Design science studies the creation of artifacts and their embedding in our physical, psychological, economic, and social environment. Traditional science studies the world as we found it; design science studies the world as we make it. In an increasingly designed world, good design is the means to improving this world through innovative, sustainable products and services, creating value, and reducing or eliminating the negative unintended consequences of technology deployment.

The Design Science PhD Program at the University of Michigan offers the opportunity to study the discovery of principles and methods for the systematic pursuit of design knowledge. As in all sciences, such discovery involves the recognition and formulation of design problems, the formulation and testing of hypotheses, and the collection of data through observation and experiment. The Program adopts a strong interdisciplinary context using theories and methods from diverse fields such as architecture, art, behavioral, social and cognitive sciences, business, computer science, engineering, life sciences, and product design.

The Program places an emphasis on quantitative and analytical approaches and seeks contributions to knowledge in the participating disciplines as well as in their integration. Example research areas include integration of marketing, economics and engineering, sustainable and life-cycle design, aesthetics, design of highly customized products, designing for an aging population, design and policy, design innovation and the psychology of design.

**Program (01) = What is Design Science?**

**Designing in the Designed World**

Technology all too often impacts our daily lives in ways that were unanticipated by the creators of the technology. An example occurs in biotechnology where the development of new genetic tests for disease is now coupled with a growing concern for how individuals cope with this information, how they manage their risk for disease given test results, and what kinds of defensive actions individuals take. Less dramatic examples occur with common artifacts, from toasters to computer keyboards, to software and video games, to automobiles and their components, even to spaces, such as homes and shopping malls. How can the design of artifacts incorporate a perspective broader than the mere functionality the artifact attempted to address originally? How can concerns over unforeseen use or unintended consequences of technology be incorporated directly into the original design thinking? How can we design products that are not only need-focused but also use-focused, taking into account the way they may affect us or change us individually and collectively?

Engineering designers start with models of the inner workings of a product to guide the design process. For example, the design of a coffee maker involves analysis of power supply and water heating. The engineering design process is a search for the configuration that optimizes a particular objective or set of objectives under physical or resource constraints. The engineering designer may ponder how design decisions affect the ease and speed of making coffee and the price per cup, but may not ponder how the coffee machine will change the user’s life style: Is fresh coffee better (fewer chemical breakdowns)? Would a large capacity dispenser vs. a personal...
Design Science

Design science is an interdisciplinary study. Clearly many disciplines play a role in design. Engineering design models are often product-focused rather than use-focused. The term use-focused refers not merely to the particular interaction of the product with the user but also to the broader societal context in which the product will be used. Other disciplines approach design differently. Industrial design does focus on how the artifact will be used, and employs techniques to assess user needs, such as interviews, observations and focus groups. Marketing also focuses on the needs of the user, but often the focus by marketers is less on product development and more on sales. A limitation inherent in the knowledge these disciplines produce is that the information is usually qualitative and not easy to incorporate into the quantitative models used by engineers. Marketing does use quantitative models that are now gradually linked with the quantitative models used by engineers. Ergonomics and human factors provide yet another view of artifact-user interaction, physical or cognitive, often leading directly into questions addressed in the life sciences and psychology. If you ask further how designs will be produced and where, how they will reach their customers, what are the natural and capital resources expended, or what is the environmental life-cycle impact of the entire enterprise, you can see that the range of disciplines potentially bearing on design is large.

The new field of design science systematically couples these multiple traditions, knowledge domains, and viewpoints. Its foundation is the quest to use analytical, quantitative or qualitative models derived from diverse disciplines and link them in a rigorous decision-making framework. Creating and understanding appropriate models, methods for linking them, and validating the results in actual design situations requires a new research and education paradigm. The design science doctoral program at the University of Michigan offers a unique opportunity to pursue and build upon this new paradigm.

program (02) = areas of study

Design science studies go beyond the basic linking of existing disciplinary models, to the expected functional and utility consequences of design decisions, as well as to the unintended consequences on individuals, society, and the environment. By studying these consequences, you can contribute to the advancement of existing models and the production of new models more relevant to the process of designing artifacts. You can also study the process of design, using past experience to advance the management of design processes, as well as our knowledge of the process and structure of innovations.

Design science program studies can be organized into the following major research domains of inquiry: decision making processes and preference structures; decision management; structure of innovation and social models; economic, marketing, business, and policy models; ergonomic, human variability, and aesthetic models; information, complexity and systems optimization; design context of high technology . You can study these research domains of inquiry in specific contexts, for example, sustainable and life-cycle design, aesthetics, design of highly customized products, designing for an aging population, and design and government policies.

