The University of Michigan
College of Engineering
Curriculum Committee

Agenda
March 20, 2007
1:30-3:00 p.m.
2210 LEC
Lurie Engineering Center

1. Approval of Minutes from January 23 and March 6, 2007 Meetings
2. Race & Ethnicity Requirement – Toby Teorey
3. MENG in Energy Science Draft Proposal
4. Sample Schedule BME
5. Sample Schedule NAME
6. NERS Curriculum Changes
7. Course Approval Forms

University of Michigan
College of Engineering
Curriculum Committee Meeting
Tuesday January 23, 2007
1:30-3:00 p.m.
Lurie Engineering Center GM Room
Minutes

Richard Robertson called the meeting to order at 1:40 p.m.

Members Present: R. Robertson, L. Bernal, J. Barker, D. Karr, K. Kearfott, M. Krug, M. Keyserling, C. Lastoskie, D. Murray, J. Pan, R. Rogers, M. Solomon, R. Sulewski, T. Teorey

Members Absent: G. Herrin, A. Hunt, P. Mazumder, M. Moghaddam, S. Pang, J. Shi, T. Szvarca

Guests: Dan Murray (UMEC), Pete Washabaugh, Brian Gilchrist, Nilton Renno, Daryl Weinert
Serap Savari (Sitting in for Mahta Moghaddam, EECS)

Motion to approve the minutes of the last meeting

The minutes of the last meeting were approved

Project Based Learning (Practicum Proposal) – Pete Washabaugh

Pete Washabaugh, from the department of Aerospace Engineering, talked about the proposed Interdisciplinary Practicum Concentration Initiative. Information regarding this was included in the meeting packet.
This is meant to be a College wide activity at some point in time.
There is not a formal curricular proposal at this time. In the future they hope to prototype and offer the base courses. Some are being prototyped and offered now (i.e. the Engineering blimp course). They might like to wrap a sequence of these courses into a formal concentration or minor.
There was some discussion regarding this proposal.

Dick Robertson said that the Committee members should take this information back to their departments to see where it fits in.

Adjournment: Motion to adjourn was made and seconded
Motion carried (approved)

Next Meeting:
March 6, 2007
1:30-3:30 p.m.
2210-LEC

University of Michigan
College of Engineering
Curriculum Committee Meeting
Tuesday March 6, 2007
1:30-3:00 p.m.
Lurie Engineering Center GM Room
Minutes

Richard Robertson called the meeting to order at 1:40 p.m.

Members Present: R. Robertson, J. Barker, L. Bernal, K. Kearfott, M. Keyserling , J. Pan, R. Sulewski, T. Teorey

Members Absent: G. Herrin, A. Hunt, D. Karr, C. Lastoskie, P. Mazumder, M. Moghaddam, S. Pang, R. Rogers, J. Shi, M. Solomon, T. Szvarca

Guest: Greg Keoleian

<u>Motion to approve the minutes of the last meeting</u>

The approval of minutes was tabled until the next meeting since they were not available at this time.

<u>Change in BiomedE Curriculum</u>

Information regarding this change was included in the meeting packet.
Since there was no BME representative in attendance at this meeting, and there was no sample schedule included, it was decided to table this request and contact the BioMed department regarding this decision.

<u>Proposed Natural Resources/Engineering MS/MSE Dual Program – Greg Keoleian</u>

Information regarding this Proposal was included in the meeting packet.
Greg Keoleian (from the School of Natural Resources) spoke regarding this proposal of a MS/MSE dual program. This would be a Masters Degree in Engineering and a Master of Science in Natural Resources and Environment. He stated that other schools don't have this Program and this program would provide solutions to sustainability challenges, such as energy, materials, water.
This Program is being supported by Departments, Dean Munson among others.

After the presentation there was some discussion regarding this proposal.

Dick Robertson asked for a motion to support this Program.
Moved and Seconded.
The Committee voted and agreed to support this Program.

<u>Course approval Forms</u>

<u>These Courses Were Tabled</u>

BME 520(X-Listed with BA 518, HMP 630, PHRM 620) New Course
ME 350 Modification – Changing Description
ME 360 Modification – Changing Description

Richard Robertson called for a motion to approve the following courses. This was moved and seconded.

