Applied Mathematics and Computational Science

Program Guide 2018-2019

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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 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 degree program does not guarantee transfer to another.

The Applied Math and Computational Science program offers specializations in two distinct directions (called "Tracks"): Applied Mathematics (AM) and Computational Science and Engineering (CSE).

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 (If applicable)

Students are admitted to KAUST from a wide variety of programs and backgrounds. In order to facilitate the design of an appropriate study plan for each individual student, all admitted students without an MS are required to take a written assessment exam when they arrive on Campus. The purpose of the assessment is to determine whether students have mastered the prerequisites for undertaking graduate-level courses taught in the program. The Academic Advisor works with admitted students to develop a study plan if needed. Students are encouraged to prepare for the assessment by refreshing the general knowledge gained from their undergraduate education before arriving at KAUST. The remedial study plan requirements must be satisfactorily completed, in addition to the University degree requirements.

3. Master's Degree Requirements

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.

The Master's Degree (M.S.) is awarded upon successful completion of a minimum of 36 credit hours. A minimum GPA of 3.0 must be achieved to graduate. Individual courses require a minimum of a 'B-'for course credit. Students are expected to complete the M.S. degree in three semesters and one Summer Session. Satisfactory participation in every KAUST's Summer Session is mandatory. Summer Session courses are credit bearing and apply towards the degree.

The M.S. degree has the following components:

- Core Courses
- Elective Courses
- Research/Capstone Experience
- Graduate Seminar 298 (non-credit). All students are required to register and receive a Satisfactory grade for the first two semesters.

3.1 M.S. Course Requirements

3.1.1 Core Courses

Applied Mathematics (AM) Track (fifteen credits)

AMCS 231 – Applied Partial Differential Equations
STAT 220 – Probability and Statistics or AMCS 241/STAT 250: Stochastic Processes
AMCS 251 – Numerical Linear Algebra
AMCS 252 – Numerical Analysis of Differential Equations
AMCS 235 – Real Analysis

Computational Science and Engineering (CSE) Track (six credits)
Students must fulfil at least two of the four core courses below:
AMCS 231 – Applied Partial Differential Equations
STAT 220 – Probability and Statistics or AMCS 241/STAT 250: Stochastic Processes
AMCS 251 – Numerical Linear Algebra
AMCS 252 – Numerical Analysis of Differential Equations

These core courses are designed to provide a student with the background needed to establish a solid foundation in the program area.

3.1.2 Elective Courses

Applied Mathematics (AM) Track
Nine credits of elective courses not necessarily within the AMCS program. Some credits may be taken outside the AMCS program subject to the approval of the Academic Advisor.

Computational Science and Engineering (CSE) Track
Students in the CSE track must take an additional eighteen credits of course work made up of:

- Six credits of Computer Science courses.
- Six credits in applications of modelling. Eligible application courses include AMCS 332 (mathematical modelling) and courses from .other programs. At least one of the modelling courses should be from outside AMCS. In case both courses are from outside AMCS, it is recommended that they be drawn from the same track.
- Six credits from AMCS courses.

The elective courses (which exclude research, internship credits, and IED courses) are designed to allow each student to tailor his/her educational experience to meet individual research and educational objectives, with the permission of the student's academic advisor.

3.1.3 Research/Capstone Experience
See sections for thesis and non-thesis options below.

3.1.4 Winter Enrichment Program
Students are required to satisfactorily complete at least one full Winter Enrichment Program (WEP).

3.2 M.S. Thesis Option
Students wishing to pursue the thesis option must apply by the ninth week of their second semester for a thesis and must have at least a 3.2 cumulative GPA.

The selected thesis advisor must be a fulltime program-affiliated Assistant, Associate or Full Professor at KAUST. This advisor can only become project affiliated for the specific thesis project upon program level approval. Project affiliation approval must be completed prior to commencing research.

3.2.1 M.S. Thesis Defense Requirements
An oral defense of the M.S. Thesis is required, although it may be waived by the Dean's Office under exceptional circumstances. A requirement of a public presentation and all other details are left to the discretion of the thesis committee.

