THE STATE EDUCATION DEPARTMENT / THE UNIVERSITY OF THE STATE OF NEW YORK / ALBANY, NY 12234

Office of Higher Education
Office of College and University Evaluation

Doctoral Proposal Cover Page

A.	Name of institution:	Rochester Institute of Technology
	Specify campus where program will be offered, if other than the main campus: RIT Main Campus, Rochester NY	
B.	CEO or designee	
	Name and title:	Dr. William W. Destler, President
	Signature and date:	

THE SIGNATURE OF THE INSTITUTIONAL REPRESENTATIVE INDICATES THE INSTITUTION'S COMMITMENT TO SUPPORT THE PROPOSED PROGRAM.

C.	Contact person, if different	
	Name and title:	Dr. Christine M. Licata, Senior Associate Provost
	Telephone :	(585)475-2953
	Fax:	(585)475-4460
	E-mail:	cmlnbt@rit.edu
D.	Proposed doctoral program title	Ph. D. in Engineering
E.	Proposed degree or other award:	Doctor of Philosophy
F.	Proposed HEGIS code	0901.00
G.	Total program credits:	66
H.	Program Format: Full-time or Part-time:	Full Time
I.	If the program will be offered jointly with another institution, name and address of the institution/branch below: Not Applicable.	

IF THE OTHER INSTITUTION IS DEGREE-GRANTING, ATTACH A CONTRACT OR LETTER OF AGREEMENT SIGNED BY THAT INSTITUTION'S CEO. IF IT IS NON-DEGREE-GRANTING, REFER TO MEMORANDUM TO CHIEF EXECUTIVE OFFICERS NO. 94-04.CONTACT THIS OFFICE IF YOU WOULD LIKE TO RECEIVE A COPY.

2. Purpose, Goals, and Objectives

The KGCOE is poised to round-out its degree offerings with a terminal degree in Engineering.

The overarching goal of the PhD in Engineering program is to produce terminal degree engineering graduates who are subject matter experts in a knowledge domain within the engineering discipline, and who will compete successfully with those who have earned discipline-specific PhDs in engineering. Instead of restricting graduates to individual engineering silos (*e.g.,* mechanical, electrical, computer, industrial, chemical) the proposed program will provide students the flexibility to become subject matter experts and engineering innovators in an open-architecture environment, fostering intellectual growth along both interdisciplinary pathways and within the bounds of conventional engineering disciplines. With this approach, the program will develop world-class researchers who can capitalize on the most promising discoveries and innovations, regardless of their origin within the engineering field, to develop interdisciplinary[1] solutions for real-world challenges.

We propose a PhD in Engineering degree that will educate the next generation of engineering leaders in a manner that will allow them to tackle some of the most daunting and complex problems facing our society. In the past, dramatically complex problems such as *"landing a man on the moon and returning him safely to the earth"* (President J. F. Kennedy to a joint session of Congress, May 25, 1961) required the full resources of an entire nation to solve. Today, we face global challenges in Energy Transportation, Healthcare and Communications that demand highly trained engineers with deep disciplinary skills and a thorough contextual understanding for their research efforts.

Our approach is to produce nimble professionals who can innovatively solve problems of global significance whose solution are beyond the scope of a single discipline.

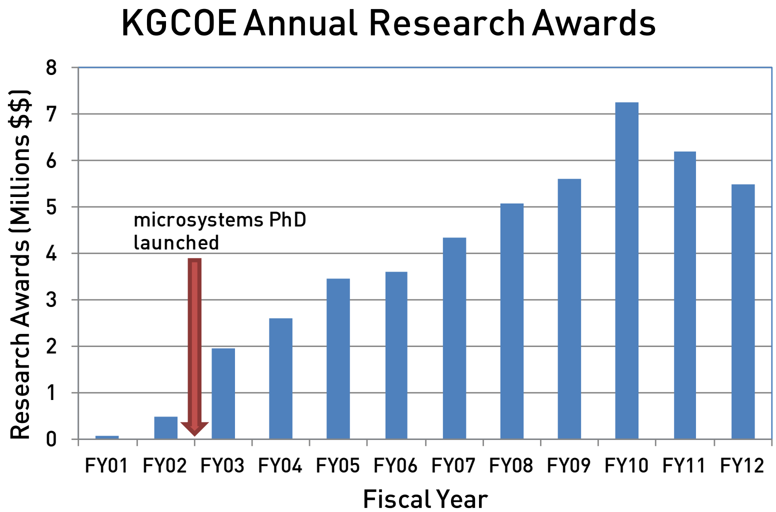
We have chosen to create a terminal degree in engineering whose participants will align with one of four application domains. These application domains provide contextual elements that are not only critical in national and global priorities but also by nature interdisciplinary, fostering collaboration among faculty and students in different engineering disciplines. The contextual elements of our proposed program will give our graduates a competitive advantage in both industry and academia, as well as opportunities for our faculty to join and develop interdisciplinary research centers.

As RIT evolves into a university that is more comprehensive in scope, with a significantly stronger emphasis on research as a complement to its teaching mission, the expectation of the faculty to build a strong and productive scholarship agenda will continue to grow in importance. The criteria for achieving tenure in the KGCOE includes the expectation that faculty members will publicly disseminate their scholarship through peer-reviewed publications and also demonstrate their ability to support their scholarly activity through a record of external funding, including elements such as graduate student assistantships, undergraduate research assistantships, travel, and other direct expenses associated with their scholarly work.

We aspire that our proposed PhD in Engineering will prove to be a role model for the way in which other programs at RIT structure terminal degree offerings in their disciplines. Unlike many PhD in Engineering programs elsewhere in the USA (which may offer traditional disciplinary programs beneath a single umbrella) our plan is to foster a new approach to doctoral education. Traditional disciplinary doctoral degrees in engineering (such as mechanical, electrical, industrial, chemical, civil, etc) provide tremendous value to society. The intent of the proposed RIT PhD in Engineering is to provide a strong foundation in traditional disciplinary studies complemented by a more thorough contextual understanding than is common in most engineering doctoral programs today.

The annual value of external research awards in the KGCOE have grown eight-fold in one decade.

The impact of this increased emphasis on scholarship is clearly visible in the growth of external funding both for RIT as a whole and for the Kate Gleason College. Indeed, in Fiscal Year 2000 the value of proposals funded at RIT was nearly $15 million, of which $861,000 was attributable to the KGCOE. By the end of Fiscal Year 2010 these annual award figures had climbed to $47.6 million for RIT overall and $7.2 million for the KGCOE, reflecting over a 3-fold increase for the Institute and more than an 8-fold increase for the Kate Gleason College. This pattern of growth in KGCOE research proposals tracked through the RIT RAPID database[2] coincided with the development and launch of the Microsystems Engineering Ph.D. program as illustrated in the Figure below.



The Ph.D. Program in Engineering will enhance opportunities for many more faculty from the Kate Gleason College of Engineering to grow their research programs to new levels of achievement.

The college-wide effort to put together the Ph.D. proposal, and the on-going conversations that continued within the College regarding the College's change in direction toward a more balanced academic model, whereby research would play a more prominent role in the mission of the College, has had a significant impact on the plan of work of every faculty member in the KGCOE, extending well beyond those who are actively engaged in the Microsystems Ph.D. program. The establishment of the Microsystems Engineering Ph.D. program also has increased the emphasis on, and recognition for, interdisciplinary collaborations. With core faculty members from both the Physics and the Chemistry Departments, the structure of the Microsystems Ph.D. program embraced interdisciplinary and cross-college collaborations from the outset.

KGCOE seek collaborative research opportunities across RIT and with other universities.

Today, numerous KGCOE faculty members are engaged in collaborative research activities with individuals in the Center of Imaging Science, and College of Computing and Information Sciences and advise students in their Ph.D. programs. The growth in external research support within the KGCOE is due in part to the engagement of these faculty in the research and advising of Ph.D. students. The launch of the Ph.D. in Microsystems Engineering enhanced the ability of faculty to grow their own research agenda, such as Satish Kandlikar who won a DOE grant of $3.4 million and Ryne Raffaelle, who won external funding of $2.4 million, both in FY2008. During FY08 through FY10, research expenditures for the core KGCOE Microsystems Ph.D. faculty accounted for 64% of the total research expenditures for the College, yet these faculty only comprise about 20% of KGCOE faculty.

37% of the tenured and

During FY11, those KGCOE faculty members who will affiliate with the *tenure track in the Kate Gleason College have grants in excess of $100,000.*

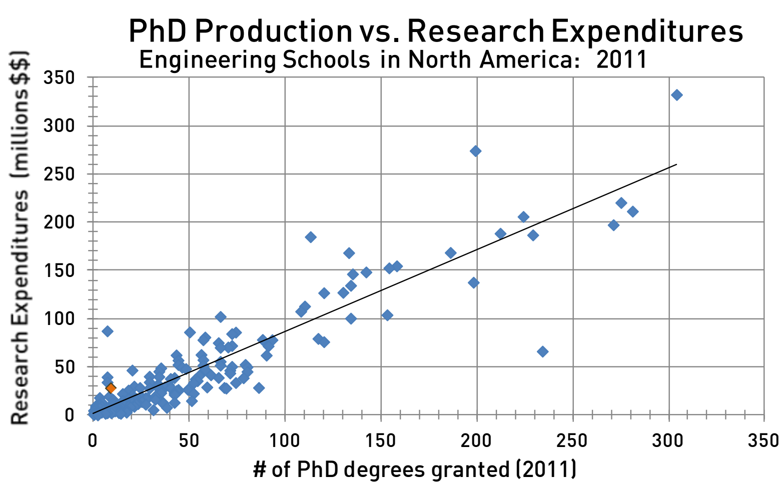
Ph.D. in Engineering had research expenditures of approximately $3.97 Million, as illustrated in Appendix II, showing faculty participation, labs, research expenditures, and publication history for each proposed application domain. While encouraging, the ability to access and grow external funding for research, particularly in the engineering disciplines, is strongly linked not only to the number of engineering faculty members at a given institution but also to the number of Ph.D. programs in engineering at the institution. Ph.D. students are key elements of the "research work force" within engineering departments.

"Invention is 10% inspiration and 90% perspiration."

Thomas Edison

Good ideas are critical to the process of gaining external research support. However, one must also complete the work that is proposed, which is 90% or more of the time and effort. Frankly, there is a limit to the amount of research that any one faculty member can be engaged. Ph.D. students play a key role in this process and, at the same time, are integral to the educational mission of an institution. In fact, many funding agencies consider this educational mission to be so important that they generally will not provide research funding[3] to investigators who are not actively engaged in the mentoring of Ph.D. students.

The American Society for Engineering Education (ASEE) maintains a database of performance metrics for Engineering Colleges, which is accessible to College of Engineering Deans across the USA.[4] Using this information, the research expenditures of Engineering Colleges in North America for the year 2011 (the most recent data published) shows a correlation between research expenditures and engineering Ph.D. degrees awarded, as illustrated in the figure below.



The recent increase in research activities is making apparent that Ph.D.

students are an essential element for realizing faculty research agendas. If the faculty of the KGCOE is to expand its scope of research activities significantly beyond current levels, it is essential that a broader base of the faculty have the access to advise Ph.D. students to assist in the research. Ph.D. students provide continuity on projects of significant scope and have a high level of commitment to the research enterprise, since their career goal is to acquire a research position. Furthermore, Ph.D. programs open up opportunities for faculty to compete effectively for grants from federal funding agencies such as the NSF, which consider strengthening the country's research workforce and capabilities their primary mission.

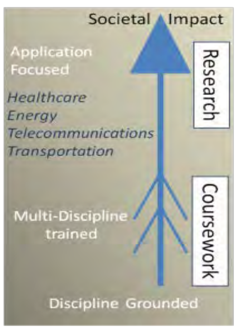


FIGURE 1. ARROW-TARGETED CURRICULUM

The solutions of societal and global grand challenges lie at the intersection of many core disciplines. Students having exposure to fields outside their core training will be more able to interact and work with others than a person with only core training. The proposed program advances an "Arrow-Targeted" curriculum to achieve Depth with a fields of study while providing societal context for research, resulting in nimble problem solvers who can tackle problems of significant global significance.

The need to balance depth of knowledge with the breadth provided by contextual understanding will become even more important in future decades. In his essay, "Preparing Steward of the Discipline"[5], Chris M. Gold of the Carnegie Foundation for the Advancement of Teaching, describes the role of doctoral degree recipients as the "stewards of the discipline" and he states that

> *"...Every scholar and steward must strike a balance between mastering breadth and depth in the discipline. Typically, doctoral students learn a small area in great depth, but this deep understanding must be place in context. Once students understand the historical context of the field -- how and when important ideas, questions, perspectives, and controversies arose or fell (or were overturned) -- then they can grasp the span and sweep of the field and locate themselves and their work in the disciplinary landscape ..."*

The proposed Ph.D. in Engineering is designed to include this contextual understanding of not only the engineering discipline, but also the societal context of the problem space in which the student will work.

This unique program at RIT will complement existing programs in

Microsystems Engineering, Sustainability, Imaging Science, and Computing and Information sciences by providing technology-specific application areas for students to focus their dissertation research. The program is designed for students to complete rigorous work in traditional disciplines complemented by interdisciplinary graduate level coursework and research. The resulting graduate from the "Arrow-Targeted" Ph.D. program will be prepared to better handle interdisciplinary research challenges than those who are formally trained in core disciplines.

The purpose of the PhD in Engineering program is to produce nimble professionals who can innovatively solve problems of global significance whose solution are beyond the scope of a single discipline.

The proposed Ph.D. in Engineering requires each student to address fundamental technical problems of national and global importance for the 21st Century. The **healthcare** industry, the **Communications** industry**,** the **energy** industry, and the **transportation** industry arguably impact every individual on the planet, and will be targeted as the inaugural industry sectors that student and faculty research will contribute to. Engineering has and will continue to play a critical role in advancing these industries and enhancing the quality of life for all. The proposed focus areas are well aligned with the National Academy of Engineering Grand Challenges[6] published in February 2008.

Interdisciplinary research and collaboration will be essential as RIT and its faculty seek large center-based funding in the future.

These industry focus areas are built upon a foundation of existing strengths at RIT. Faculty in the KGCOE are already pursuing significant sponsored research in these focus areas, as evidenced by our track record of funded projects, strong publication history, laboratories and facility infrastructure, and existing graduate course offerings. Details about our current capabilities for each focus area are outlined in Appendix II. These focus areas set the tone for strategic faculty recruiting and the creation of interdisciplinary research centers. The collaborative activities catalyzed by the Ph.D. in Engineering will stimulate curriculum development and enhance the Institute's efforts to distinguish itself as the Innovation University.

The Ph.D. in Engineering will enhance faculty recruitment and development at RIT.

The program will have a significant positive impact on RIT's ability to attract highly qualified faculty candidates with outstanding potential in both research and teaching. Recruiting of AALANA and female faculty to the KGCOE has been inhibited by the absence of a Ph.D. in engineering.[7] Enrolling current M.S.-degreed employees in RIT Ph.D. programs provides an efficient way for RIT to achieve its goal of transitioning the faculty while providing a significant and immediate cohort of Ph.D. students to drive research and foster collaboration between CAST, GCCIS and KGCOE. While the number of such internal participants is anticipated to be relatively small (approximately %5 of students in the first decade) the leverage that this collaboration will foster across colleges is expected to be significant.

These four key industry sectors collectively represent $5.7 trillion in annual expenses in the U.S. (or 39% of the US GDP).[8]

(U.S. Census Bureau, Statistical Abstracts)

Significant technology advancements in the **healthcare, energy**, **Communications** and **transportation** industries will require truly interdisciplinary approaches. The industry-driven technical challenges are of strategic importance to the national and global economies. They have been selected as the inaugural focus areas for the Ph.D. in Engineering because they will catalyze collaborative research at RIT across multiple disciplines in areas that are closely aligned with the priorities of potential industrial, state and federal research sponsors, complementing the existing Ph.D. programs at RIT and enabling faculty teams to address societal grand challenges.

The four industry sectors represent areas of national and global significance and are well aligned with the skills, interests, and research programs of the majority of faculty in the Kate Gleason College of Engineering at this time. In future decades, new industry sectors of significant importance may emerge to create an additional industry focus area, or replace one of declining significance. While the industry focus areas may change over time, the underlying terminal degree program in engineering will evolve to reflect the evolution of our discipline. This nimble and innovate terminal degree structure will enable the KGCOE to respond to the changing needs of society while placing us in a strong position to create the stewards of our discipline for the future and position RIT as a leader in engineering education at all degree levels. The following pages describe our vision for each of the industry inspired research focus areas, within the context of existing research of the KGCOE, followed by examples which illustrate the complementary nature of the Ph.D. in Engineering with the other existing RIT Ph.D. programs.

Healthcare

Focus Area Goals:

- Provide Better Devices and Delivery Systems
- Improve Care for the Aging
- Engineer Better Medicines
- Develop Efficient Bioanalytical Systems
- Advance Health Informatics and Physiological Modeling

Healthcare is one of the largest expenses in the entire U.S. Economy, measured as a fraction of gross domestic product, second only to food. Concerns about access to high quality affordable health are a global issue, prevalent in every society around the world.

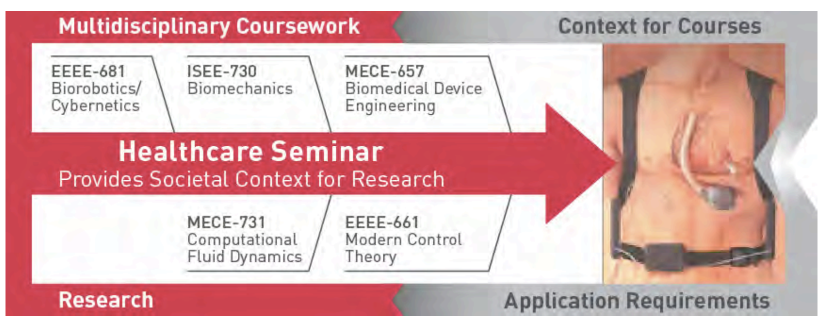
Students in the Healthcare track will apply the fundamental knowledge of their respective engineering disciplines to health-related areas; with ***research projects focused on*** the technological challenges inherent in developing ***enhanced imaging systems, assistive devices systems, methodologies to diagnose and treat diseases, physiological modeling, design of separation and bioanalytical systems for clinical applications, and optimization of the delivery and quality of healthcare processes and services.*** It is easy to envision such projects engaging a interdisciplinary team of Ph.D. students as Healthcare encompasses research activities in all of the KGCOE departments as well as other colleges at RIT.

The Healthcare focus area aligns with the Institute's campus wide initiatives and supports the recent strategic alignment with Rochester General Hospital. Collaborative relationships have also been established with several faculty members from outside the KGCOE; in particular the College of Applied Science and Technology and the College of Science, NTID, University of Rochester, and multiple industry sponsors. These partnerships have already resulted in joint proposal submissions, funded projects, and publications. Appendix II includes a summary of faculty members, research expenditures, publications, existing infrastructure and funding sources associated with Healthcare.

One example of the interdisciplinary Healthcare research being conducted in the KGCOE is the development of the Left Ventricle Assist Device (LVAD) being developed by Dr. Steven Day's team with support from the NIH and in collaboration with the Utah Artificial Heart Institute. Future PhD students who work on projects like this would be provided with a strong context for their research through the Healthcare Seminar, Focus Area Electives and disciplinary studies as described in the Curriculum.

US Healthcare Expenditures are approximately $2.5 Trillion Annually, making Healthcare the second largest component of expenses in the U.S. economy, behind only food.

(U.S. Census Bureau, Statistical Abstracts)



Engineering skills from a variety of disciplines are required to attack and solve the challenging problem of creating implantable artificial organs to extend and enhance the quality of life for individuals suffering from heart failure.

Focus Area Goals:

- Advance Energy Collection Technology
- Advance Energy Conversion Technology
- Advance Energy Management and Control Technology
- Advance Energy Distribution Technology
- Advance Energy Consumption Technology
- Advance Energy Storage Technology

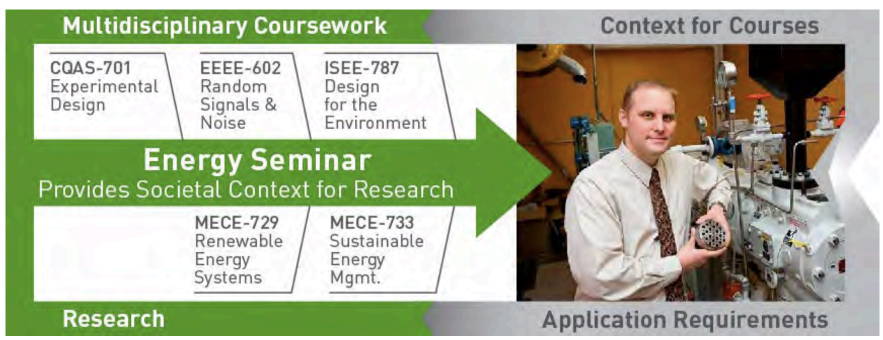
Energy Expenditures in the USA are $1.4 Trillion Annually.

(U.S. Census Bureau, Statistical Abstracts)

The goal of the Energy industry focus area is to produce Engineering Ph.D. graduates who will become recognized leaders in the field through the solution of our global energy challenges. This goal will be achieved through relevant industry -inspired applied research and basic research in energy related fields.

The Ph.D. in Engineering will expand the ability of faculty and Ph.D. students to conduct basic and applied research including pilot scale demonstrations in the six functional areas necessary for sustainable solutions to the nation's energy needs: ***energy collection, conversion, storage, distribution, control, and consumption***. There can be little doubt of the importance of both fundamental and applied research in renewable energy systems. Research efforts will range from the fundamental understanding of heat, mass, energy and momentum transport processes to pilot-scale testing and computer modeling of industrially- relevant sustainable energy systems. Appendix II includes a summary of faculty members, research expenditures, publications, existing infrastructure and funding sources associated with Energy.

As one example, coursework from across the KGCOE provides students with the background to improve reciprocating compressor technology under the direction of Dr. Jason Kolodziej, in cooperation with our industry partner Dresser Rand. Mechanical, Industrial and Electrical Engineering skills are complemented by expertise in statistics to solve this interdisciplinary problem associated with clean fuels and greenhouse gas management - one of several global energy problems being investigated in the Energy focus area by faculty in the KGCOE.



Engineering skills from a variety of disciplines are required to address the global issues of a sustainable energy system within the context of societal norms and expectations that vary widely around the globe. Technical leaders in this field need to be technically strong and also understand the socio-political context of their research in order for research endeavors to be effectively translated into real-world solutions.

Communications

Focus Area Goals:

- Enhance Sensing and Collection
- Improve Communications and Networking
- Engineer Better Computing Systems
- Enhance Signal Processing
- Enhance Security and Privacy

The Communications Industry will continue to transform society in 21st century. The proliferation of cyber and physical sensors in cell phones, smart homes, work environment, traffic monitoring, and other areas highlight the growing importance of efficiently transferring, processing and interpreting vast amounts and diverse types of data. Emerging initiatives in the Communications industry include cyber physical systems, Internet of things, and machine-to-machine communications.

The Ph.D. in Engineering will leverage and expand the ongoing research of KGCOE faculty in Telecommunication areas that include wireless communication, sensor systems and networks, embedded systems and electronics, satellite communications, signal processing and control, high performance and reliable architecture, resilient and secure systems and global networks, and emerging multimedia systems. Two cross-cutting and global societal issues that will be addressed within this focus area are ***"Intelligent Home and Personal Networks"*** and ***"Heterogeneous Mission-critical Surveillance Infra-structure."*** Appendix II includes a summary of faculty members, research expenditures, publications, existing infrastructure and funding sources associated with Communications. Communications research involves interdisciplinary training in sensing, communications, networking, computing, and signal processing of data in a secure and reliable manner to support diverse applications as illustrated in the Figure below. National and international security systems solutions require contributions from disciplines including computer, electrical, industrial and mechanical engineering.

Communications Expenditures in the USA are $600 Brillion Annually (excluding entertainment)

(U.S. Census Bureau, Statistical Abstracts)

Pursuant to The President's Council of Advisors on Science and Technology, NSF launched the Cyber-Physical Systems program jointly by the Directorates for Computer and Information Science and Engineering and Engineering.

Transportation

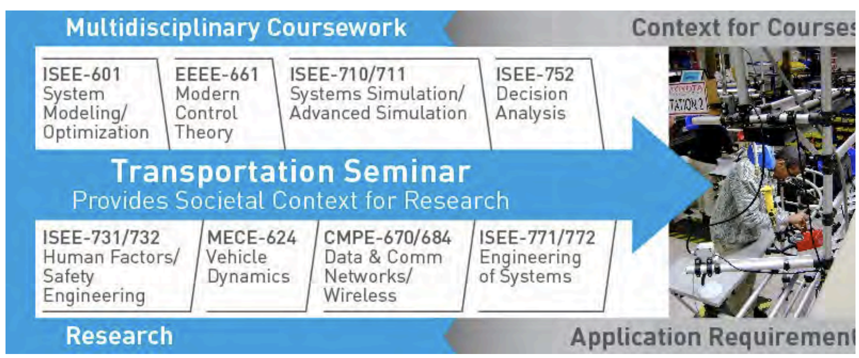
Focus Area Goals:

- Engineer New Vehicle Systems
- Revitalize and Modernize Infrastructure
- Create Innovative Distribution Systems for Goods and People
- Enhance Security and Safety
- Improve Transportation Logistics

The goal of the Transportation industry focus area is to produce Engineering Ph.D. graduates who will become recognized leaders in the field through the solution of problems including transportation infrastructure, manufacturing competitiveness, service economies, and global supply chain logistics. This goal will be achieved through relevant industry -inspired applied research and basic research in energy related fields.

Transportation systems include ground-based vehicle systems; underwater vehicles; flight and space vehicles; robotic systems; micro vehicles; intelligent manned and unmanned vehicles; remotely operated vehicle systems; freight transport systems; transportation data gathering and fusion; sensor systems for estimation of vehicle state information; transportation infrastructure; and systems of vehicles acting cooperatively. Two cross-cutting societal issues that will be addressed within this area are ***next-generation personal transportation systems*** and ***optimal strategies for vehicle routing and logistics.*** Appendix II includes a summary of faculty members, research expenditures, publications, existing infrastructure and funding sources associated with Transportation. The challenges of designing, manufacturing, and supporting modern vehicle systems and all of the associated infra-structure requires teams of professionals and expertise from multiple disciplines. Modern hybrid vehicles, for example, require a full understanding of multiple fields of engineering and technology including chemical, mechanical, electrical, and industrial engineering. These systems require a closer coupling of electrical (energy conversion), mechanical (power-train) and chemical (energy storage) engineering than traditional vehicles. Global supply chain logistics and international trade issues associated with the global supply of rare earth elements used in magnets create hugely complex research problems.

Coursework in multiple disciplines provides background for research related to smart transportation systems that provide safe and secure sustainable transportation.



Transportation Expenditures in the USA are $1.2 Trillion Annually.

(U.S. Census Bureau, Statistical Abstracts)

Engineering skills from a variety of disciplines are required to address transportation issues and their accompanying societal challenges as the world becomes more flat, and people as well as goods, become more mobile.

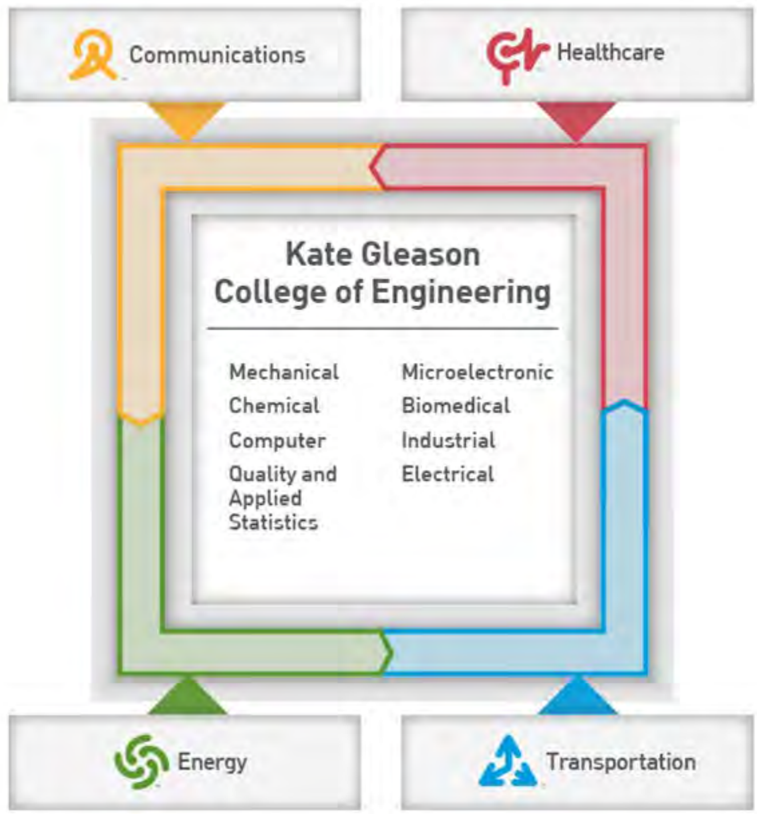
Innovation and Flexibility

The proposed Ph.D. in Engineering is designed to be flexible and provide the KGCOE with the ability to nimbly respond to the evolving needs of our society.

The KGCOE believes that our innovative approach to building strong disciplinary strength of individual technical researchers combined with industry relevant context for that research will provide a clear understanding of the manner by which basic research can be translated into real-world solutions having lasting impact.

The inaugural research focus areas for the RIT Ph.D. in Engineering are Communications, Healthcare, Energy, and Transportation. The faculty of the KGCOE is well-positioned to contribute to solving problems of global significance in these four focus areas:

The Ph.D. in Engineering will produce graduates who have the societal context needed to solve 21st Century problems.



A flexible model for academic research and education

Other global industries and their concomitant societal problems may become focal points in the future. As that perspective matures, the Ph.D. in Engineering may be readily adapted to this changing societal need, without the need to change the underlying degree program.

This evolutionary model of identifying focus areas for interdisciplinary research is enabled by the modular and flexible nature of the RIT Ph.D. in Engineering program, which we hope shall become a role model for other terminal degree programs.

The proposed Ph.D. in Engineering is well aligned with RIT's Vision, Mission, and Future, as well as building upon our historical strengths.

Vision

RIT will lead higher education in preparing students for successful careers in a global society.

The proposed Ph.D. in Engineering offers a interdisciplinary approach to prepare students for successful careers in the global society to address prominent needs in **Healthcare**, **Energy**, **Communications**, and **Transportation**. There are many careers within industry and academia for which a Ph.D. in engineering is a prerequisite.

Mission

RIT's mission is to provide a broad range of career-oriented educational programs with the goal of producing innovative, creative graduates who are well-prepared for their chosen careers in a global society.

The mission of the PhD in Engineering program is to produce nimble professionals who can innovatively solve problems of global significance whose solution are beyond the scope of a single discipline. The program will provide technology-based research and educational programs for personal and professional development through the rigorous advancement of knowledge in areas relevant to emerging technologies and social conditions, and developing the talented engineering workforce to tackle 21st century problems.

Core Values

The Ph.D. in Engineering program is designed in alignment with the RIT Core Values.

Student Centeredness

The proposed program will contribute to student centeredness by enhancing the quality of student experience at all levels, including the existing MS and BS programs in engineering. The Ph.D. in Engineering program will offer students a unique application domain focused degree not available at other institutions, and attract outstanding students who have previously not chosen to attend RIT.

Professional Development and Scholarship

More than 45 faculty members in the KGCOE are conducting externally funded research in the one of the four focus areas listed here. The Ph.D. in Engineering will provide these already successful faculty with the opportunity to mentor Ph.D. students and significantly increase scholarship in the KGCOE. Appendix II summarizes the faculty members, research contracts, labs, and publications associated with each of the four focus areas.

Integrity and Ethics

The design of the Ph.D. in Engineering program incorporates societal context as a central theme of the program of study. Through the "focus areas seminar" and "translating research into practice" courses, doctoral students will be required to position their individual research program within the context of societal needs, demonstrating a thorough understanding of professional ethics and commitment to the highest standards of academic integrity.

Respect, Diversity, and Pluralism

The Ph.D. in Engineering program will make RIT much more attractive and competitive[9] when trying to recruit top faculty candidates, and will allow us to overcome the single largest faculty recruiting obstacle we have had for the past decade.

The Ph.D. in Engineering program will cover a broad spectrum of engineering, making RIT more appealing to students[10] from programs around the world. The caliber of graduate student researchers will increase, as will the quality and quantity of research they conduct.

Innovation

The proposed Ph.D. in Engineering is an innovative approach to doctoral education that can serve as a role model for other terminal degree programs in the future. The innovative structure of the program will enable the RIT Faculty of the KGCOE to mentor the stewards of our disciplines for the 21st Century, as we tackle problems of national and global significance.

Our approach will maximize efficiency by offering shared courses among programs, expand course offerings to Master's students, and enable RIT to become an even more attractive partner for corporate research[11], as we continue to advance our state of the art facilities, leading to greater employment opportunities for all students.

Teamwork

Ph.D. students and faculty will address fundamental problems, within the context of an industry focused team. The interdisciplinary design of the entire Ph.D. in Engineering program is structured to foster teamwork and collaboration.

Building on our History

The intellectual challenges of advancing Healthcare, Energy, Communications and Transportation will allow RIT to graduate a new type of professional who is able to tackle the hugely complex problems of global relevance in each of these areas. Industry and society will benefit from fundamental advances in these fields, allowing RIT to continue our 125 year old tradition of "Engineering with an Industry Focus." We look forward to carrying this tradition forward with the four industry inspired research focus areas for the Ph.D. in Engineering.

The Ph.D. in Engineering expands upon KGCOE's historically strong product development perspective, and adds the essential element of

The philosophy of the proposed Ph.D. in Engineering is to produce nimble, flexible professionals who can be much more adaptable (both as innovative problem solvers and in their careers) than traditional engineering Ph.D.s. The four interdisciplinary focus areas have been strategically chosen to stimulate and promote

basic research in engineering as an applied science.

The goal of the Ph.D. in Engineering is to conduct fundamental research and create transformative technologies by immersing the students and faculty in an industry-inspired, interdisciplinary research environment.

collaborations across disciplines, while requiring each student to develop intellectual depth in a particular discipline specific subject area, and to expand the body of knowledge within that area through independent research. ***Engineering focuses on the development of new products and processes to enhance the world around us.*** Engineering leverages the vast knowledge base embraced by the physical and life sciences, enhanced by the quantitative power of mathematics. This program will enhance the ability of and opportunity for engineers to advance the understanding of particular phenomena from a first principles perspective. To achieve these goals, engineers often have to overcome significant technological challenges and/or need to develop novel ways to employ existing technology. Overcoming these challenges and devising novel strategies for exploiting technologies are the driving forces that motivate research in engineering. ***While it is true that individuals engaged in engineering research must focus deeply and narrowly on a particular aspect of technology to advance the state of knowledge in that area, the ultimate utility of the outcomes of such research are realized only when the results are integrated with research outcomes from multiple disciplines.*** Indeed, the historical record is replete with examples of transformational technologies whose existence is due entirely to the convergence of advancements from various disciplines.