<u>These Courses Were Approved</u>

IOE 422 Modification – Changed Description
IOE 433 (X-Listed with MFG 433) Deletion
IOE 440 (X-Listed with MFG 440) New Course
IOE 905 Deletion
MSE 593 New Course
ME 320 Modification – Changed Prerequisites from: ME 235 and ME 240 ***to: Math 215,*** **ME 235, and ME 240**

ME 450 Modification – Changed Prerequisites from: ME 350, ME 360 and ME 395 (advised) ***to: ME 350, ME 360 and ME 395 (enforced);*** Changed Credit Restrictions from: Recommend ME 495 not be elected concurrently. Not open to graduate students. ***to: May not be taken concurrently with ME495. Not open to graduate students.***
ME 487(X-Listed with MFG 488) Modification – Changed Prerequisite from: ME 481 ***to: ME 382***
ME 495 Modification – Changed Prerequisites from: ME 360, ME 395; preceded or accompanied by ME 350 ***to: ME 360, ME 395, P/A ME 335 and ME 350*****;**
Changed Credit Restrictions from: Recommend ME 450 not be elected concurrently. Not open to graduate students. ***to: May not elect ME 450 concurrently. Not open to graduate students.***
ME 631 Modification – Changing Prerequisites from: ME 230 or MFG 336 ***to: ME 235 or MFG 336***

<u>Adjournment:</u> Motion to adjourn was made and seconded
<u>Motion carried (approved)</u>

Next Meeting: March 20, 2007 (Room 2210 LEC)

UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING

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URL: http://interpro.engin.umich.edu/

Memorandum

To:	Richard Robertson Chair CoE Curriculum Committee
From:	Huei Peng H. P. Executive Director Michigan Interdisciplinary and Professional Programs
Date:	March 16, 2007
Re:	Request for approval to establish the new Interpro Program: Master of Engineering in Energy Science

On behalf of the Interdisciplinary Professional Programs and Directors, I am submitting to the Curriculum Committee the attached proposal for your review and approval.

The new degree program proposal was reviewed and discussed by the InterPro Council of Directors. This proposal was approved by the Council unanimously.

Thank you in advance for your consideration in this matter.

**MASTER OF ENGINEERING IN
ENERGY SCIENCE**

A New Professional Degree to be Awarded By The

College of Engineering

Michigan Interdisciplinary and Professional Engineering (InterPro)
The University of Michigan
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2121 Bonisteel Boulevard
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Contact: Ann Marie Sastry
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Huei Peng
Professor of Mechanical Engineering
Director, InterPro
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This document describes the Master of Engineering in Energy Science (M. Eng ESP) degree program; a new professional graduate degree program to be awarded by the College of Engineering at the University of Michigan, Ann Arbor.

Section 1 presents the philosophy and process which led to the development of this degree program and the Master of Engineering (M. Eng) degree template, as well as the Michigan Interdisciplinary and Professional Engineering (InterPro) in the College of Engineering, which will administer and award this degree program.

Section 2 provides details of the proposed new M. Eng. degree program in Energy Science, including the degree objectives and the degree requirements. Course listing and sample plan of study is provided in the appendices.

March 16, 2007

1. Introduction

1.1 National Environment

There has been a convergent awareness of strategic national interest in energy independence, with clear and compelling evidence of environmental consequences of fossil fuel dependence. Thermodynamic limitations of energy technologies have been individually, though not holistically, explored, though energy technologies are being researched, developed and marketed with a global enthusiasm not seen in three decades. Portable power technologies have now been inserted into automotive and grid technologies, and energy science is advanced at multiple scales.

Meanwhile, the unprecedented level of control of the stationary power grid, juxtaposed with our stated objective of energy independence, has spurred renewed interest in a larger-scale consideration of infrastructure. But as with revolutions in nano- and information technologies, the energy landscape is changing at multiple scales, from the 200kW unit now readily controllable by the key grid operators in the U.S, to the large power plants which must be built, to supply our growing power needs. Engineers with both breadth and depth of knowledge of energy science and technology are critically needed, as our ability to select and implement new technologies grows dramatically.

1.2 Environment for Energy Studies: University of Michigan

The University of Michigan is a leader in energy research and development. The University's unique interdisciplinary culture attracts faculty, students and collaborators from all over the world to the University. Exceptional research is being done in nuclear engineering, energy storage, hydrogen production and utilization, lighting, and advanced power sciences, complemented by deep strengths in economic modeling, lifecycle analysis, geological sciences and sustainability research.

To capture the potential synergies of this work across campus, the University created the **Michigan Memorial Phoenix Energy Institute (MMPEI)** in 2006, building on a storied tradition going back to the conclusion of the Second World War. Then, as now, the world was looking for an answer: how to harness the awesome power of atomic energy for peaceful, not destructive, use. The University inaugurated the Phoenix Project in honor of alumni and faculty who had lost their lives during the war, and the Phoenix Project became an icon of energy research in the ensuing decades. The challenge now is perhaps a magnitude greater and has taken on a truly multidimensional character, but the commitment to execute is the same: to chart the path to a sustainable future. MMPEI was launched in late 2006 with $30 million from the University, $9 million of which will be used in part to recruit top-tier energy research faculty. A number of graduate fellowships in energy research will be created. The Institute will be housed in the Michigan Memorial Phoenix Laboratory which will undergo an $11 million renovation.