A written thesis is required. It is advisable that the student submits a final copy of the thesis to the Thesis Committee Members at least two weeks prior to the defense date.

- Students are required to comply with the university formatting guidelines provided by the library [CLICK HERE]

- Students are responsible for scheduling the thesis defense date with his/her thesis committee.
- A pass is achieved when the committee agrees with no more than one dissenting vote, otherwise the student fails. The final approval must be submitted at the latest two weeks before the end of the semester.

3.2.2 M.S. Thesis Defense Committee

The M.S. 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

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 is optional.
- Co-Chairs may serve as Members 2, 3, or 4, but may not be a Research Scientist.
- Adjunct Professors and Professors 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.

View a list of faculty and their affiliations: **CLICK HERE**

3.3 M.S. Non-Thesis Option

Students wishing to pursue the non-thesis option must complete a minimum of six credits of Directed Research (299). Summer internship credits may be used to fulfill the research requirements 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 or a combination of the options listed below:

- Broadening Experience Courses: Courses that broaden a student's M.S. experience.
- Internship: Research-based Summer Internship (295). Students are only allowed to take one internship.
- PhD Courses: Courses numbered at the 300 level.

4. Doctor of Philosophy

The Doctor of Philosophy (Ph.D.) Degree is designed to prepare students for research careers in academia and industry. It is offered exclusively as a fulltime program.

There is a minimum residency requirement at KAUST of three and a half years for students entering with a B.S. Degree and two and a half 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.

The Ph.D. Degree includes the following steps:

- Securing a Dissertation Advisor.
- Successful completion of Program Coursework.
- Passing the Qualifying Examination.
- Passing the Dissertation Proposal Defense to obtain candidacy status.
- Preparing, submitting and successfully defending a Doctoral Dissertation.

4.1 Ph.D. Course Requirements

The required coursework varies for students entering the Ph.D. Degree with a B.S. Degree or a relevant M.S. Degree. Students holding a B.S. Degree must complete all Program Core/Mandatory Courses and Elective Courses outlined in the M.S. Degree section and are also required to complete the Ph.D. courses below. Students entering with a B.S. Degree may also qualify to earn the M.S. Degree by satisfying the M.S. Degree requirements; however, it is the student's responsibility to declare their intentions to graduate with an M.S.

Students entering the Ph.D. Degree with a relevant M.S. Degree must complete the requirements below, though additional courses may be required by the Dissertation Advisor.

Ph.D. Courses

- At least four courses of which at least two must be from the AMCS 300 level course list.
- Graduate Seminar 398 (non-credit): All students are required to register and receive a Satisfactory grade for the first two semesters.
- Winter Enrichment Program: Students are required to satisfactorily complete at least one full Winter Enrichment Program (WEP) as part of the degree requirements. Students who completed WEP requirements while earning the M.S. Degree are not required to enroll in a full WEP for a second time in the Ph.D. Degree.
- Satisfactory participation in every KAUST's Summer Session is mandatory. Summer Session courses are credit bearing and apply towards the degree.

4.2 Ph.D. Designation of Dissertation Advisor

The selected Dissertation Advisor must be a full time program-affiliated Professor at KAUST. The student may also select an advisor from another program at KAUST. This advisor can only become project affiliated for the specific thesis project with program level approval. Project affiliation approval must be completed prior to commencing research.

View a list of faculty and their affiliations: **CLICK HERE**

4.3 Ph.D. Candidacy

In addition to the coursework requirements, the student must successfully complete the required Ph.D. qualification milestones to progress towards Ph.D. candidacy status. These milestones consist of the subject-based qualifying examination and Ph.D. Proposal Defense.

4.3.1 Ph.D. Dissertation Proposal Defense Committee

The Ph.D. Dissertation Proposal Defense Committee, which must be approved by the student's Dean, must consist of at least three members and typically includes no more than six members. The Chair, plus one additional Faculty Member must be affiliated with the student's Program.

Member Role Program Status

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

Notes:

- Members 1-3 are required. Member 4 is optional.
- Co-Chairs may serve as Members 2 or 3.
- Adjunct Professors and Professors 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 or 3 depending upon their affiliation with the student's program. They may also serve as Co-Chairs.

