PROPOSAL 27-96

M.S. IN ENVIRONMENTAL ENGINEERING

This is a proposal to establish a M.S. in Environmental Engineering degree, as an addition to the existing M.S. in Civil Engineering program within the Department of Civil and Environmental Engineering. The M.S. in Environmental Engineering is designed to more appropriately identify (or title) the graduate students pursuing environmental engineering studies at Michigan Technological University. As identified by the American Academy of Environmental Engineers, the professional discipline of environmental engineering is defined as

"the application of engineering principles to improve and maintain the environment for the protection of human health, for the protection of nature's beneficial ecosystems, and for the environment-related enhancement of the quality of human life." 1

At present, however, all graduate students within the Department are currently awarded the M.S. in Civil Engineering. Civil Engineering is defined by the American Society of Civil Engineers as

"the profession in which a knowledge of the mathematical and physical sciences gained by study, experience and practice is applied with judgment to develop ways to utilize economically, the materials and forces of nature for the progressive well-being of humanity in creating, improving and protecting the environment, in providing facilities for community living, industry and transportation, and in providing structures for the use of mankind." 2

The proposed M.S. program in Environmental Engineering will integrate with the existing B.S. in Environmental Engineering and Ph.D. in Engineering (Environmental) programs.

Need and Motivation for the M.S. in Environmental Engineering

The current degree program at the master's level, M.S. in Civil Engineering, does not adequately describe students studying environmental engineering. The M.S. in Environmental Engineering is a more proper identification of the education a student receives within the program and what AAEE describes environmental engineering to be. The M.S. in Environmental Engineering better communicates the degree's nature to industry and the public.

Secondly, a major goal of Michigan Technological University as stated in its Five Year Strategic Plan is to increase the number of graduate students. In addition the MTU Initiative for the Environment indicates the university's emphasis on environmental education. The M.S. in Environmental Engineering degree will enhance both endeavors.

Lastly, the environmental engineering program has long been producing many master's level graduates within the Department. The M.S. in Environmental Engineering will make these graduates more visible. In essence, this proposal simply applies a more accurate title to a portion of an existing and successful M.S. program within the Department of Civil and Environmental Engineering.

Budget Issues

There will be no start-up costs for this program; the faculty, laboratories, equipment, program framework and courses already exist within the Department.

Admission Requirements

Admission will be similar to the existing M.S. in Civil Engineering. Students with a B.S. degree in engineering will be considered for admission to the program. M.S. applicants holding non-engineering degrees, provided that they meet ABET guidelines for a first degree in engineering, will also be considered for admission. This is interpreted to mean that, including both the B.S. and M.S. programs, the student must earn at least one year (48 quarter credits) of engineering science, one-half year of engineering design, and one year of basic mathematics and science.

Advisory Committee

Like the current M.S. in Civil Engineering and MTU Graduate School policies, a faculty Advisor is assigned by the department chair, based on recommendation of the faculty and consultation with the student. With the assistance of the Advisor, the student will assemble an Advisory Committee that must be approved by the department chair.

Degree Requirements

The primary focus of the M.S. in Environmental Engineering is the integration of environmental science, mathematics, and engineering application. Each student must take forty-five (45) credits. Plan A (Thesis), Plan B (Report), and Plan C (Course Work) will be options for the M.S. in Environmental Engineering.

Plan A -- Thesis Option
In addition to a minimum of 30 credits of course work and 9-15 credits of thesis research, for a 45 credit minimum total this plan requires a research thesis, supervised by the Advisor, and describes a research investigation and its results.

Course work credit distribution must be at least 18 credits must be from 500-600 level courses and no more than 18 credits may be at the 400-level

Up to 6 credits of 300-level course work earned outside the major department can be substituted for 400-level courses.

Plan B -- Report Option
Of the total minimum 45 credits, at least 36 must be earned in course work other than the project. 36 credits of course work and 3-9 credits of project research, for a 45 credit minimum total this plan requires a research report, supervised by the Advisor, and describes a research investigation and its results. at least 18 credits must be from 500-600 level courses and no more than 18 credits may be at the 400-level 3-9 credits are to be assigned to a report describing the results of an independent study project

Up to 6 credits of 300-level course work earned outside the major department can be substituted for 400-level courses.