Designing Our Future

While the industries of Rochester and the USA have evolved significantly over the past century, the importance of RIT as a driver to fuel economic growth is just as relevant today as it was in 1885. The educational needs of our graduates and the industries that they support have evolved, from classes in mechanical drawings, to certificates, Bachelor's degrees, and Master's degree. Our career oriented focus remains at the heart of what we are, and what we do. However, the nature of the careers that our graduates pursue continues to evolve.

The Carnegie Initiative on the Doctorate (CID) identified several trends in the future of doctoral education[12] in the United States:

- *"A move toward great interdisciplinarity and interaction with neighboring disciplines*
- *A growing commitment to team work -- even in disciplines traditionally marked by solitary scholarship -- with more collaboration in both research and teaching, and*

- *Greater purposefulness in reaching out to partners and audiences outside of academe in ways that connect academic work with the larger societal context."*

The time has come for the Kate Gleason College of Engineering to launch a world class Ph.D. in Engineering program. RIT has a long history of preparing graduates for engineering and technology-based careers needs by our society. RIT began with certificate based education, moved on to associated degrees (post World War II), into bachelor's degree programs (1960's and 70's), and into master's programs (1980's - 1990's). RIT began growing in to doctoral education more significantly after the year 2000. Throughout this history of change, one thing has remained constant -- that we are preparing students for successful careers to meet the needs of society. The biggest change has simply been in the nature of the education that our graduates need in order to be prepared for those careers. The hugely complex nature of the technological problems facing society today demands that an increasing number of our graduates be prepared with terminal degrees in engineering. The RIT Kate Gleason College of Engineering must take a leadership role in defining doctoral engineering education for the 21st century. This novel interdisciplinary Ph.D. in Engineering will contribute to an even brighter future for the KGCOE and RIT by increasing the ability of our graduates to make an impact in the world, attracting even more highly talented faculty and students to our programs, and raising the prestige of RIT in the greater community to the benefit of our future *and* our past graduates.

The Ph.D. in Engineering complements existing Ph.D. Programs at RIT

The proposed Ph.D. in Engineering complements the existing RIT Ph.D. programs by providing an engineering systems component for grand societal problems. The program will allow RIT to attract highly qualified students into related research areas that have an engineering emphasis, and offers name recognition for effective placement of Ph.D. graduates in both academia and industry. The table below compares and contrasts the students, degrees awarded, courses of study, and research topics of the proposed Ph.D. in Engineering beside the other RIT Ph.D. programs. The Ph.D. in Engineering is focused on bringing doctoral students to RIT who have a strong foundation, and desire to pursue continued study, in engineering. In contrast, four of RIT's existing Ph.D. programs are in the sciences.

Comparison between the Ph.D. in Engineering and existing RIT Ph.D. Programs.

The proposed program will permit synergies of applying engineering to four application domains of broad interest to society.

Areas of Commonality and Differentiation	Proposed	Existing RIT PhD Programs					
	PhD in Engineering	Microsystems	Astrophysical Science and Technology	Color Science	Computing and Information Science	Imaging Science	Sustainability
Entering students require a previous degree in Engineering?	Yes	No	No	No	No	No	No
Is the resulting PhD degree granted in Engineering?	Yes	Yes	No	No	No	No	No
Is the resulting PhD degree granted in Science?	No	No	Yes	Yes	Yes	Yes	No
Does this degree program required extensive graduate coursework in engineering?	Yes	Yes	No	No	No	No	No
Is it common for students in this program to conduct research in the area of Healthcare?	Yes	Micro- and Nano-Electronics	No	Medical Data Visualization	Access Technology, Biomedical Computing	Medical Imaging	No
Is it common for students in this program to conduct research in the area of Transportation?	Yes	No	No	No	No	No	Yes
Is it common for students in this program to conduct research in the area of Communications?	Yes	Micro and Nano Devices for Telecomm	No	No	Communication and Networking	No	No
Is it common for students in this program to conduct research in the area of Energy?	Yes	Micro-power and Nano-power Devices	No	No	Green Computing, Environmental Informatics	Earth Remote Sensing	Yes

Students from backgrounds other than engineering may pursue the PhD in Engineering by completing appropriate bridging course-work and attaining a Master's degree in any one of the KGCOE's existing Master's programs.

Real-world problems do not respect disciplinary boundaries, yet their solutions require depth of knowledge in traditional disciplines.

Like the Microsystems Ph.D. program, the proposed program is also interdisciplinary. However, the Ph.D. in Engineering includes broader focus areas and engages a greater percentage of the faculty across the college. The Ph.D. in Engineering leverages the talents of the faculty in an expansive contextual sense and to a higher scope compared to the Microsystems Ph.D. program. The proposed Ph.D. program contains several cross-pollination possibilities involving faculty across the Institute that may not possible with the Microsystems Ph.D. program.

The interdisciplinary Ph.D. in Engineering is strategically aligned with RIT's strategic research directions of Bio-X, Sustainability, and Imaging, while focusing on industry inspired focus areas.

The interdisciplinary Ph.D. in Engineering is strategically aligned with RIT's strategic research directions of Bio-X, Sustainability, and Imaging, while focusing on industry inspired focus areas. The following examples will illustrate how the proposed Ph.D. in Engineering complements several existing RIT Ph.D. Programs.

Healthcare Across RIT

Engineered systems improve healthcare. However, engineering is only one of many disciplinary fields that lead to advances in healthcare. The RIT Institute of Health Sciences includes education and research programs in healthcare and delivery. Operations research in Industrial Engineering can make hospitals more effective. The Microsystems Ph.D. program has been instrumental in developing a novel sensor for measuring blast effect, to reduce traumatic brain injury. The Imaging Science program supports biomedical imaging systems, while Color Science does research in medical data visualization, and the Computing and Information Science program conducts research in access technology and biomedical computing. NTID's unique capabilities are unparalleled. RIT will be enhanced by the Ph.D. in Engineering, with a focus on Healthcare, which includes *engineering research* in biomedical devices, medical signal processing, prosthetics, biomaterials, and assistive device technology. Together, we are stronger.

Energy Across RIT

Energy systems lie at the heart of engineering. The development of the world's best energy infra-structure including electricity, natural gas, petroleum, hydropower, wind power, nuclear power, photovoltaic power and every other form of power used to drive our economy and our quality of life were achieved by engineering. Every discipline of engineering has played an important role in our world's energy infrastructure, and must play a critical role as we deal with tomorrow's energy challenges. Energy systems engineering research can be enhanced through leveraging social and life-cycle impact research in the Sustainability Ph.D. program, micro- and nano-devices from Microsystems, green computing technologies from computing and information sciences, and Earth remote sensing technologies from imaging sciences. However, tomorrow's energy challenges cannot be solved without leading contributions from the traditional engineering fields of mechanical, electrical, chemical, and industrial engineering. Together, we are stronger.

Transportation Across RIT

Land, sea, air and space travel have been a traditional focus of engineering systems. Engineering supports research in land based travel on vehicles ranging from human powered vehicles such as bicycles, and traditional vehicle technologies of cars, trucks, and trains, to emerging technologies such as alternative fuel systems (bio fuels, fuel cells, electric vehicles). Engineering advances in air travel, in just 109 years since the Wright Brothers flight at Kitty Hawk, have seen the development lighter than air technologies, propeller aircraft, and jet engine technology. Now, as we move towards miniaturization of bio-inspired flight vehicles, engineering research requires collaboration with other disciplines such as the biological sciences. We have recently entered a new era in space travel, with the entry of commercial firms launching payloads into orbit. RIT Engineering is already playing a critical role in modern transportation systems, and we need to enhance our research capability to continue. Engineering platforms in the air and space provide the "ride" upon which modern imaging systems and communications satellites rely. Together, we are stronger.

Communications Across RIT

Signal processing, high performance and mobile computing, information and networking technologies, integrated circuits, radio and satellite communications, as well as embedded control and sensing systems are so common place in today's society that we often take for granted the large scale engineering systems and infrastructure required to support them. Communications is ubiquitous. The Computing and Information Science Ph.D. program advances the scientific understanding of communication and networking. These advances will be stronger with concurrent advances from an engineering perspective, especially in the systems. Together, we are stronger.

The Ph.D. in Engineering fosters collaboration with faculty members through tight connections to existing graduate programs.

The proposed Ph.D. in Engineering will serve a significant majority of the faculty in the KGCOE, across all disciplines within the college, as well as foster collaborations with faculty members in many of the other colleges, who are engaged in engineering-related projects that address societal grand challenges. The proposed Ph.D. program will tightly connect to the existing M.Eng. and M.S. programs, providing opportunities to enhance the quality of graduate study at RIT, attracting and retaining higher quality students and faculty researchers, and raising the overall intellectual level of our Master's programs.

Distinction with the Microsystems Ph.D. Program.

RIT currently offers a unique educational and research program leading to a Ph.D. degree in Microsystems Engineering. This program builds on the fundamentals of traditional engineering and science, combined with curriculum and research activities addressing technical challenges of micro- and nano-systems. These include the manipulation of electrical, photonic, optical, mechanical, chemical, and biological functionality to process, sense, and interface with the world at a nanometer scale. The goal of the Microsystems program is to provide the foundation to explore future technology through research in nano-engineering, design methods, and technologies for micro- and nano-scaled systems. The Microsystems program is mainly focused on systems at the micro- and nano- scale, thus limiting the number of faculty participating in the program. Graduates from the Microsystems Ph.D. program tend to be placed in industry jobs whereas graduates from the proposed program may seek jobs in government laboratories or universities due to the broader scope of the proposed program. This provides an additional source of collaboration particularly with graduates who go on to a university.

The Ph.D. in Engineering program is also complimentary to the Ph.D. Microsystems program. The interdisciplinary broad-based focus of the proposed program can serve as a student attracter to the Microsystems Ph.D. program through increased visibility and vice versa. Offering a broad “portfolio” of advanced degree programs is also attractive to prospective students even with those with plans for a Masters as a terminal degree. An avenue also exists to offer shared courses among both programs to maximize efficiency and reduce duplication particularly course related to systems engineering.

3. Academic Governance

The program will be housed in the Kate Gleason College of Engineering, which is led by the Dean of Engineering. The Dean is responsible for the strategic vision and overall operations of the KGCOE and reports to the Provost. The Dean of Engineering will establish a team of individuals to drive the Ph.D. in Engineering program. The entire program will be managed in accordance with the RIT governance structure.

Program Director

The Ph.D. program will be directly overseen by the Program Director who reports to the Dean of Engineering. The Program Director will manage the delivery of the curriculum, ensure continuous improvement of the program, and will oversee student admissions, exams, advising processes, and the research program.

Focus Area Leads

Each focus area will have a designated faculty lead, who will be responsible for coordinating the topic area seminar and foundation course offering for each application domain. The faculty lead will be responsible for facilitating collaborative research proposals within each application domain.

Core Faculty

The core faculty will drive the curriculum of the Ph.D. in Engineering Program. The core faculty consists of faculty appointed by the Dean of Engineering from academic departments throughout the KGCOE. The core faculty will regularly chair Ph.D. Student committees and will administer the examinations associated with the program.

Appointments to the core faculty from outside of engineering are made by the Provost upon the recommendation of the dean of engineering and the dean of the academic unit in which the faculty member has the primary appointment.

Extended Faculty

The extended faculty will participate in the Ph.D. program as member of Ph.D. student committees, and as committee chair with approval of the Program Director. The extended faculty consists of faculty appointed by the Dean of Engineering, as appropriate, across the university.

A faculty member must have a PhD in engineering or science to supervise a PhD student in the program. Under certain special circumstances, a person with an MS in engineering may qualify to serve as a primary advisor of a PhD student if the individual has at least 10 years of experience as a primary lead on research projects within an industry or government laboratory setting and has consistently disseminated the results of the research in peer-reviewed journals within the field.

A faculty member must be research active to advise a PhD student in the program, meaning that the person has a current record of publications in the field and either an external grant to support the student or a high probability of receiving such support within the next calendar year.

PhD Admissions

Each academic department in the KGCOE will appoint a faculty member to serve on the Ph.D. in Engineering admissions committee. Typically, this will be the graduate coordinator from the individual departments, to facilitate a close working connection between the departmental M.S. programs and the interdisciplinary Ph.D. program.

Promotion and Tenure

The KGCOE Promotion and Tenure Committee currently consists of faculty throughout the college. Core faculty members associated with the Ph.D. in Engineering will be expected to earn tenure in the KGCOE.

KGCOE Graduate Curriculum Committee

The KGCOE Graduate Curriculum Committee includes representatives from all academic programs in the KGCOE. The KGCOE graduate curriculum committee must review and approve curriculum proposals presented by the Core Faculty before they proceed to the RIT Graduate Council.

RIT Graduate Council

Additional curricular oversight is provided by RIT’s Graduate Council. The role of Graduate Council is to review graduate curricular proposals from an institute-wide perspective, maintain appropriate inter-college relationships with regard to curriculum, define the essential character of graduate study at the university, continuously review and coordinate existing graduate programs, and establish policies and procedures for the administration of graduate study.

External Advisory Board

An External Advisory Board consisting of members from academia, industry, and government will be formed. The Board will provide continuing guidance regarding the program structure, educational objectives, research agenda, and expectations for graduates.

4. Financial Resources

A financial model for the Ph.D. in engineering is presented here. The following incremental resources will be used to launch the Ph.D. in Engineering:

1. Two incremental lecturer positions assigned to the KGCOE beginning in the first year, with a two more lecturers proposed in year 4. These lecturers will be distributed around the college by the Dean, and will allow tenured and tenure-track faculty to dedicate more time writing proposals, mentoring Ph.D. students, and expanding infrastructure through competitive awards of external sponsored research contracts. Each lecturer will carry a nominal teaching load of 8 courses per academic year (16 sections per year). Each tenure/tenure-track faculty member is the KGCOE has a baseline expectation of 20% research as part of their workload, corresponding to 2 courses per year (1 per semester). The incremental lecturer positions will allow the KGCOE to provide 2 course releases to the faculty supervising the 8 entering Ph.D. students in the first year, bringing their nominal research expectation to 40% of workload. These faculty members will be expected to focus significant effort on proposal writing to support their PhD students in subsequent years. By the fifth year of the program, the four lecturers will provide 32 sections of course release per year to the faculty members supervising the expected 32 full time PhD students, with additional course release expected to be covered by grants and contracts.
2. One incremental administrative staff member. This staff member will assist the program director and Ph.D. students associated with the program. The home departments of the research faculty members and the new lecturers will provide support to those individuals.
3. A stipend is provided for the program director to cover a portion of summer appointment, and to their home department to provide release from departmental duties.
4. Stipends are provided to each of the four focus area group leaders.
5. $30,000 in incremental annual resources (acquisitions) is requested for library support of the program.
6. Stipends for 8 Ph.D. students, for one calendar year each.
7. 100% Tuition Remission for 8 Ph.D. students annually, with the expectation the Associate and Full Professors will seek 50% Tuition support for Ph.D. students in their external contracts for years 3 and beyond for each student.
8. Additional cost-sharing and matching funds for external grants and proposals to be evaluated on a case-by-case basis as future proposals are prepared for submission, similar to the process used today. However, we expect the number of matching requests to increase above today's levels, given the increased expectation of faculty for proposal writing.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 6
PROJECTED EXPENDITURES FOR THE PROPOSED PROGRAM

Expenditures[1]	Actual				Projected					
	Specify Previous AY2012-13 Academic Year[2]		Specify Current AY2013-14 Academic Year[2]		Specify AY2014-15 Academic Year[2]		Specify AY2015-16 Academic Year[2]		Specify AY2016-17 Academic Year[2]	
Personnel Expenditures	Existing[3]	New[4]	Existing[3]	New[4]	Existing[3]	New[4]	Existing[3]	New[4]	Existing[3]	New[4]
Faculty										
01. Existing Faculty	$ 88,149	$ -	$ 90,794	$ -	$ 93,517	$ -	$ 102,880	$ -	$ 98,371	$ -
02. New Faculty	$ -	$ -	$ -	$ -	$ -	$ 244,004	$ -	$ 268,429	$ -	$ 413,646
03. Total Faculty	**$ 88,149**	**$ -**	**$ 90,794**	**$ -**	**$ 93,517**	**$ 244,004**	**$ 102,880**	**$ 268,429**	**$ 98,371**	**$ 413,646**
Administrative Staff										
04. Existing Administrative Staff	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
05. New Administrative Staff	$ -	$ -	$ -	$ -	$ -	$ 34,926	$ -	$ 38,236	$ -	$ 36,381
06. Total Administrative Staff	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 34,926**	**$ -**	**$ 38,236**	**$ -**	**$ 36,381**
Clerical Staff										
07. Existing Clerical Staff	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
08. New Clerical Staff	$ -		$ -	$ -	$ -		$ -		$ -	
09. Total Clerical Staff	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
10. Total Personnel Expenditures										
Non-Personnel Expenditures										
11. Conference Travel		$ -		$ -		$ 2,269		$ 2,410		$ 2,406
12. Professional Development		$ -		$ -		$ -		$ -		$ -
13. Instructional Materials		$ -		$ -		$ -		$ -		$ -
14. Supplies		$ -		$ -		$ 2,086		$ 2,328		$ 2,382
15. Equipment		$ -		$ -		$ -		$ -		$ -
16. Proposal Development		$ -		$ -		$ -		$ -		$ -
17. Computer Equipment		$ -		$ -		$ 17,727		$ 33,358		$ 52,558
18. Library Acquisitions		$ -		$ -		$ 34,034		$ 36,146		$ 36,093
19. Total Non-Personnel Expenditures	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 56,117**	**$ -**	**$ 74,241**	**$ -**	**$ 93,439**
Aid to Students[6]										
20. Existing Aid to Students[4]	$ 178,625	$ -	$ 183,984	$ -	$ 189,503	$ -	$ 195,188	$ -	$ 389,802	$ -
21. New Aid to Students[5]	$ -	$ -	$ -	$ -	$ -	$ 245,048	$ -	$ 260,251	$ -	$ 389,802
22. Total Aid To Students	**$ 178,625**	**$ -**	**$ 183,984**	**$ -**	**$ 189,503**	**$ 245,048**	**$ 195,188**	**$ 260,251**	**$ 389,802**	**$ 389,802**
Facilities Renovations/Additions[7]										
23	$ -	$ -	$ -	$ -	$ 7,020	$ -	$ 7,642	$ -	$ 7,823	$ -
24. Total Facilities Renovations/Additions	**$ -**	**$ -**	**$ -**	**$ -**	**$ 7,020**	**$ -**	**$ 7,642**	**$ -**	**$ 7,823**	**$ -**

(1) Faculty Inflation Rate ………………………. 3.00%
(2) Academic Years as indicated
(3) Existing resources means expenditures **pertaining to the proposed program** that the institution would have or would receive even if the proposed program were not approved.
(4) New resources means expenditures engendered specifically **by the proposed program,** carried over to the following year, with adjustments for inflation, if a continuing cost.
(5) Continuing FTE enrollment means the FTE enrollment that was enrolled in the previous academic year.
(6) List number, type, source and dollar amounts of financial awards under the control of the institution.
(7) Include here minor renovations not considered capital expenditures.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 7
PROJECTED[1] EXPENDITURES FOR THE PROPOSED PROGRAM
IN OTHER DEPARTMENTS

Expenditures	1st Year(1) Academic Year AY2013-14	2nd Year(1) Academic Year AY2014-15	3rd Year(1) Academic Year AY2015-16	4th Year(1) Academic Year AY2016-17	5th Year(1) Academic Year AY2017-18
Faculty [3]					
New Resources [4]	$ -	$ -	$ -	$ -	$ -
Equipment [5]					
New Resources [4]	$ -	$ -	$ -	$ -	$ -
Other [6]					
New Resources [4]	$ 3,698	$ 7,314	$ 12,380	$ 14,365	$ 16,430
Total (Other Departments)					
New Resources[4]	**$ 3,698**	**$ 7,314**	**$ 12,380**	**$ 14,365**	**$ 16,430**

(1) Faculty Inflation Rate 3.00%
(2) Academic Years as indicated
(3) Includes salary and fringe benefits.
(4) New resources means resources in other Departments engendered by the proposed program (e.g., additional faculty teach support courses).
New resources from the previous year are carried over to the following year with adjustments for inflation, if it is a continuing cost.
(5) Include here equipment which is not a capital expenditure.
(6) Specify what is included: Incremental Library and Incremental Student Services

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 8

PROJECTED[1] REVENUE RELATED TO THE PROPOSED PROGRAM

Revenue	1st Year(1) Academic Year AY2014-15	2nd Year(1) Academic Year AY2015-16	3rd Year(1) Academic Year AY2016-17	4th Year(1) Academic Year AY2017-18	5th Year(1) Academic Year AY2018-19
Tuition Revenue [3]					
01. From Existing Sources [4]	$ -	$ -	$ -	$ -	$ -
02. From New Sources [5]	$ -	$ 86,394	$ 178,828	$ 231,340	$ 276,251
03. Total	$ -	$ 86,394	$ 178,828	$ 231,340	$ 276,251
State Revenue [6]					
04. From Existing Sources [4]	$ -	$ -	$ -	$ -	$ -
05. From New Sources [5]	$ -	$ -	$ -	$ -	$ -
06. Total	$ -	$ -	$ -	$ -	$ -
Other Revenue [7]					
07. From Existing Sources [4]	$ 3,504,534	$ 3,766,213	$ 4,027,893	$ 4,289,573	$ 4,551,252
08. From New Sources [5]	$ 342,800	$ 771,994	$ 1,207,229	$ 1,602,541	$ 1,990,252
09. Total	$ 3,847,334	$ 4,538,208	$ 5,235,122	$ 5,892,114	$ 6,541,505
Grand Total [8]					
10. From Existing Sources [4]	$ 3,504,534	$ 3,766,213	$ 4,027,893	$ 4,289,573	$ 4,551,252
11. From New Sources [5]	$ 342,800	$ 858,388	$ 1,386,057	$ 1,833,881	$ 2,266,504
TOTAL	$ 3,847,334	$ 4,624,602	$ 5,413,950	$ 6,123,454	$ 6,817,756

(1) Inflation Rate 2.50%

(2) Academic Years as indicated

(3) Incremental tuition revenue is computed from the part-time student enrollment, assuming that they are corporate sponsored at half-time.

(4) Existing sources means revenue that would have been received by the institution even if the proposed program were not approved.

(5) New sources means revenue engendered by the proposed program.
New sources from the previous year are carried over to the following year with adjustments for inflation, if it is a continuing revenue.

(6) RIT is a private institution. No state appropriations are applied to this program.

(7) Includes projected Grants and contracts from Corporate and Federal Research Program Sponsors.

(8) Enter total of Tuition, State and Other Revenue, from Existing or New Source

5. Facilities, Equipment, and Library

Facilities and Equipment

RIT has extensive laboratories supported with state-of-the-art equipment and technology, through a combination of government agency support and unparalleled corporate support.

Laboratories and Facilities in support of Healthcare

- Biomedical Device Engineering Lab
- Particle Imaging Velocimetry Lab
- Nano-Bio Interface Lab
- Glaucoma Research Lab
- Assistive Devices Lab
- Inhalation Diagnostics Lab
- Ergonomics Lab

Laboratories and Facilities in support of Energy

- Thermal Analysis, Micro-Fluidics and Fuel Cell Lab
- Renewable Energy Lab
- Thermoelectric Lab
- Wind Tunnel
- Thermo-Fluids Labs
- Heat Transfer Lab
- Thin Film Coating lab
- Nanopower Lab

Laboratories and Facilities in support of Communications

- Video and Computer Vision Lab
- Imaging and Printing Lab
- Electromagnetics Lab
- Communications Lab
- Real Time Vision and Image Processing Lab
- Networking and Information Processing Lab
- High Performance Architecture Lab
- Hardware Design Lab
- Print Research and Integrated Systems Lab

Laboratories and Facilities in support of Transportation

- Advanced Systems Lab
- Control Systems Lab
- Robotics and Instrumentation Labs
- Sustainable Energy Systems Lab
- Fuel Cell Lab
- Dynamometer Lab
- Brinkman Lab
- Machine Shop
- Toyota Production Systems lab

Library

The Wallace Library at RIT has sufficient resources for the Ph.D. in Engineering. A review of the journals available through the Wallace library indicates that sufficient information resources are provided today. The table below illustrates the wealth of information resources available to engineering researchers in each of the focus areas associated with the Ph.D. in Engineering.

Research Focus Area	Number of Journal Subscriptions Available through the Wallace Library at RIT
Communications	263 - Communications
	88 - Information Technology
	606 - Electrical Engineering
Transportation	59 - Transportation Engineering
	63 - Automotive Engineering
	121 - Aeronautics Engineering & Astronautics
	93 - Operations Research
	310 - Civil Engineering
Energy	34 - Nuclear Engineering
	348 - Chemical Engineering
	277 - Mechanical Engineering (General)
Healthcare	98 - Bioengineering
	93 - Biomedical Engineering
	119 - Hospitals and Medical Centers

A letter of support, with resource assessment from the Wallace Center is included in Appendix C.

6. Faculty

The proposed Ph.D. in Engineering program is scoped to engage more than forty-five faculty, more than half of the tenured and tenure-track faculty from all departments and programs in the Kate Gleason College of Engineering. These faculty will be joined by other faculty outside of KGCOE to participate in the proposed program. A subset of these faculty will be the core members of the program, in charge of designing and overlooking the program curriculum and policies along with the responsibility to supervise Ph.D. students. The remaining faculty will be extended faculty with the right to supervise Ph.D. students.

The inclusiveness of the program is made possible with the four industry inspired, high impact focus areas. Out of the forty-six faculty from KGCOE listed, thirteen will primarily focus on advancing sciences and technologies in the Healthcare industry, fifteen for the Energy, eleven for Communications and seven for the Transportation industry. In addition to their primary contributing area, many faculty have expertise across the focus areas. For example, the management of electrical vehicle charging through integrated communication and information infrastructure spans over the Energy, Communications and Transportation focus areas. The participating faculty are currently engaging in research, working with MS students, dual degree BSMS students, and/or limited Ph.D. students in RIT's existing Ph.D. programs. It is expected that the proposed program can enhance the research production, including publications and annual external research expenditure for these faculty, elevating RIT's reputation as a balanced research and teaching university.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 1; PART 1: ASSISTANT PROFESSORS
DATA ON FACULTY MEMBERS DIRECTLY ASSOCIATED WITH THE PROPOSED DOCTORAL PROGRAM

Name	FT/PT	Rank	Dept	Sex M/F	R/E	Articles in Refereed Journals in the past 5 yrs	External Research Expenditures FY12 YTD	External Research Expenditures FY11 YTD	Dissertation Load AY 2010-11 Com	Dissertation Load AY 2010-11 Chair	Dissertation Load previous 5 yrs. Com	Dissertation Load previous 5 yrs. Chair	# of Advisees AY 2010- Doc	# of Advisees AY 2010- Mstrs	# of Classes GR	# of Classes UG	% FTE Time to Proposed Program
						7	-	-									40%
																	40%
																	40%
						3	-	-	0	0	3	2	0	0	3	2	40%
						5	71,180	108,267		1		1					40%
						13	-	-	0	0	0	0	0	1	0	3	40%
						4											20%
							12,807	-									20%
						30	605,738	630,698	0	0	1	5	0	0	0	3	60%
						13	-	-	0	0	0	1	1	0	0	6	50%
						25	-	-	4	0	0	3	4	0	0	3	40%
						7	74,537	5,157	0	0	0	0	0	0	0	0	20%
						6	-	28,658	1	3	11	16	1	5	3	4	40%
						5			1	0	5	5	1	5	0	4	40%
						5	34,300	115,826	0	0	20	37	0	5	3	5	20%
						2			0	0	0	0	1	4	1	3	40%
							92,019	13,335									20%
						3	-	-	0	0	5	12	0	4	1	2	20%
						7	-	-	0	1	5	25	0	2	1	6	20%

[1] Racial/Ethnic Groups - Black (B), White (W), Hispanic (H), Native American Indian/Alaskan Native (N), Asian/Pacific Islander (A), Foreign (F)
[2] Specify the academic year.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 1; PART 2: ASSOCIATE PROFESSORS
DATA ON FACULTY MEMBERS DIRECTLY ASSOCIATED WITH THE PROPOSED DOCTORAL PROGRAM

Name	FT/PT	Rank	Dept	Sex M/F	R/E	Articles in Refereed Journals in the past 5 yrs	External Research Expenditures		Dissertation Load AY 2010-11		Dissertation Load previous 5 yrs.		# of Advisees AY 2010-11		# of Classes Taught		% FTE Time to Proposed Program
							FY12 YTD	FY11 YTD	Com	Chair	Com	Chair	Doc	Mstrs	GR	UG	
							363,206	1,014,649									20%
							30,627	-									20%
							2,825	37,135									40%
						11	26,998	249,827	0	0	10	21	0	0	1	3	40%
						5	-	33,019	0	0	11	24	0	7	3	3	20%
						3	-	-	0	0	0	9	0	6	6	3	10%
						2	-	3,864	4	1	0	0	0	0	0	2	40%
							-	4,222									20%
						2	-	-	4	5	10	18					10%
						3	53,630	64,426	4	5	16	29	2	4	2	2	20%
						7	16,379	-		2		1	2	6	4	3	10%
						0	150,537	109,889	0	0	1	0	0	6	2	2	20%
						6			0	0	0	0	0	0	3	4	20%

[1] Racial/Ethnic Groups - Black (B), White (W), Hispanic (H), Native American Indian/Alaskan Native (N), Asian/Pacific Islander (A), Foreign (F)
[2] Specify the academic year.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 1; PART 3: FULL PROFESSORS
DATA ON FACULTY MEMBERS DIRECTLY ASSOCIATED WITH THE PROPOSED DOCTORAL PROGRAM

				Sex		Articles in Refereed Journals in the past 5 yrs	External Research Expenditures		Dissertation Load AY 2010-11		Dissertation Load previous 5 yrs.		# of Advisees AY 2010-		# of Classes		% FTE Time to Proposed Program
Name	FT/PT	Rank	Dept	M/F	R/E		FY12 YTD	FY11 YTD	Com	Chair	Com	Chair	Doc	Mstrs	GR	UG	
						4	6,713	114,093	0	1	0	0	0	4	0	4	20%
						2	21,947	17,678	1	0	5	4	0	6	3	6	20%
						4	6,127	26,058	0	0	12	2	0	0	2	2	20%
						2			0	0	6	5	0	1	0	2	20%
						9	144,730	432,124	3	3	5	5					60%
						1	1,333	19,262	1	0	10	10	5	7	3	3	40%
						0	5,114	30,676	0	0	4	4	0	1	0	6	20%
						1	14,860	9,118	2	0	12	0	0	3	2	0	15%
						9	163,651	200,608	5	1	0	21	6	4	7	0	40%
						5	64,090	84,400	2	2	2	2	3	3	0	3	20%
						14	26,869	-	5	0	7	15	5	1	0	0	20%
						0			0	1	1	0	1	2	2	4	20%
						1	1,228,137	726,134	3	1	3	0	0	1	0	3	40%

[1] Racial/Ethnic Groups - Black (B), White (W), Hispanic (H), Native American Indian/Alaskan Native (N), Asian/Pacific Islander (A), Foreign (F)
[2] Specify the academic year.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 2
DATA ON OTHER FACULTY ASSOCIATED WITH THE PROPOSED DOCTORAL PROGRAM
(e.g., collaborative programs, master's programs)

Name	FT/PT	Dept	Sex M/F	R/E[1]	Articles in Refereed Journals in the past 5 yrs	External Research Support in Current AY ______[2]	Dissertation Load Current AY ______[2]		Any Dissertation Load in the previous 5 yrs.		# of Advisees Current AY ______[2]		# of Classes Taught Current AY ______[2]		% FTE Time to Proposed Program
							Com	Chr	Com	Chr	Doc	Mstrs	GR	UG	
Full Professor															
None Listed															
Associate Professor															
None Listed															
Assistant Professor															
None Listed															
Other															
None Listed															

[1]Racial/Ethnic Groups - Black (B), White (W), Hispanic (H), Native American Indian/Alaskan Native (N), Asian/Pacific Islander (A), Foreign (F)
[2] Specify the academic year.

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 3

PROJECTED STAFF FOR THE PROPOSED PROGRAM

Faculty / Staff	1st Year(1) Academic Year AY2014-15	2nd Year(1) Academic Year AY2015-16	3rd Year(1) Academic Year AY2016-17	4th Year(1) Academic Year AY2017-18	5th Year(1) Academic Year AY2018-19
Faculty					
01. Full-Time [2]	15	15	15	17	17
02. Existing [3]	13	15	15	15	17
03. New [4]	2	-	-	2	-
Faculty					
04. Part-Time [2]	-	-	-	-	-
05. Existing [3]	-	-	-	-	-
06. New [4]	-	-	-	-	-
Faculty					
07. Full-Time Equivalents (FTE) [5]	15	15	15	17	17
08. Existing FTE [3]	13	15	15	15	17
09. New FTE [4]	2	-	-	2	-
Administrative Staff					
10. Full-Time				1	1
11. Part-Time	1	1	1		
12. Full-Time Equivalent (FTE) [5]	0.50	0.50	0.50	1.00	1.00
13. Existing FTE [3]	-	0.50	0.50	0.50	1.00
14. New FTE [4]	0.50	-	-	0.50	-
Support Staff					
15. Full-Time	-	-	-	-	-
16. Part-Time	-	-	-	-	-
17. Full-Time Equivalent (FTE) [5]	-	-	-	-	-
18. Existing FTE [3]	-	-	-	-	-
19. New FTE [4]	-	-	-	-	-

1 Specify the academic year.
2 This line must equal the total of Existing faculty plus New faculty.
3 Existing means faculty and/or staff in the proposed program that w ould have existed at the institution even if the proposed program w ere not approved.
Existing FTE Faculty are computed from Table 1, using %FTE dedicated to this program.
All faculty in this table are full time faculty, but are allocating a fraction of their effort tow ards this program.
4 New means staff that w ill be employed specifically as a consequence of the proposed program.
New FTE staff should be carried over to the follow ing year as existing FTE staff, if a continuing staff need.
5 FTE Faculty are computed from Table 1, using %FTE dedicated to this program. FTE staff are computed in accordance w ith RIT H/R Definitions.
This number must equal the total of Existing plus New .

Recent Faculty Journal Publications in support of Healthcare

Electrical and Micro-Electronic Engineering

Yvanoff M **Venkataraman J** "A feasibility Study of Tissue Characterization using LC sensors:" IEEE Transactions on Antennas and Propagation Special Issue on Antennas and Propagation for Body-Centric Wireless Communications. Vol. 57 No 4 April 2009 pp 885-893.

Yvanoff M **Venkataraman J** and Fuller L "Impact of Multiple Tissue Layers on an Implantable LC Sensor" Microwave and Optical Technology Letters vol. 50 No.3 March 2008 p783

Industrial and Systems Engineering

Purser M. Richards A. Cook R. Osborne J. **Cormier D.** and Buckner G. (2010) "A Novel Shape Memory Alloy Annuloplasty Ring for Minimally Invasive Surgery: Design Fabrication and Evaluation" Annals of Biomedical Engineering published online and to appear in print.