Once constituted, the composition of the Proposal Committee can only be changed with the approval of both the Dissertation Advisor and the Dean.

View a list of faculty and their affiliations: **CLICK HERE**

4.3.2 Ph.D. Dissertation Proposal Defense

The purpose of the Dissertation Proposal Defense is to demonstrate that the student has the ability and is adequately prepared to undertake Ph.D.-level research in the proposed area. This preparation includes necessary knowledge of the chosen subject, a review of the literature and preparatory theory or experiment as applicable.

The Dissertation Proposal Defense is the second part of the qualification milestones that must be completed to become a Ph.D. Candidate. Ph.D. students are required to complete the Dissertation Proposal Defense within the second year of doctoral studies. The Dissertation Proposal Defense includes two aspects: a written Research Proposal and an oral Research Proposal Defense. Ph.D. students must request to present the Dissertation Proposal Defense to the Proposal Dissertation Committee at the beginning of the Semester they will defend their proposal.

There are four possible outcomes from this Dissertation Proposal Defense:

- Pass
- Pass with conditions
- Fail with retake
- Fail without retake

A pass is achieved when the committee agrees with no more than one dissenting vote, otherwise the students fails.

In the instance of a Pass with Conditions, the entire committee must agree on the required conditions and if they cannot, the Dean decides. The deadline to complete the conditions is one month after the defense date, unless the committee unanimously agrees to change it.

In the instance of a Fail without Retake, the decision of the committee must be unanimous. The deadline to complete the retake is six months after the defense date, unless the committee unanimously agrees to reduce it. Students who fail the Dissertation Proposal Defense, or who fail the Retake will be dismissed from the University.

A student who successfully passes the Dissertation Proposal Defense is deemed a Ph.D. Candidate.

4.4 Ph.D. Defense

To graduate, a Ph.D. candidate has to form a Ph.D. Dissertation Defense Committee, finalize the Ph.D. dissertation and successfully defend his/her Ph.D. dissertation.

4.4.1 Ph.D. Dissertation Defense Committee

The Ph.D. 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.

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 members 2, 3 or 6.
- Adjunct Professors and Professors 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.

The only requirement with commonality with the Proposal Committee is the Supervisor, although it is expected that other members will carry forward to this committee.

If the student has a co-supervisor, this person can be considered one of the above four members required, provided they come under the categories listed (i.e. meets the requirements of the position).

4.4.2 Ph.D. Dissertation Defense

The Ph.D. Degree requires the passing of the defense and acceptance of the dissertation. The final defense is a public presentation that consists of an oral defense followed by questions and may last a maximum of three hours.

The student must determine the defense date with agreement of all the members of the Dissertation Committee, meet deadlines for submitting graduation forms and inform the committee of his/her progress. It is the responsibility of the student to submit the required documents to the Graduate Program Coordinator at the beginning of the semester they intend to defend. It is also expected that the student submits their written dissertation to the committee at least two months prior to the defense date in order to receive feedback.

The written dissertation is required to comply with the University Formatting Guidelines which are on the library website: **CLICK HERE**

There are four possible outcomes from this Dissertation Final Defense:

- Pass
- Pass with conditions
- Fail with retake
- Fail without retake

A pass is achieved when the committee agrees with no more than one dissenting vote, otherwise the student fails. If more than one member casts a negative vote, one retake of the oral defense is permitted if the entire committee agrees. In the instance of a 'Pass with Conditions', the entire committee must agree on the required conditions and if they cannot, the Dean decides. The deadline to complete the revisions is up to one month after the defense date, unless the committee unanimously agrees to reduce it. The deadline to complete the retake is as decided by the defense committee with a maximum of six months after the defense date, unless the committee unanimously agrees to reduce it. Students who fail without retake the Dissertation Defense or who fail the retake will be dismissed from the University.

Evaluation of the Ph.D. Dissertation Defense is recorded by submitting the Result of Ph.D. Dissertation Defense Examination form within three days after the Defense to the Registrar's Office.