As the University of Michigan increases its visibility and activity in the energy arena, a lockstep effort will be needed in providing useful educational programs at all levels. Many departments offer courses related to energy, and with the growing interest at the graduate level, there is an opportunity to create a program which focuses our strengths in key areas of energy research in a graduate curriculum. The proposed M.Eng degree of the Energy Science Program (ESP) is comprised of courses which both fully display the breadth and depth of graduate educational offerings related to energy science.

In 1999, the College of Engineering established the **Office of Interdisciplinary**

Professional Programs (InterPro) to foster cooperation among disciplines within the College of Engineering and throughout the University of Michigan. InterPro serves as conduit for incorporating best practices of existing interdisciplinary professional programs into new ones, and develops programs that are responsive to the needs of industry and professional engineers. As such, this office provides both an ideal template for creation of a program in energy science, and structural support and know-how in its administration. Graduate programs currently offered through InterPro include: Automotive Engineering, Financial Engineering, Global Automotive and Manufacturing Engineering, Pharmaceutical Engineering and Program in Manufacturing. The Office of Interdisciplinary Professional Programs (InterPro) will administer the M. Eng. in ESP degree, which is described in detail in the next sections.

1.3 Program Description and Objectives

The new ESP in the College of Engineering is designed to provide critical engineering skills in interlocking energy sciences. Targeted students include 1) recently-graduated B.S. students in engineering, who wish to work in energy-related areas, or 2) experienced B.S. or M.S. engineers who wish to refocus their careers, or to have more in-depth understanding of the technical and societal drivers in energy technology development and realization.

An M.Eng is proposed as the awarded degree, rather than an M.S., because of the need for workers versed in a number of engineering technologies, and a systems-level understanding of the convergent objections of energy generation and environmental stewardship. Advanced engineering education in any of the technology areas is presently available in several degree programs, as an M.S. in Nuclear Engineering, Mechanical Engineering, or Chemical Engineering, in study of reactors, engines or fuel cells, respectively, for example. The M.Eng. degree, however, offers breadth of study in energy technologies, along with systems-level courses that address the intersection of evaluation of energy technologies with management of environmental systems.

Core engineering skills needed to address both the likely efficacy of an energy technology range from materials science to kinetics, to manufacturing and statistics. Systems skills span study of economics of siting power supplies, to the connection between environment and energy generation, to risk analysis. The key specializations addressed by the program are threefold:

1) ***CIVIL POWER***: The developing and developed worlds have vastly different infrastructures, demands and opportunities in energy technologies. The contexts of economies, geographies, and natural resources play major roles in technology implementation. In providing needed breadth and depth in understanding energy strategies, a knowledge base that includes both social and technical aspects of the challenges, is required. Coursework in this foundational area includes both technology underpinnings and social context, including a seminar-style course in which leaders give their perspectives on insertions of new technologies, around the globe.

2) ***TRANSPORTATION POWER***: The internal combustion engine has set the standard for energy and power density, and has enabled a level of performance in mobility that is challenging to reach by other sources. New technologies, including fuel cells, batteries, and hybrid systems, have been demonstrated that meet or exceed conventionally agreed-upon targets, and new infrastructure in both energy generation and automotive design and manufacturing will be required to realize the benefits of these approaches. Further, advances in fuel technologies, including clean diesel, biofuels and high compression combustion ignition, require parallel fluency in vehicle technologies, which must be adapted for their use. Coursework in this foundational area includes vehicle and power sources technology underpinnings, along with specific courses on the drivetrains of the new century.

3) ***MICROELECTRONIC AND PORTABLE POWER***: Wireless electronics have become ubiquitous in modern life, and the costs associated with power supply in equipment, maintenance, and transportation, are enormous, and a little-known but highly significant contributor to the demand on grid power. Renewable power sources have been intensively explored, but major scientific challenges remain in realization of compact and robust systems, including development of accurate lifetime models for advanced batteries and fuel cells, development of power selection tools, which offer agile selection of hybrid systems from among the many advanced sources available, and life-cycle analysis of compact power supplies, including considerations of disposal and/or recyclability. Course offerings in this foundational area include topics on specific portable power technologies, and design for sustainable portable, and other, systems.

