4 Research or Seminar courses

Use the following grades for these research or seminar courses:

- 297 Thesis Research Either IP or U
- 397 Dissertation Research Either IP or U
- 295/395 Internship(summer) Either S or U
- 298/398 Seminar Either S or U
- 299/399 Directed Research Either S or U

Summer Session and Winter Enrichment Program
Satisfactory participation in KAUST's Summer Session and Winter Enrichment Period (WEP) is mandatory. Summer Session courses are credit bearing and apply toward the degree. WEP courses do not earn credit towards the degree.

10.5 Cumulative Grade Point Average

A minimum GPA of 3.0 must be achieved in all coursework. Individual courses require a minimum of a B- for course credit.

10.6 Academic standing

A student's academic standing is based on his/her cumulative performance assessment and a semester performance based on the number of credits earned and GPA during the most recently completed semester.

Academic standing classifications are divided into four categories of decreasing levels of academic performance: (1) Good Standing; (2) Academic Notice; (3) Academic Probation; and (4) Academic Dismissal.

Cumulative Assessment

GPA	Academic standing
3.00 – 4.00	Good Standing
2.67 – 2.99	Academic Notice
2.33 – 2.66	Academic Probation
Below 2.33	Academic Dismissal

S/U Performance Academic Standing

0 – 2 credits	GPA Standing
3 – 5 credits	GPA Standing less one (1)category
6 – 8 credits	GPA Standing less two (2) categories
9+ credits	Academic Dismissal

Semester Assessment

Registered in 12 credits

Credits Earned	Academic Standing
12+credits	GPA Standing
9-11credits	GPA Standing less one (1)category
6- 8 credits	GPA Standing less two (2) category
0- 5 credits	Academic Dismissal

Semester Assessment

Registered in 9 credits

Credits Earned	Academic Standing
9+credits	GPA Standing
6 – 8 credits	GPA Standing less one (1)category
3 – 5 credits	GPA Standing less two (2) category
0 – 2 credits	Academic Dismissal

Summer Session Assessment

Credits Earned	Academic Standing
6 credits	GPA Standing
3 – 5 credits	GPA Standing less one (1)category
0 – 2 credits	GPA Standing less two (2) categories

Definitions

Good Standing:
Student is making satisfactory academic progress toward the degree.

Academic Notice:
Student is not making satisfactory progress toward the degree. A student placed on Academic Notice will be monitored in subsequent semesters to ensure satisfactory progress toward the degree (see Good Standing). If the student's performance does not improve in the following semester, the student will be placed on academic probation.

Academic Probation

Student is not making satisfactory progress toward the degree. A student placed on Academic Probation will be monitored in subsequent semesters to ensure satisfactory progress toward the degree (see Good Standing). If the student's performance does not improve in the following semester, the student will be academically dismissed.

Academic Dismissal

Student is not making satisfactory progress toward the degree and is unlikely to meet degree requirements. Dismissed students will be required to leave the University. If deemed eligible, dismissed students will have one (1)(1) week from receiving notice of dismissal to file an appeal.

Appeal Process for Students Academically Dismissed

If the student is eligible to appeal, he/she must submit a written explanation why the dismissal should be rescinded along with any supporting documentation. The Committee on Academic Performance will hear the appeal and make a decision to grant or deny the appeal based on the appeal and documentation, the student's past performance, and the likelihood that the student is capable of successfully completing his/her academic program. If the appeal is denied, the student will be required to leave the University. The decision of the Committee is final; no additional appeals are permitted.

S/U Protection

Due to the significant impact of U grades, a faculty member giving a U grade for a course involving 6 or more credits must obtain concurrence of the Dean prior to submitting the grade. If the grade is given for only a single class (including research credit) the number of credits will be capped at 6 when using the academic standing table displayed above.

Returning to Good Standing

A student not in good standing due to a GPA deficiency may return to Good Standing by improving his/her cumulative GPA such that it meets or exceeds 3.00. A student not in good standing due to U grades may return to Good Standing by completing at least 12 credits during the subsequent semester with no U grades and a semester GPA of at least 3.00 in traditionally graded courses.

11. Transferring Credits

A student may petition to transfer graduate credits from another university, upon approval of the Program Chair and the Registrar. Each student's application will be reviewed on a case-by-case basis. The following rules apply:

Up to three (3) graduate-level courses not to exceed nine credits may be transferred for credit. Courses transferred for credit cannot have been counted as credits for another granted degree.

The course grade for any course to be transferred must be a B or above.

Courses transferred for degree credit must have been taken within three (3) years prior to admission to KAUST.

The student must submit a completed KAUST Transfer of Credit form and include the Course syllabus and course description.

The student is responsible for supplying an official transcript:
The transcript may be no more than three (3) months old.
The transcript must be in English or accompanied by a certified English translation.

The grading key must be included with the transcript.
The transcript must include the course name, level, grade and credit value.
The credit value of the course must be equivalent to a minimum of three (3) KAUST credit hours.

Course Transfer and Equivalency
Graduate credit hours taken from any KAUST program may be applied to other KAUST graduate programs under the guidelines of the degree program to which the student is admitted. Graduate courses taken from another university or KAUST program that are equivalent in level and content to the designated courses in a major track may be counted toward meeting the major track requirement if their equivalence is confirmed by the program chair.

Students transferring from other Ph.D. programs may receive some dissertation research and coursework credit units, on a case-by-case basis, for related work performed at their original institution. However, such students must satisfy the written and oral requirements for a research proposal (if the proposal had been submitted and approved at the original institution, the proposal may be the same, if approved by the Research Advisor). The minimum residency requirement for enrollment of such students at KAUST is two (2) years.

12. Policy for Adding and Dropping Courses

A course may be added during the first week of the semester. Students may add courses after the first week with the permission of the instructor. Instructors have the right to refuse admission to a student if the instructor feels that the student will not have the time to sufficiently master the material due to adding the course late. A course may be dropped without penalty at any time during the first two (2) weeks of the semester. Between the second and ninth week, students can drop a course but the course will appear on the student's transcript with the grade of "W" (withdraw). After the ninth week of a full semester, courses may be dropped only under exceptional circumstances and with the approval of the Course Instructor, the Program Chair and the Registrar.

13. Program Planning

It is the sole responsibility of the student to plan her/his graduate program in consultation with her/his advisor. Students are required to meet all deadlines. Students should be aware that most core courses are offered only once per year