5. Program Courses and Descriptions

Course Notation:

Each course is listed prefaced with its unique number and post fixed with (L-C-R) where:

L = the lecture hours to count towards fulfilling the student workload during the semester.
C = the recitation or laboratory hours
R = the credit hours towards fulfilling a degree course requirement.

E.g. CS220 Data Analytics (3-0-3) has a total of three hours of lectures per week, has no labs and earns three credits for the semester.
100-level courses are preparatory in nature and do not count towards the MS or PhD degrees.

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, exponential, cosine and sine expansions, error bounds. The plane and three-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 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 mathematical software. The course consists of interactive lectures with students doing sample programming problems in real time.

AMCS 131 – Vector Calculus 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 congruence's; asymptotic notation and growth of functions; permutations and combinations, and counting principles.

AMCS 199 – Directed Study in Applied Mathematics (3-0-0) (variable credit up to a maximum of 12 credits)
A course of self-study in a particular topic as directed by faculty and approved by the division.

AMCS 201 – Applied Mathematics I (3-0-3)
Prerequisites: Advanced and multivariate calculus and elementary complex variables. AMCS 201 and 202 may be taken separately or in either order. No degree credit for AMCS majors
Part of a fast-paced two-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 Eigen analysis) 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.

AMCS 202 – Applied Mathematics II (3-0-3)
Prerequisites: Advanced and multivariate calculus and elementary complex variables. AMCS 201 and 202 may be taken separately or in either order. No degree credit for AMCS majors.
Part of a fast-paced two-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. Eigen analysis, diagonalization and functions of matrices. Complex analysis, Cauchy-Riemann conditions, Cauchy integral theorem, residue theorem, Taylor and Laurent series, contour integration and conformal mapping.

AMCS 206 – Applied Numerical Methods (3-0-3)

Prerequisites: Advanced and multivariate calculus. No degree credit for AMCS majors.
A fast-paced one-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.

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 non-linearly 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.

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, Eigen function 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 232 – Weak Solutions of Partial Differential Equations (3-0-3)

Prerequisite: AMCS 231 or 201.
This is a first course on weak solutions of partial differential equations. The course begins with a brief introduction to distributions and weak derivatives. Next we consider Sobolev spaces and fundamental results: extension and trace theorems, Sobolev and Morrey theorem, Poincare's inequality and Rellich-Kondrachov theorem. Then we examine weak solutions of elliptic equations through Lax-Milgram theorem. The course ends with a discussions of weak solutions of linear evolution equations - second-order linear parabolic equations, linear hyperbolic systems and semigroup methods.

AMCS 235 – Real Analysis (3-0-3)

Prerequisite: Advanced and multi-variable calculus.
This course is an introduction to measure and integration, the theory of metric spaces and their applications to the approximation of real valued functions. It starts with notions of convergence from sequences of continuous functions, the Ascoli- Arzela compactness theorem and the Weierstrass approximation theorem. The main body of the course deals with the theory of measure and integration and limiting processes for the Lebesgue integral. The last part covers the topics of differentiation, functions of bounded

variation and Fourier series. The course provides the main background needed in modern Advanced Mathematics related to Real Analysis.

AMCS 241 – Stochastic Processes (3-0-3) (Equivalent to STAT 250 - Stochastic Processes)

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 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, Eigen analysis, 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 and two 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.

AMCS 255 – Advanced Computational Physics (3-0-3)

This course covers a selection of advanced topics related to computational physics. Based on prior knowledge in calculus and linear algebra, the following topics are considered: Lagrangian formalism, symmetries and conservation laws, stability and bifurcation, multi-body problems and rigid bodies, linear and nonlinear oscillations, Hamiltonian formalism, canonical transformations and invariances, Liouville's theorem, discrete Lagrangian and Hamiltonian formalisms, Hamilton Jacobi theory, transition to quantum mechanics and relativity fields.

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 294 – Contemporary Topics in Applied Mathematics (3-0-0)
A course of current interest. Topics are not permanent and the content of the course will change to reflect recurring themes and topical interest. The content will be approved by the division.

AMCS 295 – Internship
Master-level supervised research.

AMCS 297 – MS Thesis (variable credit)
Master-level research leading to a formal written thesis and oral defense thereof.