2. The M. Eng. in Energy Science Degree

2.1 Degree Objectives

The main goal of the degree is:

To prepare engineers to design and implement energy technologies for innovative applications by developing strengths in their engineering discipline, to have breath in relevant engineering and science, and to understand the critical role of the environment in energy science, including economic factors.

The M. Eng. in Energy Science is motivated by the need for technical leaders in the energy area, who have depth in their own engineering disciplines, breadth across engineering disciplines, knowledge of basic management issues, and the ability to lead project teams. It further established UM's leadership role in energy and environment, through a graduate program which presently does not have a precedent nationally.

2.2 Degree Requirements

The M. Eng. degree can be awarded by any College of Engineering department (e.g., EECS, IOE, ME) or Program (e.g., Automotive, PIM). The degree requires 30 credits of course work (at least 12 credits of technical courses at 500 level and above), of which at least 24 credit hours must be graded (not pass/fail), and 15 graded credit hours must be in engineering courses. The successful completion of the degree requires a minimum grade point average of 5.0/9.0 (i.e., a B average).

The Master of Engineering in Energy Science degree has the following requirements:

(1) A total of 30 credit hours of course work, of which at least 24 credit hours must be graded (not pass/fail), and at least 18 credit hours must be in technical courses at the 500 level and above. A minimum grade point average of 5.0/9.0 (i.e., a B average) is also required.

(2) Entrance requirements are similar to other master degree programs in the College of Engineering.

- An undergraduate degree in engineering, chemistry, physics, biology or mathematics

• Graduate Record Examination

(3) Students must take two required courses for the Energy Science Program, including a required seminar course (3 credits, pass/fail) and a project course (3 credits, pass/fail).

(4) Students must take at least three classes in the Technical Depth (Engineering Core) Course Work – Core Courses (9 credits, graded).

(5) Students must also take at least two Technical Breadth (Engineering Systems) Courses (6 credits) of their choosing.

(6) Students must take at least three classes in the Energy Specialties (9 credits, graded). Two of these courses (6 credits, graded) must come from one specialty, and the other (3 credits, graded) must come from a different specialty.

The incoming student must obtain the approval of the course advisor for the planned M. Eng. in Energy Science degree program courses selected. A sample "Degree Requirements Planning Sheet and Checklist," is attached. Lists of courses to meet requirements (3)-(6) will be developed and updated annually to aid in student advising. These lists will be approved by the Energy Science Program's Council, and substitutions will require the approval of the Director of the Energy Science Program. An example program is provided for a specialization in civil power.

2.3 Faculty and Students

The Energy Science Program does not have any courses or faculty, but relies upon courses and faculty from various departments in the College of Engineering and other schools. Four new courses are under development, some based on modifications of existing courses. Faculty from various departments will be asked to participate in developing and providing lectures for these courses, and in supervising students in the team projects.

The ESP will have a Program Director who reports to the Associate Dean for Graduate Education in the College of Engineering, and an administrative staff to handle program admissions, student records, etc. An ESP Council, with faculty representatives from all interested engineering departments, will serve as a Program Advisory (or Executive) Committee. There will also be an External Advisory Board to assist the Program Director.

2.4 Description of Available/Needed Equipment

The Master of Engineering degree will not require any new equipment or facilities, since they will utilize existing resources and facilities.

2.5. Planned Implementation Date

The planned implementation date for the new professional degree in the Master of Engineering in Energy Science is Fall 2007.

2.6. Library and Other Learning Resources

The Engineering Library, the Computer Aided Engineering Network, and other College of

Engineering resources (which support existing degrees) will also support the new M. Eng. degree. No new resources will be needed.

2.7. Space

The Master of Engineering in Energy Science will not require any new space beyond modest incremental needs, due to increases in total enrollments. This new Master of Engineering in Energy Science will be housed within the Office of Interdisciplinary Professional Programs.

2.8. Accreditation Requirements

The M. Eng. degree does not require accreditation. Currently, only the undergraduate (bachelors) degrees are submitted to the Accreditation Board for Engineering and Technology (ABET) for accreditation by the College of Engineering. None of the existing graduate degrees in the College of Engineering are accredited, and there are no plans to seek accreditation for the new M. Eng. degrees.

