I. Title/Department/College: Masters of Engineering (M.Eng.) in Chemical Engineering/ Department of Chemical and Biomedical Engineering/KGCOE

II. Description of goals and justification for proposed program

From a classical perspective, chemical engineering is the branch of engineering that applies the core scientific disciplines, e.g. chemistry, physics, biology and mathematics, to transform raw materials or chemicals into more useful or valuable forms, invariably in processes that involve chemical change. In research and development, chemical engineers not only create new, more effective ways to manufacture chemicals, but also work collaboratively with chemists to pioneer the development of new high tech materials for specialized applications. The development, commercialization, and optimization of the industrial-scale processes for manufacturing chemicals and advanced materials are feats of chemical engineering. Indeed, virtually every aspect of a modern industrial economy is critically dependent upon chemical engineering for manufacturing the vast array of bulk and specialty chemicals and high-tech materials needed to create a limitless array of value-added products. Although the U.S. Department of Labor Statistics projects little growth in employment for traditional chemical-based industries, that business segment has strengthened recently due to advancement of domestic fossil fuel and biofuel production. Looking towards the future, the National Academy of Engineering has outlined 14 grand challenges that need to be faced in the 21st century (http://www.engineeringchallenges.org/). Of these, it is apparent that many of these challenges will need to be faced with chemical engineering methodologies and core training, and graduate level preparation will be essential. The job market for chemical engineers is expected to remain strong.

Chemical Engineering is a recent addition to RIT's portfolio of engineering disciplines having just graduated its first cohort of students in May, 2013. The undergraduate program has experienced tremendous growth in students, faculty, and facilities since being approved by New York State (NYS) in September of 2009. The entering freshman classes in the past few years have surpassed 60 students (although the intended target remains only 50), the waiting list for internal transfers is quite large, and as such, the enrollment has exceeded all expectations. The popularity and success of our program is largely based on the diverse faculty's commitment to teaching and scholarship excellence, as well as the state-of-the-art facilities now housed in Institute Hall (the permanent home for both the Chemical and Biomedical Engineering programs). Given the maturation of the undergraduate Chemical Engineering program, a complementary focus on graduate level education is critical to enhance our undergraduate offerings, serve the local community with advanced level training, attract external faculty candidates to RIT interested in graduate education, and help progress the research agenda of our program faculty.

The proposed program is a Master's of Engineering (M.Eng.) in Chemical Engineering with the intended goals of providing a stand-alone graduate degree that simultaneously serves the coursework needs of other graduate programs at RIT. With this program, there is an opportunity to increase the connection with local industry partners that wish for employees to take advanced coursework in chemical engineering. The proposed program creates the opportunity to attract

tuition-paying foreign students both at the New York campus as well as potentially establish a satellite program at RIT Dubai. The creation of a graduate program in Chemical Engineering, which for some students would be their terminal degree, raises the connection with RIT alumni in both reputation and loyalty to the university.

The proposed Master's program can also have tangible impact on our undergraduate Chemical Engineering program. It is widely accepted that core and elective course delivery at the Master's level continues to challenge faculty to stay current and advance their fields. Such training ultimately affects the course delivery to undergraduate students, since deeply trained faculty naturally make better decisions about fundamental concepts to teach courses at all academic levels. It is also anticipated that a B.S./M.Eng. program will be proposed once approval for the Master's program is obtained. The B.S./M.Eng. dual degree option in other engineering programs has consistently been an effective method of recruiting the KGCOE's best undergraduate students. These dual-degree students often desire the challenge of the program and recognize it as a cost-effective way to refine their skills and improve their marketability upon graduation. Therefore, the Master's in Chemical Engineering will serve as an enrollment engine that improves the quality and selectivity of our student body. The added ability to customize the Master's curriculum such that a research thesis can be pursued will offer the opportunity to support a proposal for a M.S. degree if appropriate.