AMCS 298 – Graduate Seminar (non-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 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 312 – High Performance Computing (3-0-3)
Prerequisites: Experience with Linux and C/C++ and familiarity with basic discrete and numerical algorithms.
High performance computing algorithms and software technology, with an emphasis on using distributed memory systems for scientific computing. Theoretical and practically achievable performance for processors memory system, and network, for large-scale scientific applications. The state-of-the-art and promise of predictive computational science and engineering. Algorithmic kernels common to linear and nonlinear algebraic systems, partial differential equations, integral equations, particle methods, optimization and statistics. Computer architecture and the stresses put on scientific applications and their underlying mathematical algorithms by emerging architecture. State-of-the-art discretization techniques, solve libraries and execution frameworks.

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 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.

AMCS 338 – Functional Analysis (3-0-3)

This course covers topics in Real Analysis and Functional Analysis and their applications. It starts with a review of the theory of metric spaces, the Lp spaces, and the approximation of real functions. It proceeds to the theory of Hilbert spaces, Banach spaces and the main theorems of functional analysis, linear operators in Banach and Hilbert spaces, the spectral theory of compact, self-adjoint operators and its application to the theory of boundary value problems and linear elliptic partial differential equation. It concludes with approximation methods in Banach spaces.

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)

This course starts from the basic linearized theory of wave phenomena: examples are chosen from electromagnetics, acoustics, elastics and other subjects and exposes 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 techniques in solving wave equations in heterogeneous media. Basic knowledge on eigenvalue problem, fourier transform, linear algebra, vector analysis is desired.

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.

AMCS 355 – Advanced Topics in Numerical Integration (3-0-3)

Prerequisite: AMCS 252

Numerical methods for solving initial value ODEs, especially large problems arising from semi-discretization of PDEs. Review of Runge-Kutta and multistep methods: consistency, stability, convergence, accuracy. Error estimation and step size control. Stiffness, order reduction, stage order and stiff accuracy. Logarithmic norms and one-sided Lipschitz constants. Symplectic and energy-conserving methods. Monotonicity-, contractility- and positivity-preserving methods. Methods for Multiphysics problems: stabilized methods, exponential, and additive methods. Parallel time integration methods: Parallel, deferred corrections and PFASST, extrapolation.

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 kinds 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.

AMCS 390 – Mathematical Biology (3-0-3)

The course will focus on modeling and analysis of mathematical models for a variety of topics in population biology and in the biomedical sciences including single and competing species ecological models, enzyme

reaction kinetics, epidemiology, and infectious diseases. Towards the end, we will study phenotype-structured populations and adaptive evolution.
It is intended as a graduate level course for the Applied Mathematics program and will be also of interest to students from BESE and other programs

AMCS 390F – Advanced Stochastic Processes (3-0-3)

Prerequisites: Real analysis, basic probability and random processes.
This 300-level course offers insightful results on several classes of stochastic processes in continuous time, laying the foundations to motivate graduate students to research in probability. The first part of the course is devoted to Markovian-type models and some of their generalisations. The second part deals with continuous-time martingales, the Brownian motion, its properties and its generalisations, Markov processes and invariance principles, preparing the student for topics such as stochastic integration and stochastic differential equations presented in the AMCS 336 course.

AMCS 394 – Contemporary Topics in Applied Mathematics (3-0-0)

A course of current interest. Topics are not permanent and the content of the course will change to reflect recurring themes and topical interest. The content will be approved by the division.

AMCS 395 – Internship (variable credit) (Summer semester)

Doctoral-level supervised research.

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)

Doctoral-level research leading to a formal written dissertation and oral defense thereof.

AMCS 398 – Graduate Seminar (non-credit)

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

AMCS 399 – Directed Research (variable credit)

Prerequisite: Sponsorship of advisor.
Supervised research.

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.

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. No degree credits for CS majors.

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.

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, and asymptotic notation). Divide and conquer algorithms (master theorem, integer multiplication, matrix multiplication, fast Fourier transform). Graphs (breadth-first search, connected components, topological ordering, and 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, and 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.

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 Open MP. 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.