APPENDIX A – Sample Course Template

System Integration (required: 3 credits)
ESP 501. Seminars on Energy Science, Technology and Policy (Fall)

Engineering Core (9 credits)
REQUIRED COURSE ME599-4: Energy Technologies (Winter)
ME 499. Advanced Energy Systems (Fall)
ME 599-001. Fundamentals of Energy Conversion (Fall)
ME 537. Advanced Combustion (W)
ME 589. Ecological Sustainability in Design and Manufacturing (Fall)

Energy Systems (6 credits)
CEE 460. Design of Environmental Engineering Systems (Fall)
ECON 435. Financial Economics (Winter, Fall)
IOE 452. Corporate Finance (Fall)
IOE 453. Derivative instruments (Winter)
IOE 533. Human Factors in Engineering Systems I (Fall)
ME 563. (IOE 565) (MFG 561) Time Series Modeling, Analysis, Forecasting (Fall)
NRE 574. Sustainable Energy Systems (same as **PPOL 519**) (Fall)

Energy Specialties (9 credits: two from same area; one may come from another area)

1) *CIVIL POWER*:

ME 533. Radiative Heat Transfer (Fall)
AERO 533. Combustion Processes (Fall)
NERS 442. Nuclear Power Reactor (Winter)

2) *TRANSPORTATION POWER:*

AERO 464. The Space Environment (Fall)
AERO 536. Electric Propulsion (Fall)
AUTO 563. Dynamics and Controls of Automatic Transmissions (Winter, alternate years)
ME 438. Internal Combustion Engines (Fall)
ME 533. Combustion Processes (Fall)
ME 538. Advanced Internal Combustion Engines (Winter)

3) *MICROELECTRONIC AND PORTABLE POWER:*

EECS 414. Introduction to MEMS (Fall)
ME 553. Microelectromechanical Systems (Winter, Alternate Years)
EECS 514. Advanced MEMS Devices and Technologies (Winter)
EECS 515. Integrated Microsystems (Fall)
EECS 529. Semiconductor Lasers and LEDs (Fall)
ME 559. Smart Materials and Structures (Winter)

PROJECT (required: 3 credits)
ESP 503. Projects in Energy Science

APPENDIX B – Sample Plan of Study

MASTER OF ENGINEERING IN ENERGY SCIENCE
PLAN OF STUDY FORM
(Civil Power)

DATE:_____________

Student Name: ______________________ **Student ID Number:** ___________________________

Course Number	**Course Name**	Credit Hours	Term/Year
A. Engineering Core - (9 credits)			
ME 589		3	
ME 537		3	
ME 599-01		3	
B. Energy Systems (6 credits)			
NRE 574		3	
IOE 452		3	
C. Energy Specialization (9 credits)			
NERS 442		3	
ME 533		3	
EECS 515		3	
D. Seminar and Capstone Project (6 credits)			
ESP 501		3	
ESP 503		3	

APPENDIX C – Faculty with Interests in Energy Science at UM

Assanis, Dennis
Jon R. and Beverly S. Holt Professor of Engineering, Professor of ME; Director of ARC, Co-Director of GM Engine Systems Research Collaborative Research Lab, Director of AutoLab
Room 2236 GGB, Tel: (734) 764-8464,
assanis@umich.edu
Thermal and fluid applications to automotive systems design; internal combustion engine processes and systems; development and validation of transient diesel engine simulation; in-cylinder CFD computations; experimental investigation of heat rejection; unburned hydrocarbon mechanisms and friction in spark-ignition engines.

Atreya, Arvind
Professor of ME
Room 2158 GGB, Tel: (734) 647-4790,
aatreya@umich.edu
Combustion; fire; heat and mass transfer; energy conservation; fire suppression; diffusion flame ignition and extinction under microgravity conditions; soot and NOx formation and oxidation in diffusion flames; flame spread; diesel engine combustion.

Belzowski, Bruce
Senior research associate in the Automotive Analysis Division's Industry Structure Group
Room 406 UMTRI, Tel: 734-936-2723,
bbl@umich.edu
Auto Industry Trends, Analyses, and Predictions; Powertrain Strategies; Information Technology/e-Business; Manufacturer-Supplier-Dealer Relations; Globalization of the Automotive Industry

Bernitsas, Michael
Professor and Undergraduate Program Chair of Naval Architecture & Marine Engineering, Fellow ASME, Fellow SNAME
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michaelb@umich.edu
Mooring System Dynamics, Structural Redesign and Topology/Material Evolution, Riser and Pipeline Mechanics, Current Energy Conversion

Callaway, Duncan
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Sustainable Systems

Dunietz, Barry
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molecular conductance, hydrogen fuel economy, inorganic reaction mechanisms, excited states studies of extended systems and biological systems

Filipi, Zoran
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filipi@umich.edu
Internal combustion engines; modeling and computer simulation of engine processes and systems; combustion, emissions, and heat transfer in engines; integration of powertrain and vehicle systems; hybrid propulsion.

