For all Pillars

01.800 Research Attachment/Internship
4 to 72 credits
This subject is intended to allow the PhD students to gain valuable industrial or research experience at relevant off campus industrial or research institutions.

01.900 PhD Big D Project I and 01.901 PhD Big D Project II
24 credits
PhD Big D project is a student-driven group based project course that covers multidisciplinary research, design, innovation and entrepreneurship. It is a 2-semesters pass/fail course with 24 credits that can be used to substitute some course works component subjected to pillar's specification. There are no formal contact hours, except for compulsory workshops, progress sharing sessions, and term-end presentations. Each group is composed of 2 to 4 PhD students and the group members are expected to spend about 12 hours per week. The assessment will be judged by both internal and external panels.

01.911 Teaching and Learning in the University Classroom
0 credits
The purpose of this course is to provide new PhD students opportunities to learn about the way university students learn and approaches to teaching and learning in the university in order for them to be able to be more effective at assisting or teaching in the university teaching and learning environment.

Architecture and Sustainable Design Courses

20.502 Design Computation in Architecture
12 credits
This course includes Advanced Topics in Design Optimization and Design Information Modeling.

20.503 Advanced Topics in Performative Design: Daylight and Electric Lighting
12 credits
This seminar course teaches natural and electric lighting in an architectural context. Students will learn the scientific basis of light and visual perception in order to apply them to the design of two course projects: the design and construction of an electric light fixture (luminaire) and the comprehensive lighting design of a large communal gathering space with integrated electric and daylight systems. Individual activities and lectures focus on calibrated high dynamic range photography, daylight simulations, material properties, visual comfort / perception, electric lighting design, lighting energy consumption, solar heat gains, scale model building and human behaviour.

20.504 Material Computation: Advanced Topics in Geometry and Matter
12 credits
Computation enables architects to integrate and design with multifaceted information including that of engineering and manufacturing nature. The course, Material Computation: Advanced topics in Geometry and Matter, introduces concepts and approaches towards synthetic design computation.

We conceptualise architecture as material distribution in space and explore computational analysis and form finding methods which enable a high-level of control over material/structural behaviour. Simultaneously, we look into existing and future multi-material fabrication methods to realize "effective" material distribution that balances the notion of qualitative and quantitative parameters in design.

20.505 Urban Housing Typologies
12 credits
The 'Urban Housing Typology' seminar will discuss the complex nature of urban contexts as places to formulate human habitation. Investigating the interdependencies evolving between a building's entity and its urban territory students will speculate how strategies for urban building types have contributed in the past and can contribute in the future to urban development.

20.590 PhD Pro-Seminar
12 credits
This course introduces Research Design Methods and provides a Forum for Dialogue.

20.620 PhD Independent Study in Building Technology
12 credits
In this course study, students will learn the scientific basis of natura/light and the methodology to characterize the quality of light through different varieties of tropical trees.

The activities in the course will include using high dynamic range photography with fish eye lens to estimate the leaf area index of trees and measuring illuminance, luminance and temperature under canopies of selected species of trees. In line with the activities a pilot study will be undertaken to test the resulting methodology developed for the characterisation.

20.621 PhD Independent Study in Design
12 credits
The subject concerns theories of the design process from the perspectives of architecture and engineering design. The subject will pay special attention to the question of how, where, and when in the design process it is appropriate and fruitful to apply quantitative problem solving methods (such as computational tools or mathematical optimization).

20.650 Research Project I
12 credits
This is a cross-disciplinary research project that spans two-terms. Students either have to work with a faculty from another pillar and their own ASD supervisor, or to work with another PhD student from another pillar with their ASD supervisor on a research project. The project subject must be mutually agreed by the ASD and/or faculty from another pillar and approved by the ASD PhD Committee.

20.651 Research Project II
12 credits

This is a cross-disciplinary research project that spans two-terms. Students either have to work with a faculty from another pillar and their own ASD supervisor, or to work with another PhD student from another pillar with their ASD supervisor on a research project. The project subject must be mutually agreed by the ASD and/or faculty from another pillar and approved by the ASD PhD Committee.

20.802 Methods in the Study of Architecture
12 credits
-

20.803 Advanced Topics in Digital Design and Fabrication
12 credits
-

20.804 Advanced Topics in Performative Design: Urban Sustainability
12 credits
-

20.805 Conservation Theories and Approaches of Built Heritage
12 credits
This seminar elective course teaches conservation theories and approaches in an architectural context. This course is to acquaint participants with an overview of the discipline of architectural conservation, its origins, developments, as well as inherent contradictions. The course will cover the range of scales of conservation, the smallest denominator being artifact conservation to urban conservation. Case-studies in Singapore and the region will be introduced.