The KGCOE is also currently in the final stages of approval for a Ph.D. in Engineering and the proposed Master's level coursework being developed will also serve as the core coursework for students concentrating on the chemical engineering component in the Ph.D. program. Such courses can also potentially satisfy the elective requirements for other graduate programs at RIT including the Ph.D. in Microsystems Engineering and M.S. programs in Material Science and Chemistry. Overall, the Master's degree program will attract and train industry-focused students and professionals who wish advanced-level chemical engineering training, enhance marketability to the best undergraduate students to RIT, and advance our research capabilities via Master's level students and as a feeder to both current and future Ph.D. Engineering programs at RIT.

III. Description of the new program

The M.Eng. degree in Chemical Engineering will be designed to fill the needs of the traditional student pursuing post-baccalaureate training or the practicing chemical engineer who is employed full-time and wishes to pursue a graduate degree on a part-time basis. KGCOE and the Chemical Engineering program have research and teaching-oriented faculty, as well as state of the art equipment and new facilities housed within Institute Hall. The capabilities enable full-time graduate students to study both fundamental and applied engineering problems through core and elective coursework and select independent studies with faculty advisors. The proposed program will significantly enhance the student's background in chemical engineering while also offering the opportunity to increase their applied training through graduate co-op experiences and support for research activities by college faculty and staff.

The M.Eng. in Chemical Engineering will be comprised of 30 credits, and students will be able to complete the degree in two years or less via coursework with a capstone experience satisfied by an independent study or project paper (also satisfied by a publication, proceedings, etc.). There are five 3-credit required core courses (15 credits) and the remaining credits are a combination of technical electives (including potential for advanced lab training) and approved independent studies with a faculty advisor. There is also the unique opportunity to offer a Master's co-op after 6 courses and 3.0 GPA, especially designed for students who have not participated in a career-oriented undergraduate program and desire that from a graduate degree. Students may elect to participate in a focused research/project experience by using up to three of their technical electives as an independent study with a faculty member. Thus, the proposed program can provide new student-faculty research relationships through independent studies that can become eventual thesis or Ph.D. dissertation topics.

The M.Eng. program is designed to be consistent with an intended B.S./M.Eng. dual degree in Chemical Engineering. As with the M.Eng. program, the B.S./M.Eng. degree will have graduate coursework and a capstone experience, and both will be designed to be completed in 5 years. The required M.Eng. level courses will be completed during the student's 4^{th} and 5^{th} years (9 credits of graduate-level coursework can be used to satisfy the undergraduate credit count) afforded by the relaxation of a scheduled co-op block (the co-op requirement is reduced to 40 weeks from 48).

In addition, the proposed M.Eng. program is consistent with the Ph.D. in Engineering program currently awaiting NYS approval. The five 3-credit core courses in the M.Eng. program are the same as those in the Ph.D. program. Graduate level electives developed for the M.Eng. program will also serve Ph.D. students, and those developed for the Ph.D. program may also be used for the M.Eng. students. Another advantage of designing the M.Eng. program so it is consistent with coursework in the Ph.D. program is that there is an "off-ramp" for students in the Ph.D. program who cannot pass the 1^{st} year exam or elect to transition into industry rather than continuing to pursue a Ph.D. In addition, the consistency between the proposed M.Eng. and Ph.D. in Engineering allows excellent M.Eng. students to move between programs.

IV. Description of new program's fit with RIT Academic Portfolio Blueprint Characteristics

The proposed Master's program is consistent with the objectives of the University, as embodied by RIT's educational goals. The goal of "career education" is necessarily included as the Master's program provides advanced level training that can enhance a student's career. The Master's program reflects the highest academic, personal integrity and ethical standards held by the faculty and staff. These standards are essential to student success not only in the classroom, but especially in the accurate reporting of discoveries made during research. The survival of the program depends on the success of the faculty in their research, teaching, and programmatic service, as well as the external reputation of the program and its ability to attract an excellent and diverse student body.

The M.Eng. program aligns with RIT's goal towards graduate education in terms of providing students advanced training with access to top-notch facilities and faculty in pursuit of

research projects. The advanced training also provides faculty the opportunity for career development to refine skills for enhanced teaching, and identifying excellent students for entry into Ph.D. programs. The program also offers the ability to partner with international campuses like RIT Dubai to offer coursework and potential degree offerings as an outgrowth of the success at the main campus. Lastly, the program will continue to enhance RIT's well-established national reputation for experiential learning and partnerships with industry through student co-ops and involvement of practicing professionals.