CS 337 – Information Networks (3-0-3)

Prerequisite: probability, stochastic systems, network architecture of the Internet and the systems performance
Modeling, experimental design, performance measurement, model development, analytic modeling, single queue facility, networks of queues, stochastic systems, deterministic systems, birth-death model analysis, closed network model, bottleneck, interactive networks, 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 networking systems. The course consists of a final modeling and simulation project on a novel idea that leads to publication

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

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.

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

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.

STAT 210 – Applied Statistics and Data Analysis (3-0-3)

Prerequisites: Advanced and multivariate calculus. For students outside AMCS wishing to obtain an introduction to statistical method. No degree credits for AMCS or STAT majors.

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-way tables and data analysis using statistical software.

STAT 220 – Probability and Statistics (3-0-3)

Prerequisites: Advanced and multivariable calculus, linear algebra.

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: Probability; Random variables; Expectation; Inequalities; Convergence of random variables. Statistical inference: Models, statistical inference and learning; Estimating the CDF and statistical functionals; The bootstrap; Parametric inference; Hypothesis testing and p-values; Bayesian inference; Statistical decision theory. Statistical models and methods: Multivariate models; Inference about independence.

STAT 230 – 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.

STAT 310 – Environmental Statistics (3-0-3)

Prerequisites: STAT 220, 230, 240, 250.
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.

STAT 320 – Advanced Statistical Inference (3-0-3)

Prerequisite: STAT 220, 230, 240, 250.
The course aims to provide a solid presentation of the main approaches to statistical inference, in particular of those formulations based on the so-called likelihood function, and of the most important statistical methods in current use for data modeling and for the interpretation of the uncertainty inherent in the conclusions from statistical analyses. The course is intended for students in science, engineering and statistics. At the end of the course, the student should be able to select and apply the main statistical procedures to a wide range of practical problems.

STAT 330 – Multivariate Statistics (3-0-3)

Prerequisite: STAT 220, 230, 240, 250.
An introduction to multivariate statistical models, well balancing three 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.

STAT 370 – Spatial Statistics (3-0-3)

Prerequisite: STAT 220, 230, 240, 250. Recommended: STAT 320.
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 and Marked point processes.

STAT 380 – Statistics of Extremes (3-0-3)

Prerequisites: STAT 220, 230, 240, 250. Recommended: STAT 320, 370.
This advanced statistics course aims at providing a rather deep understanding of Extreme-Value Theory results, models, and methods, as well as some experience in the practical application of these tools to real data using the statistical software R. Theoretical and practical aspects will be covered. 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.

6. University Wide Courses

University wide courses are courses in areas not tied to any specific degree program. They are designed to meet institutional requirements, provide broadening experience or to provide supplemental preparation to support students in their degree.

These are listed below:

6.1 English as a Second Language

These courses are designed to provide English language training for students who do not fully meet the University's English language entrance requirements. Students will be assigned courses based on their level of English or proficiency.

ESL 101 English as a Second Language I (6-0-0)

ESL 101 is a foundational English skills course for reading, listening, speaking and writing.
The course has a strong focus on teaching students the basics of academic writing and grammar structures in preparation for thesis work. Course materials are typically A2 level to help students acquire basic academic English skills required for graduate coursework.

ESL 102 English as a Second Language II (3-0-0)

ESL 102 is a pre- English skills course for reading, listening, speaking and writing. The course continues to focus on building academic writing and grammar skills and also have more emphasis on reading for academic purposes. Course materials are typically B1 level to help students further develop pre-intermediate English skills required for graduate coursework.

ESL 103 English as a Second Language III (3-0-0)

ESL 103 is an upper-intermediate English skills course for reading, listening, speaking and writing. The course helps to further develop academic English skills necessary to successfully complete research and thesis work. Course materials are typically B2 level to help students refine upper-intermediate English skills required for graduate coursework.

6.2 Enrichment Program – WEP Courses

The Winter Enrichment Program (WEP) takes place in January each year and is designed to broaden students' horizon.WEP is an essential and core requirement of the degree programs at KAUST. Satisfactory completion of at least one WEP is required of all M.S. students as part of the 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 WEP. To satisfy this mandatory requirement, full participation must occur within a single WEP period.