Jernigan S. Chanoit G. Veeramani A. Owen B. Hilliard M. **Cormier D**. Laffitte B. and Buckner G. (2010) "A Laparoscopic Knot-Tying Device for Minimally Invasive Cardiac Surgery" *European Journal of Cardio-thoracic Surgery* 37(3) pp. 626 - 630.

Purser M. Richards A. Cook R. Osborne J. **Cormier D**. and Buckner G. (2009) "Evaluation of Shape Memory Alloy Reinforced Annuloplasty Band for Robot-Assisted Mitral Valve Repair" *Annals of Thoracic Surgery* 88(4) pp. 1312-1316.

Proano R.A. Jacobson S.H. Zhang W. Making combination vaccines more accessible to low-income countries: The antigen bundle pricing problem *Omega* (2011) doi:10.1016/j.omega.2011.03.006

Proano R.A. Jacobson S.H. Jokela J. A multi-attribute approach for setting pediatric vaccines stockpiles *Journal of Industrial and Management Optimization* (2010) 6(4): 709-727

Proano R.A. Jacobson S.H. Jokela J. Response to "Modeling the national pediatric vaccine stockpile: Supply shortages health impacts and cost consequences" *Vaccine* (2011) doi:10.1016/j.vaccine.2010.10.048

Mechanical Engineering

Hariharan P. M. Giarra V. Reddy **S. Day** K.B. Manning S. Deutsch S.F.C. Stewart M. R. Myers M. R. Berman G. W. Burgreen E. G. Paterson and R. A. Malinauskas "Multi laboratory Particle Image velocimetry analysis of the FDA benchmark nozzle model to support validation of round robin Computational Fluid Dynamics simulations" *Journal of Biomedical Engineering* vol. 133 2011 pp. 041002 1-14.

Cheng S. M.W. Olles L.D. Joyce D.B. Olsen **S.W. Day** (2010). "Miniaturization of a Magnetically Levitated Axial Flow Blood Pump" *Artificial Organs* vol. 34 2010 p. 807–815.

Oakes J. M. **S. Day S. J. Weinstein R. J. Robinson** (2010). “Flow field analysis in expanding healthy and emphysematous alveolar models using particle image velocimetry.” *ASME Journal of Biomechanical Engineering*.v.132

Holzman R. A. **S. W. Day** R. S. Mehta and P. C. Wainwright (2008). “Jaw protrusion enhances forces exerted on prey by suction feeding fishes.” *Journal of the Royal Society Interface* . 5: 1445-1457.

Holzman R. A. **S. W. Day** and P. C. Wainwright (2008). “Integrating the determinants of suction feeding performance in centrachid fishes.” *Journal of Experimental Biology*. 211: 3296-3305.

Holzman R. D. C. Collar **S. W. Day** K. L. Bishop and P. C. Wainwright (2008). “Scaling of suction-induced flows in bluegill: morphological and kinematic predictors for the ontogeny of feeding performance.” *Journal of Experimental Biology*. 16: 2658-2668.

Day S. W. T. E. Higham and P. C. Wainwright (2007) “Time resolved measurements of the flow generated by suction feeding fish.” ***Experiments in Fluids***. 43(5): 713-724.

Holzman R. A. **S. W. Day** and P. C. Wainwright (2007). “Timing is everything: coordination of strike kinematics affects the force exerted by suction feeding fish on attached prey.” ***Journal of Experimental Biology.*** 210: 3328-3336.

Wainwright P. C. A. M. Carroll D. C. Collar **S. W. Day** T. E. Higham and R. A. Holzman (2007). “Suction feeding mechanics performance and diversity in fishes.” ***Integrative and Comparative Biology.*** 47(1): 96-106.

Wainwright P.C and **S. W. Day**. (2007) "The forces exerted by aquatic suction feeders on their prey." ***Journal of the Royal Society Interface***. 4(14): 553-560

Ghoneim H. Lawrie D.J. Dynamic analysis of a hyperbolic composite coupling. Journal of Sound and Vibration 301:43-58 2007.

Ghoneim H. Dynamic analysis of a spinning composite “deep” hyperbolic coupling. International Journal of Solids and Structures 45:4484-4497 2008.

Norton M. M. **Robinson R. J.** and **Weinstein S. J.** 2011 Model of ciliary clearance and the role of mucus rheology *Physical Review E*. 83 011921 2011.

Oakes J. **Day S. Weinstein S**. and **R. Robinson**. Flow Field Analysis in Expanding Healthy and Emphysematous Alveolar Models Using Particle Image Velocimetry *Journal of Biomechanical Engineering*. Journal Of Biomechanical Engineering. 132(2) 2010.

Berg Emily J. J. Weisman M. Oldham **R. Robinson**. Flow fields in a compliant acinus replica model using particle image velocimetry. *Journal of Biomechanics* 43(6): 1039-1047. 2010.

Harding Edward M. Jr. and **Risa J. Robinson**. Flow in a terminal alveolar sac model with expanding walls using computational fluid dynamics. *Inhalation Toxicology*. 22(8): 669–678 2010.

Robinson R.J. Russo J. and R. Doolittle. 3D Airway reconstruction using visible human data set and human casts with comparison to morphometric data. *The Anatomical Record* 292:1028-1044 2009.

Robinson R.J. Snyder P. and Oldham M. Comparison of analytical and numerical particle deposition using commercial CFD packages: Impaction and sedimentation. *Inhalation Toxicology*. 20:485-497 2008.

Sumagin R **Lamkin-Kennard K.A.** Sarelius I. (2009) A Separate Role for ICAM-1 and Fluid Shear in Regulating Leukocyte Interactions with Straight Regions of Venular Wall and Venular Convergences *Microcirculation* 16(6): 508-520.

Hanzlik J.A. Cretekos E and **Lamkin-Kennard K.A.** (2008) Biomimetic Leukocyte Adhesion: A Review of Microfluidic and Computational Approaches and Applications Journal of Bionic Engineering 5(4) 317-327.

Skuse G **Lamkin-Kennard KA**. (Topic accepted in preparation). Reverse engineering life: Physical and Chemical Mimetics for Controlled Stem Cell Differentiation. In: Methods in Molecular Biology Ed: J. Walker Humana Press New York NY (invited book chapter)

Lamkin-Kennard KA Barrett C Amsler P Zerda A Charles N. (Submitted). Development of a Protocol for Testing the Effectiveness of Flushing as Part of Catheter Maintenance. *Research in Nursing & Health.*

Jung J. **Lamkin-Kennard KA** (Submitted). Modeling the Influences of Fluid Dynamics on Cell Rolling at Venular Convergences using Y-Shaped Micro-slides *Biorheology*.

Lamkin-Kennard K.A. Lerner A. and King M.R. (2007) Teaching Biomedical Engineering Ethics in the Context of Statistics *International Journal of Engineering Education* 23(1).

Orynbayeva Z Singhal R Vitol EA **Schrlau MG** Papazoglou E Friedman G Gogotsi Y. Physiological validation of cell health upon probing with carbon nanotube endoscope and its benefit for cell interrogation. (2011) *Nanomedicine* DOI:10.1016/j.nano.2011.08.008

Nui JJ **Schrlau MG** Friedman G Gogotsi Y. Carbon nanotube-tipped endoscope for in situ intracellular surface-enhanced Raman spectroscopy. (2011) *Small* 7:540-545.

Singhal R Orynbayeva Z Sundaram RVK Niu JJ Bhattacharyya S Vitol E **Schrlau MG** Papazoglou E Friedman G Gogotsi Y. (2011) Multifunctional nanotube-based cellular endoscopes. *Nature Nanotechnology* 6:57-64.

Thompson JA Du X Grogan JM **Schrlau MG** Bau HH. (2010) Polymeric microbead arrays for microfluidic applications. *J Micromech Microeng* 20:115017 (8pp).

Schrlau MG Bau HH. (2010) The application of carbon nanopipettes in bionanotechnology. *J Assoc Lab Automation* 15:145-151. (Invited review article for special issue on bionanotechnology April 2010)

Nguyen VD **Schrlau MG** Tran SBQ Bau HH Ko HS Byun D. (2009) Fabrication of nanoscale nozzle for electrohydrodynamic (EHD) inkjet head and high precision patterning by drop-on-demand operation. *J Nanosci Nanotechnol* 9:7298-7302.

Brailoiu E Churamani D Cai X **Schrlau MG** Brailoiu GC Gao X Hooper R Boulware MJ Dun NJ Marchant JS Patel S. (2009) Essential requirement for two-pore channel 1 in NAADP-mediated calcium signaling. *J Cell Biol* 186:201-209.

Liu C **Schrlau MG** Bau HH. (2009) Single bead-based electrochemical biosensor. *Biosens Bioelectron* 25:809-814.

Schrlau MG Bau HH. (2009) Carbon-based nanoprobes for cell biology. *Microfluid Nanofluid* 7:439-451. (Invited review article)

Vitol EA **Schrlau MG** Bhattacharyya S Ducheyne P Bau HH Friedman G Gogotsi Y. (2009) Effects of deposition conditions on the structure and chemical properties of carbon nanopipettes. *Chem Vapor Depos* 15:204-208.

Schrlau MG Dun NJ Bau HH. (2009) Cell electrophysiology with carbon nanopipettes. *ACS Nano* 3:563-568. (Featured in an editorial article titled "Bridging Macro and Nano" by P.T. Hammond)

Schrlau MG Brailoiu E Patel S Gogotsi Y Dun NJ Bau HH. (2008) Carbon nanopipettes characterize calcium release pathways in breast cancer cells. *Nanotechnology* 19:325102 (5pp).

Schrlau MG Falls ER Ziober BL Bau HH. (2008) Carbon nanopipettes for cell probes and intracellular injection. *Nanotechnology* 19:015101 (4pp). (Featured article with cover image; Listed among the "Most Accessed Articles in 2008")

R. Johnson **G. R. Tsouri** and E. Walsh "Continuous and Automated Measuring of Compliance of Hand-Hygiene Procedures Using Finite State Machines and RFID" IEEE Instrumentation & Measurement Magazine Apr. 2012.

G. R. Tsouri A. Sapio and J. Wilczewski "An Investigation into Relaying of Creeping Waves for Reliable Low-Power Body Sensor Networking" IEEE Transactions on Biomedical Circuits and Systems Aug. 2011.

Recent Faculty Journal Publications in support of Energy

Chemical and Biomedical Engineering

Landi B.J.; Ganter M.J.; Schauerman C.M.; Cress C.D.; Raffaelle R. P. "Lithium Ion Capacity of Single Wall Carbon Nanotube Paper Electrodes" *J. Phys. Chem. C.* 2008 112 7509-7515.

Cress C.D.; Landi B.J.; Raffaelle R.P. "Modeling of laterally-connected nipi-Diode radioisotope batteries." *IEEE Trans. Nucl. Sci*. 2008 55 1736-1743.

Cress C.D.; Redino C.S.; **Landi B.J.;** Raffaelle R.P. "Alpha-particle induced luminescence of rare-earth doped Y2O3 nanophosphors." J. of Solid State Chemistry 2008 181 2041-2045.

Landi B.J. DiLeo R.A. Schauerman C.M. Cress C.D. Ganter M.J. Raffaelle R.P. “Multi-walled carbon nanotube paper anodes for lithium ion batteries.” *J. Nanosci. and Nanotechnol*. 2009 9 3406–3410.

Ganter M.J.; **Landi B.J**.; Worman J.J.; Schauerman C.M.; Cress C.D.; Raffaelle R.P.; “Variation of Single Wall Carbon Nanotube Dispersion Properties with Alkyl Amide and Halogenated Aromatic Solvents.” *Mater. Chem. & Physics* 2009 116 235-241.

Schauerman C.M.; Alvarenga J.X.; **Landi B.J**.; Cress C.D.; Raffaelle R.P. “Impact of nanometal catalysts on the laser vaporization synthesis of single wall carbon nanotubes.” *Carbon* 2009 47 2431-2435.

Chow D. Cheng W.; Dai H.; Wagner S.R.; Luzzi S.D.; **Landi B.J**.; He L.; Illingsworth M.L. Siochi E.J. “Pendent Polyimides Using Mellitic Acid Dianhydride. IV. Effect of Increased Zirconium-Pendent Group Content on Polymer Properties.” *High Performance Polymers* 2009 21 744-764.

Landi B.J.; Ganter M.J.; C.M.; Cress C.D.; R.A. DiLeo; Raffaelle R. P. “Carbon Nanotubes for Lithium Ion Batteries.” Energy & Environ Sci. 2009 2 549.

Cress C.D.; Schauerman C.M.; **Landi B.J**.; Messenger S.R.; Raffaelle R.P.; Walters R.J.; “Radiation effects in single walled carbon nanotube papers.” *J. Appl. Phys*. 2010 107 014316.

Landi B.J.; Cress C.D.; Raffaelle R.P. “High energy density lithium ion batteries with carbon nanotube anodes.” *J. Mater. Res.* 2010 25 1636.

DiLeo R.A.; Ganter M.J.; Raffaelle R.P. **Landi B.J.**; “Germanium-Single Wall Carbon Nanotube Anodes for Lithium Ion Batteries.” *J. Mater. Res.* 2010 25 1441

C.D. Cress J.J. McMorrow J.T. Robinson A.L. Friedman and **B.J. Landi** “Radiation Effects in Single-Walled Carbon Nanotube Thin-Film-Transistors” *IEEE Trans. Nucl. Sci.* Dec (2010).

Dileo R.A.; Castiglia A.; Ganter M.J.; Rogers R.E.; Cress C.D.; Raffaelle R.P.; **Landi B.J**.; “Enhanced Capacity and Rate Capability of Carbon Nanotube Based Anodes with Titanium Contacts for Lithium Ion Batteries.” *ACS Nano* 2010 4 6121–6131.

Alvarenga J.; Jarosz P.R.; Schauerman C.M.; Moses B.T.; **Landi B.J**.; Cress C.D.; Raffaelle R.P.; “High conductivity carbon nanotube wires from radial densification and ionic doping.” *Appl. Phys. Lett.* 2010 97 182106.

Anctil A.; Babbitt C.W.; Raffaelle R.P.; **Landi; B.J**.; “Material and Energy Intensity of Fullerene Production.” Environ. Sci. Technol. 2011 45 2353–2359

Fagan J. A.; Simpson J. R.; **Landi B. J.**; Richter L. J.; Mandelbaum I.; Bajpai V.; Ho D. L.; Raffaelle R.; Hight Walker A. R.; Bauer B. J.; Hobbie E. K. ” Dielectric Response of Aligned Semiconducting Single-wall Nanotubes.” *Phys. Rev. Lett.* **2007** *98* 147402.

DiLeo R.A.; **Landi B.J.**; Raffaelle R.P. “Purity assessment of multiwalled carbon nanotubes by Raman spectroscopy.” *J. Appl. Phys*. **2007** *101* 064307.

Krysak M.; Parekh B.; Debies T.; DiLeo R.A.; **Landi B.J.**; Raffaelle R.P.; Takacs G.A. “Gas-phase surface functionalization of multi-walled carbon nanotubes with vacuum UV photo-oxidation.” *J. Adhesion Sci. Technol.* **2007** 21 999–1007.

Cress C.D.; Hubbard S.M.; **Landi B.J.**; Raffaelle R.P.; Wilt D.M. "Quantum dot solar cell tolerance to alpha-particle irradiation" *Appl. Phys. Lett.* **2007** *91* (18) 183108 / 1-3.

Krysak M.; Jayasekar A.; Parekh B.; Oliveira L.; Debies T.; Santhanam K. S. V.; DiLeo R. A.; **Landi B. J.**; Raffaelle R. P.; Takacs G. A.; “Gas-Phase Surface Functionalization of Carbon Nanotubes With UV Photo-Oxidation.” *Polymer Surface Modification: Relevance to Adhesion* K. L. Mittal (Ed.) **2009** *5* 125-137.

Ganter M.J.; DiLeo R.A.; Schauerman C.M.; Rogers R.E.; Raffaelle R.P.; **Landi B.J.**; “Differential scanning calorimetry analysis of an enhanced $LiNi_{0.8}Co_{0.2}O_2$ cathode with single wall carbon nanotube conductive additives.” *Electrochim. Acta* **2011** *56* 7272-7277.

Rogers R.E.; Bardsley T.I.; Weinstein S.J.; **Landi B.J.**; “Solution-phase adsorption of 1-pyrenebutyric acid using single-wall carbon nanotubes.” *Chem. Eng. J.* **2011** *173* 486-493.

Cress C.D.; McMorrow J.J.; Robinson J.T.; Friedman A.L.; Hughes H.L.; Weaver B.D.; **Landi B.J.**; “Total ionizing dose-hardened carbon nanotube thin-film transistors with silicon oxynitride gate dielectrics.” *MRS Communications* **2011** in press.

Jarosz P.; Schauerman C.; Alvarenga J.; Moses B.; Mastrangelo T.; Raffaelle R.; Ridgley R.; **Landi B.**; “Carbon Nanotube Wires and Cables: Near-Term Applications and Future Perspectives.” *Nanoscale* **2011** in press.

DiLeo R.A.; Frisco S.; Ganter M.J.; Rogers R.E.; Raffaelle R.P.; **Landi B.J.**; “Hybrid Germanium Nanoparticle-Single Wall Carbon Nanotube Free-Standing Anodes for Lithium Ion Batteries.” *J. Phys. Chem. C* **2011** accepted with revision.

C. Richter C. A. Schmuttenmaer “Exciton-like trap states limit electron mobility in TiO2 nanotubes” *Nature Nanotechnology* 5 769–772 2010.

C. Richter L. Menon “Impact of adsorbed alkali ions on photoelectrochemical hydrogen production by titania nanotubes” *Energy & Environmental Science* 3 427-433 2010.

W. R. McNamara R. C. Snoeberger **C. Richter** L. J. Allen R. L. Milot C. A. Schmuttenmaer R. H. Crabtree G. W. Brudvig V. S. Batista. “Hydroxamate anchors for water-stable attachment to TiO2 nanoparticles” *Energy & Environmental Science* 2 1173-1175 2010.

C. Richter C. Jaye E. Panaitescu D. Fischer L. Lewis R. Willey L. Menon “Effect of Potassium Adsorption on the Photochemical Properties of Titania Nanotube Arrays” *Journal of Materials Chemistry* 19 2963-2967 2009.

G. Li **C. Richter** R. L. Milot L. Cai C. A. Schmuttenmaer R. H. Crabtree G. W. Brudvig V. S. Batista. "Synergistic effect between anatase and rutile TiO_2 nanoparticles in dye-sensitized solar cells" *Dalton Transactions* 45 10078-10085 2009.

W. R. McNamara R. C. Snoeberger G. Li **C. Richter** L. J. Allen R. L. Milot C. A. Schmuttenmaer R. H. Crabtree G. W. Brudvig V. S. Batista. "Hydroxamate Anchors for Water-Stable attachment to TiO_2 nanoparticles" *Energy & Environmental Science* 2(11) 1173 -1175 2009.

M. Elmoula E. Panaitescu M. Phan D. Yin **C. Richter** L. Lewis L. Menon. "Controlled Attachment of Gold Nanoparticles on Ordered Titania Nanotube Arrays" *Journal of Materials Chemistry* 19 4483-4487 2009.

E. Panaitescu **C. Richter** L. Menon "A Study of Titania Nanotube Synthesis in Chloride Ion Containing Media" Journal of the Electrochemical Society 155(1) E7-E18 2008.

A. Friedman E. Panaitescu **C. Richter** L. Menon "Formation of Nanonoodles during anodization and Etching of Alumina and Titania" *Journal of Nanoscience and Nanotechnology* 8(11) 5864-5868 2008.

C. Richter E. Panaitescu R. Willey L. Menon "Titania nanotubes prepared by anodization in fluorine-free acids" *Journal of Materials Research* 22(6) 1624-1631 June 2007.

C. Richter Z. Wu E. Panaitescu R. Willey L. Menon "Ultra-High Aspect Ratio Titania Nanotubes" *Advanced Materials* 19(7) 946-948 April 2007.

C. Richter Z. Wu L. Menon "Pattern Formation in Nanoporous Titania Templates" *Journal of Nanoscience and Nanotechnology* 7 704–707 2007.

Z. Wu **C. Richter** L. Menon "A Study of Anodization Process during Pore Formation in Nanoporous Alumina Templates" *Journal of the Electrochemical Society* 154 E8 2007.

Shetty S. Ruschak K. J. and Weinstein S. J. 2011 Model for a two-cavity coating die with pressure and temperature deformation To appear in Polymer Engineering & Science.

Walker M.E.; McFarlane J.; Glasgow D.C.; Chung E.; **Taboada-Serrano P.**; Yiacoumi S.; Tsouris C. "Influence of radioactivity on surface interaction forces" *Journal of Colloid and Interface Science* **2010** 350:595.

Taboada-Serrano P.; Ulrich S.; Szymcek P.; McCallum S.; Phelps T. J.; Palumbo A.; Tsouris C. "A multi-phase micro-dispersion reactor for the continuous production of methane gas hydrate" *Ind. Eng. Chem. Res.* **2009** 48:6448.

Hou C.-H.; **Taboada-Serrano P.**; Yiacoumi S.; Tsouris C. "Monte Carlo simulation of electrosorption selectivity of ions from mixtures of electrolytes inside nanopores" *J. Chem. Phys.* **2008** 129:224703. (*This paper was selected by the American Institute of Physics and the American Physical Society for re-publication in the December 22 2008 issue of Virtual Journal of Nanoscale Science & Technology which is an edited compilation of articles from participating publishers covering a focused area of frontier research*.)

Taboada-Serrano P.; Hou C.-H.; Vithayaveroj V.; Yiacoumi S. Tsouris C. "Comparison between Effective Electrode/Eletrolyte Interface Potential and Applied Potential for Gold Electrodes" *Ind. Eng. Chem. Res.* **2008** 47:3525.

Szymcek P.; McCallum S.D.; **Taboada-Serrano P.**; Tsouris C. "A Pilot-Scale Continuous-Jet Hydrate Reactor" *Chem. Eng. J.* **2008** 135:71.

Hou C.-H.; **Taboada-Serrano P.**; Yiacoumi S.; Tsouris C. "Monte Carlo Simulations of Electrical Double-layer Formation from Mixtures of Electrolytes inside Nanopores" *J. Chem. Phys.* **2008** 128:044705.

Tsouris C.; Szymcek P.; **Taboada-Serrano P.**; McCallum S.D.; Adams E.; Chow A.; Brewer P.; Peltzer E.; Walz P.; Johnson W.K.; Summers J. "Scaled-up Ocean Injection of CO_2-hydrate Composite Particles" *Energy & Fuels* **2007** 21:3300.

Barlow N. S. Helenbrook B. T. Lin S.P. and **Weinstein S. J.** 2010 An Interpretation of absolutely and convectively unstable waves using series solutions *Wave Motion* 47 564-582.

Theisen E. A. Davis M. **Weinstein S. J.** and Steen P. H. 2010 Transient behavior of the planar-flow melt spinning process *Chem. Eng. Sci*. 65 3249–3259.

Barlow N. S. **Weinstein S. J**. Helenbrook B. T. and Lin S. P. 2011 On the response of spatially developing flow to oscillatory forcing with application to liquid sheets Submitted to *Journal of Fluid Mechanics.*

Rogers R. E. Bardsley T. L. **Weinstein S. J**. and **Landi B**. J. 2011 Solution-phase adsorption of 1-pyrenebutyric acid using single-wall carbon nanotubes *Chemical Engineering Journal* **173** 486-493.

Shetty S. **Ruschak K. J**. and **Weinstein S. J**. 2011 Model for a two-cavity coating die with pressure and temperature deformation To appear in *Polymer Engineering & Science*.

Sandoz-Rosado E. J. **Stevens R. J.** and **Weinstein S. J**. 2011 On the Thomson Effect in thermoelectric devices Submitted to *Applied Energy*.

Norton M. M. **Robinson R. J**. and **Weinstein S. J.** 2011 Model of ciliary clearance and the role of mucus rheology *Physical Review E* **83** 011921-1 to -12.

Oakes J. M. **Day S. Weinstein S. J.** and **Robinson R. J.** 2010 Flow field analysis in expanding healthy and emphyematous alveolar models using particle image velocimetry *J. Biomech. Eng.* **132** 021008-1 to -9.

Computer Engineering

G. Minana J.I. Hidalgo J. Lanchares J.M. Colmenar O. Garnica **S. Lopez**. Reducing Power of Functinal Units in High Performance Processors by Checking Instruction Codes and Resizing Adders. IET Computing and Digital Systems. 2007

S. Lopez O. Garnica D. Albonesi S. Dropsho J. Lanchares J.I. Hidalgo. A Phase Adaptive Cache Hierarchy for SMT Processors. Microprocessors and Microsystems. 2011

J.K.Hicks **D. Kudithipudi** “Hybrid Subthreshold and Nearthreshold Design Methodology for Energy Minimization” *J. Low Power Electronics* Vol. 7 1–13 2011

S.H. Tavva **D.Kudithipudi** “Characterization of Variation Aware Nanoscale SRAM Designs” *J. Low Power Electronics* Vol. 6 N°1 April 2010.

D. Kudithipudi and E. John "Characterization of Adder circuits in Nanotechnology Designs" *International Journal of Embedded Systems* Volume 4 Number 1 / 2009 Pages: 17 – 26 2009.

D.KudtihipudiS.Petko and E.John “Caches for Multimedia Workloads: Power and Energy Trade-offs” *IEEE Transactions on Multimedia* Vol. 10(6) pp: 1013-1021 (2008).

Industrial and Systems Engineering

Harrysson O Cansizoglu O. Marcellin-Little D. **Cormier D**. and West H. (2008) "Direct Metal Fabrication of Titanium Implant Components With Tailored Materials and Mechanical Properties Using Electron Beam Melting Technology" *Materials Science & Engineering C* 28(3) pp. 366-373.

Cansizoglu O. Harrysson O. **Cormier D.** West H. and Mahale T.(2008) ”Properties of Ti-6Al-4V Non-stochastic Lattice Structures Fabricated Via Electron Beam Melting” *Materials Science & Engineering A* 492(1-2) pp. 468-474.

Cottrell C.A. **Grasman S.E.** Thomas M. Martin K.B. and Sheffield J.W. “Best Practices for Stationary and Portable Fuel Cell Markets” International Journal of Hydrogen Energy 36(13) 7969-7975 2011.

Martin K.B. and **Grasman S.E.** “An Assessment of Wind-Hydrogen Systems for Light Duty Vehicles” International Journal of Hydrogen Energy 34(16) 6581-6588 2009.

Rodgers S.F. Vudumu S.K. **Grasman S.E.** Murray S.L. and Koylu U. “Hydrogen Safety in Power Generation Applications” Professional Safety 55(9) 39-44 2010.

Thomas M. Martin K.B. **Grasman S.E.** Sheffield J.W. and Anculle E.A. “Design Layout of a Hydrogen Research and Development Garage” International Journal of Hydrogen Energy 36(13) 8017-8022 2011.

Wright C. Baur S. Grantham K. Stone R.B. and **Grasman S.E.** “Residential Energy Performance Metrics” Energies 3(6) 1194-1211 2010.

Briceno C.M. Carrano A.L. **Thorn B.K**. Esterman M. (2009). A design optimization framework to estimate environmental impacts of design decisions in consumer products. Journal of Green Building. Vol 4. No. 2 pp: 141-149.

Carrano A.L. **Thorn B.K**. and Lopez G. (2006). An integer programming approach to the construction of trend-free experimental plans on split-plot designs. Journal of Manufacturing Systems. SME. Vol 25. No 1. pp: 39-44.

Thorn B.K. Carrano A.L. Plaz C.R. Wood C.R. and Guedez E. ; User-Driven Design of Low-Cost Low Impact Solar Ovens for Rural Populations in Developing Countries; Journal of Engineering for Sustainable Development: Energy Environment and Health. Summer 2006.

Mechanical Engineering

Sandoz-Rosado E. **Stevens R. J** “Experimental Characterization of Thermoelectric Modules and Comparison with Theoretical Models for Power Generation” *Journal of Electronic Materials* Vol. 38 pp. 1239-1244 2009

Hopkins P.E. Norris P.M. **Stevens R.J.** “Influence of inelastic scattering at metal-dielectric interfaces.” *Journal of Heat Transfer* Vol. 130 pp 022401:1-9 2008.

Hopkins P.E. Norris P.M. **Stevens R.J.** Beechem T.E. Graham S. “Influence of Interfacial Mixing on Thermal Boundary Conductance across a Chromium/Silicon Interface” *Journal of Heat Transfer* Vol. 130 pp 062402:1-10 2008.

Salaway R. N. Hopkins P. E. Norris P. M. **Stevens R** “Phonon Contribution to Thermal Boundary Conductance at Metal Interfaces Using Embedded Atom Method Simulations” *International Journal of Thermophysics* Vol. 29 pp. 1987-1996 2008

Sandoz-Rosado E. **Stevens R. J** “Robust Finite Element Model for the Design of Thermoelectric Modules” *Journal of Electronic Materials* Vol. 39 pp. 1848-1855 2010.

Stevens R.J. Norris P.M. and Zhigilei L.V. “Effects of Temperature and Disorder on Thermal Boundary Conductance at Solid-Solid Interfaces: Nonequilibrium Molecular Dynamics Simulations” *International Journal of Heat and Mass Transfer* Vol. 50 pp. 3977-3989 2007

Hopkins P.E. Salaway R.N. **Stevens R.J.** Norris P.M. “Temperature dependent thermal boundary conductance at Al/Al_2O_3 and Pt/Al_2O_3 interfaces.” *International Journal of Thermophysics* Vol. 28 pp. 947-957 2007.

Gomes M. Ruina A. "Walking model with no energy cost" *Physical Review E* Vol. 83 pp. 6-9 2011

George E. **Bailey M**. Domigan W. [2010] Health monitoring methodology based on exergetic analysis for building mechanical systems. *Energy International Journal* V. 35 (2010) pp. 1216–1223.

Canfield E. **Bailey M.** Domigan W. [2010] Creation of an exergetic based fault detection and diagnosis methodology for automotive carbon dioxide air conditioning systems. *International Journal of Applied Thermodynamics* V. 13(1) pp 1-8.

Kandlikar, S. G.; Garofalo, M. L.; Lu, Z., Water Management in A PEMFC: Water Transport Mechanism and Material Degradation in Gas Diffusion Layers, FUEL CELLS Volume: 11   Issue: 6   Special Issue: SI Pages: 814-823   DOI: 10.1002/fuce.201000172   Published: DEC 2011

Yao, Z.; Lu, Y. -W.; **Kandlikar, S. G**., Effects of nanowire height on pool boiling performance of water on silicon chips, INTERNATIONAL JOURNAL OF THERMAL SCIENCES Volume: 50 Issue: 11 Pages: 2084-2090 DOI: 10.1016/j.ijthermalsci.2011.06.009 Published: NOV 2011

Sergi, Jacqueline M.; **Kandlikar, Satish G.,** Quantification and characterization of water coverage in PEMFC gas channels using simultaneous anode and cathode visualization and image processing, INTERNATIONAL JOURNAL OF HYDROGEN ENERGY Volume: 36 Issue: 19 Pages: 12381-12392 DOI: 10.1016/j.ijhydene.2011.06.092 Published: SEP 2011

Lu Zijie; Rath Cody; Zhang Guangsheng; **Kandlikar S.G**. et al. Water management studies in PEM fuel cells part IV: Effects of channel surface wettability geometry and orientation on the two-phase flow in parallel gas channels INTERNATIONAL JOURNAL OF HYDROGEN ENERGY Volume: 36 Issue: 16 Pages: 9864-9875 DOI: 10.1016/j.ijhydene.2011.04.226 Published: AUG 2011

Rath Cody D.; **Kandlikar Satish G.** Liquid filling in a corner with a fibrous wall-An application to two-phase flow in PEM fuel cell gas channels COLLOIDS AND SURFACES A-PHYSICOCHEMICAL AND ENGINEERING ASPECTS Volume: 384 Issue: 1-3 Pages: 653-660 DOI: 10.1016/j.colsurfa.2011.05.039 Published: JUL 5 2011

Yao Zhonghua; Lu Yen-Wen; **Kandlikar Satish G.** Direct growth of copper nanowires on a substrate for boiling applications MICRO & NANO LETTERS Volume: 6 Issue: 7 Pages: 563-566 DOI: 10.1049/mnl.2011.0136 Published: JUL 2011

Mukherjee A.; **Kandlikar S. G.;** Edel Z. J. Numerical study of bubble growth and wall heat transfer during flow boiling in a microchannel INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER Volume: 54 Issue: 15-16 Pages: 3702-3718 DOI: 0.1016/ j.ijheatmasstransfer.2011.01.030 Published: JUL 2011

Cooke Dwight; **Kandlikar Satish G.** Pool Boiling Heat Transfer and Bubble Dynamics Over Plain and Enhanced Microchannels JOURNAL OF HEAT TRANSFER-TRANSACTIONS OF THE ASME Volume: 133 Issue: 5 Article Number: 052902 DOI: 10.1115/1.4003046 Published: MAY 2011

LaManna Jacob M.; **Kandlikar Satish G.** Determination of effective water vapor diffusion coefficient in pemfc gas diffusion layers INTERNATIONAL JOURNAL OF HYDROGEN ENERGY Volume: 36 Issue: 8 Pages: 5021-5029 DOI: 10.1016/j.ijhydene.2011.01.036 Published: APR 2011

Lu Yen-Wen; **Kandlikar Satish G**. Nanoscale Surface Modification Techniques for Pool Boiling EnhancementA Critical Review and Future Directions HEAT TRANSFER ENGINEERING Volume: 32 Issue: 10 Pages: 827-842 Article Number: PII 931767936 DOI: 10.1080/ 01457632.2011.548267 Published: 2011

Daino MM Lu Z LaManna JM et al. **Kandlikar SG "** Through-Plane Water Transport Visualization in a PEMFC by Visible and Infrared Imaging **"** ELECTROCHEMICAL AND SOLID STATE LETTERS Volume: 14 Issue: 6 Pages: B51-B54 Published: 2011

Kandlikar SG " Selected Papers from the Seventh International Conference on Nanochannels Microchannels and Minichannels **"** HEAT TRANSFER ENGINEERING Volume: 32 Issue: 7-8 Pages: 525-526 Published: 2011.