20.806 Integrated Building Design
12 credits
The course is intended to give students enrolled a working understanding of integrated design in principle and practice. To enable students to lead and develop a performance vision for a building's design, as architects and coordinators as well as collaborate effectively in important design team meetings with consultants.

20.807 Toward Carbon-Neutral Architecture and Urban Design
12 credits
This seminar elective course teaches conservation theories and approaches in an architectural context. This course is to acquaint participants with an overview of the discipline of architectural conservation, its origins, developments, as well as inherent contradictions. The course will cover the range of scales of conservation, the smallest denominator being artifact conservation to urban conservation. Case-studies in Singapore and the region will be introduced.

20.808 Scientific Approaches to Green Design in Urban and Natural Environment
12 credits
This subject is to acquaint participants with an overview of sustainability, its origins, developments, as well as various contemporary green and liveability issues. The students will have the opportunity to explore the multi-dimensional issues of urban and natural environmental sustainability through scientific lenses and at diverse temporal and spatial scales.

20.900 PhD Research Pre-Candidacy
1-48 credits
PhD research work by doctoral students before passing the Qualifying examination

20.910 PhD Research Post-Candidacy
1-48 credits
PhD research work by doctoral students after passing the Qualifying examination

Engineering Product Development Courses

30.500 Applied Mathematics for Engineering

12 credits

The applied mathematics module will cover several mathematical topics that are useful for research and analysis across different engineering discipline. Topics may vary with the instructor but often with a focus of methods in solving mathematical problems in engineering instead of rigorous mathematical proof.

30.501 Modeling Multi-Energy Systems

12 credits

This course will introduce modern techniques for modeling multi-domain energy systems, selecting several key methods for deeper exploration. Bond-graph models, optimization using dynamic programming, and statistical parameter estimation techniques will be covered in detail. The emphasis of this course will be on sensing to obtain accurate signals, inferring using appropriately designed and validated models, and acting with stable and optimal control. Throughout this course, concepts will be presented an analyzed from the critical point viewpoint epitomized by George E. P. Box's insight that: "Essentially, all models are wrong, but some are useful." A project will be a component of the course.

Students are required to have solid undergraduate foundations in advanced calculus and linear algebra.

30.502 Research Methods

12 credits

The provision of essential tools for the analysis of empirical data is the focal of this course where you will learn to use statistics to design experiments, analyse errors and uncertainties, use probability distributions to describe uncertainties in data, and evaluate the statistical significance of experimental results. The course will also teach methods to smooth, fit, and filter data. In the final part of the course, the honest presentation of data, and ethics in research will be discussed.

30.504 Computational Science & Engineering

12 credits

Computation and simulation now pervades most fields of science and are essential to the design and development of most engineering applications. This course is aimed at covering a wide range of topics—both theoretical and practical—related to numerical methods and programming. However, this course is not aimed at covering an exhaustive compendium of numerical methods, or teaching one or more programming languages. Instead, it will be focused on learning enough to feel comfortable starting to use them in your everyday research work.

30.505 Design Science
12 credits
This class will introduce students to design science. Many design principles and methods are reviewed, applied and analyzed. Students will learn to make connections between design science and other fields in e.g. engineering and how principles in design science can be used to advance these fields. The class will cover a broad set of design methods such as customer needs analysis, methods in creativity, functional modeling, design for X, design for testing & verification.

30.506 Data Structure and Algorithms
12 credits
This course introduces data structure and algorithms for engineering research. Students will learn to design and select suitable data structure that is most efficient to represent a problem and to implement and understand effecient algorithms that solve engineering problems effectively. The students will understand the operation, implementation and performance of fundamental algorithms and data structures, and the relative merits and suitability of each for various applications. In addition, the students will develop the ability to model and implement efficient solutions for various engineering problems using appropriately selected algorithms and data structures, and analyze the complexity and compare among various techniques, in order to make the most appropriate design choices when solving real-world problems.

30.507 Materials & Bio-materials Science
12 credits
The course begins with a review on classical materials and then focus on modern functional materials and their properties: materials for energy and advanced displays, nanoscale materials (1D, 2D) and materials for biomedicines.