The research domains and application contexts reflect the interests of the program faculty and students and are likely to evolve over time.
**Decision Making Processes and Preference Structures**

Major advances have been made in the social sciences by using simple rational models as a benchmark against which to compare actual behavior by humans (e.g., the Nobel prize-winning prospect theory developed by Kahneman and Tversky that challenged expected utility as a descriptive model of decision making). These findings suggest that there may be systematic deviations from rational decision making. The design process provides a new arena against which to test basic principles about decision making, in a setting that is more realistic than the typical laboratory of the social scientist.

The optimization framework also has a set of qualitative tools that can facilitate the understanding of a decision problem. These qualitative tools can be used to develop new tests of models in the social sciences, which in turn can feed back into the design process (e.g., prospect theory can replace expected utility in an optimization model).

This use-focused approach also encourages a careful examination of the process a person follows when making a choice. What information do individuals consider when making a choice? What features are considered? Do individuals focus on the same attributes that are relevant to designers? How much choice should the individual have? Can too much choice paralyze decision making? Does the presentation of tailored artifacts, where a design model selects a subset of artifacts to present to the individual, lead to better decisions? Do such related practices (e.g., Amazon's practice of recommending books, Dell's practice of allowing a user to configure their own computer) lead to better decisions, and, if so, under what conditions?

**Decision Management**

Decision management is a term that describes the various things that managers do, wittingly and otherwise, that affect how and how well the people in their charge make their decisions. The product design process is rife with decision problems. Clearly, the ultimate success of a product or a design group rests heavily on the adequacy of the myriad design decisions made every day. Particularly in the case of complex products, the design process is a collective rather than an individual enterprise, such that supervision of the process must consider the collaborative as well as the individual activities of each group member. It is easy to cite countless instances where decision management practices have significantly shaped the fortunes of virtually every kind of organization. So what is the nature of decision management customs in design groups?

The specific research questions to be addressed can be conveniently framed within the context of a particular conceptualization of decision management and decision processes known as the 'cardinal issue perspective'. The so-called 'possibilities issue,' for example, considers the range of potential consequences of a particular design decision, rather than the more commonly studied questions of how likely it is that already-recognized consequences will actually occur. Any leader of a design organization would have to exercise decision management skills that somehow succeed in getting designers to decide routinely in ways that today are probably exceptionally rare.

Generalizing from decision making in other domains, we can speculate about the character of decision making and decision management in design groups. But how valid are these generalizations? Early research will rely on observational methods pioneered in anthropology, which have been used with some success in other fields, e.g., marketing and medicine. For instance, research team members will become participant observers in design groups. They would use standard ethnographic methods but also ones that are informed by the categories of decision scholarship more generally. Among other things, the resulting observations may yield a variety of specific propositions regarding the relationship between product success and how well the possibilities issue is addressed within different design groups.
The Structure of Innovation and Social Models

Examples of bad product design are easy to collect: We find them when we attempt to move about during our everyday lives. Product designers have a tremendous influence on how easily, and how well, individuals’ goals are met each day. However, most efforts to understand the cognitive processes in design focus on evaluation. Focus groups, prototypes, user testing, and design critique sessions are often successful in identifying problems with existing design. But beyond characterizing examples as 'good' and 'bad' for the human users, psychology has relatively little to say about how to create innovative designs.

Innovation, as opposed to invention, requires a structure that leads to good designs. Is there a way to describe and evaluate models of the design process? If yes, then such models will lead to specific preferred structures around which we can build analysis models and organize our tasks. Methods from cognitive ethnography can be used to study this question of structure. How do designers incorporate knowledge of the consumers’ needs, available technology and materials, and economic constraints, to design a truly 'human' product? Norman has characterized good design as 'user-centered,' where the human interacting with a designed artifact finds it very useful and easy to use, and readily adopts it in favor of existing alternatives. But while good product design seems to have consensual, even testable standards for evaluation, little is known about the cognitive processes leading to innovation in design.

Within psychology, work on innovation has focused on creativity and insightful problem solving. Studies of creativity have identified some aspects of successful processes. However, most psychological studies have focused on isolated problems designed to require no background knowledge, and have used undergraduate students rather than design experts as subjects. These studies fail to make use of settings where real innovation in design takes place.

An observational study of expert product designers known for their innovation, intuitive feel for the user, and product success can reveal the cognitive and social processes present in good design. Cognitive ethnography studies across products and teams can suggest processes that contribute to successful innovation.

Previous research on complex cognitive processes, such as pilot performance in the cockpit, has demonstrated that studying teams may facilitate uncovering the cognition involved because the team members frequently express their thinking through interactions with others. In addition, the physical environment allowed interaction with devices and displays, so that physical gestures and changes of location gave further clues about the influence of information sources in cognition. Thus it was possible to identify 'critical incidents' that characterize key moments in the process where outcomes are determined. Similar studies can lead to a deeper understanding of how to design for interactivity as well as the critical incidences in the creative design process.