Cooke D **Kandlikar SG "** Pool Boiling Heat Transfer and Bubble Dynamics Over Plain and Enhanced Microchannels **"** JOURNAL OF HEAT TRANSFER-TRANSACTIONS OF THE ASME Volume: 133 Issue: 5 Article Number: 052902 Published: MAY 2011

Kandlikar SG Sergi J LaManna J et al. **"** HYDROGEN HORIZON **"** MECHANICAL ENGINEERING Volume: 131 Issue: 5 Pages: 32-35 Published: MAY 2009

Kandlikar SG " A Scale Analysis Based Theoretical Force Balance Model for Critical Heat Flux (CHF) During Saturated Flow Boiling in Microchannels and Minichannels **"** JOURNAL OF HEAT TRANSFER-TRANSACTIONS OF THE ASME Volume: 132 Issue: 8 Article Number: 081501 Published: AUG 2010

Kandlikar SG " Scale effects on flow boiling heat transfer in microchannels: A fundamental perspective**"** INTERNATIONAL JOURNAL OF THERMAL SCIENCES Volume: 49 Issue: 7 Pages: 1073-1085 Published: JUL 2010

Lu ZJ Daino MM Rath C et al. **Kandlikar SG "** Water management studies in PEM fuel cells part III: Dynamic breakthrough and intermittent drainage characteristics from GDLs with and without MPLs **"** INTERNATIONAL JOURNAL OF HYDROGEN ENERGY Volume: 35 Issue: 9 Pages: 4222-4233 Published: MAY 2010

Kandlikar SG, " Microchannels: Rapid Growth of a Nascent Technology **"** JOURNAL OF HEAT TRANSFER-TRANSACTIONS OF THE ASME Volume: 132 Issue: 4 Article Number: 040301 Published: APR 2010

Kandlikar SG, " Selected papers from the Fifth International Conference on Nanochannels Microchannels and Minichannels **"** HEAT TRANSFER ENGINEERING Volume: 31 Issue: 8 Pages: 627-627 Published: 2019

Kandlikar SG " Similarities and Differences Between Flow Boiling in Microchannels and Pool Boiling**"** HEAT TRANSFER ENGINEERING Volume: 31 Issue: 3 Pages: 159-167 Published: 2010

Mukherjee A, **Kandlikar SG "** The effect of inlet constriction on bubble growth during flow boiling in microchannels **"** INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER Volume: 52 Issue: 21-22 Pages: 5204-5212 Published: OCT 2009

Kandlikar, S. G.; Lu, Z.; Lin, T. Y.; et al., Uneven gas diffusion layer intrusion in gas channel arrays of proton exchange membrane fuel cell and its effects on flow distribution, JOURNAL OF POWER SOURCES Volume: 194 Issue: 1 Pages: 328-337 DOI: 10.1016/j.jpowsour.2009.05.019 Published: OCT 20 2009

Kandlikar SG Lu ZJ **"**Fundamental Research Needs in Combined Water and Thermal Management Within a Proton Exchange Membrane Fuel Cell Stack Under Normal and Cold-Start Conditions **"** JOURNAL OF

FUEL CELL SCIENCE AND TECHNOLOGY Volume: 6 Issue: 4 Article Number: 044001 Published: NOV 2009

Kandlikar, Satish G.; Lu, Zijie, Thermal management issues in a PEMFC stack - A brief review of current status, APPLIED THERMAL ENGINEERING Volume: 29 Issue: 7 Pages: 1276-1280 DOI: 10.1016/j.applthermaleng.2008.05.009 Published: MAY 2009

Owejan JP Gagliardo JJ Sergi JM et al. **Kandlikar SG "** Water management studies in PEM fuel cells Part I: Fuel cell design and in situ water distributions **"** INTERNATIONAL JOURNAL OF HYDROGEN ENERGY Volume: 34 Issue: 8 Pages: 3436-3444 Published: MAY 2009

Lu Z **Kandlikar SG** Rath C et al. **"** Water management studies in PEM fuel cells Part II: Ex situ investigation of flow maldistribution pressure drop and two-phase flow pattern in gas channels **"** INTERNATIONAL JOURNAL OF HYDROGEN ENERGY Volume: 34 Issue: 8 Pages: 3445-3456 Published: MAY 2009

Kandlikar SG Hayner CN **"** Liquid Cooled Cold Plates for Industrial High-Power Electronic DevicesThermal Design and Manufacturing Considerations**"** HEAT TRANSFER ENGINEERING Volume: 30 Issue: 12 Pages: 918-930 Published: 2009

Kandlikar SG Lu Z Domigan WE et al. **"** Measurement of flow maldistribution in parallel channels and its application to ex-situ and in-situ experiments in PEMFC water management studies **"** INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER Volume: 52 Issue: 7-8 Pages: 1741-1752 Published: MAR 2009

Kandlikar SG " Selected papers from the Fifth International Conference on Nanochannels Microchannels and Minichannels **"** HEAT TRANSFER ENGINEERING Volume: 30 Issue: 1-2 Pages: 1-1 Published: 2009

Perry JL, **Kandlikar SG** . "Fouling and its mitigation in silicon microchannels used for IC chip cooling" MICROFLUIDICS AND NANOFLUIDICS Volume: 5 Issue: 3 Pages: 357-371 Published: SEP 2008.

Brackbill, Timothy P.; **Kandlikar, Satish G.** Application of Lubrication Theory and Study of Roughness Pitch During Laminar, Transition, and Low Reynolds Number Turbulent Flow at Microscale . HEAT TRANSFER ENGINEERING Volume: 31 Issue: 8 Pages: 635-645 DOI: 10.1080/01457630903466621 Published: 2010

Kandlikar SG" Microscale and macroscale aspects of water management challenges in PEM fuel cells" HEAT TRANSFER ENGINEERING Volume: 29 Issue: 7 Pages: 575-587 Published: JUL 2008.

Kandlikar SG" Exploring roughness effect on laminar internal flow-are we ready for change?" NANOSCALE AND MICROSCALE THERMOPHYSICAL ENGINEERING Volume: 12 Issue: 1 Pages: 61-82 Published: JAN-MAR 2008

Kuan WK **Kandlikar SG**. "Experimental study and model on critical heat flux of refrigerant-123 and water in microchannels" JOURNAL OF HEAT TRANSFER-TRANSACTIONS OF THE ASME Volume: 130 Issue: 3 Article Number: 034503 Published: MAR 2008

Varela B. Rogers J.W. " Mechanical response of discontinuous filament PVA fiber reinforced Geopolymers" PROCEEDINGS OF THE 35TH INTERNATIONAL CONFERENCE ON ADVANCED CERAMICS AND COMPOSITES" Published July 2011.

Svingala F **Varela B** "Alkali Activated Aerogels" MECHANICAL PROPERTIES AND PERFORMANCE OF ENGINEERING CERAMICS AND COMPOSITES IV volume 30 issue 2 Published 2009.

Recent Faculty Journal Publications in support of Communications

Computer Engineering

Amlan Ganguly Kevin Chang Sujay Deb Partha Pande Benjamin Belzer Christof Teuscher "Scalable Hybrid Wireless Network-on-Chip Architectures for Multi-Core Systems" IEEE Transactions on Computers (**TC**) August 2010 URL: http://www.computer.org/portal/web/csdl/doi/10.1109/TC.2010.176.

Amlan Ganguly Partha Pande Benjamin Belzer "Crosstalk-Aware Channel Coding Schemes for Energy Efficient and Reliable NoC Interconnects" IEEE Transactions on VLSI (**TVLSI**) Vol. 17 No.11 November 2009 pp. 1626-1639.

Amlan Ganguly Partha Pande Benjamin Belzer Cristian Grecu "Design of Low power & Reliable Networks on Chip through joint Crosstalk Avoidance and Multiple Error Correction Coding" Journal of Electronic Testing: Theory and Applications (**JETTA**) Special Issue on Defect and Fault Tolerance June 2008 pp. 67-81.

Partha Pande **Amlan Ganguly** Haibo Zhu Cristian Grecu "Energy Reduction through Crosstalk Avoidance Coding in Networks on Chip" Journal of System Architecture (**JSA**) Vol. 54/ 3-4 March-April 2008 pp.441-451.

Kevin Chang Sujay Deb Amlan Ganguly Xinmin Yu Suman Prasad Sah Partha Pratim Pande Benjamin Belzer and Deukhyoun Heo "Performance Evaluation and Design Trade-Offs for Wireless Network-on-Chip Architectures" Accepted for publication in ACM Journal on Emerging Technologies in Computing Systems (JETC) September 2011.

Su G.-M. Lai Y.-C. **Kwasinski A.** and Wang H. (2011) 3D video communications: Challenges and opportunities. International Journal of Communication Systems 24: n/a. doi: 10.1002/dac.1190

K. Seddik **A. Kwasinski** and K. J. R. Liu "Asymptotic Distortion Performance of Source-Channel Diversity over Multi-hop and Relay Channels" IEEE Transactions on Mobile Computing vol. 9 issue 2 pp. 270-287 Feb. 2010

A. El Sherif **A. Kwasinski** A. K. Sadek K. J. Ray Liu ``Content-Aware Cooperative Multiple Access Protocol for Packet Speech Communications'' IEEE Transactions on Wireless Communications vol. 8 issue 2 pp. 995-1005 Feb. 2009.

A. Kwasinski and K. J. R. Liu ``Source-Channel-Cooperation Tradeoffs for Adaptive Coded Communications'' IEEE Transactions on Wireless Communications vol. 7 issue 9 pp. 3347-3358 Sept. 2008.

A. Kwasinski and K. J. R. Liu ``Towards a Unified Framework for Modeling and Analysis of Diversity in Joint Source-Channel Coding'' IEEE Transactions on Communications vol. 56 issue 1 pp. 90-101 Jan. 2008.

K. J. R. Liu A. K. Sadek W. Su **A. Kwasinski** "Cooperative Communications and Networking" (650 pages) Cambridge University Press 2009.

F. Hu Q. Hao **M. Lukowiak** Q. Sun K. Wilhelm S. Radziszowski and Y. Wu Trustworthy Data Collection from Implantable Medical Devices via High-Speed Security Implementation Based on IEEE 1363 IEEE Transactions on Information Technology in Biomedicine 14(6) (2010) 1397-1404.

F. Hu X. Cao K. Wilhelm **M. Lukowiak** and S. Radziszowski NTRU-based confidential data transmission in telemedicine sensor networks Security in Ad Hoc and Sensor Networks Singapore World Scientific 2010 159-192.

F. Hu K. Wilhelm M. Schab **M. Lukowiak** S. Radziszowski and Y. Xiao "NTRU-based Sensor Network Security: A Low-power Hardware Implementation Perspective" International Journal of Security and Communication Networks Wiley Vol. 2(1) January/February 2009.

A. Savakis **M. Lukowiak** and J.Pyle "FPGA Implementation of a Lossless to Lossy Bitonal Image Compression System" Electronics and Communications Quarterly Polish Academy of Sciences Vol. 54 (4) December 2008.

G. Tsagkatakis and **A. Savakis** "Online Distance Metric Learning for Object Tracking" to appear in IEEE Trans. Circuit and Systems for Video Technology 2011.

J. S. Schildkraut N. Prosser **A. Savakis** J. Gomez A. Singh D. Nazareth H. K. Malhotra "Level Set Segmentation of Pulmonary Nodules in Megavolt Electronic Portal Images Using a CT Prior" to appear in Medical Physics 2011.

S. J. Yang A. Stotz J. Holsopple M. Sudit and **M. Kuhl** "*High Level Information Fusion for Tracking and Projection of Multistage Cyber Attacks*" Elsevier International Journal on Information Fusion Special Issue on High-level Information Fusion and Situation Awareness Vol. 10 No. 1 pp.107-121 January 2009.

D. Fava S. R. Byers **S. J. Yang** "*Projecting Cyber Attacks through Variable Length Markov Models*" IEEE Transactions on Information Forensics and Security Vol. 3 Issue 3 September 2008.

Electrical and Micro-Electronic Engineering:

M. Jaber and **E. Saber** "Probabilistic Approach for Extracting Regions of Interest in Digital Images" Journal of Electronic Imaging Vol. 19 No. 2 April - June 2010.

X. Fan H. Rhody and **E. Saber** "A Spatial Feature Enhanced MMI Algorithm for Multimodal Airborne Image Registration" IEEE Transaction on Geoscience and Remote Sensing Vol. 48 Issue 6 pp. 2580 – 2589 2010.

P. Gurram **E. Saber** and H. Rhody "A Segment-Based Mesh design for Building Parallel-Perspective Stereo Mosaic" IEEE Transactions on Geoscience and Remote Sensing Vol. 48 No. 3 March 2010.

S. Vantaram **E. Saber S. Dianat** M. Shaw and R. Bashkar "Multiresolution Adaptive and Progressive Gradient-based color image Segmentation" Journal of Electronic Imaging Volume 19 Number 1 pp. 1-21 January-March 2010.

L. Garcia **E. Saber** S. Vantaram **V. Amuso** M. Shaw and R. Bhaskar "Automatic Image Segmentation by Dynamic Region Growth and Multi-resolution Merging" IEEE Transactions on Image Processing Vol. 18 No. 10 Oct. 2009.

G. R. Tsouri and D. Wulich "Securing OFDM over Wireless Time-Varying Channels using Sub-Carrier Over-Loading with Joint Signal Constellations" Eurasip Journal on Wireless Communications & Networking - Special Issue on Wireless Physical Layer Security Volume 2009 Article ID 437824 2009.

G. R. Tsouri D. Wulich and L. Goldfeld "Enabling Dual Branch Switched Diversity in Compact Wireless Devices" IEEE Trans. on Consumer Electronics Nov. 2008.

G. R. Tsouri and D. Wulich "Capacity Analysis and Optimisation of OFDM with Distortionless PAPR Reduction" European Trans. on Communications (ETT) Aug. 2008.

Industrial and Systems Engineering

Kuhl M.E. J.S. Ivy E.K. Lada N.M. Steiger M.A. Wagner and J.R. Wilson. (2010) Univariate Input Models for Stochastic Simulation *Journal of Simulation* 4 81-97.

Recent Faculty Journal Publications in support of Transportation

Electrical and Micro-Electronic Engineering:

Iheanyi C. Umez-Eronini and **F Sahin**" Decision Theoretic Agent Design for Personal Rapid Transit Systems" Engineering Letters 15:2 pages 266 – 271 December 2007.

Pasupuleti A. **Sahin F**. "Application of soft computing techniques to estimate the effective Young's Modulus of Thin Film Materials" Engineering Letters 14:2 pages 95 – 102 June 2007.

Sahin F. Yavuz C. M. Arnavut Z. and Uluyol O. "Fault Diagnosis for Airplane Engines using Bayesian Networks and Distributed Particle Swarm Optimization" Parallel Computing vol. 33 issue 2 pp. 124 - 143 March 2007.

Industrial and Systems Engineering

Bahaji N. and **M.E. Kuhl** (2008) A Simulation Study of New Multi-objective Composite Dispatching Rules CONWIP and Push Lot Release in Semiconductor Fabrication. *International Journal of Production Research* 46 (14) 3801–3824.

Juan A.A. Faulin J. Grasman S.E. Riera D. and Méndez C. "Using Safety Stocks and Simulation to Solve the VRP with Stochastic Demands" Transportation Research Part C 19(5) 751-765 2011.

Sari Z. Grasman S.E. and Ghouali N. "Impact of Pickup/Delivery Stations and Restoring Conveyor Locations on Retrieval Time Models of Flow Rack AS/RS" Production Planning and Control 18(2) 105-116 2007.

Jarugumilli S. and Grasman S.E. "RFID-Enabled Inventory Routing Problems" International Journal of Manufacturing Technology and Management – Special Issue on Connective Technologies and Their Impact on Manufacturing and Logistics 10(1) 92-105 2007.

Mechanical Engineering

J.P. Nolan and **J.R. Kolodziej.** "Modeling of an automotive fuel cell thermal system" Journal of Power Sources 195 (2010): 4743-4752.

J.R. Kolodziej and D.J. Mook. "Model determination for nonlinear state-based system identification" Nonlinear Dynamics Accepted: September 2 2010 Available Online: September 18 2010.

J.R. Kolodziej "Thermal Dynamic Modeling and Nonlinear Control of a Proton Exchange Membrane Fuel Cell Stack" ASME Journal of Fuel Cell Science and Technology vol. 4 no. 3 pp. 255-260 Aug. 2007.

S. Boedo "Mass Conserving Cavitation Effects in Squeeze-Film Journal Bearings Subjected to Sinusoidal Loads" *STLE Tribology Transactions* vol. 54 2011 pp. 21-35.

J.F. Booker **S. Boedo** and D. Bonneau "Conformal EHL Analysis for Engine Bearing Design: A Brief Review" *Proceedings of theInstitution of Mechanical Engineers Part C: Journal of Mechanical Engineering Science* vol. 224 2010 pp. 2648-2653.

S. Demiri **S. Boedo** and W.J. Grande "Conformality Effects on the Wear of Low-Speed Large Aspect Ratio Silicon Journal Microbearings" *Wear* vol. 268 2010 pp. 361-372.

S. Boedo and J.F. Booker "Dynamics of Offset Journal Bearings—Revisited" *Proceedings of the Institution of Mechanical Engineers Part J: Journal of Engineering Tribology* vol. 223 n. 3 2009 pp. 359-369 606-607.

R.P. Neward and **S. Boedo** "Analysis of Tensioner Induced Coupling in Serpentine Belt Drive Systems" *SAE International Journal of Passenger Cars—Mechanical Systems* vol. 1 2009 pp.1009-1017.

S. Boedo Discussion of "Observations of Film Thickness Profile and Cavitation around a Journal Bearing Circumference" by S. Kasolang and R.S. Dwyer-Joyce *STLE Tribology Transactions* vol. 51 2008 pp. 242-244.

7. Curriculum

The Ph.D. in Engineering curriculum is designed to provide industrial and societal grand challenge inspired training and education through disciplinary and interdisciplinary courses, research mentorship and engineering focus area seminars. Students completing the Ph.D. in Engineering degree are expected to have a disciplinary-rooted technical strength to conduct and complete independent, original and novel collaborative interdisciplinary research contributing to a industrial and/or societal challenge.

The degree requirement comprises of a minimum of 66 semester credit hours, with a minimum of 30 course credits, 6 Engineering Focus Area Seminar credits and 30 research credits. The course requirements include the following: a **Interdisciplinary Research Methods** course that goes beyond a traditional research methods course and emphasizes interdisciplinary collaboration in modern research environment; two **Engineering Analytics** courses to build the mathematical foundation to conduct research; a **Translating Discovery into Practice in Healthcare / Energy / Communications / Transportation** course that provides a comprehensive overview of problems and solution approaches across engineering disciplines for modern industrial and societal challenges for students in each specific focus area; three **Disciplinary Foundation** courses that build the technical depth within one's discipline; and three **Focus Area Electives** to provide specialized knowledge and skill-sets relevant to the student's dissertation research within the selected focus area, which can be outside the student's primary engineering discipline. In addition to the courses, The **Focus Area Seminar** provides a broad exposure to industrial and societal grand challenges, fostering interdisciplinary interactions and collaboration among students and faculty specialized in different technical areas.

The table below shows an example schedule for entering students with BS degree in engineering disciplines. The student will take the Comprehensive Exam at the end of Year 1, the Dissertation Proposal no sooner than six months after the Comprehensive Exam and at least six months prior to the Candidacy Exam. The Dissertation Defense can occur after completion of the course requirements and at least six months after the Candidacy Exam. A minimum of three-year residency with the Ph.D. program is required before completing the degree.

The Comprehensive Exam evaluates the student's aptitude, potential and competency in conducting Ph.D. level research. The Dissertation Proposal Defense provides the opportunity for the student to elaborate and obtain feedback for his/her research direction and approaches from his/her dissertation committee. The Candidacy Exam provides comprehensive feedback to the student regarding their dissertation research progress and expected outcomes prior to Defense. The student will prepare an original, technical sound and well-written dissertation and complete his/her degree requirement with the Dissertation Defense.

TABLE: PROGRAM SCHEDULE EXAMPLE

Term: Fall 1		Term: Spring 1	
Course Number & Title	Credits	Course Number & Title	Credits
KGCOE-XXXX-805 Engineering Analytics Foundation	3	KGCOE-XXXX-XXX Engineering Analytics Elective	3
KGCOE-XXXX-800 Interdisciplinary Research Methods **(1 new course)**	3	KGCOE-XXXX-8X0 Translating Discovery into Practice in XXX **(4 new courses, 1 per focus area)**	3
KGCOE-XXXX-XXX Discipline Foundation 1	3	KGCOE-XXXX-XXX Discipline Foundation 3	3
KGCOE-XXXX-XXX Discipline Foundation 2	3	KGCOE-XXXX-XXX Dissertation Research	3
KGCOE-XXXX-890 Engineering Focus Area Seminar	1	KGCOE-XXXX-890 Engineering Focus Area Seminar	1
Term credit total:	13	Term credit total:	13
		Comprehensive Exam	
Term: Fall 2		Term: Spring 2	
Course Number & Title	Credits	Course Number & Title	Credits
KGCOE-XXXX-XXX Cross-disciplinary Elective 1	3	KGCOE-XXXX-XXX Cross-disciplinary Elective 3	3
KGCOE-XXXX-XXX Cross-disciplinary Elective 2	3		
KGCOE-XXXX-XXX Dissertation Research	3	KGCOE-XXXX-XXX Dissertation Research	6
KGCOE-XXXX-890 Engineering Focus Area Seminar	1	KGCOE-XXXX-890 Engineering Focus Area Seminar	1
Term credit total:	10	Term credit total:	10
		Dissertation Proposal Defense	
Term: Fall 3		Term: Spring 3	
Course Number & Title	Credits	Course Number & Title	Credits
KGCOE-XXXX-XXX Dissertation Research	9	KGCOE-XXXX-XXX Dissertation Research	9
KGCOE-XXXX-890 Engineering Focus Area Seminar	1	KGCOE-XXXX-890 Engineering Focus Area Seminar	1
Term credit total:	10	Term credit total:	10
		Candidacy Exam	
Term: Fall 4		Term: Spring 4	
Course Number & Title	Credits	Course Number & Title	Credits
KGCOE-XXXX-XXX Continuation of Dissertation	0	KGCOE-XXXX-XXX Continuation of Dissertation	0
KGCOE-XXXX-890 Engineering Focus Area Seminar	0	KGCOE-XXXX-890 Engineering Focus Area Seminar	0
Term credit total:	0	Term credit total:	0
		Dissertation Defense	

Program Summary	Minimum Credits: Total: 66 Course: 36 Diss: 30	Comprehensive Exam should be taken at the end of Year 1 Dissertation Proposal should be taken no sooner than six months after the Comprehensive Exam and at least six months prior to the Candidacy Exam. Dissertation Defense should be taken after completion of course requirements and at least six months after the Candidacy Exam. A minimum of three-year residency with the Ph.D. program is required before completing the degree.

Course Categories

The following provides a summary of the five course categories, designed to provide students both discipline-specific skill sets and focus-area (problem) driven education. Other than Interdisciplinary course, each category shall have a list of courses for students to choose from. Courses highlighted in tan represent contextual study within the industry focus area. Courses highlighted in light purple represent discipline foundation courses within a disciplinary area. Courses highlighted in medium purple represent depth of study within across disciplines, listed as focus area electives in the table below. Courses highlighted in green represent core courses.

Interdisciplinary Research Methods (1x): This course introduces fundamental practices on literature review, paper writing, basic analytical methods, and requires students to develop an effective statement of work.

Engineering Analytics (2x): The Engineering Analytics Foundation course provides a comprehensive coverage of mathematical topics, while the Engineering Analytics Elective provides an in-depth treatment of specific areas of mathematics, such as optimization and stochastic processes, and partial differential equations.

Translating Discovery into PractiCe in XXX (1X): This rigorous set of four engineering courses, will provide students with a comprehensive coverage of engineering challenges and solution approaches in Healthcare, Energy, Communications and Transportation. Students in each focus area will be required to take the corresponding course in this set. Students can also take additional courses from this set as electives. Faculty members from a variety of disciplines will bring their unique disciplinary perspective to the students, so that each Ph.D. student understands not only their personal research topic, but also precisely how their research fits within the global context of the focus area. This philosophical approach to doctoral education has gained extremely strong support from our industry partners as evidenced by the letters included in Appendix VI.

Discipline Foundation (3X): These foundation courses builds depth within a disciplinary field, including mechanical engineering, electrical and microelectronics engineering, computer engineering, industrial and systems engineering, chemical engineering, and biomedical engineering.

FOCUS AREA Electives (3x): The Focus Area Electives serve to provide specialized knowledge and skill-sets relevant to the student's dissertation research within the selected focus area. Each student must take at least three Focus Area Electives, drawn from courses within current degree programs. These existing courses will be gradually transformed and elevated to reflect the corresponding societal challenges and the technical depth needed for Ph.D. level education. Such transformations are expected to provide positive influence to not only the Ph.D. students but also students in the existing degree programs. Inevitably, there could be new courses being developed and introduced to explicitly address system level, application specific interdisciplinary challenges, and they may be included a future Focus Area Electives.

Students taking the Focus Area Electives will have opportunities to interact closely with students from other disciplines enabling the exchange of different engineering perspectives in the classroom and project discussion. This shall provide a broader view of the societal and industry challenges for individual's research efforts. This approach also presents an opportunity to effectively utilize existing graduate-level courses. It is expected that many current graduate-level semester courses will be eligible within one or more categories. The table below provides a sample list of courses that may fit into the different categories. An entry student who has an MS or MEng degree can transfer up to 24 credits of approved courses toward his/her Ph.D. degree. Up to 6 credits of graduate level course work in mathematics or physical sciences may be used toward course requirements for the Ph.D. program with the approval of the student's adviser and program director.

TABLE: GRADUATE COURSES ALREADY OFFERED IN THE KATE GLEASON COLLEGE OF ENGINEERING IN SUPPORT OF EACH COURSE CATEGORY IN THE PROPOSED PH.D. IN ENGINEERING PROGRAM.

Category	**Semester Courses**	
Engineering Analytics	CQAS-741 Regression Analysis	EEEE-603 Matrix Methods in EE
	CQAS-701 Found. of Experiment Design	EEEE-602 Random Signals and Noise
	CQAS-756 Multivariate Analysis	EEEE-794 Information Theory
	CQAS-747 Princ. of Stat. Data Mining	CMPE-610 Analytical Topics in CE
	ISEE-661 Linear Regression Analysis	MECE-601 Math I for Engineers
	ISEE-701 Linear Programming	MECE-602 Math II for Engineers
	ISEE-702 Int& Nonlin. Programming	
Disciplinary Foundation	CMPE-630 Digital Integ. Circuit Design	EEEE-669 Fuzzy Logic and Applications
	CMPE-660 Reconfigurable Computing	EEEE-678 Digital Signal Processing
	CMPE-670 Data and Comm. Networks	MCEE-601 Microelectronic Fabrication
	CMPE-650 Multiple Processor Systems	MCEE-602 VLSI Process Modeling
	ISEE-601 Sys. Modeling and Optimization	MECE-643 Continuous Control Systems
	ISEE-626 Contemp. Production Systems	MECE-738 Ideal Flows
	ISEE-710 Systems Simulation	MECE-744 Nonlinear Control Systems
	ISEE-711 Advanced Simulation	MECE-743 Digital Control Systems
	ISEE-751 Decision & Risk Benefit Analysis	MECE-751 Convective Phenomena
	ISEE-760 Design of Experiments	MECE-752 Tribology Fundamentals
	EEEE-620 Design of Digital Systems	MECE-754 Fund. of Fatigue and Fracture
	EEEE-621 Design of Computer Systems	MECE-785 Mechanics of Solids
	EEEE-661 Modern Control Theory	
Healthcare	ISEE-730 Biomechanics	MECE-656 Bio-Transport Phenomena
	EEEE-636 Biorobotics/Cybernetics	MECE-731 Computational Fluid Dynamics
	MECE-657 Biomedical Device Engineering	
Energy	ISEE-785 Fund. of Sustainable Engineering	MECE-733 Sustainable Energy Mgmt. MECE-
	ISEE-786 Lifecycle Assessment	739 Alt. Fuels & Energy Efficiency
	ISEE 787 Design for the Environment	MECE-828 Transport in PEM Fuel Cells
	MECE-710 Fuel Cell Technology	MECE-834 Boiling and Condensation
	MECE-729 Renewable Energy Systems	MECE-847 Micro-scale Transport Phenomena
	MECE-731 Computational Fluid Dynamics	
communications	EEEE-617 Microwave Circuit Design	EEEE-779 Digital Image Processing
	EEEE-629 Antenna Theory	MCEE-717 Memory Systems
	EEEE-661 Modern Control Theory	CMPE-651 High Performance Architecture
	EEEE-670 Pattern Recognition	CMPE-663 Real-time and Embedded Systems
	EEEE-647 Artificial Intelligence Explorations	CMPE-770 Wireless Networks
	EEEE-710 Advanced Electromagnetic Theory	CMPE-685 Computer Vision
	EEEE-711 Advanced Carrier Injection Devices	CMPE-730 Advanced Digital IC Design
	EEEE-726 Mixed Signal IC Design	ISEE-732 Systems Safety Engineering
	EEEE-768 Adaptive Signal Modeling	ISEE-741 Rapid Prototyping & Manufacturing
Transportation	ISEE-601 System Modeling and Optimization	MECE-620 Introduction to Optimal Design
	ISEE-703 Supply Chain Management	MECE-623 Powertrain Systems & Design
	ISEE-704 Logistics Management	MECE-624 Vehicle Dynamics
	ISEE-710 Systems Simulation	MECE-638 Design of Machine Systems
	ISEE-745 Manufacturing Systems	MECE-658 Intro. Engineering Vibrations
	ISEE-752 Decision Analysis	MECE-739 Alt. Fuels And Energy Efficiency
	EEEE-685 Principles of Robotics	MECE-758 Intermed. Engineering Vibrations

8. Students

The student body to be served is described in **Table 4**. Students accepted to the Phd in Engineering program must meet the highest standard of academic performance and professional conduct. Students will apply for admission to the program using standard graduate admissions procedures already in place at RIT. Additionally, students will be admitted to the program with the understanding that they will be affiliated with a faculty member in the program, and prepared to complete course work at the MS and PhD level in one or more departments in the college of engineering. RIT has active graduate recruiting and retention programs. We have dedicated support offices on campus to assist programs with the retention and academic success of under-represented groups such as women in engineering and AALANA student populations. We participate in various programs such as the Louis B Stokes Alliance for Minority Participation. RIT and the Kate Gleason College of Engineering have a long track record of providing superior academic supervision and counseling of students not only during their affiliation with the institution, but throughout their professional careers. We fully intend to extend that support to this program as well.

The projected full- and part-time enrollment for the first five years of the program are presented in **Table 5.** This projection assumes that 8 full time students will be admitted at the time of program launch, and will take a first-year exam at the conclusion of their first academic year. We anticipate a nominal 75% retention rate at this point, and show 6 of the 8 students progressing to the second year. We expect that the 2 students not successful at the first year PhD exam will have an opportunity to complete a Masters degree in one of the existing programs in the college. Since part time students are expected to be full company supported and will undergo a rigorous selection process by both the company and RIT, we are projecting a much lower attrition rate for them, and this is not apparent within the five year time frame of the projections. The projections shown in this table are conservative, and are well below the market estimates prepared by our office of graduate enrollment and career services. and discuss the assumptions upon which the enrollment projection is based. We have limited the size of the program to minimize financial risk, but are highly confident of our ability grow the program seamlessly as it becomes financially healthy. The enrollment in this program is a tiny fraction of the enrollment of the total college of engineering at both the undergraduate and graduate level. Our focus with this program in on "driving quality, not quantity."

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 4
STUDENT CHARACTERISTICS

A. Anticipated Geographic Origin of Students in the Proposed Program

Indicate the percent from:	Full-Time	Part-Time
01. County in which the program will be offered	25	75
02. Remainder of Regents Post-secondary Region in which the program will be offered	0	25
03. Remainder of New York State	25	0
04. Other State	25	0
05. Foreign	25	0
06. Total	**100%**	**100%**

B. Anticipated Racial/Ethnic Characteristics of Full-Time and Part-Time Students (Headcount) in the Proposed Program

	Percent
07. Non-resident Alien	25
08. Black Non-Hispanic	12.5
09. American Indian or Alaskan Native	0
10. Asian or Pacific Islander	0
11. Hispanic	12.5
12. White, Non-Hispanic	50
13 Total	**100%**

Institution	Rochester Institute of Technology	Date	1 July 2013
Program	PhD in Engineering	Degree	Doctor of Philosophy

TABLE 5
PROJECTED ENROLLMENT IN THE PROPOSED PROGRAM

Enrollment	1st Year(1) Academic Year AY2014-15	2nd Year(1) Academic Year AY2015-16	3rd Year(1) Academic Year AY2016-17	4th Year(1) Academic Year AY2017-18	5th Year(1) Academic Year AY2018-19
01. Full-Time Students	8	14	24	32	38
02. Part-Time Students	4	8	12	16	24
03. Total 2	12	22	36	48	62
04. Full-Time Equivalent (FTE) 3 4	15,960	16,447	16,951	17,469	18,000
05. Existing FTE 5	15,950	16,429	16,921	17,429	17,952
06. New Phd in Engineering Program FTE 6	10	18	30	40	48

(1) Approximate Enrollment data is projected for Fall Terms of each year
(2) Campus-wide Enrollment Projections are based upon 3% annual growth for the campus
(3) Full Time Equivalent enrollment is based on the projected number of part time credits consumed by part-time students, divided by 12 semester credits
(4) FTE Enrollment at RIT consists of Existing Enrollment and New FTE due to the proposed program
(5) Existing FTE enrollment means the FTE enrollment that would have existed at the institution even if the proposed program were not approved.
(6) New FTE Enrollment means the FTE enrollment that will be engendered specifically by the proposed program.
New FTE enrollment from the previous year is carried over to the following year as new FTE enrollment, with adjustments for attrition and completions

9. Evaluation

The Ph.D. in Engineering has three top level student outcomes program goals:

Program Goal 1: *"Create Knowledge":* Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.

Program Goal 2: "*Specialized Knowledge*": Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.

Program Goal 3: "*Life-Long Learners*": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

An outcomes assessment plan for each program goal is presented next.

Program Goal 1: "*Create Knowledge*"

Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.

Student Learning Outcomes	Academic Program Profile	Data Source/Measure Curriculum Mapping	Benchmark	Timeline	Data Analysis Key Findings	Use of Results Action Items
Engineering Methods - Apply math, science, and engineering to conduct experiments, and identify, formulate, analyze, and solve *problems* using *modern* techniques, skills, and engineering tools.	☒ Critical Thinking ☐ Ethical Reasoning ☒ Integrative Literacies ☒ Global Interconnectedness ☒ Creative/Innovative Thinking	**Comprehensive Exam:** Ability to apply advanced knowledge of math, science, and engineering **Thesis Proposal:** Written documents and oral thesis presentation (Standardized assessment rubic)	100% of students progressing beyond comprehensive exam 100% of students completing this degree	Annually Annually	Ph.D. Program Director	Results of all assessment metrics are shared annually with faculty and advisory board. Approved recommendations from faculty and advisory board will be integrated into the program
Communication - Communicate effectively through written, oral, and graphical means	☒ Critical Thinking ☒ Ethical Reasoning ☒ Integrative Literacies ☒ Global Interconnectedness ☒ Creative/Innovative Thinking	**Publication:** Ability to communicate effectively **Thesis Defense:** Written documents and oral presentation	100% of students will publish archival articles 100% of students completing this degree	Annually Annually	Ph.D. Program Director	Results of all assessment metrics are shared annually with faculty and advisory board. Approved recommendations from faculty and advisory board will be integrated into the program
Integrated Advanced Education - *Complete significant research experience integrating advanced knowledge in engineering*	☒ Critical Thinking ☐ Ethical Reasoning ☒ Integrative Literacies ☐ Global Interconnectedness ☒ Creative/Innovative Thinking	**Thesis Defense:** Written documents and oral thesis presentation (Standardized assessment rubic)	100% of students completing this degree 70% of students publish paper	Annually	Ph.D. Program Director	Results of all assessment metrics are shared annually with faculty and advisory board. Approved recommendations from faculty and advisory board will be integrated into the program

Program Goal 2: “Specialized Knowledge”

Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.