30.508 Optimization and Control
12 credits
This course will introduce students to mathematical optimization and its application to engineering problems. The course will cover static and dynamics optimization under algebraic, differential and integral constraints. The topics include: non-linear programing, calculus of variations, Pontryagin's Maximum Principle, Bellman's Dynamic Programming as well as number of numerical methods for solving non-linear optimization and optimal control problems. During this course, students will learn to formalize and solve optimization problems in practical scenarios.

30.509 Applied Thermodynamics
12 credits
No single event in the universe is proven violating thermodynamic laws; therefore, this course aims to connect principles, concepts and thermodynamic laws to solutions of engineering problems. It covers classical and statistical thermodynamics, principles and concepts of multicomponent and multi-phase equilibria, diffusion and nucleation. Furthermore, hands-on and practical design studies are demonstrated for nanotechnology, thermal and energy applications.

30.510 Quantum Computation and Quantum Information
12 credits
This subject will introduce students to the emerging field of quantum information processing, The course will introduce the basic theory underlying quantum computation and quantum cryptography and their implementation. The course will cover quantum models of information and computation, quantum algorithms, quantum information theory and the physics of systems capable of supporting quantum information processing. The course will begin with a self-contained introduction to quantum mechanics and so no prior knowledge of quantum mechanics is assumed.

30.511 Design Management
12 credits
This course is aimed at PhD students interested in the relationship between design theory and theories of business management (such as theories of the firm), and in particular, addresses how and why design methods could be applied to innovating business models (i.e., how firms are organized to provide value). We will cover some of the design-relevant management theory base, along with selected theories from the design traditions, with the idea that this provides students with the means to think about firms and other organizations as "design problems", and possible design frameworks and solutions for those problems.

30.512 Advanced Topics in Biomedical Engineering
12 credits
This course is intended to provide PhD students broad yet detailed understanding on emerging topics in Biomedical Engineering and Sciences. Experts from the fields of human pathophysiology, cell & molecular biology, chemical biology, drug discovery, bio-imaging, tissue engineering and diagnostics development will share latest information from their fields of expertise and discuss the cutting-edge technologies used in the respective research fields.

30.513 Understanding the Interaction between Human Behaviour, Technology and Design
12 credits
Human beings have limited cognitive abilities and limited will power. Because of this, human behavior and decision are often marked by systematic departure from logical, rational 'norms'. This course examines how technology and design interacts with and change human behavior, and how human behavior with all its proclivities redefines the status quo of technology and design. The influence of the dynamics of human interactions in cyber social networks is an example of topics to be explored in this course. Techniques for prediction and forecasting from users' perspectives also will be included in the course.

30.580 Research Project I
6 credits
Students will learn and practice research design, defining, proposing, and forming a research topic. Through a short project, students will practice the attributes and characteristics of a good research project such as critical review, creativity thinking, inter and intra-disciplinary collaboration and effective communication on the research findings.

30.590 Research Seminar I
3 credits
The PhD research seminar series is intended to broaden the students' research perspectives by learning beyond individual research areas, and to effectively communicate scientific research to a wider audience. To this end, local and external speakers are invited to speak at this platform, while students get the opportunity to prepare and present conference-style talks on topics of their interest. Taken together, the course intends to foster a strong research culture at SUTD while inviting active participation to spark new research ideas.

30.591 Research Seminar II
3 credits
PhD research seminar series is intended to give PhD students the opportunity to prepare and present conference-style talks on the topics of their research. External speakers and faculty will also be invited to speak at this platform. These seminars are intended to foster a strong research culture at SUTD where the latest and greatest results are brought from the lab and communicated clearly to a broad audience.

30.600 Special Topics in Psychology
12 credits
Introduction to key psychological concepts and research methods; special topics may include language and bilingualism, developmental and cognitive psychology, human-machine interaction, etc.; hands-on experience in designing and conducting a research project that include literature search, research hypothesis formation, data collection, statistical analysis, report writing and project presentation.

30.621 Independent Study – Robotics
12 credits
-

30.622 Independent Study – Material Science
12 credits
-

30.801 Industry Design Project
12, 24, or 36 credits
Industrial Project is project-based module, which may have a research, development or design focus, is investigative in nature and provides an opportunity for students to go to local industries/research institutes and apply their knowledge gained in SUTD in real life. We will also focus on training them to prepare industrial proposals, create industrial collaborations and develop the leadership in managing their projects. Moreover, this course will also provide a regular opportunity for industrial interaction for our PhD students.