V. Synergy with other programs

The M.Eng. program is synergistic with other programs both within and outside of KGCOE. The importance and inter-relationship of the proposed M.Eng. program with the future B.S./M.Eng. and Ph.D. programs (both Microsystems Engineering and the proposed Engineering) has been described in detail in Section III. Outside of engineering, the most natural linkages with other programs are in the areas of Material Science and Chemistry. Certain elective courses in Chemical Engineering and as well as Chemistry and Material science will likely be suitable for students in all of these programs to foster important interdisciplinary interactions. It is also conceivable that coursework in other colleges like Liberal Arts (Public Policy, Economics), Business (Management, Finance), and Sustainability will support the technical electives for the M.Eng. students. Opportunities to engage faculty in each of these disciplines to conduct independent studies with the students will assuredly lead to further interdisciplinary benefit in terms of innovative teaching and scholarship.

VI. Administrative structure for the new program

The M.Eng. program will be administered by the Department of Chemical and Biomedical Engineering. The Department Head will designate a graduate chairperson whose responsibility is to manage the curriculum and assess its efficacy against defined goals and objectives. The B.S. program is managed by the Department Head, and the B.S./M.Eng. program will be administered jointly with the Graduate Program Director. The Assistant to the Department Head and all departmental staff associated with the undergraduate program will support the administrative needs of the Master's program, although an additional staff person is potentially needed to meet the increased load, especially if a dedicated lab course and numerous lab-based independent studies are required. Students will be advised in the independent studies and coursework by their faculty advisors, and if necessary, other advising services can be provided by dedicated advisors assigned to the department, the Assistant to the Department Head, and the Department Head.

VII. Enrollment Management Expectations and Sustainment

Enrollment Management and Career Services reviewed the concept paper for a new Master of Engineering degree in Chemical Engineering. The review concludes that an opportunity exists to expand graduate student enrollment in engineering, provide a graduate option for students who have interest but are not committed to a Ph.D. program in engineering, and provide an option for current

RIT students to earn an accelerated B.S./M.Eng. degree. In addition, the idea of a bridge program for analytically-oriented (mathematically-talented) students with a B.S. in Chemistry can also be considered to achieve enrollment goals. For example, B.S. Chemistry students would likely need to take the undergraduate courses in reactor design and separations in addition to meeting all other requirements to satisfy the M.Eng. degree.

The following is a direct response from Diane Ellison, Assistant Vice President in Graduate Enrollment Services, who on January 6, 2013, concludes that 20 students per year is viable based on the summary:

> *The external market for the program as presented is somewhat limited, as students would be required to have a B.S. chemical engineering degree in order to enroll in the [M.Eng.] degree. The market could be expanded by developing a "bridge" program that would allow students with degrees in such areas as chemistry, physics, other engineering areas, or related programs to consider the [M.Eng.] option. In addition the market is competitive, as similar programs that offer one year completion options exist in New York State at the University of Rochester, Cornell University, University at Buffalo, Syracuse University, Clarkson University and Rensselaer. Data from the GRE student search service indicates that market interest worldwide in chemical engineering is 1/3 that of mechanical engineering and 1/5 that in electrical engineering.*
>
> *Given this, it is essential that the program options include both the [M.Eng.] in chemical engineering that can be marketed to prospective full-time students in the US and abroad, as well as the B.S./[M.Eng.] program for current RIT students enrolled in Chemical Engineering. It is anticipated that combined enrollment in both of these programs, plus 2 – 3 part-time students per year could yield your enrollment target of 20 students (FTE) per year, based on the assumptions that follow.*
>
> 1. *The program will be offered entirely on campus, and projections are based on offering both the [M.Eng.] Chemical Engineering, and the B.S./[M.Eng.] option for undergraduate students who are currently enrolled in the undergraduate chemical engineering degree program at RIT. Enrollment numbers provided here are based on both of these programs being approved on the same timeline.*
> 2. *The program will attract primarily full-time students, though it can be completed part-time with courses being offered in the evenings. We anticipate 2 new part-time students per year.*
> 3. *Both full-time and part-time students must be able to begin the program in either Fall or Spring semester.*
> 4. *Consider development of a "bridge" program that would allow students with degrees other than chemical engineering to be considered for admission.*
> 5. *Scholarship support is limited to RIT central funding of 25 - 30% of overall tuition revenue redirected to scholarship through Institute Graduate Scholarship allocation. Any additional funding for graduate students will come from research grants and outside resources.*

