Master of Science

in

Chemical Engineering

GRADUATE STUDENT HANDBOOK

Department of Chemical Engineering
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Dr. Keith Schimmel, Graduate Program Coordinator
Dr. Franklin G. King, Department Chairperson

NOTICE

This handbook is prepared for use by applicants to the Master of Science Program in Chemical Engineering at North Carolina A&T State University. It is designed for recruitment and information purposes and should be used only as a guide. Information contained herein is accurate at the time of printing. Important changes in fee structure, financial assistance, admission requirements, academic and other programs may occur without notice. For current information, please consult the appropriate University office.

The University publishes a general bulletin which includes information regarding undergraduate programs, University facilities, and other information that may be of interest to undergraduate and graduate students. A comprehensive bulletin listing all graduate programs is available on the web at ncat.edu and a copy may be obtained from the Graduate Office, Room 122, Gibbs Hall, North Carolina A&T State University, Greensboro, NC 27411.

NONDISCRIMINATION POLICY AND INTEGRATION STATEMENT

North Carolina Agricultural and Technical State University is committed to equality of educational opportunity and does not discriminate against applicants, students, or employees based on race, color, national origin, religion, sex, age, or handicap. Moreover, North Carolina Agricultural and Technical State University is open to people of all races and actively seeks to promote racial integration by recruiting and enrolling a larger number of caucasian students.

TABLE OF CONTENTS

I THE UNIVERSITY and COMMUNITY

North Carolina A&T State University is a unique, state-supported University. It is the only comprehensive University in North Carolina which has a College of Engineering and a School of Agriculture in consonance with its land-grant tradition. In addition, strong program offerings are provided in the College of Arts and Science and Schools of Business and Economics, Education, Nursing and Graduate Studies.

Located just nine blocks from the metropolitan downtown of Greensboro, A&T enjoys a unique role in the North Carolina System of Higher Education. From its beginning in 1891, the University has developed into a 8,000 student educational complex with a 188 acre campus, an annual budget of more than $56 million, and a variety of degree programs of which many are unduplicated and unique to this campus.

Graduate studies at North Carolina Agricultural and Technical State University have been in operation since 1939. Beginning with one discipline, the School of Graduate Studies has expanded to 37 areas of study including adult education, English, food and nutrition, agricultural economics, applied mathematics, biology, chemistry, architectural engineering, chemical engineering, civil engineering, electrical engineering, industrial engineering, mechanical engineering and computer science. The university presently has an enrollment of over 700 Graduate Students and is planning to add programs in a few other majors over the next few years.

There are two libraries on campus that serve the teaching and research needs of the Chemical Engineering Department. The F.D. Bluford Library is the main library for the entire university and houses nearly 400,000 volumes of which over 22,000 volumes are directly related to engineering. The Chemistry library is located in Hines Hall, the location of the Chemistry Department. A total of 400 engineering periodicals are available in Bluford library. The Chemistry Library holds another 68 periodicals. There are 109 periodicals related to chemical engineering. Present holdings are adequate for undergraduate course offerings and, when combined with the holdings at nearby universities are considered to be adequate for an MSChE program.

Through a cooperative loan agreement, North Carolina A&T State University has access to the holdings of other universities in the state of North Carolina. The universities in the state that have significant engineering and science holdings include Duke University, North Carolina State University, the University of North Carolina at Chapel Hill, and the University of North Carolina at Charlotte.

Greensboro, Winston-Salem, High Point, and Burlington, all within a radius of 25 miles, are the major cities in the Piedmont Triad. Greensboro is served by the Piedmont Triad International (GSO) Airport. The Triad is the most heavily populated metropolitan area and six-county region in North Carolina. Among the major industries and companies in the area are the corporate headquarters of Burlington Industries and Jefferson Pilot Life Insurance Company. New industries in the region include such high-technology engineering companies as Ciba Geigy, Dow Corning, Proctor & Gamble, Analog Devices, Konica, AMP, and Volvo-White Truck Corporation. Other universities in the area include the University of North Carolina at Greensboro, Bennett College, Wake Forest University, and Guilford College. To the east are Research Triangle Park (60 miles) and Raleigh (78 miles), the state capital. The state's largest city, Charlotte, is 85 miles to the southwest. Many professional and cultural activities flourish in the region. Greensboro has been noted for its outstanding quality of life in recent Rand-McNally surveys.

II THE COLLEGE OF ENGINEERING

The North Carolina Agricultural and Technical State University College of Engineering is the second largest of the four nationally accredited engineering schools in the state and the only one in the highly industrialized Piedmont region. The College is an affiliate of the Microelectronics Center of North Carolina. The recently dedicated Mars Mission Research Center is funded by NASA and conducts composite materials research. The College of Engineering is recognized nationally as one that is advancing with modern technology and producing graduates capable of moving ahead in today's technical world. It is one of six historically black engineering schools in the nation. The growth of the school has been steady, from 621 students in 1979-80 to a current enrollment of over 1900. There are over 200 graduate students in the College of Engineering. The $8.5 million McNair Hall provides the College of Engineering with modern and adequate space, for the foreseeable future.

The College of Engineering offers BS and programs in Architectural, Chemical, Civil, Electrical, Industrial, Mechanical Engineering, and Computer Science. The College also offers Ph.D. programs in Mechanical Engineering and Electrical Engineering.