Economic, Marketing, Business, and Policy Models

Marketing models have been developed over the last 50 years to analyze consumer choice and many other aspects of product design. Underlying these models is a presumption that the engineering process can be decoupled from measuring consumers’ needs and subsequently communicating product benefits to them. The prevailing overarching methodology, in fact, is one which gauges the success of a product or group of products based on three disjoint tasks: (1) measuring consumer reaction to products profiled in terms of their underlying ‘attributes’, (2) choosing promising target products so that designers and engineers can attempt to build them; and (3) taking the resulting candidates, those faring well by (1) and (2), and forecasting their market potential at a specific point in time. Little is known about the effects and artifacts of decoupling these procedures, and even less is known about how to fully integrate them or allow them to intercommunicate over time.

The most successful marketing methodology –used in the design of thousands of products and services– is conjoint analysis. Yet conjoint, and all other methodologies, treats products as groups of disembodied attributes, such as durability, speed, price, etc. How those attributes are chosen in the first place, how they interact, whether
they are the same for everyone, what levels (e.g., different price points) are relevant to consumers, how engineers and aestheticians figure into the process, all are considered peripheral in the determination of 'optimal' products. A chief research goal would be to restore the many interwoven strands of the design process to an equal footing in formal optimization methodologies.

Marketing theorists and practitioners focus great energy on the assessment of 'new' products. A typical 'new' product might take an existing product and add additional features to it, or combine features from products already available. Less typically, it might be something truly novel, offering features or user benefits unavailable in any form. Real-world products tend to skew towards the former, 'line extension' sort, simply because they are easier to assess, communicate and predict about. Truly novel products, particularly these for which design and 'emergent' uses play a large role, tend to wither in the long and grueling march to market introduction. Among the intended outcomes of design science research is how to avoid stifling true innovation simply because it is easier to put numbers to the mildly and predictably new, rather than the transformative. In particular, we must study how to allow key elements of design and aesthetics to enter marketers' vocabulary and decision processes.

Numerous practical design issues can be addressed. Marketers at present do a good job figuring out what to produce to fulfill consumers' wishes in two situations: When the product is 'high involvement', (a lot of thought goes into choosing it) or is relatively simple (it has few dimensions of importance to consumers). Roughly speaking, our methods work when we know a lot about what consumers are looking for, and when there isn't much they are looking for. The vast majority of products and services lie outside these demarcations: anything for which there is a large experiential component; where aesthetics matter (art, furnishings, appliances); where there are long-term, complex considerations (homes, major durables); where there is a great deal of future uncertainty and investment (educational programs); where important attributes differ greatly among users (autos); where the playing field is rapidly shifting (anything high-tech). In each of these situations, there is a non-trivial psychological, aesthetic or engineering-based component. As a result, the best methods used to measure, quantify and plan the product creation process are difficult to apply or unreliable. In such cases, marketers fall back on methods rife with potential for bias: asking people what they want, and letting managers wade through their verbal replies. It is in this comparatively uncharted realm of product realization that design science research break new ground.

A key idea pervading product design in marketing is heterogeneity, where consumers differ in what they seek from a particular product. In recent years, demography has introduced two powerful differentiation variables: life stage and globalization. The emergence of older consumers as an economic force is poised to redefine multiple industries over the coming decades. Among the challenges of designing and marketing products will be to account for the differing needs of large segments of consumers at various stages of their lives, particularly as they progressively require assistance. Product designers will also need to become increasingly conversant with cross-cultural designs: those that can compete in the global marketplace without sacrificing usability in any particular nation or culture. Merely extending or adapting existing designs, those fashioned for the 'typical' consumer – Western, young, educated, media-literate– will not adequately address the needs of such diverse groups.

**Ergonomic, Human Variability, and Aesthetic Models**

Current education in human factors and design has little in common. Design instruction consists of pointing students toward handbooks of prescriptive guidelines. In addition to a need for more and better models of human capabilities and requirements, there is an even greater need for research in methods for integrating knowledge of human requirements into the design process and for teaching students about these requirements.

An important source of variance in the performance and success of products designed for use by people is the people themselves. Design quality and value are often affected more by the variance in the human users than by the variance attributable to the product's hardware. Consequently, optimization of products used by people will benefit from consideration of human variance through robust design methodologies.
Human factors are represented in the optimization problem by models of anthropometric variability, postural variability, objective performance criteria, and subjective responses. Anthropometric variability describes the user population with respect to body dimensions; postural variability (e.g., a seating position) is partly predictable from body dimensions, but considerable residual variance remains that must be taken into account in the design evaluation; objective performance criteria include safety-related measures, such as proximity to dangers or fields of view (e.g., 95% of drivers must be able to see a point on the ground two meters in front of the vehicle); subjective criteria include the cost of 'dis-accommodation,' the situation where when a person's preferred component location(s) or posture are not accommodated by the design, a concept tightly linked to marketing evaluations.