6.3 Innovation and Economic Development

Innovation and Economic Development (IED) courses are meant as a broadening experience and are not technical electives. Students should consult with their program to ensure credits can be applied toward their degree.

6.3.1 IED 210 – Technology Innovation and Entrepreneurship (3-0-3)

This course introduces students to using an entrepreneurial and design thinking view to solving real-world challenges including the pathway to commercializing research. It is about changing methods of thinking and equipping graduate students to be able to understand and manage innovation in the corporate world. This course is open to all M.S. students as an elective and to Ph.D. students with permission of their academic advisors.

6.3.2 IED 220 – New Venture and Product Innovation Challenge (6-0-6)

This intensive 8 week module will give a small select group of students, the opportunity and time to develop a detailed value proposition for a product based on an existing piece of intellectual property. This technology may be from the KAUST IP portfolio or potentially from a corporate partner. As part of the program, students will be provided with an overview of key creative subjects related to new product development including; key aspects of intra/entrepreneurship, innovation management including new product development, Go-to-Market strategies as part of commercialization roadmaps, as well as general knowledge on relevant creativity and design thinking. It will also enable students to develop these skills in a full time, heavily mentor-led and experiential learning environment that includes regular pitches and feedback from a wide range of pre-selected mentors from both inside and outside KAUST including international experts.

7. 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			

7.1 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 Failing (F) 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 Incomplete grade while in a degree program at KAUST.

7.2 In-Progress Grades

Thesis Research (297) or Dissertation Research (397) should be graded as In-Progress (IP) or Unsatisfactory (U) 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.

7.3 Research and Seminar Courses

297 =	Thesis Research	-Either 'IP' or 'U'
397 =	Dissertation Research	-Either 'IP' or 'U'
295/395 =	Summer Internship	-Either 'S' or 'U'
298/398 =	Seminar	-Either 'S' or 'U'
299/399 =	Directed Research	-Either 'S' or 'U'

8. 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:

- Good Standing
- Academic Notice
- Academic Probation
- Academic Dismissal

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.

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 category
6-8 Credits	GPA Standing less two categories
9+ Credits	Academic Dismissal

Semester Assessment (Registered in 12 Credits)

Credits Earned	Academic Standing
12+ Credits	GPA Standing
9-11 Credits	GPA Standing less one category
6-8 Credits	GPA Standing less two categories
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 category
3-5 Credits	GPA Standing less two categories
0-2 Credits	Academic Dismissal

Summer Session Assessment

Credits Earned	Academic Standing
6 Credits	GPA Standing
3-5 Credits	GPA Standing less one category
0-2 Credits	GPA Standing less two categories

Definitions:

Good Standing

Student is making satisfactory academic progress towards the degree.

Academic Notice
Student is not making satisfactory progress towards the degree. A student placed on Academic Notice will be monitored in subsequent semesters to ensure satisfactory progress towards 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 towards the degree. A student placed on Academic Probation will be monitored in subsequent semesters to ensure satisfactory progress towards 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 towards 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 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 Unsatisfactory (U) Grades, a Faculty Member giving a 'U' Grade for a course involving six or more credits must obtain concurrency 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 six 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 3.0. A student not in Good Standing due to 'U' Grades may return to Good Standing by completing at least twelve credits during the subsequent semester with no 'U' grades and a semester GPA of at least 3.0 in traditionally graded courses.

9. Transferring Credits
A student may petition to transfer graduate credits from KAUST or another University upon approval of the Program Director and the Registrar.

Each student's application will be reviewed on a case-by-case basis.

The following rules apply:

- Students entering the program with an M.S. Degree from KAUST may transfer unused coursework toward the Ph.D. program requirements subject to program level approval.
- Up to three graduate-level courses not to exceed nine credits may be transferred for credit. Courses already used for another degree cannot be used as transferred credits.
- 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 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 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 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 towards meeting the major track requirement if their equivalence is confirmed by the Program Director.

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 enrolment of such students at KAUST is two years.

10. 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 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 Withdraw (W). 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 Director and the Registrar.

11. 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.