III THE CHEMICAL ENGINEERING DEPARTMENT

The Department of Chemical Engineering at North Carolina A&T was established in August 1985 with the appointment of two faculty members and the enrollment of six students. The program in chemical engineering was established as a result of the Consent Decree agreement with the UNC system to promote racial integration. Since the establishment, the program has shown remarkable growth and became accredited by the Accreditation Board for Engineering and Technology (ABET) in 1991. Currently the chemical engineering department has eight full-time faculty members and over 160 undergraduate majors. The program was evaluated by ABET following graduation of the first class in 1990 and again in 1995. Accreditation of the program has been extended until the next general review in 200l.

In 1987, the department began participating in a general Master of Science in Engineering degree (MSChE), program, which has been authorized for the College of Engineering at A&T. The department offered a chemical engineering option of the MSChE degree until August 1998 when the Department became authorized to offer the MSChE program. Enrollment growth for the MS has been strong and steady, but limited because no university resources have been provided. Currently, twenty students are pursuing the MSChE degree. The faculty has attracted over $6,300,000 in external funding since the program began. In spite of the increased competition for shrinking federal funds, external funding is expected to be maintained after the proposed program is established because of faculty commitment and effort.

The Chemical Engineering program at A&T is one of only two programs in North Carolina and the only one at an HBCU on the east coast from Virginia to Florida. The establishment of the MSChE program at A&T will provide great service to the state of North Carolina and to the Piedmont Triad area. It will also provide graduate level education at an HBCU and thus help the efforts of the Department of Education to increase the number of minority students with advanced degrees. Presently, Howard University is the only HBCU that provides M.S. training in Chemical Engineering. Florida A&M University, however, participates in a joint program with Florida State University.

The faculty members in the department have research interests in diffusion through porous media, mixing, thermodynamics, surface and interfacial phenomena, membrane separations and membrane reactors, process dynamics and control, chemical reaction engineering, computational fluid mechanics, environmental engineering, biomedical engineering, and biochemical engineering. Research in most of these areas are funded through State and Federal agencies. The department has already established research laboratories for diffusion measurements, thermodynamics, and membrane science. The department has two gas chromatographs, a high performance liquid chromatograph, an FTIR, and an atomic absorption spectrometer.

The department is a major participant in the $3.35 million, six year project recently funded by the Air Force Office of Scientific Research titled "FAST Center for Environmental Remediation, Fate and Transport of Hazardous Chemicals". Dr. Kabadi is the principal investigator of the project, and Dr. Schimmel will lead the research efforts in the area of bioremediation. The objective of this project is to establish a center at A&T that conduct quality research in the area of environmental science and technology. The center will expand and continue its activities through the 21st century. Students interested in research in environmental areas are encouraged to apply for the M.S.E. program in chemical engineering. Inquiries about additional information on the FAST Center should be directed to the office of the principal investigator.

A major project in the thermodynamics laboratory is to develop computer software for the convenient evaluation of the thermodynamic properties of coal-derived liquids. A procedure for vapor-liquid equilibria calculation for these systems has been developed. The liquid mixtures are defined by continuous thermodynamics. Additionally, a high temperature, high pressure flow apparatus has been designed and built for measurement of VLE data necessary for further model development. The current efforts include extensions of the above work for estimating calorimetric properties of coal derived liquids and measurement of multi-component VLE data for model validations.

The diffusion measurements laboratory has excellent facilities for studying the diffusion of gases

through porous media. The laboratory has a funded project to determine the diffusion of carbon dioxide and iodine through volcanic rock formations. A project to determine the diffusion of gases through model solids made from regular particles is also underway. Recently, the laboratory received support from U.S. DOE to develop composite membranes for separation of hydrogen from gas mixtures at high temperatures.

Mathematical modeling of sub-surface phenomena occurring during in situ bioremediation of hazardous organics is being carried out in cooperation with the Idaho National Engineering Laboratory. Work is under way in the recently developed biochemical engineering laboratory to measure semiempirical parameters to which the model is most effective. Recently, the department received a grant from U.S. EPA to develop contained liquid membrane technology to extract and concentrate heavy metals from dilute waste streams.

The determination of the effect of surface treatment on the adhesion between a fiber and a matrix in carbon fiber reinforced polymeric composite materials is part of the interfacial studies in composite materials group. In particular, surface treatment by a low temperature plasma is being investigated. The surface properties are characterized using SEM, AES, and XPS techniques. Studies with air, argon, nitrogen, and ammonia plasmas can be made to evaluate the effect of physical shape and size factors, such as surface interlocking and molecular entanglement, on fiber-matrix adhesion. Further work in this area includes the study of kinetic reaction mechanisms to optimize condition for better chemical bonding between fiber surface and the polymeric matrix. Also, in Resin Transfer Mold (RTM) processing of carbon-epoxy composites, the effect of surface active agents on voids or air entrapment is being investigated.