A domain of direct interest and application is the design of medical equipment. For example, design of implants and prostheses is often done without sufficient consideration for the procedure itself. The required design of the necessary instrumentation follows the design of the prostheses resulting in increased complexity, cost and potential for errors. A holistic approach, as envisioned here, can have dramatic impact on medical health care costs and the comfort of patients and doctors.

Human factors research on interface and visual displays has traditionally defined interface effectiveness with criteria such as legibility or difficulty of target search and information access. The consideration of aesthetics is often ignored in human factors analysis of interfaces and displays. Artists and designers, in contrast, have long treated aesthetics as a major aspect of their work; however, they rarely employ experimental methods to examine the validity of their hypothesis and they mainly describe aesthetic terms in qualitative or subjective languages that do not easily allow for quantitative evaluation. Previous research on computational modeling and experimental investigation of interface and display aesthetics has resulted in preliminary quantification of the effects of three compositional elements: balance, symmetry, and grouping. Similarly, aesthetic evaluation of a wide range of interfaces including automobile and webpage design has been documented. Much more research is needed to include more design variables (such as color, shape, curvature, density, motion) and to integrate these models with other computational ones.

There is also a rich history of work in quantifiable aesthetics, such as golden section proportions and its generalizations, by classical and modern masters in the fields of architecture and industrial design. Further developing and linking aesthetic models with engineering functionality models, an effort popularized in Japan as Kansei Engineering, is an important area of design science research.

Information, Complexity, and Systems Optimization

From an engineering perspective, design of artifacts has been successfully modeled in a mathematical design optimization framework. Design optimization involves a mathematical statement of design objectives to be optimized (minimized or maximized) as functions of the design variables. Design restrictions are represented by equality or inequality constraint functions of the design variables that must be satisfied by an optimized design solution.

Design and product development in modern organizations can be modeled as distributed multilevel mathematical optimization frameworks. Complexity introduced through the interdisciplinary nature of design science can be addressed in this context, at least partially. The assembly of disciplinary models and methods for matching their requirements is an important research question. There is also an underlying need for an information technology infrastructure that can support the data collection and management necessary for building the models, as well as the communication among various decision-making models.

Frameworks for complex system optimization traditionally have been static, involving the definition of a system hierarchy, development of disciplinary/subsystem models, and mapping of their interactions. If the hierarchy changes the modeling process is repeated. However, modern design environment hierarchies are not static.
Rigorous strategies for system optimization that maintain integrity of information flow in an evolving hierarchy is a major research challenge.

There is considerable uncertainty in the mathematical design optimization models: computed responses of the physical system are based on imprecise environmental parameters, designs cannot be realized exactly, cash flows, product demand and human behavior can be forecasted only in a statistical sense. Therefore the adopted design strategies must be formulated to deal with such uncertainties.

The Design Context of High Technology

The thinking and methods of design science can be studied and implemented within the context of specific technologies or application domains. For example, design science methods can be applied to analyze the impact of new technology results in the areas of electric propulsion, energy, smart materials and structures, medical equipment, sustainable design, and designing for an aging population. Students can undertake studies in these domains based on their own interests and the interests of design science faculty.

program (04) = coursework

Coursework requirements include: (A) a core two-semester course sequence (6 credits) consisting of DESCI 501 and DESCI 502, and two semesters (1+2 credits) of DESCI 790 shown as Group A below; (B) five courses (15 credits) selected from existing disciplinary offerings shown as Group B below.

Group A: Core courses (9 credits):

The first course aims at establishing a common experience in ‘doing design.’ The second course aims at providing a common basis for ‘studying design.’ The colloquium will provide exposure to modern research topics and a forum for interactions and building a community.

**DESCI 501 Analytical Product Design (3)***

Design of artifacts is addressed from a multidisciplinary perspective that includes engineering, art, psychology, marketing, economics, and other disciplines. Using a decision-making framework, emphasis is placed on quantitative methods, building mathematical models, and accounting for interdisciplinary interactions. Students work in team design projects from concept generation to prototyping and design verification. Usually offered in the Fall Term

**DESCI 502 Design Process Models (3)***

Interaction and coordination of decisions based on multi-discipline design analyses is studied in the context of a newly developed artifact. Innovation and creativity are addressed as elements of the design process. Enterprise design decisions made on functionality and business criteria are analyzed within organizational, cultural and social models. Students propose and test novel analysis methods and design process models. Usually offered in the Winter Term.

**DeSci 790 Design Science Colloquium (1+2)***

Topics on Design Science are presented by doctoral candidates and by invited speakers across campus and from outside the University. The aim of the colloquium is to aid in identifying appropriate dissertation topics and build a community. Must be taken twice; first time enrollment is for 1 credit and the second for 2 credits, requiring individual research study and presentation. Usually offered in the Fall Term.
Group B: Required Electives (15 credits):

Students must select one course from each of three different disciplines as listed below (9 credits), and one additional course from two of these disciplines (6 credits). Students can petition the program advisor to substitute courses not in this list. The list is updated through periodic reviews.