Student Learning Outcomes	Academic Program Profile	Data Source/Measure Curriculum Mapping	Benchmark	Timeline	Data Analysis Key Findings	Use of Results Action Items
“Career Focus”: Demonstrate proficiency in a foundational set of courses as well as a concentrated course of study and research in a focus area of Engineering.	☒ Critical Thinking ☐ Ethical Reasoning ☒ Integrative Literacies ☐ Global Interconnectedness ☒ Creative/Innovative Thinking	**Course Plan** : Approved Graduate Plan of Study Required set of courses Focus area/elective courses **Thesis Defense:** Written documents and oral thesis presentation (Standardized assessment rubic)	100% of students 80% of students earn a grade ≥ B 80% of students earn a grade ≥ B 100% of students completing this degree will publish	Annually Annually	Ph.D. Program Director	Results of all assessment metrics are shared annually with faculty and advisory board. Approved recommendations from faculty and advisory board will be integrated into the program

Program Goal 3: "Life-Long Learners"

Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

Student Learning Outcomes	Academic Program Profile	Data Source/Measure Curriculum Mapping	Benchmark	Timeline	Data Analysis Key Findings	Use of Results Action Items
Contemporary Issues - A knowledge of contemporary issues, an understanding of the impact of engineering solutions in a global and societal context, and the recognition of the need for life-long learning.	☐ Critical Thinking ☒ Ethical Reasoning ☐ Integrative Literacies ☒ Global Interconnectedness ☒ Creative/Innovative Thinking	**Focus Area Seminar:** Exposure to industry relevant research and the impact of research in a global and societal context **Exit Survey:** Knowledge of contemporary issues	Student attendance required for all semesters 90% of students with rating at least 3/5	Biannually Biannually	Ph.D. Program Director	Results of all assessment metrics are shared annually with faculty and advisory board. Approved recommendations from faculty and advisory board will be integrated into the program

Appendix A: Course Outlines for New Courses

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-800: Multidisciplinary Research Methods

1.0 Course Approvals

Required approvals:	**Requested Date:**	**Granted Date:**
Academic Unit Curriculum Committee		
College Curriculum Committee		
Optional approvals:	**Requested Date:**	**Granted Date:**
General Education Committee	N/A	N/A
Writing Intensive Committee	N/A	N/A
Honors	N/A	N/A

2.0 Course Information

Course Title:	Multidisciplinary Research Methods	
Credit Hours:	3	
Prerequisite(s):	None	
Co-requisite(s):	None	
Course proposed by:	Committee	
Effective date:	Aug-30-2013	
Meeting Format	**Contact hours**	**Maximum students/section**
Classroom	3	60
Lab	0	0
Studio	0	0
Other (Specify)	0	0

2.1 Course Conversion Designation

Check if:	**Designation**	**Please indicate equivalent quarter course(s):**
	Semester Equivalent	
	Semester Replacement	
X	New Course	

2.2 Semester(s) offered (check)

Fall	Spring	Summer	Other
Yes			

2.3 Student Requirements

Students required to take this course (Program/Year)
PhD students in the PhD in Engineering program
Students who may elect to take this course (Program/Year)
Graduate Students in engineering or related discipline

3.0 Goals of the course (including rationale for the course, when appropriate):

The goals of the course is to educate the students so that they will be able to
3.1 Critically analyze and review research literature in engineering fields.
3.2 Comprehend and conduct qualitative and quantitative data analysis
3.3 Identify and elaborate potential research problems in engineering disciplines
3.4 Collaborate with students in different engineering disciplines to discuss cross-disciplinary research problems

4.0 RIT Catalog Course description

Course Number: KGCOE-XXXX-800 Multidisciplinary Research Methods
This course introduces students to research methods in engineering disciplines. A primary focus of the course is on conducting critical reviews of research literature, perform qualitative and quantitative data analysis and work in cross-disciplinary teams to discuss research problems across engineering disciplines. At the conclusion of the course, each student is expected to submit an individual research proposal that demonstrates the research method skill sets obtained in the course. (Pre-requisites: None; Co-requisites: None)
Class 3, Lab 0, Studio 0: Credit 3

5.0 Possible resources (texts, references, computer packages, etc.)

Text:
N/A
Software:
N/A

6.0 Topics (Outline)

6.1 Literature Review Skills
- Journal and conference search techniques and citation process
- From comprehension to synthesis of findings from literature review

- Identifying technical gaps

6.2 Data Analysis

6.3 Cross-disciplinary research problem

- Recognizing research problems outside of core discipline
- Techniques to approach peers in different disciplines for research discussion
- Finding complementary skills to solve cross-disciplinary problems

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome:	Exam & Quizzes	Homework	Labs	Projects
(1) To critically analyze and review research literature in engineering fields		X		X
(2) To comprehend and conduct qualitative and quantitative data analysis		X		X
(3) To identify and elaborate potential research problems in engineering disciplines		X		X
(4) To collaborate with students in different engineering disciplines to discuss cross-disciplinary research problems				X

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: ”Create Knowledge”: Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.
Program Goal 2: “Specialized Knowledge”: Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.
Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-800 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-800 Multidisciplinary Research Methods

Program Outcomes	Slightly	Moderately	Significantly
"Create Knowledge"	X		
"Specialized Knowledge"	X		
"Life-long Learners"			X

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	Assessment Method
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**
Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-805 Engineering Analytics Foundation

1.0 Course Designations and Approvals

Required course approvals:	**Approval request date:**	**Approval granted date:**
Academic Unit Curriculum Committee		
College Curriculum Committee		

Optional designations:	**Is designation desired?**		***Approval request date:**	****Approval granted date:**
General Education:	Yes	**No**		
Writing Intensive:	Yes	**No**		
Honors	Yes	**No**		

2.0 Course information:

Course title:	**KGCOE-XXXX-805 Engineering Analytics Foundation**
Credit hours:	3
Prerequisite(s):	Graduate Standing
Co-requisite(s):	None
Course proposed by:	Kathleen A Lamkin-Kennard
Effective date:	August 2013

	Contact hours	**Maximum students/section**
Classroom	3	48
Lab		
Studio		
Other (specify)		

2.a Course Conversion Designation* (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to:
	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:

X	New

2.b Semester(s) offered (check)

Fall X	**Spring X**	Summer	Other

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

2.c Student Requirements

Students required to take this course: (by program and year, as appropriate) PhD Students in KGCOE
Students who might elect to take the course: MS students in engineering discipline

In the sections that follow, please use sub-numbering as appropriate (eg. 3.1, 3.2, etc.)

3.0 Goals of the course (including rationale for the course, when appropriate):

3.1 To understand the concepts of linear and nonlinear differential equations
3.2 To learn the techniques for solving ordinary differential equation, initial and boundary value problems
3.3 To provide the skills required to solve ordinary linear differential equations using Laplace Transform.
3.4 To provide the skills required to solve first and special second order nonlinear differential equations
3.5 To understand the concept of frequency domain and Fourier Transform.
3.6 To be able to find the forward and the inverse Laplace Transform.
3.7 To be able to apply Laplace transform to solve boundary value problems
3.8 To develop an in depth understanding of matrices and matrix techniques and their application in various disciplines.
3.9 To develop an in depth understanding of determinants, matrix inversion techniques and solutions to simultaneous linear equations.
3.10 To develop an in depth understanding of linear vector spaces, normed vector spaces, and orthogonality principles.
3.11 To develop an in depth understanding of eigenvalues, eigenvectors, singular value decomposition and matrix diagonalization techniques.
3.12 To develop an in depth understanding about matrix polynomials, and functions of matrices using Cayley Hamilton theorems, and Modal matrix techniques.
3.13 To develop an understanding of optimization techniques.
3.14 To develop an understanding of complex variables and complex functions.

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered). Please use the following format:

Course Number: XXXX-805 Name of Course :Engineering Analytics Foundation
This course trains students to utilize mathematical techniques from an engineering perspective, and provides essential background for success in graduate level studies. An intensive review of linear and nonlinear ordinary differential equations and Laplace transforms is provided. Laplace transform methods are extended to boundary-value

problems and applications to control theory are discussed. Problem solving efficiency is stressed, and to this end, the utility of various available techniques are contrasted. The frequency response of ordinary differential equations is discussed extensively. Applications of linear algebra are examined, including the use of eigenvalue analysis in the solution of linear systems and in multivariate optimization. An introduction to Fourier analysis is also provided.

Prerequisite(s): Graduate Standing) **Class 3, Lab 0, Credit 3 (F)**

Co-requisite(s): None

5.0 Possible resources (texts, references, computer packages, etc.)

Text:
Advanced Engineering Mathematics," 4th edition, by Dennis G. Zill and Michael R. Cullen, ISBN #076374591X.
Software:
MATLAB

6.0 Topics (outline):

6.1 Techniques for Solving Ordinary differential equations: Initial and boundary value problems

- Motivation, equation classification, boundary and initial value problems
- Linear 1st order equations.
- Nonlinear 1st order equations, Separable, and Bernoulli equations
- Linear 2nd order equations with constant coefficients: General form: Homogeneous, particular solutions. Reduction of order for repeated roots and shortcut procedure
- Nonhomogeneous ODEs: Method of undetermined coefficients, and Variation of parameters
- Application of homogeneous, particular methodology to equations of any order
- Non constant coefficient linear equations of 2nd order: Euler-Cauchy equations, Exact: Reduce to lower order equation
- Introduction to higher order nonlinear equations

6.2 Laplace Transformas

- Definition of transform and inverse transforms, existence, linearity, and examples
- Method of partial fractions
- s-shifting
- Transforms of derivatives
- Application to initial value problems
- Transforms of integrals
- Step functions, t-shifting
- Dirac delta function
- Extension of Laplace method to boundary value problems
- Convolution
- Systems of ODEs using transforms
- Perspective—use in control theory

- Initial and final value theorems

6.3 Additional Transformation Techniques

- Fourier Transforms – why needed in comparison with Laplace?
- Extension of general techniques to other transforms, e.g. Z-transforms

6.4 Linear Algebra

- Introduction: Why are matrix operations so important?—Solution of linear and nonlinear systems
- Matrix Algebra: Scalar multiplication of matrices, Matrix addition, Matrix Multiplication,
- Matrix transpose and properties. Dot product through the use of a transpose
- Special real Matrices
- Solution of linear algebraic systems
  - Physical discussion of possible solutions of linear algebraic system
  - Augmented matrices
  - Gaussian elimination
  - Row echelon (and reduced) form
  - Possible results
  - Applications to square matrices
- Rank of matrix and existence and uniqueness
- Determinants and their properties
- Cramer's rule
- Matrix inverses and applications (Gauss Jordan Elimination, Adjugate)
- Finite difference example yielding linear system
- Matrix eigenvalues and eigenvectors
- Applications of eigenvalue analysis:
  - Systems of linear differential equations
  - Principle Stresses
  - Optimization
- Eigenvalue and eigenvector properties
  - Transpose
  - Symmetric matrices
  - Orthogonal matrices; application of projection
  - Skew Symmetric
  - Matrix Factorizations (LU, Choleksy, QR)
  - Singular Value Decomposition (SVD)
- Matrix Diagonalization
- Applications of matrix diagonalization
  - Powers of matrices
  - Solutions of inhomogeneous linear systems

6.5 Complex Functions

- Review of Complex Variables
- Complex Functions
  - Definition, and properties of complex functions
  - Roots of complex functions
  - Complex Integration

• Application of Complex Functions for solving ODEs

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome:	Exam & Quizzes	Homework	Labs	Projects
(1) An ability to differentiate between linear , time invariant and nonlinear DFE.	X	X		
(2) An ability to solve linear and nonlinear differential equations and boundary value problems.	X	X		
(3) An ability to use transform techniques such as Laplace Transform to solve ordinary differential equations and boundary value problems.	X	X		
(4) Understand matrices, matrix algebra, elementary matrix operations, determinants, matrix inversion.	X	X		
(5) an Ability to compute determinants, inverse of matrices, and solve systems of linear equations using Gauss Elimination, and Gauss-Jordan elimination	X	X		
(6) Understand and utilize vector spaces to solve systems of equations.	X	X		
(7) Compute eigenvalues and eigenvectors, diagonalize matrices and perform singular value decompositions	X	X		
(8) Compute functions of matrices using Cayley Hamilton Theorem	X	X		
9) An ability to use complex numbers and functions to solve engineering problems	X	X		

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: ”Create Knowledge”: Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.

Program Goal 2: "Specialized Knowledge": Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.

Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-800 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-800 Multidisciplinary Research Methods			
Program Outcomes	**Slightly**	**Moderately**	**Significantly**
"Create Knowledge"	X		
"Specialized Knowledge"		X	
"Life-long Learners"	X		

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	**Assessment Method**
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	

	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**
Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-810 Engineering in Healthcare

1.0 Course Designations and Approvals

Required course approvals:	**Approval request date:**	**Approval granted date:**
Academic Unit Curriculum Committee		
College Curriculum Committee		

Optional designations:	**Is designation desired?**		***Approval request date:**	****Approval granted date:**
General Education:	Yes	**No**		
Writing Intensive:	Yes	**No**		
Honors	Yes	**No**		

2.0 Course information:

Course title:	**KGCOE-XXXX-830 Engineering in Telecommunications**
Credit hours:	3
Prerequisite(s):	Graduate Standing
Co-requisite(s):	None
Course proposed by:	M.G. Schrlau and S. Day
Effective date:	August 2013

	Contact hours	**Maximum students/section**
Classroom	3	30
Lab		
Studio		
Other (specify)		

2.a Course Conversion Designation* (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to:

	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:
X	New

2.b Semester(s) offered (check)

Fall	**Spring X**	Summer	Other

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

2.c Student Requirements

Students required to take this course: (by program and year, as appropriate) PhD Students in KGCOE in Healthcare track
Students who might elect to take the course: Students with graduate standing in Engineering disciplines and those with related background

In the sections that follow, please use sub-numbering as appropriate (e.g. 3.1, 3.2, etc.)

3.0 Goals of the course (including rationale for the course, when appropriate):

The goals of the course is to educate the students so that they will be able to

3.1 Gain a comprehensive understanding of engineering challenges in and solution approaches for the healthcare industry.

3.2 Develop a technical perspective of biological systems and processes to guide engineered healthcare solutions.

3.3 Understand, measure, and analyze the quantitative aspects of the healthcare sciences.

3.4 Apply engineering approaches and multidisciplinary analytical knowledge and tools with technically proficiency to create solutions for the healthcare industry.

3.5 Conduct a literature review across engineering disciplines to obtain knowledge for cross-disciplinary engineering solutions in the healthcare industry.

3.6 Critically evaluate and quantitatively analyze engineering designs and solutions in the healthcare industry.

3.7 Be able to work in a multidisciplinary team to engineer practical solutions for healthcare industry.

3.8 Develop the ability to effectively communicate with professionals outside the engineering disciplines to understand the challenges and create synergistic solutions for the healthcare industry.

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered). Please use the following format:

Course Number: XXXX-810 Engineering in Healthcare

This course provides a comprehensive overview of how engineering and life sciences are integrated to solve pressing biomedical problems in the global healthcare field. The course is structured to provide both breadth and depth of engineered solutions and opportunities in healthcare: Students will explore the challenges, approaches, and solutions involving a broad range of technical disciplines but will also apply engineering methodologies and detailed technical knowledge to quantitatively analyze problems in healthcare as well as propose and design practical solutions. Solutions will incorporate state-of-the-art engineering analysis methods and utilize engineering-relevant analytical and computational modeling. The course will cover a wide range of topics, from the characterization, restoration, and/or substitution of normal functions in humans to the optimized administration of healthcare. The course will focus on high-impact, transformative engineering used to derive information from cells, tissues, organs, and organ systems, extract useful information ranging from complex biomedical signals to healthcare management and logistics, design structures and materials for eventual medical use, and create new methods of controlling living systems. The course will be taught by a team of faculty across multiple disciplines and includes a team project component.

Prerequisite(s): Graduate Standing, Class 3, Lab 0, Credit 3 (F)

Co-requisite(s): None

5.0 Possible resources (texts, references, computer packages, etc.)

Text:
N/A
Software:
N/A

6.0 Topics (outline):

6.1 Introduction to Engineering in Healthcare
- Current Healthcare System and Industry
- Current Challenges in Healthcare
- The Need for Engineering in Healthcare
- Engineering in Healthcare Success Stories

6.2 Introduction to Healthcare Science
- Functional Anatomy (gross anatomy, histology, cytology)
- Biomolecules and Biochemistry
- Immunology and Pathology
- Cardiac Physiology
- Neurophysiology

6.3 Quantitative Healthcare Science
- Systems Approach and Methodology
- Stochastic Biological Processes
- Evidence-Based Medicine
- Bioinformatics
- Medical Informatics
- Biomedical Instrumentation and Signal Processing
- Biomechanics

- Microscopy and Spectroscopy

6.4 Engineering in Healthcare Science

- Ergonomics
- Organizational and Logistical Optimization
- Biocompatible Materials
- Tissue Engineering and Biomimetic Materials
- Assistive Devices
- Biomimetic Devices
- Biosensors
- Nanobiotechnology
- Biophotonics
- Medical Imaging

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome:	Exam & Quizzes	Homework	Labs	Projects
7.1 Identify and describe the current and most pressing challenges in the healthcare industry.	X	X		X
7.2 Articulate the role engineering has played in solving challenges in healthcare and the significant opportunities for engineering in the future.	X	X		X
7.3 Identify and describe the components that make up the body, organs, tissue, and cells that relate to the challenges in healthcare.	X	X		
7.4 Describe the processes and quantify the function of organs, circulatory system, various tissue, and cells that relate to the challenges in healthcare.	X	X		X
7.5 Apply systems approaches and methodologies to understand and evaluate biological systems and challenges in healthcare.	X	X		X
7.6 Describe, measure, and evaluate biological and healthcare systems as stochastic processes.	X	X		X
7.7 Identify, describe, evaluate, and design the instrumentation and signal processing used in the biomedicine.	X	X		X

7.8 Describe microscopy and spectroscopy techniques used in healthcare and calculate their efficacy.	X	X		X
7.9 Evaluate and calculate the forces and moments on the body during strenuous activity and design ergonomic solutions.	X	X		X
7.10 Understand, evaluate, and propose practical solutions to operational and logistical challenges in healthcare.	X	X		X
7.11 Design biomimetic materials and devices that replace, enable, or enhance normal human function.	X	X		X
7.12 Design benchtop or implantable sensors to detect molecules or biological processes and evaluate their efficacy.	X	X		X
7.13 Describe emerging fields in healthcare (e.g., biophotonics, nanobiotechnology, medical imaging), understand their current limitations or challenges, evaluate their impact, and propose growth opportunities.	X	X		X
7.14 Work effectively in a multidisciplinary team to engineer practical solutions for healthcare industry.	X			X
7.15 Effectively communicate with professionals outside the engineering disciplines (e.g., chemists, biologists, pharmacists, medical doctors, clinicians, etc.) to understand the challenges and create synergistic solutions for the healthcare industry.				X
7.16 Identify and comprehend relevant engineering and medical literature in order to evaluate challenges in and propose solutions for the healthcare industry.				X

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: "Create Knowledge": Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.
Program Goal 2: "Specialized Knowledge": Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.
Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-810 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-810 Engineering in Healthcare			
Program Outcomes	**Slightly**	**Moderately**	**Significantly**
"Create Knowledge"	X		
"Specialized Knowledge"			X
"Life-long Learners"			X

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	**Assessment Method**
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	

Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**

Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-820 Engineering in Energy

1.0 Course Designations and Approvals

Required course approvals:	**Approval request date:**	**Approval granted date:**
Academic Unit Curriculum Committee	9/24/2012	
College Curriculum Committee		

Optional designations:	**Is designation desired?**		***Approval request date:**	****Approval granted date:**
General Education:	Yes	No [x]		
Writing Intensive:	Yes	No [x]		
Honors	Yes	No [x]		

2.0 Course information:

Course title:	Engineering in Energy
Credit hours:	3
Prerequisite(s):	None
Co-requisite(s):	None
Course proposed by:	Committee
Effective date:	September 1, 2013

	Contact hours	**Maximum students/section**
Classroom	3	20
Lab		
Studio		
Other (specify)		

2.a Course Conversion Designation* (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to:
	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:
[x]	New

2.b Semester(s) offered (check)

Fall	Spring X	Summer	Other

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

2.c Student Requirements

Students required to take this course: (by program and year, as appropriate) PhD Students enrolled in the KGCOE interested in the Energy Application Domain.
Students who might elect to take the course: Graduate students in engineering or other related disciplines

In the sections that follow, please use sub-numbering as appropriate (eg. 3.1, 3.2, etc.)

3.0 Goals of the course (including rationale for the course, when appropriate):

- To provide a background for the analysis of energy systems including life cycle and multi-criteria engineering tools and methodologies
- To provide an assessment of current energy resources and impacts on environment
- To present a range of technologies for energy conversion
- To summarize the prevalent technologies for storing energy
- To analyze the limitations in transmission of energy
- To assess the challenges in large scale generation and storage
- To understand energy conversion and storage in transportation applications
- To provide perspectives on emerging materials and devices in energy systems
-

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered). Please use the following format:

KGCOE- XXXX-820 Engineering in Energy
This course introduces students to major energy technologies focused on engineering designs, economic constraints, and societal impacts. This course investigates the systemic relationships involved with energy conversion, distribution, and storage for both stationary and transportation applications. Consideration of fossil fuels and nuclear energy to supply global energy demands will be used as a basis to evaluate the potential implementation of alternative, sustainable energy sources. Analysis of the environmental and economic impacts for prevalent energy technologies will serve to identify the challenges of deployment. A summary of emerging materials and device designs on traditional energy systems will provide perspectives on the next generation energy technologies. The instruction will rely on lectures, textbooks, seminal and cutting edge publication articles and term projects. Students will be evaluated based on homework assignments, class presentations, examinations and projects.
Prerequisite: **Graduate Standing, Class 3, Lab 0, Credit 3 (F)**

Co-requisite(s): None

5.0 Possible resources (texts, references, computer packages, etc.)

Text: “Energy Systems Engineering” Authors: Francis M. Vanek and Louis D. Albright Publishers: McGraw Hill Text: “Sustainable Energy Systems Engineering” Authors: Dr. Peter Gevorkian Publishers: McGraw Hill

6.0 Topics (outline):

1. Systems Modeling for Energy Systems
2. Environmental and Economic Tools for Energy Systems
3. Stationary Energy Systems
    - Fossil fuel combustion
    - Advanced Coal Gasification
    - CO_2 sequestration and reformation
    - Nuclear reprocessing and breeder reactors
4. Electrical energy transmission
    - Power quality and grid management
    - Smart grid technologies
5. Electrical energy storage
    - Battery technology
    - Capacitor technology
6. Transportation Energy Technologies
    - Advanced engine concepts
    - Natural Gas Vehicles
    - Electric/fuel cell
    - Fischer Tropsch Fuels
    - Biofuels
7. Alternative Energy Conversion
    - Geothermal technologies
    - Solar technologies
    - Wind technologies
8. Advanced materials and concepts for energy systems design

=

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

	Assessment Method		
Course Learning Outcomes	Exams & Quizzes	Homework	Demonstration/ Presentation
1. Develop methodologies to quantify	X	X	

3

energy efficiency and environmental impacts for differing technologies.			
2. Develop an understanding of transition energy technologies that reduce dependency on fossil fuels	X		
3. Build a working knowledge of emerging sustainable energy technologies	X		
4. Establish ability to conduct an energy systems analysis from material inputs to energy outputs including all external factors			X

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: "Create Knowledge": Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.
Program Goal 2: "Specialized Knowledge": Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.
Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-820 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-820 Engineering in Energy			
Program Outcomes	**Slightly**	**Moderately**	**Significantly**
"Create Knowledge"	X		
"Specialized Knowledge"			X
"Life-long Learners"			X

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	Assessment Method
Communication		
	Express themselves effectively in common college-level written forms	

	using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**
Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-830 Engineering in Communications

1.0 Course Designations and Approvals

Required course approvals:	**Approval request date:**	**Approval granted date:**
Academic Unit Curriculum Committee		
College Curriculum Committee		

Optional designations:	**Is designation desired?**		***Approval request date:**	****Approval granted date:**
General Education:	Yes	**No**		
Writing Intensive:	Yes	**No**		
Honors	Yes	**No**		

2.0 Course information:

Course title:	**KGCOE-XXXX-830 Engineering in Communications**
Credit hours:	3
Prerequisite(s):	Graduate Standing
Co-requisite(s):	None
Course proposed by:	S. Jay Yang
Effective date:	August 2013

	Contact hours	**Maximum students/section**
Classroom	3	30
Lab		
Studio		
Other (specify)		

2.a Course Conversion Designation* (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to:
	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:

X	New

2.b Semester(s) offered (check)

Fall	**Spring X**	Summer	Other

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

2.c Student Requirements

Students required to take this course: (by program and year, as appropriate) PhD Students in KGCOE in the Communication Track
Students who might elect to take the course: Students with graduate standing in Engineering disciplines and those with related background

In the sections that follow, please use sub-numbering as appropriate (e.g. 3.1, 3.2, etc.)

3.0 Goals of the course (including rationale for the course, when appropriate):

The goals of the course is to educate the students so that they will be able to

3.1 Have a comprehensive understanding of engineering challenges and solution approaches for the Communications industry

3.2 Conduct literature review across engineering disciplines to obtain knowledge for cross-disciplinary engineering solutions in the Communication industry

3.3 Work in a multidisciplinary team and develop critical analysis of engineering solutions for Communications industry

3.4 Comfortably elaborate solution approaches in multiple engineering disciplines for the Communication industry

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered). Please use the following format:

Course Number: XXXX-830 Engineering in Communications

This course will provide students with a comprehensive overview of engineering challenges and solution approaches in the Communications Industry. The proliferation of cyber and physical sensors and increasing processing power in cell phones, smart homes, work environment, traffic monitoring, and other areas highlight the growing importance of efficiently transferring, processing and interpreting vast amounts and diverse types of data. Students will learn about advances in wireless communication, sensor systems and networks, embedded systems and electronics, satellite communications, signal processing and control, high performance and reliable architecture, resilient and secure systems and global networks, and multimedia systems. Students will work in a multidisciplinary team to conduct literature review and present their critics for emerging initiatives in the Communications industry.

Prerequisite(s): Graduate Standing, Class 3, Lab 0, Credit 3 (F)

Co-requisite(s): None

5.0 Possible resources (texts, references, computer packages, etc.)

Text: N/A **Software:** N/A

6.0 Topics (outline):

6.1 Challenges and Solutions in Communication Industry

- Wireless communication
- Sensor systems and networks
- Mobile and Ad Hoc Networks
- Embedded systems and electronics
- Satellite communications
- Signal processing and control
- High performance computing and architecture
- Resilient and secure systems
- Multimedia systems

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome:	Exam & Quizzes	Homework	Labs	Projects
(1) To have a comprehensive understanding of engineering challenges and solution approaches for the Communications industry	X	X		X
(2) To conduct literature review across engineering disciplines to obtain knowledge for cross-disciplinary engineering solutions in the Communication industry		X		X
(3) To work in a multidisciplinary team and develop critical analysis of engineering solutions for Communications industry				X
(4) To comfortably elaborate solution approaches in multiple engineering disciplines for the Communication industry	X	X		X

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: ”Create Knowledge”: Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.
Program Goal 2: “Specialized Knowledge”: Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.
Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-830 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-830 Engineering in Communications			
Program Outcomes	**Slightly**	**Moderately**	**Significantly**
“Create Knowledge”	X		
“Specialized Knowledge”			X
“Life-long Learners”			X

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	**Assessment Method**
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world’s populations	
	Identify contemporary ethical questions and relevant stakeholder positions	

Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**
Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-XXX Engineering in Transportation

1.0 Course Designations and Approvals

Required course approvals:	**Approval request date:**	**Approval granted date:**
Academic Unit Curriculum Committee		
College Curriculum Committee		

Optional designations:	**Is designation desired?**		***Approval request date:**	****Approval granted date:**
General Education:	Yes	**No**		
Writing Intensive:	Yes	**No**		
Honors	Yes	**No**		

2.0 Course information:

Course title:	**KGCOE-XXXX-840 Engineering in Transportation**
Credit hours:	3
Prerequisite(s):	Graduate Standing
Co-requisite(s):	None
Course proposed by:	Scott E. Grasman
Effective date:	August 2013

	Contact hours	**Maximum students/section**
Classroom	3	48
Lab		
Studio		
Other (specify)		

2.a Course Conversion Designation* (Please check which applies to this course).**
*For more information on Course Conversion Designations please see page four.

	Semester Equivalent (SE) Please indicate which quarter course it is equivalent to:

	Semester Replacement (SR) Please indicate the quarter course(s) this course is replacing:
X	New

2.b Semester(s) offered (check)

Fall	**Spring X**	Summer	Other

All courses must be offered at least once every 2 years. If course will be offered on a bi-annual basis, please indicate here:

2.c Student Requirements

Students required to take this course: (by program and year, as appropriate) PhD Students in KGCOE with Transportation Focus
Students who might elect to take the course: Other KGCOE PhD Students KGCOE MS students with the appropriate background

In the sections that follow, please use sub-numbering as appropriate (eg. 3.1, 3.2, etc.)

3.0 Goals of the course (including rationale for the course, when appropriate):

3.1 To understand the application of data mining and analytics to transportation systems
3.2 To learn techniques for modeling and simulation of transportations systems
3.3 To understand the challenges and solution approaches in robotics
3.4 To provide an in-depth understanding of traffic engineering and traffic flow theory
3.5 To learn techniques for network design, facility location, and routing
3.6 To understand concepts related to the design and use of alternative fuels and vehicles,
3.7 To model and understand multifaceted aspects of transportation safety
3.8 To apply economic and environmental criteria to transportation decisions
3.9 To understand the impact of human behavior and public policy on transportation systems

4.0 Course description (as it will appear in the RIT Catalog, including pre- and co-requisites, and quarters offered). Please use the following format:

Course Number: XXXX-840 Engineering in Transportation

This course covers challenges and solution approaches for the engineering of transportation systems. Topics covered span several engineering disciplines, as well as aspects related to business and public policy. As such, the course requires the completion of a multidisciplinary team project. Problems addressed include economic and sustainability analysis of a transportation infrastructure, traffic modeling, network design, routing, transportation safety, human behavior, and public policy.

Prerequisite(s): Graduate Standing) Class 3, Lab 0, Credit 3 (F)

Co-requisite(s): None

5.0 Possible resources (texts, references, computer packages, etc.)

Text:
Software:

6.0 Topics (outline):

6.1 Statistical Analysis
- Data Mining
- Business Analytics

6.2 Modeling and Simulation
- Deterministic Models
- Stochastic Modeling
- Simulation

6.3 Robotics
- Electronics and signals
- Mechanical and locomotion

6.4 Traffic Engineering/Traffic Flow Theory
- Signaling
- Queuing Theory

6.5 Logistics Modeling
- Network Design
- Facility Location
- Vehicle/Inventory Routing Problems

6.6 Sustainable Transportation
- Alternative Fuels & Vehicles
- Congestion Pricing
- Public Transportation

6.7 Transportation Safety
- Passenger Safety
- Pedestrian Safety

6.8 Transportation Socio-Economics
- Capital Investment Decisions
- Life Cycle Analysis
- Human Behavior
- Public Policy

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome:	Exam & Quizzes	Homework	Labs	Projects
(1) An ability to apply data mining and analytics	X	X		X
(2) An ability model transportation systems	X	X		X
(3) An ability to design traffic systems	X	X		X
(4) An ability to apply problem solving	X	X		X

techniques to network design and operation				
(5) Understand general concepts related to alternative fuels and vehicles	X	X		X
(6) Understand facets of transportation safety	X	X		X
(7) An ability to apply economic and sustainability approaches to transportation decisions	X	X		X
(8) Understand the impact of human behavior and public policy on transportation systems	X	X		X
9) An ability to use complex numbers and functions to solve engineering problems	X	X		X

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: "Create Knowledge": Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.
Program Goal 2: "Specialized Knowledge": Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.
Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-840 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-840 Engineering in Transportation			
Program Outcomes	**Slightly**	**Moderately**	**Significantly**
"Create Knowledge"	X		
"Specialized Knowledge"			X
"Life-long Learners"			X

9.0

	General Education Learning Outcome Supported by the Course, if	**Assessment Method**

	appropriate	
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**

Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N)** - No corresponding quarter course(s).

ROCHESTER INSTITUTE OF TECHNOLOGY
COURSE OUTLINE FORM

KGCOE

Academic Unit: Kate Gleason College of Engineering

KGCOE-XXXX-890: Engineering Focus Area Seminar

1.0 Course Approvals

Required approvals:	**Requested Date:**	**Granted Date:**
Academic Unit Curriculum Committee		
College Curriculum Committee		
Optional approvals:	**Requested Date:**	**Granted Date:**
General Education Committee	N/A	N/A
Writing Intensive Committee	N/A	N/A
Honors	N/A	N/A

2.0 Course Information

Course Title:	Engineering Focus Area Seminar	
Credit Hours:	3	
Prerequisite(s):	None	
Co-requisite(s):	None	
Course proposed by:	Committee	
Effective date:	Aug-30-2013	
Meeting Format	**Contact hours**	**Maximum students/section**
Classroom	3	60
Lab	0	0
Studio	0	0
Other (Specify)	0	0

2.1 Course Conversion Designation

Check if:	**Designation**	**Please indicate equivalent quarter course(s):**
	Semester Equivalent	
	Semester Replacement	
X	New Course	

2.2 Semester(s) offered (check)

Fall	Spring	Summer	Other
Yes	Yes		

2.3 Student Requirements

Students required to take this course (Program/Year)
PhD students in the PhD in Engineering program
Students who may elect to take this course (Program/Year)
Graduate Students in engineering or related discipline

3.0 Goals of the course (including rationale for the course, when appropriate):

The goals of the course is to provide the students exposures to contemporary research problems and engineering advances in the Healthcare, Energy, Telecommunications and Transportation industries.

4.0 RIT Catalog Course description

Course Number: KGCOE-XXXX-890 Engineering Focus Area Seminar
This course runs in four parallel tracks, one for each of the four industrial themed focus areas: Healthcare, Energy, Telecommunications and Transportation. Students are required to go to the seminars of their selected track, and are encouraged to go to the other ones. Industrial and academic researchers will present in the seminar series. The students will be required to submit short reviews for each seminar they attended. (Pre-requisites: None; Co-requisites: None)
Class 1, Lab 0, Studio 0: Credit 1

5.0 Possible resources (texts, references, computer packages, etc.)

Text:
N/A
Software:
N/A

6.0 Topics

Contemporary issues and research advances in engineering for Healthcare, Energy, Telecommunications and Transportation industries.