IV CHEMICAL ENGINEERING FACULTY and RESEARCH INTERESTS

Yusuf G. Adewuyi, Associate Professor, PhD, University of Iowa.
Research Interests:
- Chemical Reaction Engineering & Catalysis
- Environmental Engineering

Shamsuddin Ilias, Associate Professor, PhD, Queen's University at Kingston.
Research Interests:
- Computational Fluid and Particle Dynamics
- Membrane Separations and Membrane Reactors
- Environmental Engineering

Vinayak N. Kabadi, Professor & Director of FAST Center for Environmental Remediation, Fate and Transport of Hazardous Chemical, PhD, Pennsylvania State University.
Research Interests:
- Thermodynamics by Computer Simulations
- Thermodynamics of Coal Liquids
- Environmental Engineering

Franklin G. King, Professor & Chairman, D.Sc., Stevens Institute of Technology.
Research Interests:
- Process Dynamics and Control
- Diffusion through Porous Media
- Aseptic Processing and Packaging

Kenneth L. Roberts, Assistant Professor, PhD, University of South Carolina
Research Interests:
- Reaction Engineering
- Environmental Catalysis
- Synthesis of Noble Structured Materials

Keith A. Schimmel, Associate Professor & Graduate Program Coordinator, PhD, Northwestern University.
Research Interests:

- Membrane Separations and Membrane Reactors
- Multiphase Flow
- Bioremediation
- Environmental Engineering

Gary B. Tatterson, Professor, PhD, The Ohio State University.
Research Interests:

- Turbulence & Mixing
- Multiphase Flow
- Plant Design

NAME & RANK E-Mail	DEGREES	PE LICENSE
Yusuf G. Adewuyi Associate Professor adewuyi@ncat.edu	BS, Ohio Univ., 1978 MS, Iowa Univ., 1980 PhD, Iowa Univ., 1985	

AREA OF SPECIALIZATION
Chemical environmental engineering, applied heterogeneous catalysis and surface science, environmental remediation and pollution prevention sono/chemical reaction engineering and separations; reactive mass transfer and air pollution control.

Shamsuddin Ilias Associate Professor ilias@ncat.edu	BS, BUET, Dhaka, 1974 MS, UPM, Dhahran, 1979 PhD, Queen s, 1986	Ohio

AREA OF SPECIALIZATION
Membrane separations and membrane reactors, computation fluid and particle dynamics, diffusion in porous media, environmental engineering.

Vinayak N. Kabadi Professor kabadi@ncat.edu	BS, Bombay, 1973 MS, Sunny-Buffalo, 1976 PhD, Penn State Univ., 1982

AREA OF SPECIALIZATION
Molecular thermodynamics of liquids and liquid mixtures, thermodynamic and transport properties of coal liquids and petroleum fractions, solar detoxification and photocatalytic oxidation of organic pollutants, environmental impact studies of organic pollutants, environmental impact studies of organic pollutants.

Franklin G. King Professor and Chairperson king@ncat.edu	BS, Penn State Univ., 1961 MS, Kansa State Univ., 1962 MEd, Howard Univ., 1976 DSc, Stevens Institute, 1966

AREA OF SPECIALIZATION
Pharmacokinetics of environmental contaminants and space anti- cancer drugs; diffusion through porous media and membrane barriers; process control.

Kenneth L. Roberts Assistant Professor kroberts@ncat.edu	BS, Georgia Tech, 1990 MS, Georgia Tech, 1992 PhD, Univ. of South Carolina, 1977

AREA OF SPECIALIZATION
Catalysis and catalytic materials. Development of environmentally benign technologies and processes. N_2O, VOC and NOx emission control technologies. Surfactant/supercritical fluid cleaning of substrates.

Keith A. Schimmel Associate Professor and Graduate Coordinator schimmel@ncat.edu	BS, Purdue Univ., 1984 MS, Northwestern Univ., 1986 PhD, Northwestern Univ., 1990	North Carolina

AREA OF SPECIALIZATION
Environmental engineering, biomediation, membrane and reactors, extraction and absorption.

Gary B. Tatterson	BS, Pittsburgh Univ., 1972	Texas

Professor
gbt@ncat.edu

MS, Ohio State Univ., 1974
PhD, Ohio State Univ., 1977

AREA OF SPECIALIZATION

Mixing, dispersion, phase contacting, turbulence, Newtonian, non-Newtonian and multi-phase flow behavior, image processing for flow measurement, liquid/liquid dispersion, gas dispersion, power consumption, solids suspension, remote temperature measurement.

V MISSION and OBJECTIVE

The mission of the graduate program in Chemical Engineering is to provide advanced level study in chemical engineering. The program will serve as preparation for further advanced study at the doctoral level or for advanced chemical engineering practice in industry. The program goals are to satisfy the following objectives.

1. To provide study at the master s level for graduates from the North Carolina A&T undergraduate program in chemical engineering and from other accredited bachelor of science programs in chemistry and chemical engineering.

2. To provide local practicing chemical engineers in the Piedmont Triad who are engaged in providing engineering services to industry and business with an evening program of graduate study in chemical engineering.

3. To promote growth of chemical engineering research at North Carolina A&T and to serve the State of North Carolina and the eternal communities- national and international.

4. To enhance the chemical engineering program at the undergraduate level by offering a variety of technical electives and attracting and retaining quality faculty for teaching and research.

DEGREE OFFERED

Master of Science in Chemical Engineering (MSChE)

VI GENERAL AND DEPARTMENTAL REQUIREMENTS

All applicants to MSChE program must have earned a bachelor s degree from a four-year college. Students that meet this requirement may be admitted to the graduate school. Applicants are admitted without discrimination of race, color, creed, sex, religion or national origin. Applicants may be admitted to graduate studies unconditionally, provisionally, or as special students. Detailed admission requirements are given later.

The Master of Science in Chemical Engineering consists of three distinct options, a thesis option, a project option and a course work option. Requirements for each of the options are given in the following table.