Architecture and Urban Planning

ARCH 513 Social Change & Architecture
ARCH 516 Architectural Representations
ARCH 519 Theories of Urban Design
ARCH 552 Architectural Design V
ARCH 571 Digital Fabrication
ARCH 575 Building Ecology
UP 526 Sociocultural Issues in Planning and Architecture
UP 572 Transportation and Land Use Planning
UP 659 Gender and Development
UP 747 Technology and Planning

Art and Design

ARTDES 610 Directed Studio Practice

Business

MKT 501/503 Marketing Management
MKT 601 Strategic Market Planning
MKT 603 Strategic Brand Management
MKT 607 Distribution Systems
MKT 612 Retailer Behavior & Customer Management
MKT 613 Consumer Behavior
MKT 619/620 Marketing Research Design and Analysis
MKT 625 Innovation and New Product Management
MKT 630 Decision Models Marketing
OMS 551/552 Operations Management
OMS 605 Manufacturing & Supply Operations

Engineering

IOE 533 Human Factors in Engineering Systems I
IOE 536 Cognitive Ergonomics
IOE 552 Financial Engineering I
IOE 553 Financial Engineering II
IOE 565 Time Series Analysis
IOE 623 Computational Finance
ME 508 Product Liability
ME 509 Patents, Trademarks, Copyrights
ME555 Design Optimization
ME558 Discrete Design Optimization
ME559 Smart Materials and Structures
ME577: Materials in Manufacturing and Design
ME581 Global Product Development
ME587 Reconfigurable Manufacturing for Market Responsiveness
ME589 Ecological Sustainability in Design and Manufacturing

Environmental Studies (multi-school)

CEE 586: Industrial Ecology
CEE 686: Case Studies in Environmental Sustainability
EIH 572: Environmental Impact Assessment
OMS 613: Sustainable Manufacturing
SPH 616: Global Health: Anthropological Perspectives
SPH 584: Hazardous Wastes: Regulation, Remediation, and Worker Protection
UP532: Sustainable Development: Resolving Economic & Environmental Conflicts
PolSci 761: Global Environmental Change and the State
AAS 596: History of Environmental Thought and Activism

Information Science

Information 621: Ethics, Values, and Information Dilemmas

Information 648/748: Infoculture: Theory and Methods in the History and Sociology of Information Technology

Behavioral and Social Sciences

Anthropology

AnthrCul 554: Media Anthropology

Economics

Econ 601/602: Microeconomic Theory I and II

Econ 631: Industrial Organizations and Public Policy

History

History 606: Technology, Knowledge, and Culture

Psychology

Psych 500 Cognitive Neuroscience of Higher Level Processes

Psych 613 Adv Statistics I

Psych 614 Adv Statistics II

Psych 644 Computational Modeling of Cognition

Psych 682 Advanced Social Psychology

Psych 687 Methods of Survey Sampling

Psych 711 Questionnaire design

Psych 721 Mathematical psychology

Psych 722 Decision Processes

Psych 746 Human Performance

Psych 785 Group Processes

Group C: Dissertation work (12-18 credits):

These are standard Rackham courses for research credit.
Sample Programs

The programs below are constructed as examples of how a particular student may structure his/her course curriculum. Students with the same disciplinary background will likely select different combinations of courses based on individual interest and preference.

Sample Program 1: Student with MS degree in Mechanical Engineering

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<tr>
<th>Year 1 Fall</th>
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<tbody>
<tr>
<td>DESCI 501 Analytical Product Design</td>
<td>DESCI 502 Design Process Models</td>
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<td>IOE 552 Financial Engineering I</td>
<td>Psych 614 Adv Statistics II</td>
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<td>Psych 613 Adv Statistics I</td>
<td>ME555 Design Optimization</td>
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<td>DESCI 790 Design Science Colloquium (1)</td>
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<tr>
<td>Psych 721 Mathematical psychology</td>
<td>MKT 630 Decision Models Marketing</td>
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<tr>
<td>MKT 501/503 Marketing Management</td>
<td>(extra credits if desired)</td>
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<td>DESCI 990 Pre-cand Diss. Research</td>
<td>DESCI 990 Pre-Cand Diss. Research</td>
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<td>DESCI 790 Design Science Colloquium (2)</td>
<td>Prelim Examination</td>
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Sample Program 2: Student with MA/Equivalent study in LSA/Psychology

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<td>DESCI 502 Design Process Models</td>
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<td>Psych 644 Comp. Modeling of Cognition</td>
<td>Psych 746 Human Performance</td>
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<tr>
<td>IOE 536 Cognitive Ergonomics</td>
<td>SPH 616: Global Health: Anthrop. Persp.</td>
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<td>DeSci 790 Design Science Colloquium (1)</td>
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<td>IOE 533 Human Factors in Engin. Systems</td>
<td>MKT 612 Retailer Behavior &amp; Customer Management (extra credits if desired )</td>
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<td>MKT 613 Consumer Behavior</td>
<td>DESC 995 Dissertation Research</td>
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people (01) = faculty