Plan C -- Course Work Option
Of the minimum 45 credits of course work required, at least 27 credits must be from 500-600 level courses and no more than 18 credits may be at the 400-level

Up to 6 credits of 300-level course work earned outside the major department can be substituted for 400-level courses. The Plan C option is intended primarily for persons with professional experience.

Due to the interdisciplinary nature of Environmental Engineering, there are no structured course requirements. Instead each M.S. student, under the guidance of the Advisory Committee, will tailor an academic plan of mutual interest and benefit. The general requirements will be under the control of the

Advisory Committee to ensure that the student's course work addresses the basic criteria of educational programs for environmental engineers as defined by AAEE. Specifically, the program must address

"the dependence of mankind on a healthy environment; the conception, design and operation of engineered systems affording protection of human health and the environment; the interactions and transformations that occur across environmental media (i.e. surface water, groundwater, land, and air); the behavior of natural systems in response to outside stimuli caused by man's activities; and the need to work closely and effectively with other professionals in multi-disciplinary teams to meet the challenge of environmental protection." 3

In addition to the general requirements, each student must declare an emphasis area for focused study. Again, with consultation of the Advisory Committee, a sequential development of course work will be selected to increase exposure to one of the following major focus areas of environmental engineering: Surface water quality and water resources Environmental systems modeling Pollution prevention Environmental chemistry Wastewater Solid waste and hazardous wastes Atmospheric systems and air pollution control Groundwater and subsurface remediation

While candidates could fulfill all course requirements from offerings in the Department of Civil and Environmental Engineering, course work outside the Department will be encouraged when appropriate.

Sample Degree Courses

The number of environmental engineering courses offered by the Department of Civil and Environmental Engineering faculty are evenly distributed throughout the year. At the 500-level, four are offered in the Fall, five are offered in the Winter, and four are offered in the Spring Quarter. At the 400-level, six are offered in the Fall, three are offered in the Winter, and five are offered in the Spring Quarter. All students within the M.S. program will have ample course offerings every term to fulfill degree requirements, as shown in the following list of courses (course number, course title, term offered, instructor).
CE 550 Air Quality Modeling (W, 3 cr.) Paterson
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 554 Biological Treatment Processes (W, 4 cr.) Baillod
CE 555 Water Quality Modeling (W, 3 cr.) Auer
CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden
CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke
CE 558 Advanced Atmospheric Chemistry (F, 3 cr.) Honrath
CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic
CE 503a Environmental Organic Chemistry I (S, 3 cr.) Perlinger
CE 503b Biogeochemistry (S, 3 cr.) Urban
CE 502a Environmental Organic Chemistry II (W, 3 cr.) Perlinger
GE 594 Transport in Porous Media (W, 3 cr.) Gierke
GE 595 Mathematical Modeling of Earth Systems (S, 3 cr.) Mayer
CE 402 Environmental Engineering Design Project (F, W, S, Su, 3 cr.) All
CE 450 Drinking Water Treatment (F, 3 cr.) Hand
CE 451 Wastewater Treatment Engineering (W, 3 cr.) Hand
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 453 Surface Water Quality Engineering (F, 3 cr.) Auer
CE 455 Solid and Hazardous Waste Management (F, 3 cr.) Mihelcic
CE 456 Hazardous Waste Treatment (S, 3 cr.) Hand
CE 458 Air Quality Engineering (W, 3 cr.) Honrath
CE 459 Atmospheric Physics and Chemistry (S, 3 cr.) Paterson
CE 467 Open Channel Hydraulics (F, 3 cr.) Santeford
CE 468 Water Resources Engineering (S, 3 cr.) Santeford
GE 421 Hydrogeology (F, 3 cr.) Mayer
GE 493 Site Investigation (W, 3 cr.) Mayer

GE 494 Groundwater Engineering (S, 3 cr.) Gierke
GE/CM 496 Fundamentals of Subsurface Remediation (F, 4 cr.) Gierke, Mayer, Shonnard