Option	Semester Hours Required
Thesis	24 Credits of Courses and 6 Credits of Thesis
Project	30 Credits of Courses and 3 Credits of MS Project
Course Work	33 Credits of Courses

All students pursuing any of the MSChE options must complete four (4) courses from the MSChE core courses. In addition, students must enroll in MSChE seminar each semester. The four (4) core courses must be selected from the following list:

Number	Course	Credit
CHEN 620	Advanced Chemical Engineering Analysis	3(3-0)
CHEN 630	Transport Phenomena I	3(3-0)
CHEN 710	Transport Phenomena II	3(3-0)
CHEN 720	Advanced Chemical Reaction Engineering	3(3-0)
CHEN 750	Separation Processes	3(3-0)
CHEN 760	Advanced Chemical Engineering Thermodynamics	3(3-0)

THESIS OPTION

All students enrolled in this program must take six credit hours of thesis and twenty four credit hours of courses. Of the twenty four credit hours of courses, at least nine credit hours of courses must be at 700 level. Four courses (12 credit hours) from MSChE core courses list. With the approval of the thesis advisor, a student may take nine credit hours of graduate courses from outside the CHEN Department in the areas of Mathematics, Science and Engineering. Thesis option students must pass an oral, public defense of their work. The defense is evaluated by a committee of three faculty who are appointed by the thesis advisor and the CHEN Graduate Program Coordinator. The defense committee serves as a professional review of the quality of the student s work and, in conjunction with the academic advisor, assists the student in the research work required for the thesis. An affirmative vote by a majority of the committee after the defense is necessary for the student to pass. No comprehensive course exam is required.

COURSE WORK OPTION

This option requires 33 credits of course work approved by the advisor and MSChE program coordinator. Of the thirty three credit hours of courses, at least fifteen credit hours of courses must be at 700 level and must take four courses (12 credit hours) from the MSChE core courses. With the approval of the MSChE Graduate Program Coordinator, a student may take nine credit hours of graduate courses from outside the CHEN Department. No formal advisory committee is needed, but the student must select an advisor. Students wishing to receive advanced training without an interest in solving a publishable problem or in writing a technical report will be attracted to this option. Students in this option must pass a written comprehensive examination. The examination follows the general course material of the student and set by 3 or more examiners selected by the CHEN Graduate Program Coordinator, one shall be the advisor. The student must satisfy the majority of examiners to pass the comprehensive examination. The

examination is given during the student's final semester.

PROJECT OPTION

This option requires 30 credits of course work and 3 credits of project work (CHEN 766). The advisor and student select a suitable project of mutual interest to both. No formal advisory committee is required for the option. The project option may interest those who wish to investigate a specific problem and write a technical report. Of the thirty credit hours of courses, at least twelve credit hours of courses must be at 700 level. Students must take four courses (12 credit hours) from the MSChE core courses. With the approval of the MSChE Graduate Program Coordinator and/or project advisor, a student may take nine credit hours of graduate courses from outside the CHEN Department. In lieu of a final comprehensive examination, project option students must pass a public, oral defense of their project. The defense is evaluated by a committee of three faculty who are appointed by the project advisor and the CHEN Graduate Program Coordinator. One of the committee members will be the students advisor. The defense is evaluated by a committee of three faculty who are appointed by the project advisor and the CHEN Graduate Program Coordinator. One of the committee members will be the student s advisor. The defense committee serves as a professional review of the quality of the student s work and, in conjunction with the academic advisor, assists the student in the research work required for the thesis. An affirmative vote by a majority of the committee after the defense is necessary for the student to pass. No comprehensive course exam is required.

MSChE Curriculum
First Year

Fall

Dept	No	Course	Cr
CHEN	620	Adv CHEN Analysis	3
CHEN	630	Transport Phenomena I	3
CHEN	700	CHEN Grad Seminar	0
CHEN	720	Adv Chem Rxn Engr	3
Elective			3
			12

Spring

Dept	No	Course	Cr
CHEN	750	Separation Process	3
CHEN	760	Adv CHEN Thermo	3
CHEN	700	CHEN Grad Seminar	0
Elective			3
Elective			3
			12

Second Year

Fall

Dept	No	Course	Cr
CHEN	700	CHEN Grad Seminar	0
CHEN	777	Thesis	3
			3

Spring

Dept	No	Course	Cr
CHEN	700	CHEN Grad Seminar	0
CHEN	777	Thesis	3
			3

IV FINANCIAL ASSISTANCE

Graduate students in Chemical Engineering are generally eligible for two types of support: Teaching Assistantships and Research Assistantships. The assistantships generally pay the full or a major part of the tuition and living expenses (currently about $800 to $1,050 per month). To be elligible for this type of support a student must be registered for graduate level courses or must receive semester credits for thesis. Details of types of support are as follows:

1. Teaching Assistantships - generally entail assisting in the teaching of lower level courses or grading homework assignments. Duties could also include tutoring or holding programs sessions for students or developing laboratory experiments or related duties for about 15 to 20 hours per week for the duration of the assistantship period. The assistant is expected to possess (1) the necessary proficiency with the subject matter, (2) suitable oral and written english communication skills, and (3) the willingness and dedication in the opinion of his or her supervisor to perform adequately the specific duties required of the position. Teaching Assistantships are awarded each semester on a contract basis. Acceptance of teaching assistantship contract binds the student to remain at the University to fulfill his duties until the end of the semester for which the contract was awarded.