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Assistant Professor, School of Information
Information Technology, Creativity and Innovation, Knowledge Intensive Organizations

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Professor, Marketing, School of Business Administration
Choices Under Uncertainty, Mathematical Psychology, Bayesian Econometrics, Dynamic Programming

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Anthropological Demography, Social Change, Social Organization, Women's Status

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Environmental Economics, Market-based Environmental Regulation

Alec Gallimore (alec.gallimore at umich.edu)
Arthur F. Thurnau Professor; Professor, Aerospace Engineering; Associate Dean, Academic Programs and Initiatives, Horace H. Rackham School of Graduate Studies
Electric Propulsion, Plasma Diagnostics, Space Plasma Simulation, Electrode Physics

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Professor and Interim Chair, Electrical Engineering and Computer Science
Plasma Diagnostics, Spacecraft Technology

Richard Gonzalez (gonzo at umich.edu)
Professor and Department Chair, Psychology
Judgement and Decision Making, Product Design, Medical Decision Making, Applied Statistics

Sharon Herbert (sherbert at umich.edu)
Professor, Classical Archaeology and Greek; Director and Curator, Kelsey Museum of Archaeology
Greek Archaeology, Vase Painting, Hellenistic Near East

Richard Hughes (rehuges at umich.edu)
Associate Professor, Orthopaedic Surgery, Medical School; Associate Professor, Biomedical Engineering
Ergonomics, Rehabilitation Engineering and Ergonomics, Mathematical Modeling, Computer Simulation

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Professor, Mechanical Engineering
Kinematics and Synthesis of Mechanisms, Product Design and Manufacturing Automation, MEMS, Adaptive Structures
Yili Liu (yililiu at umich.edu)
Arthur F. Thurnau Professor; Associate Professor, Industrial and Operations Engineering
Cognitive Modeling, Cognitive Ergonomics, Cognitive Psychology, Engineering Aesthetics, Human Factors, Human-Computer Interaction

John Marshall (johnjm at umich.edu)
Assistant Professor, School of Art and Design
Hybrid forms of Art and Design Practice

Malcolm McCullough (mmmc at umich.edu)
Associate Professor, Taubman College of Architecture
Digital Design, Interaction Design

Jason Owen-Smith (idos at umich.edu)
Assistant Professor, Sociology and Organizational Studies
Institutional and Organizational Change, Innovation, Complex Social and Economic Networks, Commercialization of Academic Research

Panos Papalambros (pyp at umich.edu)
Donald C. Graham Professor of Engineering; Professor, Mechanical Engineering; Professor, School of Art and Design; Professor, Taubman College
Optimal Design, New Product Development

Matthew Reed (mreed at umich.edu)
Associate Research Scientist, Industrial and Operations Engineering, Transportation Research Institute
Impact Biomechanics, Physical Ergonomics and Engineering Anthropometry, Cognitive Ergonomics

Kazuhiro Saitou (kazu at umich.edu)
Associate Professor, Mechanical Engineering
Models and Synthesis of Product and Systems, Design for Manufacture, Assembly, Environment and Supply Chains

Allen Samuels (allenall at umich.edu)
Professor, School of Art and Design
Design Beyond Current Technologies, Design for an Aging Population, Emergency Shelter Design

Colleen Seifert (seifert at umich.edu)
Professor, Psychology; Professor, School of Information
Cognitive Science, Cognitive Modeling, Intelligence, Knowledge Representation, Memory Retrieval, Problem Solving

Steven Skerlos (skerlos at umich.edu)
Associate Professor, Mechanical Engineering
Environmental and Sustainable Technology Systems, Life Cycle Product Design Optimization, Pollution Prevention Technologies
The graduate student community in design science includes students majoring in design science and students from other disciplines who have been involved with the program. Prospective students may contact the graduate students below for further information on their experience with the program.