Many courses offered by faculty outside the Civil and Environmental Engineering Department could also be taken, as approved by the Advisory Committee. Examples of such supporting courses include:
BL 546 Advanced Ecology-Ecosystems (W, 3 cr.) Kerfoot
CM 501 Molecular Transport (F, 3 cr.) Morrison
CM 502 Turbulent Transport (S, 3 cr.) Morrison
CM 535 Advanced Chemical Engineering Kinetics I (W, 3 cr.) Rogers
CM 536 Catalysis and Reactivity of Solids (W, 3 cr.) Mullins
FW 555 GIS for Resource Management (W, 4 cr.) Maclean
FW 554 Remote Sensing of the Environment (F, 4 cr.) Maclean
GE 551 Geophysical Applications of Remote Sensing (S, 3 cr.) Rose
BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking
BL 405 Environmental Biochemistry II (S, 3 cr.) Lueking, Adler
BL 421 Environmental Microbiology (W, 4 cr.) Bagley
BL 445 Limnology (F, 4 cr.) Keen
CM 498 Pollution Assessment and Prevention (W, 3 cr.) Shonnard
FW 422 Wetlands (F, 4 cr.) Gale, Shetron
GE 406 Introduction to Meteorology (S, 3 cr.) Kostinski
GE 425 Global Change and Earth Systems (W, 4 cr.) Rose, Bluth
GE 470 Applied Geoscience Data Analysis (W, 3 cr.) Bornhorst
MA 430 Numerical Analysis (F, W, S, Su, 4 cr.) Hicks
ME 474 Fuels and Combustion (F, 3 cr.) Cho
BA461/561, Natural Resource Economics
BA463/563, Environmental Economics
BA456, Environmental Law

Examples of possible focus area course work follow. After identifying an area of study, a typical M.S. student would be encouraged to take three or more courses out of the appropriate list (or other courses approved by the Advisory Committee) to gain greater exposure to one of the major focus areas of environmental engineering.

Surface water quality and water resources
CE 450 Drinking Water Treatment (F, 3 cr.) Hand
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 453 Surface Water Quality Engineering (F, 3 cr.) Auer
CE 468 Water Resources Engineering (S, 3 cr.) Santeford
CE 555 Water Quality Modeling (W, 3 cr.) Auer
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 503a Environmental Organic Chemistry I (S, 3 cr.) Perlinger
CE 503b Biogeochemistry (S, 3 cr.) Urban
CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden
BL 546 Advanced Ecology-Ecosystems (W, 3 cr.) Kerfoot
FW 555 GIS for Resource Management (W, 4 cr.) Maclean
BL 445 Limnology (F, 4 cr.) Keen
FW 422 Wetlands (F, 4 cr.) Gale, Shetron

Environmental systems modeling
CE 550 Air Quality Modeling (W, 3 cr.) Paterson
CE 555 Water Quality Modeling (W, 3 cr.) Auer
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 554 Biological Treatment Processes (W, 4 cr.) Baillod
CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke

CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic
GE 595 Mathematical Modeling of Earth Systems (S, 3 cr.) Mayer
FW 554 Remote Sensing of the Environment (F, 4 cr.) Maclean
GE 470 Applied Geoscience Data Analysis (W, 3 cr.) Bornhorst
MA 430 Numerical Analysis (F, W, S, Su, 4 cr.) Hicks

Pollution prevention
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 459 Atmospheric Physics and Chemistry (S, 3 cr.) Paterson
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 555 Water Quality Modeling (W, 3 cr.) Auer
CE 550 Air Quality Modeling (W, 3 cr.) Paterson
CE 503b Biogeochemistry (S, 3 cr.) Urban
CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic
GE 421 Hydrogeology (F, 3 cr.) Mayer
CM 498 Pollution Assessment and Prevention (W, 3 cr.) Shonnard

Environmental chemistry
CE 450 Drinking Water Treatment (F, 3 cr.) Hand
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 558 Advanced Atmospheric Chemistry (F, 3 cr.) Honrath
CE 503a Environmental Organic Chemistry I (S, 3 cr.) Perlinger
CE 503b Biogeochemistry (S, 3 cr.) Urban
CE 502a Environmental Organic Chemistry II (W, 3 cr.) Perlinger
BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking
BL 405 Environmental Biochemistry II (S, 3 cr.) Lueking, Adler