Fogler, H. Scott
Vennema Professor of Chemical Engineering
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Flow and reaction in porous media, fused chemical relations, gellation kinetics, colloidal phenomena, and catalyzed dissolution

Forrest, Stephen
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Condensed matter physics, organic and group III-V semiconductor materials, and optics

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environmental economics and empirical industrial organization

Gallimore, Alec
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Electric Propulsion, Space Propulsion, Plasma Physics

Gidley, David
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positron and positronium physics, materials research

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Advanced Structural Engineering Analysis, Seismic Analysis and Design, Reinforced and Pre-Stressed Concrete Structures, Structural Steelwork, Timber Construction, Load-bearing Brickwork, Structural Stainless Steel, Glass Structures, Light Weight Fabric Structures, Polymer Materials Structures, Integrated CAD Modeling and Analysis, Housing and Industrialized Manufacture, Sustainable Design for Buildings, Low Energy Design for Buildings, Multi Physics Building Simulation Analysis

Glotzer, Sharon
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Assembly of nanoscale systems; supercooled and metastable liquids and complex fluids, colloids, and complex fluids; biomimetic materials design; computer simulation

Goldman, Rachel
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structure-property relationships in thin films and heterostructures

Green, Russell
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earthquake engineering

Halloran, John
Alfred Holmes White Collegiate Professor of MSE
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peterjon@umich.edu
Electromagnetic Meta-materials, Solid Oxide Fuel Cells, Solid Free Form Fabrication (SFF) by stereolithography and ink jet methods; novel tough structural ceramics; ceramic processing and manufacturing

Helfand, Gloria
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ghelfand@umich.edu
different regulatory approaches to pollution control

Hoffman, Andrew
Holcim (US) Professor of Sustainable Enterprise, Co-Director of the Erb Institute
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the nature and dynamics of change within institutional and cultural systems

Hu, Jack
Professor of ME, Associate Dean for Research, CoE, University Co-Director of GM Collaborative Research Laboratory on Advanced Vehicle Manufacturing
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jackhu@umich.edu
Design, simulation and control of manufacturing processes, including statistical process control, integration of statistical process control with automatic control, robust design; applications to assembly and joining processes, in particular resistance welding processes; flexible manufacturing systems

Hunter, Mark
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population processes and ecosystem processes in terrestrial environments

Kanicki, Jerzy
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organic and molecular electronics, thin-film transistors and circuits, and flat panel displays technology including organic light-emitting devices

Kaviany, Massoud
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Thermal science; heat transfer physics; transport, reaction, and phase change in porous media

Keoleian, Greg
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life cycle design, life cycle assessment, and industrial ecology

Kieffer, John
Professor of MSE
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the fundamental relationships between processing conditions, structure, and properties of ceramics, hybrid polymer-inorganic composites, and nano-porous materials

Kim, Jinsang
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Biopolymers, molecular biosensors, protein/DNA microarrays, artificial actuators

Kota, Sridhar
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Kinematics and synthesis of mechanisms and mechanical systems; design of compliant mechanisms with applications to MEMS and adaptive structures; product design and manufacturing automation; design of reconfigurable machines

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Nanotechnology, composites, thin films, tissue engineering, self organization of nanocolloids, and atomic force microscopy

Ku, Pei-Cheng
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Nano-photonics, electronics, and fabrication

Laine, Richard
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the synthesis and processing of inorganic and organometallic polymers

Lee, John
Professor, Nuclear Engr & Radiolocial Sci
Room: 2911 Cooley, Tel: 734 764-9379,
jcl@umich.edu
Nuclear reactor physics, reactor kinetics, fuel cycle analysis, reactor safety analysis, power plant simulation and control

Lehnert, Nicolai
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Bioinorganic Chemistry, Physical Inorganic Chemistry, Spectroscopy, Bioorganometallic Chemistry, Heme-Nitrosyl Model Complexes, Porphyrins, Nitric Oxide, Denitrification, Density-Functional Calculations

Levine, Jonathan
Professor and Chair of the Urban and Regional Planning program
Room: 2150 A+AB, Tel: 734 763 0039,
jnthnlvn@umich.edu
the relationships between transportation systems and land use in metropolitan regions, factors that drive the development of such systems, and the efficiency of public transit

Lyon, Tom

Dow Professor of Sustainable Science, Technology and Commerce; Professor of Business Economics; Professor of Natural Resources
Room: E3613 Ross School of Business, Tel: (734) 615-1639,
tplyon@umich.edu
the interplay between corporate strategy and public policy including corporate environmentalism, electric utility investment practices, natural gas contracting, innovation in the health care sector, and the introduction of competition in regulated industries

Marans, Robert
Emeritus Professor of Architecture + Urban Planning, Senior Research Scientist, Instutute for Social Research
Tel: 734 763 4583,
marans@umich.edu
the built and natural environments, neighborhood quality, recreation behavior and parks, and retirement housing

Martin, William
Professor and Chair of Nuclear Engineering and Radiological Sciences
Room: 1911 Cooley, Tel: 734 764 5534,
wrm@umich.edu
the development of computational methods for the solution of problems in neutron transport, reactor core analysis, reactor thermal/hydraulics, and nonlinear radiation transport.