2. Research Assistantships - generally entail working with a faculty member on a research investigation of a scholarly nature. The assistant may be expected to search for pertinent literature, read and understand related topical literature, perform research of an analytical or experimental nature, or contribute to technical reports and publications. Research assistants are normally expected to work about 15 to 20 hours of work per week during the academic year and to work full time on the project over the summer months. Research assistants are expected to be reasonably competent in the research subject matter and must display an interest in and willingness to learn additional material on the subject.

To apply for financial assistance, please fill out the attached financial assistance form and return it to the Chemical Engineering Department. GRE (Graduate Record Examination) scores, although not necessary, will be given consideration in making decisions regarding financial assistance. To obtain financial assistance, the graduate student must be enrolled in courses which are applicable to the student's degree program.

Students may also apply for and obtain funding in the form of fellowships, or scholarships from external sources not under the administration of the Chemical Engineering Department. The department informs students of various opportunities as they become available. Notable among them is the GEM graduate fellowship program for minority graduate students. This fellowship pays tuition, fees and a stipend of $5,000 per graduate academic year, and during the summer, the students are required to intern at a company that is a member of the National Consortium for Graduate Degrees for Minorities in Engineering, Inc. Information and application forms for GEM fellowships may be obtained from the Chemical Engineering Department.

VIII ACADEMIC MATTERS

ADVISING

All students who are enrolled in the MSChE Program must have an academic advisor. Upon admission to the program, the Graduate Program Coordinator will act as the student's advisor on a temporary basis.

Early in the first semester, the Graduate Program Coordinator will provide new graduate students with a list of available research projects. The students will be required to list two or three projects in the order of their preference. The Chemical Engineering faculty will then meet and assign research projects to students. The emphasis will be on providing each student with a research project of their preference. It might, however, not be possible to provide each student with their top choice. Once a research project is assigned, the faculty coordinator of that project will be the student's academic advisor.

In the first semester of enrollment, selection of courses and subsequent changes must be approved and signed by the Graduate Program Coordinator. The permanent advisor directs the student's course work and thesis as soon as a thesis project is selected.

TRANSFER OF CREDIT

Up to six semester hours of graduate work may be transferred from another university provided it was not a part of any prior undergraduate degree requirement. The course content must adequately replace current graduate offerings in the student's curriculum. Transfer credits should be at a level comparable to 600 or 700-level courses at A&T.

APPLICATION FOR GRADUATION

A candidate for graduation must file an application for graduation at least thirty (30) days prior to the close of the session in which he/she expects to complete the requirements for the degree. A student secures the application forms from the Chemical Engineering Graduate Program Coordinator. The student's advisor must approve the application before it is sent to the Graduate School Office. A copy of the completed application should be filed with the Graduate Program Coordinator. Failure to meet the deadline may result in delay of graduation for the candidate.

COMMENCEMENT

Diplomas are awarded only at the commencement exercises following the completion of all requirements for the degree. Attendance at commencement is required of all graduating students unless individually excused by the Dean of the Graduate School.

SEQUENCE of ACTIVITIES for MSChE CANDIDATES

1. Apply to the Graduate School for Admission to the MSChE program.
   a. Complete application form
   b. Pay application fee
   c. Request or present all necessary transcripts
2. Receive admission notification from the Graduate School.

3. Apply for Financial Aid

4. Receive Financial Aid decision from Graduate Program Coordinator

5. Upon Enrollment,

   a. See Graduate Program Coordinator for appointment of temporary advisor to register for first semester courses.

   b. Obtain TA assignment

   c. Apply for a Social Security Card

6. Prepare course schedule for the first semester with assistance of the temporary advisor. Begin work on removal of deficiencies or special conditions, if any.

7. Present the preferences of research projects to the Graduate Program Coordinator who will after meeting with the Chemical Engineering faculty assign a research project and hence the academic advisor.

8. Consult with the advisor and:
   a. Complete a degree plan
   b. Select an advisory committee

9. Obtain approval by all concerned for the degree plan. Place the plan on file with Graduate Program Coordinator's office.

10. Schedule and present a thesis/proposal. Place a copy on file with the permanent advisor and the Graduate Program Coordinator.

11. Consult with the advisor and:
    a. Complete the research work and write a thesis.
    b. Obtain the approval of the committee.
    c. Schedule and complete the thesis presentation and defense.

12. File application for graduation through permanent advisor.

ADMISSION REQUIREMENTS

All applicants to MSChE program must have earned a bachelor s degree from a four-year college. Students that meet this requirement may be admitted to the graduate school. Applicants are admitted without discrimination of race, color, creed, sex, religion or national origin. Applicants may be admitted to graduate studies unconditionally, provisionally, or as special students.

Decisions on admission are made by the Dean of the Graduate School with recommendations from the MSChE Program Coordinator and the Chemical Engineering Graduate Admissions Committee.

The Admissions decision is based on the candidates academic credentials and not on available financial aid.

UNCONDITIONAL ADMISSION

Unconditional admission to the Master of Science in Engineering Program with Chemical Engineering option will be granted to graduates of ABET accredited chemical engineering programs who have attained a minimum of a 3.0 Grade Point Average on their overall undergraduate program of study.

PROVISIONAL ADMISSION

Persons may be evaluated to be admitted provisionally to the MSChE program, on a case by case basis, if any of the following conditions apply:

1. The undergraduate degree is not from an ABET accredited program in engineering.

2. The undergraduate degree is not in engineering but in a closely related curriculum with a substantial engineering science content.