7.0 Intended course learning outcomes and associated assessment methods of those outcomes (please include as many Course Learning Outcomes as appropriate, one outcome and assessment method per row).

Course Learning Outcome:	Exam & Quizzes	Homework	Labs	Projects
(1) To gain exposure to contemporary engineering research challenges and solutions approaches in Healthcare, Energy, Communications and Transportation industry		X		
(2) To provide high level reviews of research presentations		X		

8.0 Program outcomes supported by this course

The Program Outcomes of the Ph.D. in Engineering degree are listed below, for which students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

Program Goal 1: "Create Knowledge": Produce graduates who will create knowledge through independent research to advance the field of engineering as an applied science.
Program Goal 2: "Specialized Knowledge": Produce graduates who will have a strong foundation in engineering knowledge, and the necessary specialized education in a concentrated field of study to be able to successfully pursue careers or mentor others in their study of engineering.
Program Goal 3: "Life-Long Learners": Produce graduates who will adapt to technological advances and continue to develop socially relevant engineering solutions using the skills and knowledge acquired through continued education and training as well as independent inquiry.

The table below indicates how this course supports achievement of the Graduate Program Outcomes of the Ph.D. in Engineering degree program. The degree to which XXXX-890 satisfies each program outcome is indicated by (X) corresponding to slightly, moderately, and significantly.

XXXX-890 Engineering Focus Area Seminar			
Program Outcomes	**Slightly**	**Moderately**	**Significantly**
"Create Knowledge"	X		
"Specialized Knowledge"	X		
"Life-long Learners"			X

9.0

	General Education Learning Outcome Supported by the Course, if appropriate	Assessment Method
Communication		
	Express themselves effectively in common college-level written forms using standard American English	
	Revise and improve written and visual content	
	Express themselves effectively in presentations, either in spoken standard American English or sign language (American Sign Language	

	or English-based Signing)	
	Comprehend information accessed through reading and discussion	
Intellectual Inquiry		
	Review, assess, and draw conclusions about hypotheses and theories	
	Analyze arguments, in relation to their premises, assumptions, contexts, and conclusions	
	Construct logical and reasonable arguments that include anticipation of counterarguments	
	Use relevant evidence gathered through accepted scholarly methods and properly acknowledge sources of information	
Ethical, Social and Global Awareness		
	Analyze similarities and differences in human experiences and consequent perspectives	
	Examine connections among the world's populations	
	Identify contemporary ethical questions and relevant stakeholder positions	
Scientific, Mathematical and Technological Literacy		
	Explain basic principles and concepts of one of the natural sciences	
	Apply methods of scientific inquiry and problem solving to contemporary issues	
	Comprehend and evaluate mathematical and statistical information	
	Perform college-level mathematical operations on quantitative data	
	Describe the potential and the limitations of technology	
	Use appropriate technology to achieve desired outcomes	
Creativity, Innovation and Artistic Literacy		
	Demonstrate creative/innovative approaches to course-based assignments or projects	
	Interpret and evaluate artistic expression considering the cultural context in which it was created	

10.0 Other relevant information (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

***Optional course designation; approval request date:** This is the date that the college curriculum committee forwards this course to the appropriate optional course designation curriculum committee for review. The chair of the college curriculum committee is responsible to fill in this date.

****Optional course designation; approval granted date:** This is the date the optional course designation curriculum committee approves a course for the requested optional course designation. The chair of the appropriate optional course designation curriculum committee is responsible to fill in this date.

*****Course Conversion Designations**

Please use the following definitions to complete table 2.a on page one.

- **Semester Equivalent (SE) –** Closely corresponds to an existing quarter course (e.g., a 4 quarter credit hour (qch) course which becomes a 3 semester credit hour (sch) course.) The semester course may develop material in greater depth or length.

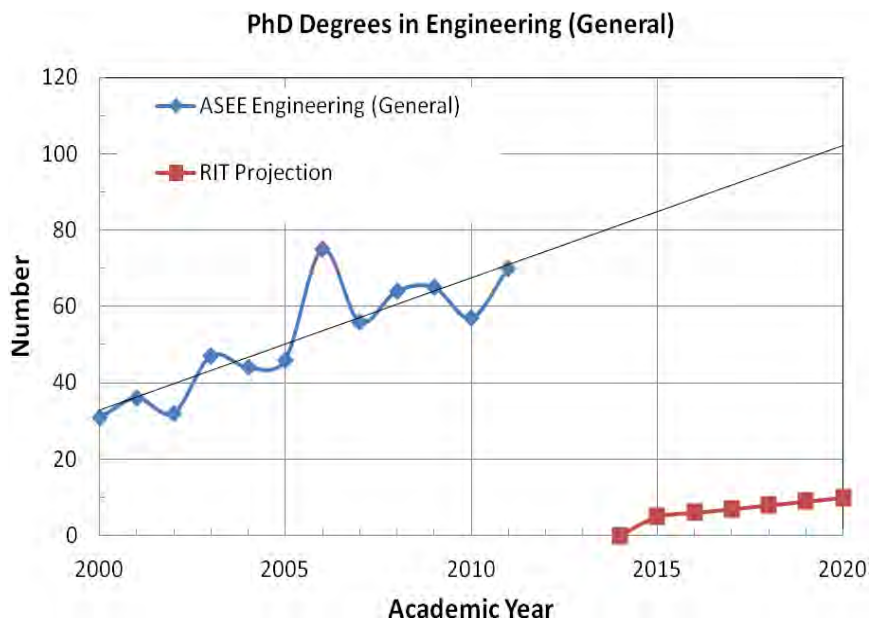
- **Semester Replacement (SR) –** A semester course (or courses) taking the place of a previous quarter course(s) by rearranging or combining material from a previous quarter course(s) (e.g. a two semester sequence that replaces a three quarter sequence).
- **New (N) -** No corresponding quarter course(s).

Appendix B: Enrollment and Market Analysis

Anticipated Graduation Rate

We have ***projected an 80% graduation rate for the PhD in Engineering*** program. This performance is on-par with other PhD programs at RIT.

The RIT Ph.D. in Engineering program will rapidly become a significant national producer of doctoral graduates in the "Ph.D. General" engineering category, as illustrated in the Figure below.



Engineering (General) Doctoral Degrees through 2020. An RIT Interdisciplinary Engineering Degree program has the potential to become positioned as a significant player contributing nearly 10% of the annual graduates by 2020 using conservative projections.

If we position our program to be lumped with the "Engineering (Other)" category it will be very difficult for us to achieve a significant impact on national level statistics. For example in the year 2010 there were 517 Engineering Ph.D. (Other) graduates while there were only 57 Engineering Ph.D. (General) graduates. If RIT can position a new engineering Ph.D. degree program to clearly fall in the "General" category and make sure that we consistently fill out our ASEE reports to that effect each year then we can drive perception in the market place even if we grow to the model level of ten graduates in the early years. A key challenge faced by other Ph.D. programs at RIT is that they tend to get lost in national rankings because of low name recognition.

Competing Regional and National Programs

A Ph.D. in Engineering will position RIT in a strong competitive position at the National Level. While it may be difficult for RIT to rapidly achieve high rankings in traditional engineering Ph.D. disciplinary areas we believe that there is an excellent potential for us to develop a national reputation with our unique multi-disciplinary approach and still be captured and ranked by widely recognized bodies such as the American Society for Engineering Education[xiii]. The Engineering (General) category of the ASEE data set is presented in the table below. During 2011 there were 712 students enrolled in Engineering (General) Ph.D. programs. The RIT Ph.D. in Engineering can have an observable influence on these enrollment figures which will certainly draw attention to our program by our peers.

Doctoral Enrollment	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aerospace	1200	1206	1321	1459	1797	1780	1657	1703	1913	1996	2069
Architectural	57	61	65	65	44	25	27	36	53	55	68
Biological / Agricultural	350	373	412	400	461	507	524	589	655	728	710
Biomedical	1949	2348	2903	3546	3936	4411	4668	4894	5289	5601	5849
Chemical	3992	4620	5044	5185	4995	5025	4980	5154	5475	5625	5832
Civil	4134	4543	4666	4971	4548	4383	4319	4179	4625	5032	5088
Civil / Environmental	—	—	—	—	136	230	377	497	509	501	672
Computer Sci. (In Eng.)	3264	3941	4835	5174	6406	6346	6307	6308	6761	7031	7511
Electrical / Computer	12070	13694	15419	16074	15472	15303	15431	15381	16440	17042	17054
Engineering (General)	168	176	280	342	341	572	499	520	571	633	712
Engineering Mgmt.	299	477	342	487	314	240	261	257	337	366	382
Eng. Sci. & Eng. Physics	702	746	872	902	1036	966	937	981	962	951	966
Environmental	270	293	472	416	875	769	871	828	884	964	964
Industrial / Manuf.	1850	2050	2246	2427	2546	2521	2449	2432	2757	2881	2894
Mechanical	5584	6212	7117	7295	6777	6982	6937	7273	8076	8674	9058
Metallurgical & Mat'ls.	2235	2425	2690	2831	3281	3302	3620	3667	3815	3941	4249
Mining	62	63	69	89	93	71	105	77	83	60	107
Nuclear	418	409	453	464	580	589	647	667	705	805	810
Other	2683	3441	3200	3664	3201	3328	3434	3638	3699	4018	4278
Petroleum	159	185	198	210	238	211	268	369	404	465	523
TOTAL	41446	47263	52604	56001	57077	57561	58318	59450	64013	67369	68796

Doctoral Engineering Program Enrollment by Discipline for 2001 through 2011. "Engineering By The Numbers" 2011 Profile of Engineering Statistics, Brian L. Yoder, American Society for Engineering

Education available on-line at http://www.asee.org/papers-and-publications/publications/college-profiles/2011-profile-engineering-statistics.pdf (and previous editions for earlier data).

This history of engineering doctoral degrees awarded shows similar trends as illustrated in the following table. An RIT Engineering Ph.D. program will have observable impact in just a few years in this category while offering a degree in any one of the traditional disciplines might require a much longer time to be "noticed" by our peers. There were 70 Ph.D.s awarded in "Engineering (General)" during 2011. If we are able to rapidly grow our program to the point of graduating even 10 graduates per year we will be observed as a large contributor in this category. This allows us to present our program as being highly innovative while still falling within a traditional ranking category used by the ASEE.

Doctoral Degrees	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aerospace	216	211	197	210	259	244	259	252	276	254	280
Architectural	2	4	2	7	6	2	8	11	7	7	6
Biological/ Agricultural	72	68	69	90	68	66	65	88	80	87	114
Biomedical	219	213	240	339	333	436	536	662	722	733	812
Chemical	645	632	592	655	805	834	898	888	836	905	863
Civil	574	628	618	644	725	767	770	706	707	681	747
Civil / Environmental (1)	—	—	—	—	20	29	51	100	87	92	78
Computer	80	76	95	125	115	191	193	216	230	248	229
Computer Sci. (In Eng)	381	350	410	494	606	761	867	847	863	849	880
Electrical	691	627	644	720	834	939	1064	1006	959	992	1030
Electrical / Computer	840	776	761	901	938	1112	1234	1169	1055	1038	1185
Engineering (General)	36	32	47	44	46	75	56	64	65	57	70
Engineering Mgmt.	32	26	30	40	35	39	37	35	44	46	43
Eng. Sci. & Eng. Physics	132	100	102	109	111	131	143	133	150	160	155
Environmental	57	83	89	124	112	129	133	138	143	134	154
Industrial/ Manuf.	231	274	275	306	302	348	398	401	381	352	383
Mechanical	858	796	792	855	964	1132	1161	1140	1216	1078	1225
Metallurgical & Mat'ls	408	342	388	442	464	519	584	617	598	603	632
Mining	11	11	12	7	11	16	15	13	12	6	4
Nuclear	84	64	81	61	76	81	88	103	87	114	115
Other	443	429	398	403	457	460	447	447	511	517	521
Petroleum	32	30	28	28	46	40	48	50	54	42	56
TOTAL	6044	5772	5870	6604	7333	8351	9055	9086	9083	8995	9582

[1] New discipline added in 2005.

Engineering Doctoral Degrees by Discipline for 2001 through 2011. "Engineering By The Numbers" 2011 Profile of Engineering Statistics, Brian L. Yoder, American Society for Engineering Education available on-line at http://www.asee.org/papers-and-publications/publications/college-profiles/2011-profile-engineering-statistics.pdf (and previous editions for earlier data).

Anticipated Geographic Draw

RIT KGCOE offers a spectrum of Bachelors and Masters degree programs in a range of engineering disciplines. Our undergraduate BS programs are five year programs which include one year of co-operative education work experience. The KGCOE offers dual degree programs that allow highly motivated students to apply for admission in their second year. The Master of Engineering degree offered by the ME and ISE departments is a non-research degree primarily focused in preparing students for workforce entry. The MS degrees are offered by all of the departments in the KGCOE and have a more traditional MS-Thesis research orientation. Students may move into the BSMS program from either the BS or the BS/MEng program. Students typically complete both their BS and MS degrees within six years of entry to RIT as a first year undergraduate. The departments in the RIT KGCOE also offer traditional MEng (non thesis) and MS (thesis) Master's degrees for students who have completed their BS degrees elsewhere. We anticipate that students will enter the Ph.D. in Engineering program from (a) our BS programs (b) our BS/Masters' programs (c) our Master's programs and (d) other institutions.

Table S.1 illustrates how a student would progress through the Ph.D. in Engineering, when they enter the program with a Bachelor of Science degree from an ABET accredited or similar undergraduate program. This would be the common entry point for international students who choose to attend RIT for their doctoral program

TABLE S.1. EXAMPLE PROGRAM OF STUDY FOR A STUDENT WHO ENTERS THE ENGINEERING PH.D. PROGRAM WITH A B.S. DEGREE IN ENGINEERING.

Yr	Term	Event	SCH	Cum SCH
1	Fall	RIT Graduate Courses	12	12
	Spring	RIT Graduate Courses	12	24
	Summer	PhD Comprehensive Exam Fail = MS Only, Pass = Continue PhD		24
2	Fall	RIT Graduate Courses	9	33
	Spring	RIT Graduate Courses	9	42
	Summer	PhD Dissertation Proposal Exam	3	45
3	Fall	PhD Dissertation Research	9	54
	Spring	PhD Dissertation Research PhD Candidacy Exam	9	63
	Summer	Continue Research as Needed Phd Dissertation Defense Exam	3	66
4,5,6		Continue Research as Needed		

Table S.2 illustrates how a student would progress through the Ph.D. in Engineering, when they enter the program with a Master of Science degree in engineering. This path would be typical of students who had completed their BS elsewhere, come to RIT for a Master's degree, and then decided to continue on for their Ph.D. degree, or of students who specifically come to RIT to work with a faculty member after having completed their Master's degree elsewhere.

TABLE S.2 . EXAMPLE PROGRAM OF STUDY FOR A STUDENT WHO ENTERS THE ENGINEERING PH.D. PROGRAM WITH A M.S DEGREE IN ENGINEERING.

Yr	Term	Event	SCH	Cum SCH
		Other University MS Courses		24
1	Fall	RIT Graduate Courses	9	33
	Spring	RIT Graduate Courses	9	42
	Summer	PhD Comprehensive Exam Fail = Depart Program, Pass = Continue PhD		42
2	Fall	RIT Graduate Courses	6	48
	Spring	PhD Dissertation Research	6	54
	Summer	Phd Dissertation Proposal Exam	6	60
3	Fall	PhD Dissertation Research	6	66
	Spring	PhD Dissertation Research PhD Candidacy Exam	6	72
	Summer	Continue Research as Needed Phd Dissertation Defense Exam	6	78
4,5,6		Continue Research as Needed		

Table S.3 illustrates how a student who enters RIT directly from high school can adapt their educational pathway as their career interests evolve. While few students in high school know that they desire to pursue a doctoral degree, many students come to this conclusion over a period of time, as their view of their career matures. RIT has a unique opportunity to help these students discover the correct pathway for them ... as the student's perspective on graduate education evolves, they can move seamlessly from the BS program into dual degree BS/MS programs. Those students who are particularly strong can be encouraged to flow directly into our Ph.D. in Engineering.

TABLE S.3 . EXAMPLE PROGRAM OF STUDY FOR A STUDENT WHO ENTERS RIT FROM HIGH SCHOOL, AND PROGRESSES THROUGH THE BACHELOR'S, MASTER'S AND PH.D. PROGRAMS IN THE KGCOE AT RIT.

Yr	Term	Event	SCH	Cum SCH
1	Fall	RIT Freshman Courses	17	17
	Spring	RIT Freshman Courses	17	34
2	Fall	RIT Sophomore Courses	17	51
	Spring	RIT Sophomore Courses	17	68
	Summer	Co-Op Block 1 Admitted to BS/MS	0	68
3	Fall	Co-Op Block 2	0	68
	Spring	RIT Junior Classes	17	85
	Summer	RIT Junior Courses Write MS Thesis Proposal	17	102
4	Fall	Co-Op Block 3	0	102
	Spring	RIT Senior Classes	15	117
	Summer	Research Co-op #4 Conduct MS Thesis Research	0	117
5	Fall	RIT Senior Classes and RIT BS/MS Classes	12	129
	Spring	RIT MS Courses	15	144
	Summer	MS Thesis Research	0	144
6	Fall	MS Thesis Research Apply for Fast-Track PhD	6	150
	Spring	MS Thesis Research Admit to Fast Track PhD	0	150
	Summer	BS + MS Graduation MS Defense = PhD Comp. Exam Fail = MS Only, Pass = Continue	0	150
7	Fall	Graduate Courses	6	156
	Spring	Graduate Courses	6	162
	Summer	PhD Dissertation Proposal Exam	3	165
8	Fall	PhD Dissertation Research	12	177
	Spring	PhD Dissertation Research PhD Candidacy Exam	12	189
	Summer	Continue Research as Needed Phd Dissertation Defense Exam	3	192
9,10		Continue Research as Needed		

The RIT KGCOE has a strong track record of placing our graduates into Ph.D. programs. We clearly have a population of students who desire to pursue a doctoral degree and our BS and Masters programs are clearly viewed as good preparation for Ph.D. study. In the past decade over 50 graduates of the RIT KGCOE have entered Ph.D. programs as illustrated in the table below. In recent years the rate at which our graduates enter Ph.D. programs has increased dramatically.

TABLE S.4. TEN YEAR HISTORY OF RIT KGCOE GRADUATES WHO HAVE ENTERED PH.D. PROGRAMS FOLLOWING THEIR STUDIES AT RIT.

Department	First name	Last name	Grad	Ph.D. school
Computer	Names	Removed	2012	SUNY Binghamton
Industrial			2012	Planning to Attend
Industrial			2012	Planning to Attend
Industrial			2012	Planning to Attend
Industrial			2012	RIT Microsystems
Mechanical			2012	RIT Microsystems
Mechanical			2012	MIT
Mechanical			2012	Princeton
Computer			2011	Univ. of Cal. at Berkeley
Computer			2011	RIT Microsystems
Mechanical			2011	Cornell Univ.
Mechanical			2011	Colorado State Univ.
Mechanical			2011	Georgia Tech
Mechanical			2011	Univ. of Colorado
Mechanical			2011	Univ. of Central Florida
Mechanical			2011	Univ. of Central Florida
Mechanical			2011	RIT Microsystems
Applied Statistics			2010	U. of Buffalo
Applied Statistics			2010	RIT
Computer			2010	RIT
Mechanical			2010	U. Mass Amherst
Mechanical			2010	Univ. of Utah
Mechanical			2010	Georgia Tech
Mechanical			2010	Univ. of Pennsylvania
Mechanical			2010	GIS at RIT
Applied Statistics			2009	U. of Pittsburgh
Computer			2009	Carnegie Mellon Univ.
Industrial			2009	Univ. of Pennsylvania
Industrial			2009	SUNY Buffalo
Mechanical			2009	Columbia Univ.
Mechanical			2009	UC Boulder
Mechanical			2009	Univ. of Utah
Mechanical			2009	Univ. of Alabama

Table S.4. (CONTINUED)

Department	**First name**	**Last name**	**Grad**	**Ph.D. school**
Mechanical	Names	Removed	2009	Virginia Tech
Mechanical			2009	Univ. of Rochester
Mechanical			2009	Univ. of Utah
Mechanical			2009	Cornell Univ.
Mechanical			2009	Pennsylvania State Univ.
Mechanical			2009	Texas A & M Univ.
Industrial			2009	SUNY Buffalo
Mechanical			2008	Purdue
Mechanical			2008	Purdue
Mechanical			2008	Univ. of Cal. at Berkeley
Applied Statistics			2008	U. of Utah
Industrial			2008	Imaging Science at RIT
Mechanical			2008	Univ. of California
Mechanical			2008	Univ. of Kentucky
Mechanical			2008	Tashkent Univ.
Mechanical			2008	Drexel
Mechanical			2008	Purdue
Industrial			2008	GIS at RIT
Applied Statistics			2007	U. of Connecticut
Applied Statistics			2007	U. of Pittsburgh
Computer			2007	Princeton
Industrial			2007	Univ. of Michigan
Industrial			2007	SUNY Buffalo
Mechanical			2007	Syracuse Univ.
Mechanical			2007	Clemson
Mechanical			2007	Pennsylvania State Univ.
Mechanical			2007	Cornell Univ.
Industrial			2007	Univ. Michigan
Applied Statistics			2006	Va Tech. / (now) Ga Tech.
Computer			2006	Univ. of Rochester
Computer			2006	SUNY Buffalo
Applied Statistics			2005	Michigan State
Applied Statistics			2005	U. of Oklahoma
Applied Statistics			2005	Syracuse U.
Industrial			2005	UC Berkeley
Industrial			2005	Harvard
Mechanical			2005	Florida Interntl. Univ.
Applied Statistics			2004	U. of Maryland
Industrial			2004	Georgia Tech
Mechanical			2004	Univ. of S. Florida Tampa
Industrial			2003	Microsystems at RIT
Industrial			2002	Case Western Reserve

Career Opportunities

Career opportunities for Ph.D. in Engineering graduates include professorships, research scientists and post-doctorate positions in academia, industry and government laboratories. The job market for tenure-track and tenured professorships has been more competitive than ever, due to higher education budget cuts and increasing doctorate awardees. As this trend continues, the readiness of Ph.D. graduates with dual-career (industry and academia) will be critical to provide the competitive edge.

According to the Council on Graduate Education[xiv] and the Educational Testing Service:

> *"Between 2010 and 2020, about 2.6 million new and replacement jobs are expected to require an advanced degree, with a projected increase of about 22% for jobs requiring a master's degree and about 20% for jobs requiring a doctorate or professional degree. Advanced education levels continue to be associated with lower unemployment rates and higher salaries ... Individuals earning doctorates in engineering are most likely to go into business/industry ... Employers advocated stronger ties between graduate school experiences and workforce needs. They believed that graduate programs need a multidisciplinary focus, that graduate students need to understand how knowledge in one area can be applied o solve problems in another, and that graduate students need to learn to be innovative and entrepreneurial."*

The proposed Ph.D. in Engineering focuses on student education and mentoring with industry-themed interdisciplinary challenges. Extending from the success of RIT's career oriented BS, MEng, and MS programs, faculty mentors in KGCOE and other colleges will be comfortably instill the collaborative and global perspective for innovation to our graduates. The cross-disciplinary exposure through the seminars and course-work collaboration will reinforce the collaborative practice throughout the Ph.D. residency. The design of the proposed Ph.D. in Engineering is expected to enable our graduates to be the new breed of doctorates who can seamlessly and effectively bring the industrial perspective to the classroom as well as bring the theoretical foundation to new product development.

In addition to industry and government R&D laboratories, graduates from the proposed Ph.D. program may join academic institutions. We anticipate that placement into academic positions will represent up to 20% of the program graduates during the first five years.

Appendix C: Internal Support Letters

The following is a list of internal support letters provided in the appendix.

R·I·T Internal Support Letters

* RIT Enrollment Management & Career Services
* The Wallace Center at RIT
* KGCOE Graduate Studies Committee
* Dean S. Maggelakis, College of Science
* Dean A. Sears, GCCIS

From: James G. Miller (EMCS VP)
To: Edward Hensel Jr.;
cc: Harvey J. Palmer; Diane Ellison;
Subject: Ph.D. Proposal
Date: Wednesday, November 07, 2012 3:05:08 PM

Dear Ed,

This response is based on: 1) our review of the concept paper you shared proposing within KGCOE a new Ph.D. in Engineering; and 2) pertinent details we discussed in our meeting on Monday, October 29. Subsequently, I shared all with Diane Ellison, AVP for Graduate and Part-time Enrollment Services. We are in full agreement in our response.

I am pleased to advise that from a market perspective, the proposal you shared for a Ph.D. in Engineering with domains in Healthcare, Energy, Telecommunications and Transportation has the full support of EMCS and the Office of Graduate and Part-time Enrollment Services. From a strategic perspective we believe that the program continues to build a core area of strength at the Institute and provides important opportunities to leverage further international initiatives and important ties with business, government, and industry.

Both Diane Ellison and I do not foresee any difficulty in attracting sixteen new entry full-time students in the near term or in the foreseeable future. Further, we believe four new part-time enrollees each year is conservative, especially if you consider expanded corporate partnership possibilities. We believe that there will be more than sufficient demand both for full-time and part-time new student targets you have established for each domain and for the program overall.

Further we believe there are development opportunities for faculty in developing countries. Clearly potential exists for expanding existing/emerging university partnerships and agreements in the Dominican Republic, Colombia, Peru and Ecuador , just to name a few. Additionally, we see added interest being generated from critical agencies such as Fulbright and OAS. Adding these dimensions to the targeted outreach already planned will support RIT's globalization agenda and continue our distinctive partnership opportunities in areas both important to RIT and KGCOE as well as to partners both here and abroad.

Finally, adding such a program to KGCOE's portfolio will likely increase demand for KGCOE's existing Masters' degree programs as it provides expanded opportunities for talented MS students to continue for terminal engineering degrees and elevates RIT’s overall profile within national universities.

I appreciate the opportunity to provide comment at this stage of program development. Please do not hesitate to contact Diane Ellison or me if you desire additional information.

Jim Miller

R·I·T
Rochester Institute of Technology

Sophia Maggelakis, Ph.D.
Dean, College of Science
84 Lomb Memorial Drive
Rochester, New York 14623-5603
(585)-475-2483 Fax: (585)-475-2398
Email: sxmsma@rit.edu

January 21, 2013

Dr. Harvey J. Palmer
Dean
Kate Gleason College of Engineering

Dear Harvey:

It is my pleasure to convey my support for the proposed Ph.D. program in Engineering. The College of Science has been a longtime partner with the Kate Gleason College of Engineering and this program will provide another avenue for more collaborations.

The proposed Ph.D. program in Engineering will enrich RIT's academic portfolio and will contribute to its mission by preparing graduates who will help meet our nation's needs for more STEM professionals. Such a program will also contribute to the growth of our research agenda and towards meeting our research and scholarship targets. A new Ph.D. in engineering will enhance opportunities for research collaborations with our college and will offer more opportunities for interdisciplinary research projects involving students and faculty from both colleges and from the STEM colleges in general.

I wish you all the best in this new initiative.

Sincerely,

Sophia Maggelakis

Sophia A. Maggelakis, Ph.D.
Dean, College of Science
Professor of Mathematics

R·I·T

Rochester Institute of Technology
B. Thomas Golisano College
of Computing and Information Sciences
Office of the Dean
20 Lomb Memorial Drive
Rochester, NY 14623-5604
585-475-7203 • Fax 585-475-4775

To: Harvey Palmer, Dean

From: Andrew Sears, Dean

Date: January 28, 2013

Re: PhD in Engineering

The proposed Ph.D. in Engineering appears to be a well-designed program that will accomplish the stated goals of developing knowledge creators in the broad areas of Transportation, Energy, Communications, and Health. The proposal makes a strong, logical case that the existing talents of the faculty will be leveraged and maximized by focusing on areas of existing strength specialization, with the realization that opportunities will change over time.

While is appears that there will be some degree of overlap with both existing and proposed PhD programs, this appears inevitable given the current focus on PhD programs that are broad and inclusive. As an example, at present there are faculty supervising PhD students within the PhD in Computing and Information Sciences who could decide that the proposed PhD in Engineering is a better fit. As a result, the proposed program could draw some faculty and students from existing programs. On the other hand, this will provide students and faculty with an additional option that may better fit their needs and interests. The table provided helps to make clear that such overlap may be more superficial than real. One of the major differentiators of this program from the existing PhD in Computing and Information Sciences is the admissions requirement of a degree in engineering. While some of our incoming doctoral students have degrees in engineering others do not. Given the nature of the proposed degree, the PhD in Engineering will focus more on extending engineering solutions.

There is a significant advantage to a program such as the PhD in Engineering as compared to traditional stratification that is the norm elsewhere. Such a program allows ideas from a variety of engineering disciplines to be leveraged as significant problems are addressed. This opens possibility of collaboration with and participation of domain specialists and researchers from across RIT's other programs and colleges.

The practical, use-inspired approach that is described is similar to the approach used in our PhD program. Two such application-oriented programs can perhaps create a synergy that will propel RIT ahead as a research institution that specializes in real and valuable solutions. Discussions with Dr. Pengcheng Shi, the Director of our PhD in Computing and Information Sciences, show his belief that you clearly have the faculty talent within your college to succeed. Dr. Shi is supportive of the proposal, but notes that your growth may be slower than expected unless there is considerable investment from RIT. A strategy for RIT's overall research reputation is probably worth discussing at some point. However, it is clear that the proposed PhD in Engineering will leverage existing strengths and faculty talent, which is clearly sufficient at this point to begin ramping up the program.

We have some concern about the following section in the proposal: "A faculty member must have a PhD in engineering or science to supervise a PhD student in the program. Under certain special circumstances, a person with an MS in engineering may qualify to serve as a primary advisor of a PhD student if the individual has at least 10 years of experience as a primary lead on research projects within an industry or government laboratory setting and has consistently disseminated the results of the research in peer- reviewed journals within the field." In particular, the concern is if this results in having too many non-PhD faculty supervising PhD students it could hurt the reputation of this program and RIT PhDs more generally.

In summary, we believe that the PhD in Engineering will be a positive addition to RIT's portfolio of PhD programs. It would appear to have a high probability of success, based on the current success of faculty in related areas. The "inter-engineering" approach that is described is refreshing in that it uses all possible engineering approaches to tackle serious problem.

We wish you the best of luck, and look forward to future collaboration.

Memorandum

TO: Harvey Palmer
Dean, Kate Gleason College of Engineering

CC: Shirley Bower
Director, RIT Libraries
Sheila Smokey
Manager, RIT Libraries Acquisitions & Serials

FROM: Linette Koren
Engineering Librarian, RIT Libraries

DATE: November 5, 2012

RE: Library support for proposed Ph.D. in Engineering

This letter serves to state the proposed funding model to achieve the level of library/research support needed for the Ph.D. in Engineering.

RIT Libraries now use a demand/user driven model of acquisition for the majority of its book purchases ensuring books purchased are those that users want. This model will be tweaked to fully encompass all four industry sectors of the Ph.D. program.

As the number of Ph.D. programs continues to grow, the Ph.D. in Engineering will certainly benefit from resources already purchased to specifically support these existing programs. Many faculty and students from all colleges benefit daily from library resources such as IEEE Xplore, Web of Science, and the SPIE Digital Library to name a few.

While fully leveraging the resources we have access to in support of graduate education, RIT Libraries realizes, through experience with supporting the Ph.D. in Microsystems, that additional resources will be needed to support research efforts in the burgeoning areas of energy, telecommunications, transportation, and healthcare. While our current holdings (journals and databases) are at acceptable levels for undergraduate and masters level programs, we do admit a specific weakness in the area of transportation and a general weakness to support all four industry sectors at a Ph.D. level.

Experience has shown that specific resource needs do not present themselves at the planning stage of a new program. Hence it would be premature to state (guess, really) what journals and databases faculty and students in this program would need to support their research. It is also not known what new resources will be created in these growth areas that faculty and students cannot work without.

It is my recommendation that based on the average costs of journals and databases in the areas of science and technology that **$30,000** annually be allocated to the library in support of the Ph.D. in Engineering. These funds will be spent in close and regular dialogue between the director of the program and myself with input from all faculty and students associated with the program.

R·I·T

Rochester Institute of Technology

Office of the Dean
Kate Gleason College of Engineering
James E. Gleason Building
(585) 475-2145   Fax (585) 475-6879

January 8, 2013

Dear Harvey:

After thorough deliberation and review, *<u>the KGCOE Graduate Studies Committee unanimously approved the proposed Ph.D. in Engineering program</u>*. The committee indicated that there is significant grass-roots faculty support for a Ph.D. program in Engineering and felt this proposed program provides an opportunity for a majority of the KGCOE faculty, from across the various engineering disciplines, to engage and participate in, given the multidisciplinary nature of the program.

Sincerely,

Jacqueline R. Mozrall, Ph.D.
Professor and Associate Dean

Appendix D: External Letters of Support

The following is a list of external support letters provide in the appendix.

Healthcare

* Ortho-Clinical Diagnostics / Johnson & Johnson
* Simpler Healthcare
* Rochester General Hospital
* Blue Highway
* SimPore, Inc.

Communications

* Anaren Microwave, Inc.
* Harris RF Communications
* Freescale Semiconductor
* Qualcomm
* Synaptics
* APX Labs

Transportation

* NASA Langley
Raytheon
Boeing
* Systems Technologies, Inc.
* Impact Technologies, Inc.
Alstom, Inc.
* The Gleason Works

Energy

* Cerion Enterprises
* MicroGen Systems
Dresser Rand
* GE Energy
IBM, Inc.

* indicates letter included in Appendix

Ortho Clinical Diagnostics

PART OF THE Johnson & Johnson FAMILY OF COMPANIES

November 6, 2012

Dr. Harvey Palmer
Rochester Institute of Technology
James E. Gleason Building
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dean Palmer:

Thank you for sharing your proposal for a new PhD program at the Kate Gleason College of Engineering. As I read the proposal, I became increasingly excited with the prospect that PhD engineering students would be trained in an interdisciplinary manner focused on the healthcare industry. Along with healthcare, the other interdisciplinary focus areas of the PhD proposal—Transportation, Telecommunications, and Energy—are foundations of our industrial society and I endorse them.

As the Vice President of Research and Development at Ortho Clinical Diagnostics, I am of course invested in the hiring of highly-qualified PhD students who can progress our research agenda. Students trained as described in the proposed PhD program will be well able to solve problems in the healthcare sector. For example, it is impossible for a healthcare product to be designed that does not involve the merging of technology from a variety of disciplines including Chemical, Electrical, and Mechanical Engineering, with exposure to Biomedical Engineering and Health Sciences. Further Clinical Science and Health Care Economics are areas that should be leveraged.

An impediment to success of many starting PhD employees is their inability to translate their very deep knowledge and skill set obtained during their PhD work into the broader applications of that research. As a result, traditionally trained PhD students can find it difficult to work with PhDs from other disciplines, which is unfortunate because their composite skills are necessary to deliver a healthcare product. The contextual elements of the proposed program afforded by its interdisciplinary nature will give its PhD graduates a competitive advantage in the workplace. My organization will certainly consider hiring students from this program.