McManus, Walter
Research Scientist, University of Michigan Transportation Research Institute
Room: 402 UMTRI, Tel: 734 615 6743,
watsmcm@umich.edu
Auto Industry Trends, Analyses, and Predictions, Energy Efficiency and Emissions, Alternative Powertrains, Adoption of New Technologies, Quality and Statistical Methods, Public Policy Analysis, Economics of the Automotive Industry, Automotive Consumer Research, Emissions Policies and Standards

Meadows, Guy
Professor of AOSS, Professor of Naval Architecture & Marine Engineering, Director of Ocean Engineering Laboratory
Room: 124A Marine Hydrodynamics Laboratory, Tel: (734) 764-5235,
gmeadows@umich.edu
Observational physical oceanographic research coordination, Coastal hydrodynamics, Active upper ocean dynamics remote sensing and ocean instrumentation, Severe storm generated waves and resulting surf zone circulations, Sediment transport from the coastal regions to the deep basins of the great lakes and oceans studies, Oceanographic instrumentation design and construction to measure variety of oceanic phenomena

Michalak, Anna
Assistant Professor Department of Civil and Environmental Engineering, *and* epartment of Atmospheric, Oceanic and Space Sciences
Room: 183 EWRE Building, Tel: (734) 763-9664,
Anna.Michalak@umich.edu
geostatistical interpolation and inverse modeling methods, groundwater contaminant source identification, constrained optimization, lagrangian numerical methods, and atmospheric greenhouse gas surface flux estimation

Mirecki-Millunchick, Joanna
Associate Professor of MSE
Room: 2640 CSE, Tel: 734-647-8980,
joannamm@umich.edu
the materials and surface sciences of semiconductor thin film nucleation and epitaxy using a number of growth platforms, including Molecular Beam Epitaxy (MBE), Chemical Vapor Deposition (CVD), and ion assisted deposition

Navvab, Mojtaba
Associate Professor of Architecture

1205D Art & Arch, Tel: (734) 936-0228
moji@umich.edu
Daylight, electric light, acoustics, environmental technology, energy efficiency and LEED certification, environmental control systems, plants growth, research methods, simulation and gaming in planning, photovotaic system, integrated resource planning

Norton, Richard
Assistant Professor of Urban and Regional Planning Program
rknorton@umich.edu
2000 Bonisteel Blvd, Tel: (734) 936-0197
Environmental planning, sustainable development, land use and planning law, coastal area resource management, planning theory, research methods

O'Donnell, Thomas
Adjunct Professor in Science, Technology & Society (STS) and Social Science Programs, Residential College (RC), LS&A, Associate Memeber of Michigan Center for Theoretical Physics (MCTP), Health Physicist, Phoenix Memorial Labs/Ford Nuclear Reactor (PML/FNR)
124 Tyler, Tel: (734) 651-0077
twod@umich.edu
study of technological change and its social consequences (STS) and especially the "Information Age", the global oil system, political analysis and commentary (samples of published works)

Parson, Edward
Professor of Law and Natural Resources and Environment, School of Natural Resources and Environment
432 Hutchins Hall, Tel: (734) 763-6133
parson@umich.edu
Environmental policy, the political economy of regulation, the role of science and technology in policy and regulation, and the analysis of negotiations, collective decisions, and conflicts.

Pecoraro, Vincent
Professor of Chemistry, Research Professor, Biophysics Research Division, Fellow, American Association for the Advancement of Science
3823 Chemistry, Tel: (734) 763-1519
vlpec@umich.edu
bioinorganic chemistry, characterization of inorganic clusters

Peng, Huei
Professor of Department of Mechanical Engineering, Director of Automotive Engineering Program
G036 Auto Lab, Tel: (734) 936-0352
hpeng@umich.edu
Adaptive and optimal controls, vehicle dynamics and control-active suspension, integrated motion control, adaptive cruise control, rollover prediction and prevention, driver modeling, collision warning and avoidance, hybrid electric vehicles, fuel cell vehicles

Phillips, Jamie
Assistant Professor of Department of Electrical Engineering and Computer Science
2417D EECS Bldg, Tel: (734) 764-4157
jphilli@umich.edu
Zinc oxide and related materials, ferroelectric thin films, infrared detector materials and device technology