3. Any deficiencies revealed in the undergraduate transcript may be removed by the inclusion of no more than 12 semester credit hours of appropriate undergraduate course content not for graduate credit.

4. Under special conditions, candidates with a B.S. degree in chemical engineering might be considered if their undergraduate GPA is below 3.0

A student admitted provisionally will be required to meet with the Graduate Program Coordinator to develop a list of undergraduate courses that must be taken to eliminate deficiencies in the undergraduate transcript.

All provisionally admitted students must earn a minimum of a 3.0 grade point average on the first nine graduate course credits they complete. In addition, a "B" grade point average must be earned on all non-credit undergraduate courses if any were required as a condition of admission. In addition to these provisions, other conditions may be imposed on a case-by-case basis as approved by the Graduate School.

SPECIAL STUDENT STATUS

Students who hold an undergraduate degree outside of engineering normally have course deficiencies exceeding 12 semester credits. These students can be considered for special student status - undergraduate until such time that their deficiencies are reduced so that they can qualify for provisional admission. Persons with massive undergraduate deficiencies even though they might hold an undergraduate degree, should consider applying as transfer students to the undergraduate Chemical Engineering program.

Students who are not seeking a graduate degree at A&T are also classified as special students. They are admitted in order to take courses for self-improvement. If a student subsequently wishes to pursue a degree program, he/she must request an evaluation of his/her record. The Graduate School reserves the right to refuse to accept towards a degree program credits which the candidate earned while being enrolled as a special student; in no circumstances may the student apply towards a degree program more than twelve semester hours of graduate credits earned as a special student.

SPECIAL ADMISSION REQUIREMENTS FOR APPLICANTS WITHOUT A CHEMICAL ENGINEERING DEGREE

Applicants with a non-chemical engineering undergraduate degree must have completed at least two semesters of calculus to be considered for admission to the MSChE program as a student. Students without a degree in chemical engineering will not be considered for financial aid until their undergraduate deficiencies fall below 12 credits. Upon admission these students will develop their MSChE curriculum with assistance from the MSChE Program Coordinator. The curriculum will be such as to include at least

one semester of physical chemistry and organic chemistry, completion of the undergraduate with sequence (Calculus II and Differential Equations) and the attainment of satisfactory computer literacy. In addition they will be required to take CHEN 200 (Chemical Process Principles) and a minimum of five of the following seven undergraduate chemical engineering courses:

CHEN 300 - Transfer Operations I
CHEN 310 - Chemical Engineering Thermodynamics
CHEN 320 - Transfer Operations II
CHEN 340 - Process Dynamics and Control
CHEN 400 - Mass Transfer Operations
CHEN 420 - Chemical Reaction Engineering
CHEN 430 - Process Design I

A curriculum will be designed for each of these students according to their background and interests.

APPLICATION PROCEDURE

All applicants for the MSChE program must have earned a bachelors degree from a four year institution. All applicants for admission must submit the following documents.

a. Application Form Completed (Two Copies)

b. Processing Fee, $35.00

c. Original Transcripts(s) - Two Copies

d. Three letters of recommendations.

All documents and the $35 processing fee must be sent to:

Note: Your application fee of $35.00 must be in the form of: (1) a bank money order drawn on an American bank, or (2) a cashier's check drawn on an American bank, or (3) an American Express Traveler's check.

A copy of the application should also be sent to the Chemical Engineering Department Graduate Program Coordinator. Processing of applications cannot begin until they are complete, with all supporting documents, at least fifteen days before a registration period. Foreign nationals are required to apply early. Applicants may be admitted to graduate studies unconditionally, provisionally, or as special students. Applicants are admitted without discrimination because of race, color, creed, sex, religion or national origin.

SPECIAL ADMISSION REQUIREMENTS FOR FOREIGN STUDENTS

In addition to the other application material, foreign nationals are required to provide the following material:

1. All foreign applicants, except those from English-speaking countries, must provide proof of English language proficiency by obtaining acceptable scores on the Test of English as a Foreign Language (TOEFL). While this test does not affect the student's admission, failure to pass it may necessitate taking remedial English courses designed to improve the student's ability to communicate in the English language. A minimum TOEFL score is set by the Graduate School. Currently, the minimum score is 550.

2. All foreign students should show Financial Certification for the required amount of money from the applicant's sponsor and the appropriate bank before an I-20 can be issued. The applicant will be sent a Financial Certification form once he/she has been granted admission. This form should be mailed to:

The Office of International and Minority Student Affairs
North Carolina A&T State University
Room 221, Murphy Hall
1601 East Market Street
Greensboro, NC 27411

Applicants who cannot provide Financial Certification, but are applying for financial assistance need not send the Financial Certification form until a decision is reached on the award. The Financial Certification form should then be completed and mailed along with the award letter to the Office of International and Minority Student Affairs.

3. All foreign nationals currently residing in U.S.A. are required to fill out a Transfer Clearance form and send it to the Office of International and Minority Affairs, in addition to the Financial Certification form.

LIST OF CHEN COURSES AND DESCRIPTIONS

CHEMICAL ENGINEERING GRADUATE/ADVANCED UNDERGRADUATE COURSES

CHEN-600 Advanced Process Control **Credits 3**
The course covers advanced methods for controlling chemical processes: adaptive control, feed forward control, cascade control, multivariable control, multi-loop control, decoupling, and deadtime compensation. Emphasis is placed on computer design.