6. *Most full-time students will take 12 credits per semester, making it possible to complete the coursework and capstone in two semesters plus summer. Part-time students will take 3 – 6 credits per semester.*
7. *Aggressive external marketing, as well as the development of partnership agreements with appropriate industry partners and organizations will be critical to marketing and enrolling students.*
8. *The timing of the approval process will affect projections for the first year.*

A review of the enrollment analysis has been certified by Dr. James Miller, Senior Vice President for Enrollment Management & Career Services, and the following is a direct response from him to Dean Harvey Palmer on February 14, 2014:

Dear Harvey,

Your proposal for a M.Eng. and B.S./ M.Eng. in Chemical Engineering has my full endorsement. Previously, Diane Ellison did share her response with me before sending.

Regarding projections provided previously by Diane Ellison, I find them to be reasonable based on the program as described in concept paper. While attracting predominately full-time students, the program may also appeal to a few part-time students though I expect this number will be quite small. Thus the combined intake of 20 full-time students annually in M.Eng. and B.S./M.Eng. is most reasonable. The program FTE after the first year will depend in part on assumptions about academic course loads of full-time students. If you expect students for most part to consume 12 credits per semester, the likely FTE in year 2 and beyond will approximate 24-26 FTE per annum; on the other hand, if you project that full-time students will consume 9 credit hours /semester, the likely FTE in year 2 and beyond will be between 28-32. Total net tuition revenue will be same since credit hours required are 30.

In estimating these FTE's I am assuming little or no doubling up of course offerings to broaden appeal to part-time market; nor do I factor in any substantive on-line offerings. If these were to be added in later years, the FTE estimates above would have to be increased. Likewise, if a bridge is developed for other majors, numbers above could increase. I have assumed students would be able to commence study in both Fall and Spring semesters.

I believe this proposal does indeed meet goals for program articulated in concept paper. I believe it is an important and logical next step in building our comprehensive KGCOE program portfolio. I think the 30 hour M. Eng. And B.S./M.Eng. is the correct strategy at this time.

I trust this is helpful. Let me know if you need more.

Sincerely,
Jim Miller

VIII. Impact on Resources including Utilization of Existing Resources and Cost Model Analysis

The cost model analysis using student enrollment target of 18-20 students/year and the resulting number of courses that need to be taught in the program each semester suggests that an additional three tenure track faculty members (3 FTE) will be needed. Financial support for graduate level equipment and supplies are also budgeted. The administrative load will be handled by a dedicated graduate chairperson from the department faculty adjusted for in the annual plan of work and basic staff assistance will be provided by existing department level support. Two new faculty labs are available on the 2nd floor of Institute Hall and research space will be allocated to the new faculty members in conjunction with proposed research needs. There are also state-of-the-art teaching labs located in Institute Hall which can support any graduate lab courses or independent studies for the students.

IX. Conclusion

In short, we propose a Master's degree program to (1) attract and train industry-focused students and professionals who wish advanced-level chemical engineering training, (2) attract the best undergraduate students to RIT, (3) advance our research capabilities via Master's level students and (4) serve as a feeder to both current and future Ph.D. Engineering programs at RIT. The M.Eng. program is synergistic with other programs at RIT, not only within engineering, but also in the areas of chemistry and material science. The program will require some incremental resources in faculty and staff, and it is anticipated that existing building infrastructure/offices will be adequate to meet the immediate needs of the program.