30.901 Graduate Project Seminar I
3 credits
Graduate Project Seminar I course is a mandatory module for all EPD PhD students. The main objective of this course is to enable graduate students to improve and optimize their research planning, organisation and presentation skills – oral and writing. As part of this module, students are required to attend seminars/ invited talks (both internal and external when possible) and also present individual research projects and plans.

30.900 PhD Research Pre-Candidacy
1-48 credits
PhD research work by doctoral students before passing the Qualifying examination

30.910 PhD Research Post-Candidacy
1-48 credits
PhD research work by doctoral students after passing the Qualifying examination

Engineering Systems and Design Courses

40.510 Linear Optimization
12 credits
This is a graduate level course on linear optimization. It covers the theory and computational aspects of optimizing a linear function over a polyhedron. Specifically, the topics include linear and integer programming formulations, duality theory, Simplex algorithm and its variants, sensitivity analysis, network flow problems and algorithms, theory of polyhedral convex sets, systems of linear equations and inequalities, theory of alternatives, and details of computational implementation of the algorithms. It also includes solution techniques specific to integer programming at an introductory level, ellipsoid method, and some advanced topics (such as interior-methods or complexity theory) selected by the instructors.

40.520 Stochastic Modeling
12 credits
This is an introductory graduate level class in (non-measure theoretic) stochastic processes. Topics to be covered include Poisson processes, Markov chains (discrete and continuous time), Renewal theory, Random walks, Gaussian processes. Applications to queueing systems, risk analysis, networks are also discussed.

40.521 Probability Theory
12 credits
This course will provide the fundamental concepts of measure-theoretic probability. Previous knowledge of elementary probability and real analysis is expected, but the general measure-theoretic tools will be developed in the course.

40.530 Statistics
12 credits
This course will provide the fundamental concepts of statistics. The topics covered include probability review, fundamentals of statistics, unbiased estimation, parametric estimation, non-parametric estimation, as well as hypothesis testing and confidence intervals.

40.540 Operations Management
12 credits
This course will provide an introduction to the theory and practice of operations management. Topics covered include demand modeling and forecasting, production and inventory control, revenue management, supply chain coordination, facility location, and service system operation and design. The course will draw upon tools from optimization theory, dynamic programming, queuing theory, game theory, and statistics. The course will expose students to analytical, empirical and behavioral research methods in operations management. Special emphasis will be given to the link between operational issues and strategic objectives regarding cost, responsiveness, flexibility, product variety, and customer differentiation, among others.

40.550 Microeconomics
12 credits
This course provides an introduction to microeconomic theory. The course will cover models of individual decision making, preferences, utility, revealed preference, choice under uncertainty, classical demand theory, Producer theory under perfect competition, monopoly, oligopoly and basic welfare analysis.

40.570 Linear Control Systems
12 credits
This course is a first graduate course in dynamical systems and control theory, considering systems of the form $x'(t) = Ax + Bu$. Topics include Linear dynamics, stability, phase plane analysis, transition matrix, matrix exponential, and variation of constants formula, adjoint equation, controllability and observability of linear systems, minimal realizations, optimal control through least squares theory, estimation & filtering, including Kalman Filter.

40.590 Research Seminar
0 credits
Prominent invited speakers will present talks covering different research areas of the ESD pillar. This will expose the students to the frontier of research and will indicate possible directions for their own investigation. Furthermore, the seminar series will provide the students with the possibility of establishing long term connections with researchers and research centres. Though compulsory, the seminar series provides no credits.

40.650 Game Theory
12 credits
This is a graduate level course in Game Theory which aims at providing the fundamental concepts of non-cooperative game theory, and at showing a broad spectrum of applications in different fields. The topics to be covered in this course include strategic-form games, extensive form-games, mixed strategies, behaviour strategies, equilibrium refinements, correlated equilibria, games with incomplete information, auctions, repeated games, bargaining, evolutionary game theory and learning.

40.752 Economics of Communication Networks
12 credits
This course aims at providing the basic microeconomic models for communication networks, investigate the role of prices as a control mechanism in the sharing of resources, analyse various pricing and competition issues. Topics covered include key microeconomic concepts, externalities, pricing theory, economic models of queues, cost sharing, economics of transport protocols and wireless, bandwidth auctions, interconnection models, network neutrality.