CHEN-605 Biochemical Engineering **Credits 3**
The course covers basic phenomena involved in biological systems, biochemical reaction systems, microbiology, and biological processes. Application of engineering methods to the design and control of biological systems. Biochemical production of industrial chemicals. Biological waste treatment. Immobilized enzyme technology.

CHEN-608 Bioseparations
The course is an introduction to the separation and purification of biochemicals. Separation processes are characterized as primarily removal of insolubles, isolation of products, purification or polishing. Processes covered include filtration, centrifugation, cell disruption, extraction, absorption, elution chromatography, precipitation, ultrafiltration, electrophoresis and crystallization. Students are required to complete a design project on a bioseparation process.

CHEN-610 Advanced Chemical Engineering Thermodynamics **Credits 3**
Molecular thermodynamics of fluid phase equilibria, introduction to statistical thermodynamics, thermodynamics of nonequilibrium processes.

CHEN-615 Fuels and Petrochemicals **Credits 3**
Topics important to the production of fuels are covered. Topics include extraction and processing of fossil fuels, synfuels, and fuels from renewable resources. Topics also include distillation, refining, fermentation, catalytic reactions, and removal of undesirable by-products. The design of fuel processes include emphasis on economic and environmental impact. Prerequisite: Senior standing in CHEN courses.

CHEN-618 Air Pollution Control **Credits 3**
The economic, social and health implications of air pollution and its control are covered. To understand the problems better, the sources, types and characteristics of man-made air pollutants will be discussed. The course will review some of the main regulations and engineering alternatives for achieving different levels of control. An air pollution control system will be designed. (Course is to be cross referenced with CIEN 618) Prerequisite: Senior standing in CHEN courses.

CHEN-620 Advanced Chemical Engineering Analysis **Credits 3**
Solution of chemical engineering problems by advanced mathematical techniques. Solution of uncoupled and coupled momentum, heat and mass transfer problems. Solution of linearized dynamic equations representing staged operations by matrix analysis. Advanced design and optimization of chemical processes.

CHEN-622 Pollution Prevention **Credits 3**
The concept of pollution prevention and its application through industrial ecology, risk assessment and life-cycle assessment methodologies are covered. Topics include pollution prevention at the macroscale (industrial sector), mesocale (unit operations), and microscale (molecular interactions). A process involving membrane separation steps will be designed and analyzed.

CHEN-625 Basic Food Process Engineering **Credits 3**
This course covers basic food processing topics including food preparation operations. Topics included are slurry flow, processing operations, microbology and health hazards, diseases and medicines, and their effects on humans. Prerequisite: Senior standing in CHEN courses.

CHEN-630 Transport Phenomena **Credits 3**

A unified approach to momentum, energy, and mass transfer with emphasis on the microscopic approach. Development of the differential transport balances. Applications in solving simple chemical process problems.

CHEN-635 Mixing Processes and Equipment Scale-up **Credits 3**

The courses covers practical design concepts of mixing and multi phase processing in agitated tanks. Strategies for increasing plant throughput, improving contacting and mixing and selecting equipment will be given. This course provides information on: 1) judging the level of difficulty of a mixing process; 2) using practical elements of laminar, transitional and turbulent mixing; 3) mixing times and 4) increasing throughput for all types of systems and power. The course treats jet mixing, gas sparged mixing and mechanical mixing. The course provides basic concepts on using pilot plant studies for process translation and scale- up. Equipment design is stressed. Prerequisite: Senior standing in CHEN courses.

CHEN-640 Computer-Aided Chemical Process Design **Credits 3**

The development and use of computer-aided models for process equipment design is stressed. Model results are compared with the ASPEN PLUS simulation package. Students study the Interrelationships between design and process variables using computer simulation. Optimization methods are applied to chemical process design. Prerequisite: Senior standing in CHEN courses.

CHEN-645 Environmental Remediation **Credits 3**

The course introduces students to traditional and developmental methods for removal and detoxification of hazardous wastes at contaminated sites and from industrial waste streams. Chemical, thermal, biological and physical methods of remediation are covered. The course deals with hazardous wastes in soils, groundwater, surface water, wastewater ponds and tanks. The emphasis is on destruction, removal and containment methods using mathematical models for contaminate fate and transport. Recent advances in emerging technologies are also discussed. Each student will complete an environmental remediation design project. Prerequisite: Senior standing in CHEN courses.

CHEN-660 Selected Topics in Chemical Engineering **Credits 3**

Topics covered include selected chemical engineering topics of interest to students and faculty. The topics will be selected before the beginning of the course and will be pertinent to the programs of the students enrolled.

CHEN 666 Special Projects in Chemical Engineering **Credits 3**

Study arranged on a special chemical engineering topic of interest to both student and faculty member, who will act as supervisor. Topics may be analytical and /or experimental and should encourage independent study.

CHEN-710 Transport Phenomena II **Credits 3**

This course is an advanced treatment of the mechanisms of momentum, heat and mass transport. Emphasis is on methods of solution of transport problems for coupled systems where two or more transport processes interact. Other topics include Non-Newtonian Flow, Boundary Layer Theory, and the Analysis and solution of transport problems of significance in chemical processes.

CHEN-720 Advanced Chemical Reaction Engineering **Credits 3**

This course includes an advanced treatment of chemical reaction engineering including effect of non-ideal flow and fluid mixing on reactor design, as well as multi-phase reaction system and heterogeneous catalysis and catalytic kinetics.