I have been a routine contributor to RIT over the years because I consider it to be an essential economic and intellectual resource to our community. I have been an avid supporter of nationally recognized WE@RIT (Women in Engineering) program, and am also serving on the Industrial Advisory Board for the newly established Chemical Engineering program. I am impressed that RIT engineering continues to create novel and innovative programs that anticipate the needs of the future. The PhD program that has been proposed certainly is forward-looking, and in my opinion is destined to be successful. In addition to its own merits, the decision to create a non-traditional interdisciplinary PhD program is strategically sound, in that its graduates will not be competing head on with those from existing schools with established infrastructure. Rather, RIT engineering students will occupy a niche that students from other schools cannot easily fill.

For the above, reasons, I enthusiastically endorse the interdisciplinary PhD in engineering proposed by the Kate Gleason College of Engineering.

With warm regards,

Holly M. Hillberg

Holly M. Hillberg
Vice President, Research & Development

100 Indigo Creek Drive, Rochester, NY 14626-5101
Phone 585-453-3320

GE Energy

Dale J. Davis, Esq.
Senior Counsel - Intellectual Property
300 Garlington Road
Greenville, SC 29615
USA

T +1 864-254-4662
F +1 864-254-4662
M +1 864-884-7656
Dial Comm: 8* 288-7656

December 19, 2012

Dr. Harvey Palmer
Rochester Institute of Technology
James E. Gleason Building
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dean Palmer:

I highly recommend the proposed PhD program at the Kate Gleason College of Engineering. In my view, the proposed program will benefit the RIT brand and its graduates.

RIT has truly blossomed since I graduated with a BSME in 1996. Then, a PhD was not offered. However, it was offered by many other Universities. As RIT continues to evolve, the proposed program will broaden RIT's brand and worldwide reputation.

As a Senior IP Counsel for a major GE business, I interact with many PhDs. A missing link in their training is the integration of academia with fundamental knowledge of specific industry sectors. The interdisciplinary foci of Energy, Healthcare, Telecommunications, and Transportation are specific to current and growing worldwide demands. PhDs should have a broader view, and understanding, of these worldwide demands. I believe the marketplace will reward those with this understanding. I also believe that RIT's proposed program will provide that understanding.

Best Regards,
/s/
Dale J. Davis, Esquire

freescale

November 13, 2012

Re: PhD in Engineering at RIT

Dear Dr. Harvey Palmer,
For the past several Computer Engineering Advisory Board meetings, one of the topics we have been discussing is the importance for RIT to offer a Doctorate in Engineering degree. I am very interested in RIT pursuing this initiative and support having this degree offering. I think of this addition as a series of building stones that will serve RIT, industries, and the Rochester area community.

First, RIT is known as one of the top technical institutions in the country. Having this long history of quality engineering education, RIT needs to further its legacy by offering a comprehensive program for students to continue on their path of education excellence. In this challenging job environment, many students are electing to remain in school to further their education and receive an advanced degree, which in turn will provide them with a broader and deeper portfolio of skills to use in pursuing a career.

Second, RIT already established as a leader in engineering education, will be able to continue on its quest to be a well-known research institute. Not only will students have the opportunity to continue to pursue their passions, but RIT will be able further attract quality faculty to join the Computer Engineering department, as well as other departments in the Kate Gleason college of Engineering. Faculty will be able to pursue their areas of interest and work side-by-side with doctorate students to conduct research that will enrich technology advancements to carry into industry.

Lastly, I think of the Rochester area community and how having an engineering doctorate program in place will impact it. I have seen the tremendous growth in the Rochester area over the past 10 years---more retail, more restaurants and more businesses and see the addition of this program as very supportive of that growth. Many students tend to want to stay close to their familiar surroundings. Graduating more students, better equipped with technical skills and research knowledge to go into businesses, will bring further strength to the community. Being at RIT's Imagine Festival for the past 3-4 years and seeing the tens-of- thousands of people from the community attending, certainly makes me think that the community will welcome and embrace the higher level of talent with open arms.

Although not an alum of RIT, I am very proud to be a member of the Computer Engineering Advisory board and associated with RIT. I believe introducing an engineering doctorate program will elevate the levels of education, research, faculty-student collaboration, and involvement in the community.

Sincerely,

Andy

Andy Mastronardi
Director, University Programs
Freescale

Freescale Semiconductor, Inc. 6501 William Cannon Drive West MD: OE58, Austin, TX 78735 www.freescale.com

HARRIS

HARRIS CORPORATION

RF Communications Division
1680 University Avenue
Rochester, NY USA 14610
phone 1-585-244-5830
fax 1-585-242-4755

www.harris.com

November 2, 2012

Rochester Institute of Technology
83 Lomb Memorial Drive
Rochester, NY 14623-5603

Attention: Dr. Harvey Palmer, Dean of Kate Gleason College of Engineering.

Dear Dr. Palmer,

It is my distinct pleasure to provide this letter of recommendation for the PhD in Engineering proposal offered by Professor S. Jay Yang, Department Head, Computer Engineering Dept.

Currently, I am a Senior Engineering Manager and Individual Contributor with Harris Corporation, RF Communications Division. I have been a member of Harris Corporation's RF Communication Security technical staff since 1992. I hold a Bachelor of Science (1986), Master of Science (1988) and Doctor of Philosophy (2001) Degrees in Electrical Engineering from the State University of New York at Buffalo and have been a licensed "Professional Engineer" (License No. 069432) in the State of New York since 1992. I am an industry recognized-expert in the area of secure communications systems design. This includes the design of encryption, key management and authentication systems and algorithms. I have authored/co-authored 15 peer reviewed articles and hold 13 patents with an additional two pending.

At RIT, I have served on the Industrial Advisory Board for the Computer Engineering Department since 2008. I have collaborated with the Computer Engineering Dept on Harris funded projects since 2007. Harris Corporation has funded multiple projects with the Department, as strategic investments in future technical capabilities for our products. Several of these projects are ongoing. Harris has contributed $400,000 towards the establishment of "The Harris Corporation Computer Engineering Design Center" and, since 2010; Harris has invested almost $300,000 in project funding. We have been extremely impressed with the caliber of the principal investigators and the talented students that have worked on these projects. In fact, Harris has gone on to hire many of these students into strategic positions within our engineering organization.

As our company has grown, we have begun to rely more and more on original, applied research as a basis for products and product features that differentiate our offerings from our competitors. The Harris relationship with RIT has been productive in this regard. The proposed PhD in Engineering program will enhance these results not only by attracting more high capability faculty and students, but also through the cross-disciplinary innovation that this program promises to provide.

As a whole, Harris employs a large population of RIT BS and MS graduates throughout the corporation. This proposal will allow RIT to meet the additional corporate wide need for PhD level graduates who are up to the challenge to grow as researchers and business leaders.

I am excited with this concept and encourage you to accept this proposal.

Very highest regards,

Michael T. Kurdziel, PhD, PE
Senior Engineering Manager and Chief Cryptographer
Harris Corporation, RF Communications Division

assuredcommunications™

November 26, 2012

Dr. Edward Hensel, Ph.D.
Department Head
Dept. of Mechanical Engineering
Kate Gleason College of Engineering
James E. Gleason Building
77 Lomb Memorial Drive
Rochester, NY 14623

Subject: Support Letter for Ph.D. Program in Mechanical Engineering at RIT

Dear Dr. Hensel:

Impact Technologies, A Sikorsky Innovations Company, is a leading research company in the areas of Condition-Based Maintenance (CBM) and Prognostics and Health Management (PHM) for the defense and industrial markets. Impact currently employs nearly 110 personnel in its offices in Rochester, NY and State College, many with advanced engineering degrees, including over 10 with Ph.D. degrees in both Mechanical and Electrical Engineering. We are continually looking to hire talented engineering students with advanced degrees and we would highly support a Ph.D. program in Mechanical Engineering at RIT. Given RIT's strong commitment to a practical yet rigorous engineering education using its co-op program and leading design teams for various engineering competitions, a Ph.D. program at RIT would be a natural fit. Such an extension to RIT's current strengths would most likely result in graduating the most practical yet analytically sound Ph.D. student available in the market today. We would look forward to supporting the ME department in the pursuit of this mission and of course help in any way possible if called upon.

Sincerely,

Michael J. Roemer, Ph.D.

Technical Fellow, Sikorsky Aircraft
Chairman, SAE HM-1 Committee for Integrated Vehicle Health Management

Impact Technologies | Headquarters: 300 Canal View Blvd., Rochester, NY 14623 585.424.1990 • Fax: 585.424.1177

October 22, 2012

Dr. Agamemnon L. Crassidis
Associate Professor, Mechanical Engineering
Chair, Graduate Council
Rochester Institute of Technology
James E. Gleason Building, Rm GLE 09-2101
76 Lomb Memorial Drive
Rochester, New York 14623-5603

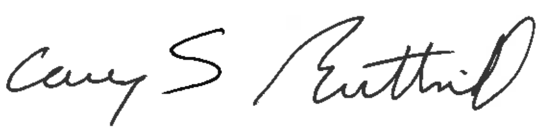
Dear Dr. Crassidis,

Thank you for sharing your proposal for a new Ph.D. program at the Kate Gleason College of Engineering that will focus on 4 technology areas: Transportation, Telecommunications Industry, Healthcare, and Energy.

The NASA Langley Research Center has as its mission the support of Agency goals and missions in Aeronautics, Atmospheric Science, and Access to Space disciplines. The Dynamic Systems and Control Branch at Langley in particular is focused on research in System Identification, Modeling, Simulation, Guidance, and Control as it relates to Launch Systems, Aircraft, Unmanned Air Vehicles, and Spacecraft.

The preferable candidate for hiring at NASA Langley is a recent graduate with a Masters or Ph.D. in the Engineering, Mathematics, Computer Science, Physics, or Chemistry fields, and some experience in practical applications. The area in your proposal entitled "121 - Aeronautics Engineering & Astronautics" is, of course, the one mostly to align with NASA Langley interests.

While my opinion is not an official NASA position, I endorse the creation of the Ph.D. program and see its multidisciplinary nature as an advantage.



Carey S. Buttrill
Head, Dynamic Systems and Control Branch
NASA Langley Research Center

Robert Andosca, Ph.D.

December 14th, 2012

Dr. Edward Hensel, Department Head
Dept. of Mechanical Engineering
Kate Gleason College of Engineering
James E. Gleason Building
77 Lomb Memorial Drive
Rochester, NY 14623

Concerning: Letter of Support for Proposed Ph.D. in Engineering Program

Dear Dr. Hensel:

MicroGen wholeheartedly is in support of RIT's proposed Ph.D. in Engineering Program. MicroGen is a leading company in the development of micro piezoelectric vibrational energy harvesting systems providing power scavenger/energy harvester products with unprecedented efficiency in micro-power generation from usually wasted ambient vibrational energy. One of the proposed program's greatest strength related to our business is the multi/interdisciplinary nature of the program. Another major strength is in the domain application approach rather than a specific discipline approach which trends very well with hiring practices here at MicroGen. In particular, MicroGen's core business in the area of micro piezoelectric vibrational energy harvesting requires researchers with expertise in a wide area of disciplines (such as electrical, mechanical, microsystems, materials, and computer engineering) related to a domain application area, i.e., energy. Therefore, an extremely attractive candidate is one with a broad breath knowledge base in multiple disciplines with specific energy domain applications. The nature of the proposed Ph.D. in Engineering program fulfills these needs quite nicely along with future industry and academia employment trends. I myself sought degrees across multiple disciplines (B.S. in Mathematics and Physics and Ph.D. in Material Science) to bring required knowledge to bear in the initial development of our energy harvesters. We strongly feel that days of the single focus discipline engineer have passed in both industry and academic fields. This program fits in extremely well with this future trend and would be an attractor for us or any employer in industry and academia. We also envision, as MicroGen continues its aggressive growth, sending many of our non-Ph.D. workforce part time through the program outlined here within. We are located within one mile of RIT and can easily accommodate and support our employees in attaining a high level broad knowledge based Ph.D. in Engineering. We eagerly await the start of this program.

Sincerely,

Robert Andosca, Ph.D.
President and CEO

www.microgensystems.com

SYSTEMS TECHNOLOGY, INC

13766 S. HAWTHORNE BOULEVARD • HAWTHORNE, CALIFORNIA 90250-7083 • PHONE (310) 679-2281
FAX (310) 644-3887

18 December 2012

To: Dr. Agamemnon L. Crassidis
Associate Professor, Mechanical Engineering
Chair, Graduate Council
Rochester Institute of Technology
James E. Gleason Building, Rm GLE 09-2101
76 Lomb Memorial Drive
Rochester, New York 14623-5603

Subject: Support for New Multidisciplinary Doctor of Philosophy in Engineering

Dr. Crassidis:

Systems Technology, Inc. is a small R&D company in Southern California with 55 year history in vehicle dynamics, flight controls, modeling and simulation, and human factors. These diverse fields of expertise require that we find agile engineers with multidisciplinary backgrounds. For example, one recent program involved the development of automated controllers to improve the safety and efficiency of oil drilling platforms. Successful results required a multidisciplinary approach that incorporated knowledge from our past work in transportation applied to a problem for the energy industry.

A second example is our new driving simulator for the occupational therapy market. The OT simulator product was designed for ease of use in a clinical setting where the progress of patients can be easily tracked and evaluated. To build this product our traditional modeling and simulation expertise had to be combined with emerging expertise in the needs of the healthcare industry. Only with an engineering staff that is capable of merging the requirements of these diverse industries can successful results be achieved.

For this reason I strongly endorse the proposed new multidisciplinary doctor of philosophy in engineering program of Rochester Institute of Technology that encompasses the diverse industries of healthcare, telecommunications, energy, and transportation.

David H. Klyde
Vice President Research & Engineering Services

November 20, 2012

Dr. Harvey Palmer, Dean
Kate Gleason College of Engineering
James E. Gleason Building
Rochester Institute of Technology
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dean Palmer:

Thank you for sharing your proposal for a new PhD program at the Kate Gleason College of Engineering. The proposed interdisciplinary training approach will be a great asset to the students and their future employers.

At Anaren we are organized into multidisciplinary teams consisting of Project Management, RF Engineering, Mechanical Engineering and Manufacturing Engineering. By working concurrently in these groups we have reduced develop time enabling us to be a market leader in passive RF products. I have come to expect highly skilled Engineers who have excellent interdisciplinary work skills from RIT. As a result I have personally hired 4 Engineers and numerous Coops from RIT. RIT is the second most common University for Engineers at Anaren.

Over 50% of the Electrical Engineers at Anaren have their PhDs in RF/Microwave Engineering. Correspondingly they have extreme depth of knowledge in their field. Unfortunately they do lack experience working on interdisciplinary teams which limits their productivity. This is a skill that we train them on after they have been hired.

Based on my professional experience, your proposed interdisciplinary training approach for the PhD program will set RIT and your graduates apart, benefitting the University, the students, and industry.

Best Regards,

Michael Len
Mechanical & Process Engineering Manager

Anaren Microwave, Inc. 6635 Kirkville Road East Syracuse, NY 13057 Phone: 315 432 8909 Fax: 315 432 9121 www.anaren.com

BLUE HIGHWAY
DESTINATION: INNOVATION

26 November 2012

Harvey J. Palmer, Ph.D., P.E.
Professor and Dean
Kate Gleason College of Engineering
Rochester Institute of Technology
James E. Gleason Building
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dean Palmer:

I recently had the privilege of reviewing the Rochester Institute of Technology (RIT) Kate Gleason College of Engineering Concept Paper for the proposed Ph.D. in Engineering program. Consequently, I felt compelled to write this letter in support of this Concept since I believe it holds great promise for contributing to the primary challenges faced by this Country, and abroad. In addition, I believe by-products of this endeavor are sustainable economic development, RIT growth and recognition as a top tier institution of higher learning, entrepreneurial faculty attraction and retention, and top tier student attraction and retention. Furthermore, knowing first-hand the capabilities, history and stellar reputation of RIT, plus the passion and focused trajectory of the Institution's Administration, I have no doubt RIT will be successful at launching, maturing, and reaping success from the Ph.D. in Engineering Program.

As the President, CEO and Cofounder of Blue Highway (www.blue-highway.com), a Professor of Forensic Science in the Forensic and National Security Sciences Institute at Syracuse University (http://forensics.syr.edu/index.html), and a consultant to academia, government, and industry, I'm intimately familiar with the challenges of establishing, building, leading and managing an innovation culture that's focused on value-adding translational research, economic development, entrepreneurialism, institutional sustainability and growth - which is exactly what RIT is undertaking with the Ph.D. in Engineering program. What's particularly exciting to me is that RIT - via this Concept - is creating a blend of academia, government, industry, and portfolio management, thereby, comprehensively bridging the gap from idea to commercialization.

I look forward to the realization of this exciting program. Therefore, please consider me as an interested party, a supporter, and partner for the success of the Ph.D. in Engineering program.

Yours sincerely,

Albert J. Di Rienzo

Albert J. Di Rienzo
President & CEO
Blue Highway
Professor of Forensic Science
Syracuse University
2-212 Center for Science & Technology
Syracuse, NY 13244
315-443-6209 (office)
315-443-8011 (fax)
adirienzo@blue-highway.com

CERION ENTERPRISES

November 16, 2012

Dean Harvey Palmer, Ph.D.
Kate Gleason College of Engineering
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623

Dear Dean Palmer:

I am writing this letter to express my enthusiastic support and commitment for the Proposal for a Ph.D. Program in Engineering within the Kate Gleason College of Engineering.

I am the Founder and Chief Technology Officer of Cerion Enterprises, LLC; a 35 person materials science company composed of five business verticals: Energy, NRx (central nervous system therapeutic drugs), Power (Li ion battery cathodes), Catalysts and Biologics.

Cerion has had a long and fruitful relationship with the Rochester Institute of Technology (from which I graduated with a Bachelors of Science degree). Cerion was the first Clean Energy company to graduate from RIT's business incubator, Venture Creations (July 2007) and currently employs 8 Ph.D. scientists (chemical engineers, mechanical engineers, physical chemists, and synthetic inorganic chemists). In addition, Cerion currently has sponsored research contracts with RIT valued at over $200,000 per year and has donated over $100,000 of equipment to the Department of Chemistry. I have personally supervised the research of two MS Chemistry candidates and our group has sponsored over a dozen undergraduates either for research credit or in co-operative employment capacity.

Not only does Cerion have a multitude of research projects that the Ph.D. candidates of your proposed program can tackle (some of which I have recently discussed with Prof. Steve Weinstein), I see a critical need in our organization for the graduates of this program. I applaud the signature nature of the proposed program, particularly the opportunity for consilience (intersection of multiple disciplines) and the salutary effect it will have in keeping RIT students and graduates at the cutting edge of engineering research while using research as a pedagogical tool to enhance learning and critical problem solving skills.

Please let me know how I may be of further assistance with this proposal.

With very best regards,

Ken Reed

Kenneth J. Reed, Ph.D.
Founder and Chief Technology Officer
Cerion Enterprises, LLC
1 Blossom Road
Rochester, NY 14610

SiMPore Inc.
Precision Membrane Technologies

December 15, 2012

Dr. Harvey Palmer, PhD
Professor and Dean
Kate Gleason College of Engineering
James E. Gleason Building
Rochester Institute of Technology
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dr. Palmer,

I am writing in enthusiastic support of the proposed PhD Program in Engineering within the Kate Gleason College of Engineering.

As you know, SiMPore is developing and commercializing novel ultrathin membranes for healthcare and materials science applications ranging from portable hemodialysis to electron microscopy. SiMPore has relied upon the Kate Gleason College of Engineering at RIT to help train and prepare engineers that design and manufacture SiMPore membranes. As a growing startup company, SiMPore has hired seven engineering co-op students and recent graduates over the last few years. Today, two of those former co-op students are full-time fabrication engineers. The practical and entrepreneurial training at RIT is highly desirable and a match to our company culture.

I look forward to the opportunity to work with students and graduates of your proposed PhD in Engineering with a concentration in Healthcare. Many of our research and product areas fall under the healthcare umbrella. However, the development of biomedical products requires an interdisciplinary team and skillset. It is likely that students who have multidisciplinary training with an application focus, such as healthcare, will be better prepared to contribute to interdisciplinary teams such as ours. We look forward to the opportunity to work you and your students as you develop the PhD Program in Engineering.

Respectfully,

Richard D. Richmond
Chairman
SiMPore Inc.
rrichmond@simpore.com

SiMPore Inc. • 150 Lucius Gordon Drive • Suite 121 • West Henrietta NY 14586
Phone (888) 323-NANO • Fax (888) 249-2935
www.simpore.com

24 November, 2012

Dr. Harvey Palmer
Kate Gleason College of Engineering
Rochester Institute of Technology
James E. Gleason Building
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dean Palmer:

It is my sincere pleasure to write in support of your proposed PhD engineering program that is to be housed in the Kate Gleason College of Engineering at the Rochester Institute of Technology. I particularly like the multidisciplinary nature of the program. The four focus areas (energy, health, transportation and telecommunications) constitute important and growing segments of both US and worldwide economy.

I joined Eastman Kodak Company as a research scientist in 1984. In 1996, I joined Sharp Laboratories of America (SLA) Inc as a member of the founding team. In 2011 when I left SLA, I was the Chief Technology Officer and Director. I am currently a Senior Director of Technology at Qualcomm Corporation in San Jose, California. I have considerable experience at RIT both through serving as an adjunct professor in the Department of Electrical Engineering during my tenure at Kodak as well as collaborating with research faculty on different projects while at Kodak and Sharp Corporation. At SLA, we have frequently hired graduate students from RIT as summer R&D Interns.

I personally share your commitment to providing quality education for the next generation of engineers and scientists in the broad discipline of communication engineering. This effort is an investment that will yield a competent future workforce for the telecommunication industry as well as government research labs and academia. We are always looking for talented researchers in the area of communication who can contribute to R&D in our industry to create and take advantage of opportunities in mobile communications.

The telecommunication industry is expected to grow to close to $2 trillion in the next four years, with the US telecommunication industry comprising the largest share of it. The communication industry encompasses a wide array of technologies such as wireless communications, internet services, fiber optic networks, and commercial satellite communications. The enabler technologies for most of these disciplines include one, two, and three dimensional signal processing, source and channel coding, displays, low-power connectivity, communications and applications processing.

Over the last ten years, the US wireless industry has invested an enormous $300 billion to install the most efficient seamless communications networks in the world. The telecommunications industry as a whole generates over 2.4 million jobs in the US, which is expected to grow by another 200,000 in 2013 due to the growing adoption of next generation 4G LTE networks. The huge growth expected for this industry creates unique opportunities for engineers, scientists and academics for technological advancement in this dynamic field.

Needless to say, the four focus areas of the proposed PhD program will also cater to the needs of students from emerging economies such as China, India, and Latin America as healthcare, energy, transportation and mobile communications are top of national socioeconomic agendas of those countries. It is also important to realize the natural synergy and interrelationships among these four thrust areas: secure wireless low-power communications is at the heart of mobile personalized health; cost effective and efficient electrical storage is not an enabler of renewable energy at utility scales but also an important ingredient for making electrical vehicles more affordable and wide spread. Telematics and wireless communications are becoming more and more commonplace in cars for increasing safety, energy efficiency, and reducing commute times helping people live more productive lives.

In summary, I provide my full personal support to your proposal for the interdisciplinary PhD program in engineering due to my sincere belief that all stakeholders, including the society in general, will substantially benefit from its creation.

Sincerely,

M. Ibrahim Sezan, Ph.D.
Senior Director of Technology
Qualcomm

Gleason

The Gleason Works

1000 University Avenue
P.O. Box 22970
Rochester, NY 14692-2970, USA
Tel: (585) 473-1000
Fax: (585) 461-4348
www.gleason.com

December 26, 2012

Dr. Harvey Palmer, Dean
Kate Gleason College of Engineering
James E. Gleason Building
Rochester Institute of Technology
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dr. Palmer,

It is my pleasure to offer this letter of endorsement for the proposed PhD in Engineering program through the Kate Gleason College of Engineering.

As a former Mechanical Engineering Manager and now Chief Engineer at Gleason, I can say confidently that technical leadership within our industry will be one of the keys to success in the future. The proposed PhD in Engineering program would prepare graduates to contribute more effectively and completely in the development of machine tools and related industries. I am excited by the realistic approach of exposing students to multidisciplinary training while maintaining a focus on core areas of study as this is more representative of effective engineering within industry and skills that we look for in technical leaders.

The application domain focus areas of Energy and Transportation, specifically, align well with the goals and technology developments within Gleason. Effective power transmission and energy creation are at the heart of many of the industries that our products serve. I believe collaboration between Gleason and research studies within these areas would be a natural outcome of the successful creation of this PhD program. In addition, students exiting the PhD program with this experience and research focus would be prime candidates for integration into our technical workforce.

With a Masters of Engineering in Mechanical Engineering Degree from RIT and I am personally excited for additional opportunities to enhance my own education, and I would strongly encourage many of my colleagues to do the same with a program such as the one proposed. Having been in the position of finding avenues for continued education, it is clear that this program will serve the needs more effectively of future, existing, and former students both in and outside of RIT, contributing to RIT's history of being a leader in the education of engineering.

I strongly support the formal creation of the PhD in Engineering program to continue to enhance the relationship and collaboration that RIT has built with Gleason and the community and I applaud RIT's focus on developing innovative ways to educate the future engineering leaders.

Sincerely,

Michael J. Walker
Engineering Project Leader and Chief Engineer, The Gleason Works

January 1, 2013

Dear Dr. Yang,

On behalf of APX Labs, LLC, I would like to express my full support for the Kate Gleason College of Engineering Concept Paper: Proposal for a Ph.D. in Engineering. As a 2008 BS/MS Computer Engineering graduate from RIT, under the guidance of Dr. Melton, it not only makes me proud to see the school expanding, but equally excites me by the talent and class of individuals the Ph.D. program will produce.

From first-hand experience, I know the rigor and quality of an RIT education. It's an education that provided me a solid base and breadth of knowledge to start my own defense company, APX Labs, two years after graduating. During that time, the company grew from two engineers to a mix of forty composed of computer scientists, computer engineers, graphic designers, animators, imaging scientists, and mechanical engineers. APX has gained a strong reputation and is highly respected within the intelligence, and defense community namely due to hiring exceptional talent from RIT, and other top tier schools.

I truly believe the cross-disciplinary nature of the proposed Engineering Ph.D. will create a new type of professional highly sought out by top companies. At APX Labs, the company performs work in the areas of telemedicine, multi-modal biometrics, autonomous vehicle control, sensor integration, high-performance computing and data transmission related to intelligence, surveillance, and reconnaissance. There's not one single focus area, so having engineers with a mixed and diverse background becomes highly attractive. The 4 application specific domains outlined in the proposal of healthcare, energy, communication, and transportation are exactly in-line with the types of engineers that APX wants to hire.

Aside from the ability to hire top-talent from a school I know and trust, I'm also highly interested in the opportunities for collaborative research the program will present. A portion of APX's revenue is from research SBIR/STTR and solicitations to the DOD, NSF, DARPA, and other government agencies. It would bring me great pride to help support the Ph.D. program by jointly pursuing collaborative research opportunities.

I wholeheartedly express my support for this proposal.

Sincerely,

John Martellaro
CTO, APX Labs, LLC

APX Labs
2350 Corporate Park Drive | Suite 510 | Herndon, VA 20171
www.apx-labs.com

November 9, 2012

Steven J. Weinstein
Professor and Department Head
Department of Chemical and Biomedical Engineering
Rochester Institute of Technology
Engineering Hall (Bldg. 17), Room 2635
160 Lomb Memorial Drive
Rochester, NY 14623-5604

Dear Steve,

In my view, if RIT is to move to a higher level in its prestige recognition nationally then RIT must add PhD programs and enhance its research mission.

We face similar challenges at Rochester General Hospital as those facing RIT with respect to competing with larger and longer established institutions for higher quality faculty and students. The RIT/RGHS Alliance offers a special opportunity for collaboration in the area of Healthcare research.

I have met several members of your Department who are already conducting research in biomedical engineering. I have read their grants and given advice. The overarching problem is that the infrastructure at RIT does not allow your faculty to compete as well as they might because RIT lacks both PhD and post doctoral training in many Departments and Colleges. RIT has traditionally relied on its undergraduate students to assist faculty in research. The problem is that the undergraduate students stay on projects for such a short time that just about the time they have reached a point on the learning curve where they might contribute to the research they move on to the next semester.

I am aware from discussions with Dean Ornt and VP Research Ryne Raffaelli that there is a critical mass of research in healthcare scattered across the RIT campus. Bringing the participating faculty together with a more collaborative and focused research agenda may be a key to improving the success of faculty recruitment and retention, attracting higher quality students who might otherwise chose institutions like MIT, and more effectively competing for research grants. To facilitate such a goal adding a PhD program as described in your proposal would be a perfect fit.

I am pleased to endorse your proposal and offer my experience and expertise. Any role that the RGH Research Institute might offer will be given full consideration.

Sincerely,

Michael E. Pichichero, MD, Director Rochester General Hospital Research Institute
Research Professor, Health Sciences and Technology, Rochester Institute of Technology, Rochester, New York
Michael.Pichichero@rochestergeneral.org

November 26, 2012

Dr. Harvey J. Palmer, P.E.
Professor and Dean
Kate Gleason College of Engineering
Rochester Institute of Technology
77 Lomb Memorial Drive
Rochester, NY 14623-5603

Dear Dr. Palmer:

Thanks for sharing your proposal for a new Ph.D. program at Kate Gleason College of Engineering that will focus on four technology areas: Transportation, Telecommunications Industry, Healthcare, and Energy. We work directly in these areas or with clients supporting these areas. Our year over year growth in Healthcare since 2003 is now leading our client portfolio and this particular area is in an acute crisis state needing very serious breakthrough improvements.

Simpler Consulting L.P. is a leading global management consulting firm that helps companies improve processes to stimulate business impacting results. Unlike traditional management consulting firms specializing in developing strategy and then falling short on execution, Simpler plays an active role in helping clients to create an organizational structure which continuously seeks out opportunities to make these breakthrough level improvements. With our proprietary Simpler Business System®, Simpler has delivered the fastest and most enduring Lean Transformations at hundreds of organizations across a wide array of industries including manufacturing, government, insurance and healthcare.

We are very active in recruiting multidisciplinary engineering graduates from RIE and support the proposed new multidisciplinary doctor of philosophy in engineering at RIT. In particular we deal with many highly educated individuals in our healthcare sector. We are always engaged with many MD's and Ph.D.'s. They expect us to match wits with them and take waste out of their "scientific approach" to improvement. We need the best possible thought leaders in process improvement and innovation.

Steve Matteson
Vice President and General Manager
Client Services, Healthcare
Simpler
www.simpler.com

3488 S Applegate Drive | New Palestine, IN 46163 | (336) 633-9014 | mattesons@simpler.com

90 Linden Oaks
Rochester, NY 14625

To
Dr. Dhireesha Kudithipudi,
Associate Professor
GLE-3429, Dept. of Computer Engineering,
Rochester Institute of Technololgy
Rochester, NY-14623

Date:11/19/12

Synaptics Inc. is a leading developer of human interface solutions which enhance the user experience in the expanding digital lifestyle. We were founded in 1986 by Federico Faggin and Carver Mead and over the last 26 years we have grown from a neural network research organization into the leading human interface solutions partner of a global customer base. Simply put, our next-generation interfaces set users free to interact with devices in ways the world couldn't have imagined a decade ago.

Our combination of technology, expertise, innovation, comprehensive and customized solutions (from prototyping to module design to manufacturing to testing), and exceptional customer support makes us the right choice for partners that want to differentiate in the market.

I personally work in the Rochester NY design center as the Director of IC design for touch and integrated touch and display products. Our local design center has grown from ten people four years ago to approximately forty five engineers today. We have partnered with RIT during this growth process and it has helped us form an excellent team.

Our relationship with RIT has been in place for a large number of years now. The original founders of the design center are all alumni from RIT. I have also been a faculty of the CET department and an adjunct professor for ten years now. I am also performing research in Dr. Dave Borkholder's lab as part of my Ph.D. studies in Microsystems engineering. We are active employers of RIT CO-OP students from CE, CET, EE, and Microsystems engineering. As the appropriate full time opportunities occur we often fill the vacancies with these students.

The proposed Ph.D. in engineering is an exciting growth opportunity for RIT. At Synaptics Inc. we design human interface solutions. To be successful in this area we must work in a cross disciplinary manor. The design of one of our touch products often involves collaboration from Mechanical engineers, Material scientists, Electrical engineers, Software Engineers and Microelectronic engineers. Having access to a student population that has a doctoral degree which combines these disciplines would be very useful for us both locally and in Santa Clara. This would also provide us faculty that are actively involved in research which could benefit our future products. For all of these reasons I recommend that RIT put in place the Ph.D. in engineering program. I look forward to working with RIT to help us make Synaptics more successful in the future.

Regards,

11/19/2012

X Jeffrey S. Lillie

Jeffrey S. Lillie
Director, IC Design
Signed by: Jeffrey S. Lillie

Appendix E: Space Allocation/Renovation Request

Appendix E: Space Allocation/Renovation Request

REQUEST FOR ALLOCATION OR RENOVATION OF SPACE

Date: **15 June 2013**

☐ Additional Space ☒ Change in Usage or Assignment ☐ New Space Construction ☐ Existing Space Modification

Time frame for request: ☐ Imminent ☐ Immediate 6- 12 months ☒ Intermediate 1-3 yrs ☐ Projected: 4 – 6+ yrs

REQUESTOR INFORMATION

Division: **ACADEMIC AFFAIRS**
Department: **Kate Gleason College of Engineering**

Submitter's Name: **Harvey Palmer** Title: **Dean of Engineering**

E-mail: **hjpeen@rit.edu** Phone: **5-6361** Fax: **5-6879** RIT Address: **77 Lomb Memorial Drive**

If different from submitter
Contact Person: **Edward Hensel** Title: **Department Head of M.E.**

Email: **echeme@rit.edu** Phone: **5-7684** Address: **76 Lomb Memorial Drive** Fax: **5-7710**

Briefly describe the function of your department:

Academic Programming. This space request is in support of a new PhD in Engineering

Current total assignable square footage of your department: **0.0** sq ft.

Number of faculty: Full-time **4** Part-time _____ Adjunct _____
(4 incremental faculty, distributed into existing KGCOE academic units)

Number of staff: exempt_____ non exempt **0.5**

Number of student workers: Graduate **12** Post-Doc_____ Co-op_____

Will the # of people in this department increase or decrease w/in the next 2 years? Yes **X** No ____

If there will be an increase, indicate amount and source of anticipated growth.

One Director, 0.5 FTE Staff in Sept 2014, growing to 1.0 FTE staff in Sept. 2017.

If there will be a decrease, identify the number and types of positions.

No decrease anticipated.

Please address the urgency and rationale for this allocation. Include benefits if approved and consequences if not approved.

Full details of the proposed program including costs and benefits were reviewed through the College Graduate Committee, RIT Graduate Committee, Academic Senate, Senior Administration, and Board of Trustees.

SPACE REQUEST

Sq. ft.: 1600 # of rooms **12** Number of occupants per room: **6@1 person each, 6@2 people each**
Hours in use/week: **40** How long is space needed? **Permanent**

Space will be used for: PhD Program Direction, Staff Assistant, 12 PhD Students, 4 Lecturers in various KGCOE Depts.