40.900 PhD Research Pre-Candidacy
1-48 credits
PhD research work by doctoral students before passing the Qualifying examination

Updated on Dec 2015

40.910 PhD Research Post-Candidacy
1-48 credits
PhD research work by doctoral students after passing the Qualifying examination

40.911 Research Project I
0 credits
Directed research project

40.912 Research Project II
0 credits
Directed research project

41.500 Real Analysis
12 credits
This course will provide the fundamental concepts of real analysis. The topics covered include metric spaces, normed spaces, Riemann-Stieltjes integral, as well as Lebesgue measure and integral.

41.520 Discrete Mathematics
12 credits
This course will bring the students up to speed with some of the classical topics in discrete mathematics. These topics include logic and proofs, algorithms, formal languages and grammar, elementary number theory, graph theory, and enumerative combinatorics. The course will also introduce a number of newer developments in computer algebra (including creative telescoping and integer relations). Only basic knowledge of standard first year mathematics and elementary probability will be assumed.

Information Systems Technology and Design Courses

50.500 Analysis of Algorithms
12 credits
This course will cover the techniques for algorithm analysis, with examples from various sorting and search algorithms, dynamic programming, greedy algorithms, amortized analysis, B-trees, Fibonacci Heaps, and graph algorithms.

50.510 Computer Networks
12 credits
Students will learn the principles and practice of computer (inter)-networking, including network applications, transport protocols, network protocols, data link protocols, wireless networks, mobile networks, network security, and selected advanced topics.

50.511 Wireless Communications and Networking
12 credits
This is a graduate-level introduction to the fundamentals of wireless communications and networking. The focus is on design, analysis, and fundamental limits of wireless transmission systems, wireless networks, and development of foundations for research in this field.

50.530 Software Engineering
12 credits
This course will provide students with an introduction to a range of fundamental problems in building reliable or correct software, including but not limited to requirement engineering, software design, software validation and testing. In particular, students will learn to develop concurrent Java applications with thread safety. Students will learn cutting edge research results on tackling these problems and apply the results to real-world software systems.

50.570 Machine Learning
12 credits
This graduate level machine learning course develops a foundation for research on intelligent data processing. The topics that we plan to cover in this course include the following: classification, regression, clustering, matrix factorizations, generative and discriminative models, model selection and generalization issues, structured prediction problems, graphical models, reinforcement learning, scalability issues, and various applications.

50.571 Digital Signal Processing
12 credits
Provide an understanding of the fundamentals of digital signal processing suitable for a range of signal processing applications. Topics include discrete-time signal representation and analysis, Fourier transform, z-transform, comparing discrete-time and continuous-time signals and systems, and digital filter design.

50.572 Graphics & Visualization
12 credits
This course provides an introduction to computer graphics algorithms, software and hardware. Topics include ray tracing, the graphics pipeline, transformations, texture mapping, shadows, sampling, global illumination, splines, constructive solid geometry, procedural modeling, animation basics, skinning, particle systems and colour. Advanced topics and latest research works will be covered.

50.573 Database Systems
12 credits
This course is designed to introduce graduate students to the foundations of database systems. The goal is to cover a broad range of basic topics in database systems to ground the students in the field and to prepare them for research in databases. The course is based on lively discussion of important papers from the literature, covering basic topics such as query processing, optimization, concurrency control, recovery, transaction management, and advanced topics such as distributed database systems, column store, Map Reduce, NoSQL and in-memory systems.

50.574 Theory and Application of Software Security
12 credits
This course will provide a graduate-level introduction to software security, both from a theoretical and a practical perspective. Topics to be covered include an overview of the fundamental formal security notions and models (such as information flow analysis and access control), the most common software vulnerabilities and their countermeasures and software-based cryptographic building blocks. Students will be able to further specialize in a cutting edge topic (such as side-channel analysis, software diversity for security and secure multi-party computation) and will develop a practical project based on a recent scientific publication on the subject.

50.580 Project
12 credits
Students taking this course are required to finish a one or two-term project advised by a faculty member in any pillar other than ISTD, possibly with a co-advisor from ISTD. The project is subject to approval by the ISTD graduate committee.

50.590 Research Seminar
3 credits
The ISTD seminar series will offer a platform for the presentation and discussion of research results by graduate students, post-doctoral fellows, members of faculty and guest speakers. One or two speakers will be featured in each session. Speakers' presentations will be followed by a question and answer session and general discussion.

50.900 PhD Research Pre-candidacy
1-48 credits
PhD research work by doctoral students before passing the Qualifying examination

Updated on Dec 2015

50.910 PhD Research Post-Candidacy
1-48 credits
PhD research work by doctoral students after passing the Qualifying examination