**Sookyung Cho (sookie at umich.edu)**

Ph.D. Pre-candidate (Design Science)
Value Transition into Marketing
**Disciplines:** Psychology and Marketing
**Co-advisors:** Richard Gonzalez and Carolyn Yoon

**Rafael Ramos (arramos at umich.edu)**

Ph.D. Pre-candidate (Design Science)
Space Systems Designs
**Disciplines:** Systems Design and Information
**Co-advisors:** Brian Gilchrist and Ixchel Faniel

**Tahira Reid (tnreid at umich.edu)**

Ph.D. Candidate (Design Science)
Interdisciplinary Product Design and Decision Making
**Disciplines:** Mechanical Engineering and Psychology
**Co-advisors:** Panos Papalambros and Richard Gonzalez

**Mobeen Shaukat (mshaukat at umich.edu)**

Ph.D. Pre-candidate (Design Science)
Co-creation of Products and Services
**Disciplines:** Mechanical Engineering, Marketing and Industrial Design
**Co-advisors:** Kazuhiro Saitou and John Marshall
<table>
<thead>
<tr>
<th>People</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esra Suel</td>
<td>esrasuel at umich.edu</td>
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<tr>
<td>Katie Whitefoot</td>
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<tr>
<td>Seda Yilmaz</td>
<td>seda at umich.edu</td>
</tr>
</tbody>
</table>

**People (03) = Partners**

- **Aalborg University, Aalborg, Denmark**: Niels Olhoff (no at ime.aau.dk), John Rasmussen (jr at ime.aau.dk)
- **Bradley University, Peoria, Illinois**: Julie Reyer (jreyer at bradley.edu)
- **Carnegie-Mellon University, Pittsburgh, Pennsylvania**: Jonathan Cagan (cagan at cmu.edu), Jeremy Michalek (jmichalek at cmu.edu)
- **Chalmers University of Technology, Gothenburg, Sweden**: Hans Johannesson (hans.johannesson at me.chalmers.se), Johan Malmqvist (joma at chalmers.se), Rikard Soderberg (rikard.soderberg at me.chalmers.se)
- **Ecole Centrale du Nantes, Nantes, France**: Jean-François Petiot (Jean-François.Petiot at irccyn.ec-nantes.fr)
- **Iowa State University, Ames, Iowa**: Judy Vance (jmvance at iastate.edu)
- **Kyoto University, Kyoto, Japan**: Masataka Yoshimura (yoshimura at prec.kyoto-u.ac.jp), Shinji Nishiwaki (shinji at prec.kyoto-u.ac.jp)
- **Massachusetts Institute of Technology, Boston, Massachusetts**: Warren Seering (seering at mit.edu), Maria Yang (mcyang at mit.edu), Olivier de Weck (deweck at mit.edu)
- **Northwestern University, Evanston, Illinois**: Wei Chen (weichen at northwestern.edu)
- **Osaka University, Osaka, Japan**: Kikuo Fujita (fujita at mech.eng.osaka-u.ac.jp)
- **Parsons School of Design, New School University, New York City**
- **Penn State University, State College, Pennsylvania**: Tim Simpson (tws8 at psu.edu), Matt Parkinson (parkinson at psu.edu)
- **Stanford University, Stanford, California**: Larry Leifer (leifer at cdr.stanford.edu)
admission (01) = who should apply?

The design science program currently offers the degree of Doctor of Philosophy in Design Science. A master’s degree may be offered at a later time. Applicants must have earned at least a bachelor’s degree at the time of admission. A master’s degree in a relevant discipline or equivalent coursework must have been earned prior to advancement to doctoral candidacy. Examples of relevant disciplines are the physical, behavioral, life, and social sciences, engineering, business, art, product design, architecture. The bachelor’s and master’s degrees do not need to be in the same discipline. However, it is expected that students entering the program will have a good foundation in at least one of the disciplines contributing knowledge to design science.

The program is specifically designed to accommodate students with a diversity of backgrounds, who are interested in design research and practice at an advanced level. Each student will have a tailored program of study based on her/his background and interests. The number of admitted students each year is very small.

The program follows the tradition of rigorous scholarship at the University of Michigan. Program graduates may pursue careers in academia, industry or government. The program offers a new, non-traditional degree. As such, it carries a risk in how it may be received by future employers. Students are selected based on their academic achievement, their potential for innovation, and their ability to be self-directed and to manage risk.

The program has a strong analytical and quantitative orientation. Therefore students with strong analytical and mathematical skills (typical for students with backgrounds in the physical sciences and engineering) will be particularly suitable for pursuing studies in the program. Students will have the opportunity to further build such skills, as required.

Students planning to pursue a master’s degree at the U-M and then continue their studies in the design science program should apply for early admission to the program. This will allow them to consult with program advisors and to structure their master’s studies so that they are best prepared for their doctoral work.

Applicants from fields that do not grant masters degrees, or who do not wish to pursue a master’s degree, must consult the program director. Typically, such students will have to earn an additional 24 credits within an approved discipline before they can achieve doctoral candidacy.

admission (02) = application process

If you are interested to apply to this program you should proceed with the following steps.

1. Fill in the online form in the join us section of this site.

2. Complete the Rackham application form. Following standard Rackham guidelines, you need to submit: (i) the completed application form; (ii) statement of purpose, specifically addressing your suitability and interest
for the program; (iii) your resume; (iv) three recommendation letters; (v) your GRE scores (general portion).