Wastewater
CE 451 Wastewater Treatment Engineering (W, 3 cr.) Hand
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 554 Biological Treatment Processes (W, 4 cr.) Baillod
CE 556 Physical and Chemical Treatment (S, 4 cr.) Crittenden
CE 503a Environmental Organic Chemistry I (S, 3 cr.) Perlinger
CM 535 Advanced Chemical Engineering Kinetics I (W, 3 cr.) Rogers
BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking
BL 405 Environmental Biochemistry II (S, 3 cr.) Lueking, Adler
BL 421 Environmental Microbiology (W, 4 cr.) Bagley

Solid and hazardous wastes
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 455 Solid and Hazardous Waste Management (F, 3 cr.) Mihelcic
CE 456 Hazardous Waste Treatment (S, 3 cr.) Hand
CE 554 Biological Treatment Processes (W, 4 cr.) Baillod
CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke
CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic
CE 503a Environmental Organic Chemistry I (S, 3 cr.) Perlinger
BL 404 Environmental Biochemistry I (W, 3 cr.) Adler, Lueking
BL 421 Environmental Microbiology (W, 4 cr.) Bagley
GE 421 Hydrogeology (F, 3 cr.) Mayer
GE 493 Site Investigation (W, 3 cr.) Mayer

Atmospheric systems and air pollution control
CE 458 Air Quality Engineering (W, 3 cr.) Honrath

CE 459 Atmospheric Physics and Chemistry (S, 3 cr.) Paterson
CE 550 Air Quality Modeling (W, 3 cr.) Paterson
CE 553 Environmental Process Engineering (F, 4 cr.) Crittenden
CE 558 Advanced Atmospheric Chemistry (F, 3 cr.) Honrath
CE 503b Biogeochemistry (S, 3 cr.) Urban
GE 551 Geophysical Applications of Remote Sensing (S, 3 cr.) Rose
CM 498 Pollution Assessment and Prevention (W, 3 cr.) Shonnard
GE 406 Introduction to Meteorology (S, 3 cr.) Kostinski
GE 470 Applied Geoscience Data Analysis (W, 3 cr.) Bornhorst
GE 425 Global Change and Earth Systems (W, 4 cr.) Rose, Bluth
ME 474 Fuels and Combustion (F, 3 cr.) Cho

Groundwater and subsurface remediation
CE 450 Drinking Water Treatment (F, 3 cr.) Hand
CE 451 Wastewater Treatment Engineering (W, 3 cr.) Hand
CE 452 Water Chemistry (F, S, 4 cr.) Mihelcic, Urban, Perlinger
CE 557 Groundwater Quality Modeling (F, 3 cr.) Gierke
CE 559 Fate in Soil & Groundwater (F, 3 cr.) Mihelcic
GE 421 Hydrogeology (F, 3 cr.) Mayer
GE 493 Site Investigation (W, 3 cr.) Mayer
GE 494 Groundwater Engineering (S, 3 cr.) Gierke
GE/CM 496 Fundamentals of Subsurface Remediation (F, 4 cr.) Gierke, Mayer, Shonnard
CM 498 Environmental Chemical Engineering (W, 3 cr.) Shonnard
GE 594 Transport in Porous Media (W, 3 cr.) Gierke
GE 595 Mathematical Modeling of Earth Systems (S, 3 cr.) Mayer

Oral Examination or Defense

Examination by and approval of the Advisory Committee is required for awarding the Master of Science in Environmental Engineering. The Advisory Committee will examine the general professional knowledge, course work, and in Plans A and B, the thesis or report of each master's candidate.

An oral presentation of the thesis or report will be made following the completion of the written work. Copies of the thesis or report are to be distributed to the Advisory Committee at least two weeks prior to the examination data.

The thesis, report, or course work examination is acceptable if the Advisor and at least two of the other three Advisory Committee members concur on its acceptance. The oral presentation for the thesis or report is open to the public.

References

1 American Academy of Environmental Engineers, AAEE Environmental Engineering Program Criteria Draft, February 3, 1996, p. 1.
2 American Society of Civil Engineers, ASCE Official Register, 1996, p. 366.
3 American Academy of Environmental Engineers, AAEE Environmental Engineering Program Criteria Draft, February 3, 1996, p. 1.

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Approved by President: November 7, 1996
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