CHEN-730 Advanced Biochemical Engineering **Credits 3**

This course is the study of advanced topics in biochemical engineering and enzyme engineering, highlighting research trends. Modeling and optimization of biochemical systems are also covered, as well as the design and analysis of enzyme reactors and the use of enzymes in industrial, environmental and medical applications.

CHEN-740 Advanced Chemical Process Design **Credits 3**
Topics in advanced conceptual process engineering such as process analysis, process synthesis and process optimization are covered. Specific topics include: flowsheeting, design variable selection, computational algorithm formulation, separation sequences, heat exchanger networks, recycle-purge processes, process design and simulation software development, including physical and thermodynamic properties packages.

CHEN-750 Separation Processes **Credits 3**
Differential and equilibrium stage operations involving non-isothermal and multi-component systems are covered. Other topics covered include simultaneous mass transfer and chemical reaction and dispersion effects. Applications to operations such as absorption, extraction, chromatography, distillation, ion exchange, and membrane separation are also studied.

CHEN-760 Advanced Chemical Engineering Thermodynamics
This is an advanced course covering topics in molecular thermodynamics of fluid phase equilibria. Statistical thermodynamics and thermodynamics of nonequilibrium processes are introduced.

CHEN-786 Special MSChE Project **Credits 3**
The course is intended for students who want to complete an analytical or experimental project of interest to the student and instructor. The course may be completed by Project Option students, but does not substitute for CHEN 796.

CHEN-789 Special Topics **Credits 3**
A course design to allow the introduction of potential new courses on a trial basis or offering of special course topics on a once only basis. The course may be offered to individuals or groups of students. A definite topic and the title must be agreed upon by the advisor before the student registers for the course.

CHEN-792 Masters Seminar
This course provides a forum for the presentation and discussion of selected topics of interest to chemical engineering graduate students such as faculty research interests, communication, safety, job prospects and research results. Seminar credits do not apply to degree requirements.

CHEN-793 Masters Supervised Teaching **Credits 3**
This course is designed to provide the Masters student with an introduction to classroom teaching under the supervision of a faculty mentor. The student will observe and participate in classroom teaching, lecture preparation, student evaluation, and grading. Masters students may take this course only during a semester that they serve as a teaching assistant. The course supervisor(s) will observe and provide feedback to the student during the assignment and evaluate the student s performance. Credits for this course do not apply toward degree requirements.

CHEN-794 Masters Supervised Research **Credits 3**
This course is supervised research under the mentorship of a faculty member. It is not intended to serve as the project nor thesis topic of the masters student.

CHEN-796 Masters Project
This is an independent, analytical or experimental project involving research or design in an area of interest to the instructor and the student. This course must be completed by, and only by, Master of Science in Chemical Engineering (MSChE) project option students. A written proposal and an oral defense are required.

CHEN-797 Masters Thesis
The student will select, complete, present and defend a thesis topic under the direction of his/her graduate advisor.

OTHER RELEVANT COURSES

MATH-651 Methods In Applied Mathematics I **Credits 3**
An introduction to complex variables and residue calculus, transform calculus (Fourier, Laplace, Hankel, Mellin, etc. Transforms), higher order partial differential equations governing various physical phenomena, nonhomogeneous boundary value problems, orthogonal expansions, Green's functions and variational principles.

MATH-652 Methods of Applied Mathematics II **Credits 3**
An introduction to integral equations and conversion of differential problems into integral equations of Volterra and Fredholm types, solution by iteration and other methods, existence theory, eigenvalue problems, Hilbert-Schmidt theory of symmetric kernels and topics in the calculus of variation, including optimization of integrals involving functions of more than one variable, Hamilton's principles, Strum-Liouville theory, Rayleigh-Ritz methods, etc.)

MEEN-626 Advanced Fluid Dynamics **Credits 3**
Derivation of Navier-Stokes Equations, continuity equation and energy equation; exact solutions of Navier-Stokes Equations, invicid flow, potential theory, complex potentials and conformal mapping.

MEEN-655 Computational Fluid Dynamics **Credits 3**
This technical elective course provides an introduction to numerical methods for solving the exact equations of fluid dynamics. Finite difference methods are emphasized as applied to viscous and inviscid flows over bodies. Students are introduced to a modern Computational Fluid Dynamics computer code. Prerequisites: Math 332, and either MEEN 415, or MEEN 416.

MEEN-656 Boundary Layer Theory **Credits 3**
This course covers the fundamental laws governing flow of viscous fluids over solid boundaries. Exact and approximate solutions are studied for various cases of boundary layer flow including laminar, transitional, and turbulent flows. Prerequisites: MEEN 415 or MEEN 416.

MEEN-731 Conduction Heat Transfer **Credits 3**
Development of the general heat conduction equation. Applications to one, two and three dimensional steady and unsteady boundary value problems in heat conduction. Closed form and numerical solution techniques. Prerequisites: MEEN 562 or equivalent.

MEEN-732 Convection Heat Transfer **Credits 3**
Analysis of heat convection in laminar and turbulent boundary layer and pipe flow; dimensional analysis; free convection; condensation and boiling.

MEEN-733 Radiation Heat Transfer **Credits 3**
A comprehensive treatment of basic theories; radiation characteristics of surfaces and radiation properties taking account of wave length, direction, etc.; analysis of radiation exchange between idealized and real surfaces; fundamentals of radiation transfer in absorbing, emitting and scattering media; interaction of radiation with conduction and convection. Prerequisite: MEEN 562 or equivalent.