Note the following:

- Your statement of purpose should include description of the Design Science research areas you are interested in and names of possible faculty that could serve as your advisors.
- Recommendation letters from proposed dissertation advisors should indicate their willingness to advise you.
- GRE test results completed within five (5) years of application to the program are required for admission consideration.

3. After Step 2 is completed and prior to final admission to the program you must also complete the following:

- Obtain confirmation by two faculty from two different disciplines that agree to serve as dissertation advisors. You should pursue this as early as possible. Contact faculty associated with the program and discuss with them common interests and potential research work. The program staff will assist in this process based on your application materials. Faculty not listed here as affiliated with the program may also serve as advisors upon consultation with the program.
- Conduct an interview with the Program Admissions Committee. The interview will assist in assessing how well you may fit in the program, potential for success, and suitability for financial aid.
- Finalize financial support details. You must have certified financial support for at least two years of study. Such financial support can come from research projects of potential faculty advisors, NSF or other scholarships, U-M fellowships and other financial aid, and personal funds. Students without clear, certified, financial support will not be admitted to the program.

Applications can be submitted at any time. However, applications should be submitted no later than January 31 (for fall admissions) and September 30 (for winter admissions) to allow timely consideration of eligibility for financial aid. Applications beyond these deadlines may still be considered, but admission decisions are made on a rolling basis so early application is encouraged. Only a small number of students are admitted each year.

FINANCIAL AID

The program has very limited funds for financial aid. The majority of financial aid must be secured by the applicant through contacting potential dissertation advisors or sources outside the program. For example, domestic students can apply for graduate NSF fellowships, which give maximum study flexibility.

getting involved (01) = contact us

Program Co-Chair:

Professor Panos Y. Papalambros

University of Michigan, 2250 G. G. Brown Building, Ann Arbor, MI 48109, USA
email: pyp at umich.edu
URL: http://www-personal.umich.edu/~pyp/
telephone: 734-647-8401
facsimile: 734-647-8403
Program Co-Chair:

Professor Richard Gonzalez
University of Michigan, 3008 East Hall, Ann Arbor, MI 48104, USA
email: gonzo at umich.edu
URL: http://www-personal.umich.edu/~gonzo/
telephone: 734-647-6785

Program Coordinator:

Gail E. Carr
University of Michigan, 2633 CSE Building, 2260 Hayward Street, Ann Arbor, MI 48109-2121, USA
email: info-designscience@umich.edu, gailcarr@umich.edu
telephone: 734-763-0480
facsimile: 734-763-2523

For general questions contact info-designscience@umich.edu

Frequently Asked Questions

Are self-initiated dual degrees available?

No. The Design Science Program is a Rackham Interdepartmental Degree Program (IDP) and according to Rackham Graduate School rules it cannot be combined with other disciplines for a self-initiated or dual self-initiated degree. If there is recurring student interest for a dual degree with a specific program, an agreement with the other program will be sought.

How do I apply to the program?

Fill out the online application from Rackham. Hard copies of the application are not available.

Who do I contact for help with the admissions application?

You should contact the Program Administrator at info-designscience@umich.edu.

When are the deadlines to submit applications?

Applications can be submitted at any time. However, applications should be submitted no later than January 31 (for fall admissions) and September 30 (for winter admissions) to allow timely consideration of eligibility for financial aid. Applications beyond these deadlines may still be considered, but admission decisions are made on a rolling basis so early application is encouraged.

Are GRE scores required for admittance?

Yes. The institutional code is 1839. The department code is 1889.

Are there minimum GPA and GRE requirements?

There are no minimum cut-off scores but admitted students are likely to have scores similar to other competitive programs in Rackham.
Are TOEFL scores required? Who should submit TOEFL scores?
Yes. Applicants should see Rackham for TOEFL requirements.

Can applicants who have previously applied to the program reapply?
Applicants can reapply if the program administrator or director advises them to do so.

Can part-time students enroll in the program?
The program is currently designed primarily for full-time students, at least until they have reached candidacy. Full-time status allows the students to take courses in the proper sequence and interact with their peer cohort. Students interested in part-time participation should contact the program administrator or director.

Can I get the application fee waived?
No.

Who should write recommendation letters for me?
Anyone familiar with your academic and other accomplishment relevant to studying in this program, for example, professors and job supervisors. If a U-M professor is willing to serve as dissertation co-chair, she or he should state that in their recommendation letter.

How can I check the status of my application?
By contacting the program administrator at info-designscience@umich.edu

When will I know if I’ve been accepted?
As you see from the admission process description, acceptance is a multi-step process that includes securing two advisors and proven financial support. You will be intimately involved in this process and will know at what stage you are. Typically we would like Fall admissions to be completed by May 1 and Winter admissions by October 1.

How can I obtain Financial Aid?
You must request that in your application form. You must also discuss financial support possibilities with your intended dissertation co-advisors. Financial aid usually will be a combination of fellowship support and graduate research assistantship associated with a research project.