Classroom _____ Administration **X** Storage _____ Support Space ____ Conference Room _____
Studio (specify type) ______________________________ Rehearsal Space _____ Performance Space _____

Laboratory
Instructional lab: Wet ____ Dry _____ Computer Lab _____
Research lab Wet ____ Dry _____ Computer Lab _____
Other (specify)
Grant funded: Yes _____ No _____
If yes, has grant been funded? Yes _____ No _____
If yes, start and end dates of the grant?

If no, when do you anticipate funding?

Is the space requested part of a new faculty start-up package? Yes _____ No _____
If yes, who is the faculty member? ___________________________

Offices:

Faculty Office: Full-time **1** Lecturer **4** Part-time _____ Adjunct _____ Research _____

Staff Office (circle one): Exempt___ Non Exempt **1** Full-time _____ Part-Time **1** Temporary _____

Explain work to be performed in this space:

Administration of the PhD in Engineering Program

Student Office: Grad Student **12 (2 per office)** Post Doc Student _____ Co-op Student _____

Other (please specify):

Could new space be shared or serve dual purpose? Yes **X** No ____
(if yes, please give an example of shared/dual usage; if no, give reason)
Yes - Staff support can be shared with another function if a desk within a larger office is located.

Is an off-campus location to fill this request possible? Yes ____ No **X**
(if no, give reason)

This is an academic program associated with the KGCOE

Special Requirements for Requested Space: (e.g. HVAC needs. Be specific)

General purpose office space.

FOR CHANGE IN USAGE OR ASSIGNMENT (with no modifications of space)

Previous assignee:
Plans for accommodating previous assignee/use (if applicable):

Previous use:

Classroom _____
Exempt Staff office_____
Conference Room _____
Instructional lab _____
Faculty office _____
Non Exempt Staff Office_____
Storage _____
Research lab _____
Administration _____
Grad Student _____
Other (specify) ___________________________
Wet ____ Dry _____
Support Space _____
Co-op Student _____

Proposed new assignee: _____________________________ When is the space needed? ________________________

FOR NEW CONSTRUCTION OR EXISTING SPACE MODIFICATION

Briefly describe why this new construction or modified is needed.

Will any existing space be vacated if this request is approved? Yes ____ No ____
If yes, please list rooms that will be vacated:

Do you have funding for space construction/modification? Yes ____ No ____
If yes, what is funding source?

Have you consulted with Campus Planning and Design & Construction Services? Yes _____ No ______
If no, provide reason.

Have you consulted with Educational Technology Services (if necessary, e.g. classroom, conference room? Yes _____ No ______

Do you have a funding source(s) for the construction or modification? Yes _____ No _____
If yes, identify the funding source(s), the amount of funding, and the time-line for receiving/expending funds.

Have funds been requested through the university budget hearing process for the renovations? Yes _____ No ______
If yes, which fiscal year and what is the status of the request? ____________

Will there be incremental costs associated with the new space? (e.g. power, maintenance, security, support staff not noted above).
Yes _____ No _____

Please attach all concept work produced for this project by Campus Planning & Design or designated outside organization.

Please attach written cost estimate for your project plus any other supporting documentation, including documentation from The Wallace Center Support Services for rooms requiring audiovisual support

REVIEW AND APPROVAL SIGNATURES

When a request crosses departments, colleges or academic affairs support units, signatures from all affected areas must be secured.

1. Department Chair/Director

Signature ____________________ Title ____________________ Date ________

2. College Dean or as appropriate Associate Provost / Assistant Provost

Signature ____________________ Title ____________________ Date ________

Note to College Deans/Associate Provost/Assistant Provost:
List and prioritize this request with any other space request from your area currently pending with the Academic Affairs Space Committee or University Space Committee:

Return this completed form with signatures 1 & 2 to: Sue Provenzano, Eastman 2109

3. Academic Affairs Space Committee Chair

Signature ____________________ Date ____________________

4. Provost and Senior Vice President for Academic Affairs

Signature ____________________ Date ____________________

5. University Space Committee Chair (if needed)

Signature ____________________ Date ____________________

6. President (if needed)

Signature ____________________ Date ____________________

Attachment 1: Site Visit Team Report and Institutional Response

New York State Education Department
Office of Higher Education
Office of College and University Evaluation

Conflict of Interest Guidelines for Peer Reviewers of Doctoral Programs

Conflict of Interest

There must be no conflict of interest or appearance of a conflict of interest with the institution under review. There is a conflict of interest when the potential peer reviewer/consultant:

(1) is a present or former employee, student, member of the governing board, owner or shareholder of, or consultant to the institution where the program is under review;

(2) is a spouse, parent, child, or sibling of an individual or persons listed in (1) above;

(3) has expressed an opinion for or against the proposed program under review;

(4) is seeking or being sought for employment or other relationship of any kind with the institution where the program is under review;

(5) has a personal or professional relationship with the program or institution where the program is under review that might compromise objectivity; and/or

(6) has a competitive relationship with the institution that might compromise objectivity.

I have reviewed the Conflict of Interest Guidelines. To the best of my knowledge, I do not have a conflict of interest or the appearance of a conflict of interest with:

Print name of institution:

University of Michigan

Signed: 

Printed name of Peer Reviewer: Daniel J. Inman, Ph.D.

Date: 2 Feb 2013

New York State Education Department
Office of Higher Education
Office of College and University Evaluation

Conflict of Interest Guidelines for Peer Reviewers of Doctoral Programs

<u>Conflict of Interest</u>

There must be no conflict of interest or appearance of a conflict of interest with the institution under review. There is a conflict of interest when the potential peer reviewer/consultant:

(1) is a present or former employee, student, member of the governing board, owner or shareholder of, or consultant to the institution where the program is under review;

(2) is a spouse, parent, child, or sibling of an individual or persons listed in (1) above;

(3) has expressed an opinion for or against the proposed program under review;

(4) is seeking or being sought for employment or other relationship of any kind with the institution where the program is under review;

(5) has a personal or professional relationship with the program or institution where the program is under review that might compromise objectivity; and/or

(6) has a competitive relationship with the institution that might compromise objectivity.

I have reviewed the Conflict of Interest Guidelines. To the best of my knowledge, I do not have a conflict of interest or the appearance of a conflict of interest with:

Print name of institution: ~~LIZY K JOHN~~ RIT

Signed: [signature]

Printed name of Peer Reviewer: LIZY K. JOHN

Date: Feb 4, 2013

New York State Education Department
Office of Higher Education
Office of College and University Evaluation

REPORT FORM FOR EVALUATION OF DOCTORAL PROGRAM PROPOSALS

Institution:	Rochester Institute of Technology
Program Title	Doctor of Philosophy in Engineering
Date(s) of Evaluation:	3-4 February 2013
Evaluator(s):	Daniel J. Inman and Lizy K. John

I. Program

1. Assess program purpose, structure, and requirements as well as formal mechanisms for program administration and monitoring.

The purpose of the program is to train PhD students and perform research in an open architecture environment such that graduates will be innovators in interdisciplinary research and industry ready. This is reflected in the structure and degree requirements. The proposed PhD in Engineering avoids focusing on a narrow technology but rather focuses on four industry areas of need (communication, energy, health care and transportation) set into an evolutionary philosophy. Currently most universities are trying hard to break down the barriers between traditional engineering topics and create multidisciplinary research centers, whereas the proposed program is interdisciplinary without the stigma of traditional silo education.

The formal mechanisms for program administration and monitoring is through a program director reporting directly to the Dean's office in the college of engineering in conjunction with the usual tenure and promotion committee (tenure is held within a KGCOE department), an external advisory board, a curriculum committee and a university wide graduate council. This is a rather standard university administrative structure with the exception of all being held at the college level rather than a specific department, thus nurturing the necessary interdisciplinary nature of the proposed program.

2. Comment on the special focus of this program as it relates to the discipline. What are plans and expectations for continuing program development and self-assessment including ongoing external reviews?

The nimble structure of the proposed program allows for continued development driven by the changing needs of society and industry. And external advisory board is planned consisting of members from academia, industry and government. The board will provide continued guidance on program structure, objectives, research agenda and expectations for graduates. Program outcomes for assessment are clearly defined in the proposal.

3. Assess the breadth and depth of coverage in terms of faculty availability and expertise, regular course offerings and directed study, and available support from related programs. What evidence is there of program flexibility and innovation?

The flexibility and innovation in the proposed program is actually its centerpiece. The program offers core engineering skill courses, followed by a series of new courses designed to instill innovation into its students. The proposal offers flexibility and refers to itself as a "nimble" program design to react to future needs in industry and society at the PhD level.

4. Discuss the relationship of this program to undergraduate, master's and other doctoral programs of the institution. Consider interdisciplinary programs, service function, joint research projects, support programs, etc.

   There are 6 other doctoral programs at RIT only one in the College of Engineering. The existing engineering PhD program is narrowly focused on microsystems, whereas the proposed program is broadly based and interdisciplinary. However, numerous core courses exists at the graduate level already through their current masters degree programs to sustain core courses in the proposed program with little or no modification (the exception being the Engineering Analytics Course). The other 5 non-engineering doctoral programs occasionally allow engineering faculty to chair a student, but these are non-engineering students, which provides a totally different research environment affecting both research results and recruiting efforts. In many cases their high quality MS students go on to seek PhDs at other, usually first tier, institutions because the current PhD option is not available in engineering at RIT.

5. What evidence is there of <u>need</u> and <u>demand</u> for the program locally, in the State, and in the field at large? What is the extent of occupational demand for graduates? What evidence is there that it will continue?

   A National Academy of Engineering (NAE) report emphasizes the need for interdisciplinary degree programs and research. Demand is established by corporate support. Numerous letters from companies indicate a strong desire to hire students educated in the program and a desire to financially support students. The four focus areas addressed by the proposed program are those aligned with the NAE's Grand Challenges published in 2008 substantiating the need for research and education in these areas.

II. <u>Faculty</u>

1. What is the <u>caliber of the full-time and part-time faculty</u>, individually and collectively, in regard to education, college teaching experience, experience in doctoral education including dissertation supervision, research and publication, professional service, and national recognition in the field?

   There are no part time faculty involved in this program. The full time faculty members all have PhD's from top tier research schools and a history of both publication and funding. Hence they are of high quality with excellent pedigree. Many have supervised or co supervised PhD dissertations in other departments or colleges. They are also involved in the appropriate technical societies and engaged in service to the community. The faculty is poised to move forward in research but are limited by not having a PhD program.

2. What are the faculty members' primary areas of <u>interest</u> and <u>expertise</u>? How important to the field is the work being done? Discuss any <u>critical gaps</u>.

   The faculty involved in this program come from all the basic engineering disciplines (mechanical, electrical, chemical, …etc.). There are no critical gaps. The work being done is aligned with the various research directions listed as important be the NAE in its documentation.

3. Assess the composition of faculty in terms of <u>diversity</u> (race, gender, seniority).

   The KGCOE has a relatively high number of diverse faculty members. For instance the ME department has 30% female, well over the national average. Furthermore KGCOE has significant programs to recruit underrepresented groups. This includes a Future Faculty Program funded by RIT which brings 80 people to campus from under represented groups and encourages them to become faculty members. Interesting applicants are hired as postdocs or faculty. RIT has had success in this avenue of hiring.

4. Evaluate faculty activity in generating funds for research, training, facilities, equipment, etc.
37% of the faculty currently have grants valued at over $100,000 for research. Since starting their first PhD program (microsystems) in 2002, their research funding has risen from $500,000 per year to $5.5 million per year. This clearly indicates their ability to leverage a PhD program into additional funding to support the program.

5. Assess the faculty in terms of size and qualification for the areas of specialization which are to be offered. Evaluate faculty workload, taking into consideration responsibility for undergraduate, master's, and other doctoral programs. What are plans for future staffing?
The plans for staffing are to move current research productive faculty into the proposed program and to replace their teaching loads in the core program with new instructor hires. As the program grows there plans to hire new faculty into the program, with their base appointments being in the various traditional departments but their research interests aligned with the proposed program. Note that at RIT tenure is held in the college, not in a specific department. 47 faculty have been identified as having interest in the proposed program and expertise to substantiate their participation.

6. Discuss credentials and involvement of adjunct and support faculty.
There are no plans to use adjunct faculty in the proposed program.

III. Students

1. Comment on the student clientele which the program seeks to serve, and assess plans and projections for student recruitment and enrollment.
The plans to recruit PhD students are those normally associated with a University PhD program. In addition RIT will use its substantial industry base and its own MS program to recruit. This will expand to a more national program as they establish themselves. They will capitalize on the uniqueness of their degree program. The have a modest goal at the outset of 16 students with funding set aside for these. They also have an aggressive plan for encouraging minority and female applicants.

2. What are the prospects that recruitment efforts and admissions criteria will supply a sufficient pool of highly qualified applicants and enrollees?
They already have a number of students waiting to get into this program. Because of the uniqueness of their program and its interdisciplinary nature along with their four major topic areas they should have no problem filling their ranks. Past experience allows such a prediction. The areas of health care, transportation, energy and communications are the center of attention at the national level and will help fill their ranks with high quality applicants.

3. Comment on provisions for encouraging participation of persons from underrepresented groups. Is there adequate attention to the needs of part-time, minority, or disadvantaged students?
Yes. RIT has a number of programs to encourage and seek minority and disadvantaged students. This consist of running a McNair Scholarship Program, a GEMS Scholarship Program and other outreach activities. Their own institute for the deaf is an example of their abilities to address the needs of disadvantaged students. Their strong connection with NY State companies speaks to their ability to address the needs of part time students. They also have an NSF ADVANCE grant which will be helpful in improving participation of underrepresented minorities.

4. Assess the system for monitoring students' progress and performance and for advising students regarding academic and career matters.
A substantial assessment matrix is presented in the proposal centered round the three main goals of the program: create knowledge, specialized in knowledge and life-long learning.

These are integrated above the normal PhD type program assessments of exams, presentations and a dissertation defense.

5. Discuss prospects for placement or job advancement.
RIT has a long-standing tradition of integrating its students in to industrial careers and this program is no different. Evidence for placement of graduates of this program is given in the substantial number of letters from companies who support this program and are looking forward to hiring its graduates.

IV. Resources

1. What is the institution's commitment to the program as demonstrated by the operating budget, faculty salaries and research support, the number of faculty lines relative to student numbers and workload, support for faculty by non-academic personnel, student financial assistance, and funds provided for faculty professional development and activities, colloquia, visiting lecturers, etc.
The Vice President of Research office provides several programs for seeding research growth including monies for revising and resubmitting proposals, funding specifically for junior faculty, special assistance for senior faculty in a variety ways. The Provost has committed funding for the first class of 16 PhD students by providing their stipend and tuition. Space has been provided to accommodate the students. A special fund has been established by the VP of Research to provide postdoctoral support to increase diversity.

2. Discuss the adequacy of physical resources and facilities, e.g., library, computer, and laboratory facilities, internship sites, and other support services for the program, including use of resources outside the University.
RIT has excellent resources and facilities of the nature expected at a substantial research oriented institution. This includes all sorts of laboratories (clean room, manufacturing facilities etc.) strong library support and substantial computing facilities. Several of their labs are supported directly by corporate sponsors.

V. Comments

1. Summarize the major strengths and weaknesses of the program as proposed with particular attention to feasibility of implementation and appropriateness of objectives for the degree offered.
The major strength of this program lies in its inherently interdisciplinary nature. While major research one universities are struggling to find ways to promote interdisciplinary research within colleges of engineering, the proposed program lays interdisciplinary study and research as its foundation. Because it is not a program centered in a department but rather a college level degree and because it is a degree in “Engineering” and not named as chemical, mechanical etc., the program creates an environment for truly interdisciplinary education and research which can be tailored to a particular interdisciplinary topic defined by specific research needs. Thus a sharing of resources and a collaborative environment forms the root of this program rather then the confines of traditionally defined engineering disciplines (the stove pipes or silos). The program is centered on the grand challenge technical areas outlined by the NAE and is structured in such away as to be adaptable to future research needs of the nation as they become identified. There are no particular weaknesses except that any new program will have to go through various challenges. The faculty evaluation system will gradually evolve as the emphasis on research goes up. But the faculty have already thought about it and have plans for tackling it. Hence we will not consider it a major weakness.

2. In what ways will this program make a unique contribution to the field?

The uniqueness of the program lies in its very definition as interdisciplinary focused on cross disciplinary subjects of national importance rather than the traditional engineering subjects (Mechanical, Electrical, Chemical, etc.). This creative approach to solving modern engineering problems is pathway to the future of advanced engineering education for the terminal degree.

3. Include any further observations important to the evaluation of this doctoral program proposal and provide any recommendations for the proposed program.

The external reviewers firmly believe that the State of New York has a unique opportunity to lead the nation in educational reform at the PhD level by approving this program. This would be a very difficult program to pull off within a standard engineering college with a long history of departmental driven research agendas. At RIT there is no existing PhD program in the traditional topics to prejudice the creation of a truly interdisciplinary education and research program. Last RIT is seriously poised to make the transition to a significant PhD granting institution having hired wisely over the last five to ten years with faculty from first tier engineering colleges and has a faculty who will take a huge step forward in research productivity given the opportunity to recruit PhD students into their funded research projects. There is strong evidence that the proposed program will substantially increase the flow of external research dollars into the institution and the state from both corporate and federal sources. Furthermore, the lack of a Ph. D program will seriously cripple the excellent faculty RIT has hired in recent years in their ability to attract research funding, research students and conduct research.

FACTORS TO BE CONSIDERED IN EVALUATION OF DOCTORAL PROGRAM PROPOSALS

A. Program Purpose, Design, and Administration

1. Accuracy and clarity in proposal description and program materials
The proposal itself is a clearly delineated description of materials and administration and measurement for success.

2. Program's unique contribution to the field
Major research institutions across the country are trying hard to break down the barriers between the traditional engineering disciplines (or silos). The proposed PhD program is unique in that it has no silos and is built around the concept of interdisciplinary education and research. It is also "nimble" in nature with a built in ability to adjust its focus as demands for skills change in the market place.

3. Appropriateness of program objectives for the degree offered
The program objectives clearly define a path of interdisciplinary study and research satisfying the purposed of the proposed degree path.

4. Appropriateness of requirement for achieving program objectives:
   Course work - core, cognate, specialization, total credit hours
      This is consistent with other PhD programs across the country with a solid core base of traditional courses plus the introduction of new courses to promote PhD study in an interdisciplinary context with regard for social value.
   Residency
      One year of residency is required, a standard among PhD programs and allows for part time industry participation.
   Internship, practicum, field experience
      RIT is a master of internships and interaction with corporate practicums and will carry this forward into their proposed PhD program with their multitude of industrial contacts.
   Examinations
      The PhD program follows the natural standard of a qualifying exam, a prelim and a dissertation defense. In addition annual reviews are provided for.
   Statistics/Research tools
      RIT has full complement of statistics and research tools.
   Dissertation
      The dissertation rules and requirements follow those of existing PhD programs in terms of rigor, novelty and significance.

5. Depth and breadth of coverage
The depth of the program builds on their previous success at creating a fully functioning PhD program in microsystems. The are able to draw on their very successful MS programs in the traditional areas of engineering to provide depth and broad coverage in the proposed areas which are those in which they are having current funding and student recruitment success.

6. Appropriateness of sites and adequacy of supervision for student internships, practica, and field experiences
The facilities and faculty are fully capable and experienced in this area.

7. Integration or cooperation with other programs, divisions, and universities
Because of its interdisciplinary nature, there is a great deal of integration and collaboration with existing programs across the university, while still maintaining its identity as an engineering degree.

8. Program administration and leadership
The leadership and administration of the proposed program falls across the levels from the core faculty up through provost who are all enthusiastic and well qualified to run this program.

9. Self-assessment, planning, and provision for future needs
A strong, well organized planning for future needs is in place and includes an external advisory board as well as the usual college and university level oversight committees. The program is actually built upon a

premise that it will change and evolve as research needs of the society and nation evolve.

B. Faculty

1. Academic preparation and background experience

The faculty are all of fantastic pedigree and have excellent experience having built wonderful programs with out the advantage of a PhD student body. They are well positioned to leap forward with the proposed PhD program.

2. Research, publication, and recognition in the field

The publication and research record is well documented with lists in the appendix of the proposal. They are publishing in the best and most appropriate venues for their chosen research topics and have received recognition for this.

3. Involvement in problems of practice services

NA

4. Competency as:

Teachers

RIT has a strong history and tradition of teaching excellence which will continue in the proposed program.

Research leaders

The research oriented faculty have a good and established publication record.

Dissertation mentors

Many have experience in mentoring dissertations in the current PhD programs.

Intern supervisors

RIT is coop based undergraduate program and those faculty who are involved in research and will be involved in this program often have students as interns in their research projects. Second they often involve themselves in mentoring senior design projects.

4. Sufficiency in number for program coverage, diversity, and vitality

RIT has a critical mass (47) of faculty interested to be engaged in this program designed initially for 16 students. There faculty constitute a diverse group both in culture and research discipline and is largely a young vital group of academics.

5. Distribution of faculty workload and time devoted to proposed doctoral program

The proposal outlines a unique period of growth by using instructors to back fill the teaching load at the undergraduate level left of those faculty devoting their time to the proposed doctoral program. The ability to use and train PhD students will enhance their productivity by providing longevity in their research enterprise.

6. Policy on tenure and promotion and ongoing faculty development and assessment

The tenure policy at RIT lies in at the college level, not within the departments. Hence those involved in the PhD program will be evaluated in the normal fashion. The tenure policy at RIT has evolved over decades as it has moved from a teaching only institution to a MS granting institution with light research to an institution with a significant research portfolio and has managed its tenure process responsibly through these changes.

7. Plans for recruitment of quality faculty and staff development

RIT offers a number of staff development programs that provide resources for submitting proposals, seed funds of various types as incentives to excel at research an obtain funding. They offer a “boot camp” for proposal writing, which has had a remarkable success rate (80%). Their recruitment tactics are very sophisticated and stifled only by not having a PhD program. Their statistics on RIT offers that are declined point directly to the lack of PhD program. With said program their recruitment success will increase including helping to recruit from top quality underrepresented groups.

8. Involvement and qualifications of adjunct and part-time faculty

No adjunct or part-time faculty are involved in the proposed program.

C. Students

1. System for student admissions, advising, and monitoring of progress and performance
Their system for selecting students is to capitalize on their academic strengths and research areas, making the most of their own graduates and recruiting from their many industrial contacts. Their advising and monitoring is a sophisticate program including the normal dissertation advisor contact but also includes annual meetings and updates with the dissertation committee. They also participate in programs such as the McNair Scholarship program and the GEMS program to attract underrepresented minorities into their program.
2. Projections for admissions and enrollment; critical mass
The program is slated to target 16 students in the first year, with any of this slots already identified. A conservative growth rate of a few per year as planned tied to the success of research funding.

3. Student/faculty ratio
The ratio is around 20 to 1 in most programs. For the proposed program it will be less.

4. Awareness of the job market; placement/employment of graduates
RIT is the second larges coop school in the country and as such the faculty have very strong connections to industry and this translates to excellent employment statistics. In addition there are numerous letters of support for this program from companies included in the proposal.

D. Resources

1. Institutional commitment
The provost, vice president for research and dean of graduate studies were interviewed and are firmly in favor of the proposed program.

2. Faculty success in obtaining external grant support
37% of the faculty (42) at RIT College of Engineering has grants over $100,000.

3. Student financial support
The university will fund the first 16 students for the first year with this number winding down as the research grants pick up to fund the first class of PhD students. In addition there are commitments from industry to fund two of the initial students already in place.

4. Internal support for faculty professional activities and development
Membership fees to professional societies is provided along with travel to professional development workshops.

5. Classroom and office availability and adequacy for academic and advisement purposes
Interviews with faculty indicate that office space is adequate and class rooms are well sized.

6. Library facilities and holdings
RIT has excellent library facilities and holdings comparable to most universities. Money is also budgeted for library holding improvements based on the emerging needs of the proposed program.

7. Computer facilities and services
RIT has excellent computer facilities and services comparable to most universities.

8. Laboratory and other special facilities
RIT has substantial laboratory space and state of the art equipment across the traditional disciplines. While on cannot predict what equipment will be need for research projects of the next decade, RIT is well positioned to obtain required instrumentation through their substantial industry support network.

9. Clerical and other support services
The proposed program has a program director, 4 area leaders and on full time staff member which is more then adequate for the 16 students they plan to have in the initial enrollment.

10. Resources for future support
Vice President of Research provides seed money for travel for visiting sponsors and for writing proposals

or getting initial results. Sponsor Projects office provides help with submitting proposals.

RESPONSE TO SITE VISIT REPORT

Institution:	Rochester Institute of Technology
Program Title	Doctor of Philosophy in Engineering
Date(s) of Evaluation:	3-4 February 2013
Evaluator(s):	Daniel J. Inman and Lizy K. John

RIT gratefully acknowledges the efforts and insights of the site visit team in preparing their report on the proposed PhD in engineering, and has incorporated the feedback from the reviewers in the final version of the proposal approved by the RIT Board of Trustees and being delivered to the New York State Department of Education for review.

Specific comments on each portion of the external review report follow.

I. Program

1. Assess program purpose, structure, and requirements as well as formal mechanisms for program administration and monitoring.

   RIT agrees with the external review report that the proposed program is interdisciplinary without the stigma of traditional silo education, and that the administrative structure of the program is a rather standard university administrative structure with the exception of all being held at the college level rather than a specific department, thus nurturing the necessary interdisciplinary nature of the proposed program.

2. Comment on the special focus of this program as it relates to the discipline. What are plans and expectations for continuing program development and self-assessment including ongoing external reviews?

   RIT agrees with the external review report.

3. Assess the breadth and depth of coverage in terms of faculty availability and expertise, regular course offerings and directed study, and available support from related programs. What evidence is there of program flexibility and innovation?

   RIT agrees with the external review report.

4. Discuss the relationship of this program to undergraduate, master's and other doctoral programs of the institution. Consider interdisciplinary programs, service function, joint research projects, support programs, etc.

   RIT agrees with the external review report.

5. What evidence is there of need and demand for the program locally, in the State, and in the field at large? What is the extent of occupational demand for graduates? What evidence is there that it will continue?

   RIT agrees with the external review report.

II. Faculty

1. What is the caliber of the full-time and part-time faculty, individually and collectively, in regard to education, college teaching experience, experience in doctoral education including dissertation supervision, research and publication, professional service, and national recognition in the field?

   RIT agrees with the external review report.

2. What are the faculty members' primary areas of interest and expertise? How important to the field is the work being done? Discuss any critical gaps.

   RIT agrees with the external review report.

3. Assess the composition of faculty in terms of diversity (race, gender, seniority).

   RIT agrees with the external review report.

4. Evaluate faculty activity in generating funds for research, training, facilities, equipment, etc.

   RIT agrees with the external review report.

5. Assess the faculty in terms of size and qualification for the areas of specialization which are to be offered. Evaluate faculty workload, taking into consideration responsibility for undergraduate, master's, and other doctoral programs. What are plans for future staffing?

   RIT agrees with the external review report.

6. Discuss credentials and involvement of adjunct and support faculty.

   RIT agrees with the external review report and confirms that there are no plans to use adjunct faculty in the proposed program.

III. Students

1. Comment on the student clientele which the program seeks to serve, and assess plans and projections for student recruitment and enrollment.

   RIT agrees with the external review report and acknowledges launching the program with limited enrollment initially. Based on feedback from the administration, we have adapted the roll-out plan to begin with an initial cohort of 12 students, which will then grow over time as the program demonstrates success. RIT will continue with our aggressive plan for encouraging minority and female applicants.

2. What are the prospects that recruitment efforts and admissions criteria will supply a sufficient pool of highly qualified applicants and enrollees?

   RIT agrees with the external review report.

3. Comment on provisions for encouraging participation of persons from underrepresented groups. Is there adequate attention to the needs of part-time, minority, or disadvantaged students?

   RIT agrees with the external review report.

4. Assess the system for monitoring students' progress and performance and for advising

students regarding academic and career matters.

RIT agrees with the external review report.

5. Discuss prospects for placement or job advancement.

RIT agrees with the external review report.

IV. Resources

1. What is the institution's commitment to the program as demonstrated by the operating budget, faculty salaries and research support, the number of faculty lines relative to student numbers and workload, support for faculty by non-academic personnel, student financial assistance, and funds provided for faculty professional development and activities, colloquia, visiting lecturers, etc.

RIT agrees with the external review report. Based on feedback from the administration, we have adapted the roll-out plan to begin with an initial cohort of 12 students, which will then grow over time as the program demonstrates success. The Provost has committed funding for the first class of 12 PhD students by providing their stipend and tuition. This support will continue to evolve over time as warranted by program success. Space has been provided to accommodate the students. A special fund has been established by the VP of Research to provide postdoctoral support to increase diversity.

2. Discuss the adequacy of physical resources and facilities, e.g., library, computer, and laboratory facilities, internship sites, and other support services for the program, including use of resources outside the University.

RIT agrees with the external review report.

V. Comments

1. Summarize the major strengths and weaknesses of the program as proposed with particular attention to feasibility of implementation and appropriateness of objectives for the degree offered.

RIT agrees with the external review report.

2. In what ways will this program make a unique contribution to the field?

RIT agrees with the external review report.

3. Include any further observations important to the evaluation of this doctoral program proposal and provide any recommendations for the proposed program.

RIT agrees with the external review report, and appreciates the reviewer's perspective that they *"firmly believe that the State of New York has a unique opportunity to lead the nation in educational reform at the PhD level by approving this program. This would be a very difficult program to pull off within a standard engineering college with a long history of departmental driven research agendas. ... RIT is seriously poised to make the transition to a significant PhD granting institution having hired wisely over the last five to ten years with faculty from first tier engineering colleges and ... There is strong evidence that the proposed program will substantially increase the flow of external research dollars into the institution and the state from both corporate and federal sources."*

End Notes

---

[1] For the purpose of this proposal, the term "interdisciplinary" is used in a manner consistent with both the National Science Foundation and the National Academy of Engineering. NSF refers to and uses the NAE definition:

> *"Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice."*

Facilitating Interdisciplinary Research, (Quote on page 2) Committee on Facilitating Interdisciplinary Research, National Academy of Sciences, National Academy of Engineering, National Academies Press, Washington, DC, USA, 2004, 332 pages.

[2] The RIT RAPID database is maintained by sponsored research services. This data was used to generate the historical trends of research proposal activity in the KGCOE. Access to the database requires RIT authorization and is available at https://apps.rit.edu/research/srs/rapid/login.php

[3] Dr. Kathleen Lamkin-Kennard is an Associate Professor in Mechanical Engineering, who was promoted to the rank of Associate Professor in 2012, following her review during the 2011-12 academic year. In her promotion documentation, Dr. Lamkin-Kennard noted the challenges of being selected for the prestigious NSF CAREER award following three attempts. She stated:

> *" In 2008, 2009, and 2010, I submitted proposals to the National Science Foundation (NSF) CAREER Award program (CBET Division, General and Age Related Disabilities Engineering Program) to investigate "Systems Modeling of Flow and Transport Mechanisms in Glaucoma". Although my proposals ultimately were not funded through this highly competitive program, I was pleased that the overall reviews for the proposals were well received and the overall panel recommendation for the proposal was, "**Recommended if funds are available"** three years in a row. The overall intellectual merit and competitiveness of the proposal is evident from the panel summary statement that noted, **"Her proposal demonstrates a great vision and was well written". Identified weaknesses, including a reliance on undergraduate researchers and lack of involvement of Ph.D. students,** were largely out of my control."*

[4] The American Society for Engineering Education (ASEE) maintains a database of performance metrics for Engineering Colleges, which is accessible to College of Engineering Deans across the USA. Access to the database requires ASEE authorization and is available at http://www.asee.org

[5] This quotation is taken (page 11) from the essay "*Preparing Stewards of the Discipline*" by C.M. Golde is contained in Golde, C.M., Walker, G.E, (Editors) (2006), *Envisioning the Future of Doctoral Education: Preparing Stewards of the Discipline,* **Carnegie Essays on the Doctorate**, The Carnegie Foundation for the Advancement of Teaching, Jossey-Base, A Wiley Imprint, San Francisco, CA

[6] National Academy of Engineering Grand Challenges published a list of 14 grand challenges in February 2008. Complete details of the challenges and the motivation behind them is available to the public at the NAE website:
http://www.engineeringchallenges.org/cms/challenges.aspx

The NAE Grand Challenges for engineering are:\

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

[7] Recruitment of AALANA and Female faculty has been a challenge that RIT has struggled with for over a decade. For example, there were eight new-hire offers (out of 20 total offers) made by the RIT M.E. Department and subsequently declined; seven of the individuals cited the lack of a Ph.D. program as their deciding factor. Of the eight rejections, five candidates were women, three were African American and one was Latino American. Only one of the candidates declining an offer of employment was a white male. The proposal section "Enhancing Faculty Recruitment for New RIT Faculty" describes the importance of access to terminal degree students for new faculty.
[8] U.S. Census Bureau, Statistical Abstracts. Access to the reports and the database are open to the public, available at: http://www.census.gov/compendia/statab/

[9] The Industrial and Systems Engineering department made three tenure-track offers to women over the past 12 years, all of which were rejected, citing the lack of a Ph.D.

program. The proposal section "Enhancing Faculty Recruitment for New RIT Faculty" describes the importance of access to terminal degree students for new faculty.

[10] During AY2011-12, the Mechanical Engineering Department conducted an analysis of 104 applications to the Master's program in mechanical engineering for students interested in beginning their studies in Fall 2012. Of the 104 applications studied, nine of the applicants stated in their personal statement that they wished to pursue a Ph.D. in mechanical engineering at RIT even though such a program is not offered or listed on any application materials. The department receives dozens of informal inquiries each year from international students who express interest in doctoral study. Even with a highly selective admissions process, this anecdotal information suggests that there is strong international market interest.

[11] Several letters of support from corporate partners, available for review in Appendix VI, document the value that companies place on the education that doctoral students will receive from participation in the Ph.D. in Engineering program. These company letters speak both to the value of the Ph.D. graduates to their future workforce needs and the appeal of partnering with RIT on fundamental and applied research problems in the four focus areas.

[12] Walker, G.E, Golde, C.M., , Jones, L., Conklin-Bueschel, A., Hutchings, P. (2008). *The Formation of Scholars: Rethinking Doctoral Education for the Twenty-First Century,* The Carnegie Foundation for the Advancement of Teaching, Jossey-Base, A Wiley Imprint, San Francisco, CA. (Quotation from Page 37).

[xiii] *Doctoral Engineering Program Enrollment by Discipline for 2001 through 2011. "Engineering By The Numbers" 2011 Profile of Engineering Statistics, Brian L. Yoder, American Society for Engineering Education available on-line at* http://www.asee.org/papers-and-publications/publications/college-profiles/2011-profile-engineering-statistics.pdf

[xiv] Wendler, C., Bridgeman, B., Markle, R. Cline, F., Bell, N., McAllister, P., and Kent, J. (2012). *Pathways Through Graduate School and Into Careers,* Princeton, NJ: Educational Testing Service.