Resnick, Paul
Professor of School of Information
314 West Hall, Tel: (734) 647-9458
presnick@umich.edu
Convening technologies, dynamic ride sharing, motivating contribution the public good in on-line communities, recommender and reputation systems

Sastry, Ann Marie

Professor of Materials Science and Engineering, Biomedical Engineering and Mechanical Engineering
2140 GGBL, Tel: (734) 764-3061
amsastry@umich.edu
Numerical and experimental work in disordered materials systems, including biological tissues and energetic materials. Design of batteries, including engineered and bioengineered constructs, and optimization of power supplies

Savage, Phillip
Professor of Chemical Engineering
3034 HH Dow, Tel: (734) 764-3386
psavage@umich.edu
Reaction kinetics and mechanisms: reactions in supercritical fluids, catalysis: applications in degradation of hazardous chemicals, green chemistry, and hydrogen production.

Schwank, Johannes
Professor of Chemical Engineering
3074 HH Dow, Tel: (734) 764-3374
schwank@umich.edu
Fundamental and applied research problems in heterogeneous catalysis, thin films, and chemical sensors

Shih, Albert
Professor of Mechanical Engineering Department and Biomedical Engineering Department, Deputy Director of S.M. Wu Manufacturing Research Center
1029 HH Dow, Tel: (734) 647-1766
shiha@umich.edu
Design and manufacturing; biomedical device design; biomedical manufacturing; medical innovation; surgical thermal management; machining of advanced engineering materials; micro manufacturing; precision engineering; optical metrology

Max Shtein
Assistant Professor of Materials Science and Engineering and Macromolecular Science and Engineering
2014 HH Dow, Tel: (734)764-4312
mshtein@umich.edu
Organic semiconductors, organic-inorganic hybrid materials and nanocomposites geared toward efficient energy conversion

Sick, Volker
Professor of Mechanical Engineering Department
2023 AL, Tel: (734) 647-9607
vsick@umich.edu
Development and application of laser techniques for combustion diagnostics; molecular spectroscopy; turbulence; internal engine combustion; comparisons with detailed modeling; industrial applications

Skerlos, Steven
Associate Professor of Mechanical Engineering Department
3001E EECS, Tel: (734) 615-5253
skerlos@umich.edu
Automotive materials, biological sensors, environmental and sustainable technology, environmental impact of manufacturing

Stefanopoulou, Anna
Professor of Mechanical Engineering Department
G034 AL, Tel: (734) 615-8461
annastef@umich.edu
Powertrain control systems and architectures; vehicle/transportation control; control of advanced automotive engines (VVT, EVA, VGT, HCCI, EAT, etc); fuel cell power and hydrogen reforming; control of breathing through valves, vanes, and membranes; modeling, identification, and feedback control; modular (decentralized) controller architectures.

Sun, Jing
Associate Professor of Naval Architecture & Marine Engineering
211 NA&ME Bldg, Tel: (734) 615-8061
jingsun@umich.edu
Control system development and optimization for marine and automotive propulsion systems, modeling, control and optimization of fuel cell systems and fuel cell based combined heat and power (CHP) systems, adaptive control theory, advanced control methodologies

Thompson, Levi
Professor of Chemical Engineering, Director of Hydrogen Energy Technology Laboratory
3026 HH Dow, Tel: (734) 936-2015
ltt@umich.edu
Nitride and carbide catalysts, microreactors and fuel processors for fuel cells, novel water gas shift and steam reforming catalysts, micro-fuel cells and electrocatalysts

Thornton, Katsuyo
Assistant Professor of Materials Science and Engineering
2042 HH Dow Building, Tel: (734) 615-1498
kthorn@umich.edu
Advanced and novel materials, behavior of materials, computational materials, microstructure measurements and analysis

Thouless, Michael
Professor of Mechanical Engineering Department and Materials Science and Engineering
2282 GGBL, Tel: (734) 763-5289
thouless@umich.edu
Micro-mechanical modeling of materials; interfacial fracture mechanics; adhesion; mechanical properties of adhesive joints; mechanical properties of thin films and coatings.

Troesch, Armin
Professor and Chair of Naval Architecture & Marine Engineering
212 NA&ME Bldg, Tel: (734) 763-6644
troesch@umich.edu
Linear and nonlinear optimization, naval architecture and marine engineering, nearshore coastal hydrodynamics, wave mechanics

Uher, Ctirad
Professor of Physics and Applied Physics, Chair of Department of Physics
261 West Hall, Tel: (734) 764-3933
cuher@umich.edu
Novel thermoelectric materials, high-Tc superconductors, diluted magnetic semiconductors

Van der Ven, Anton
Assistant Professor of Materials Science and Engineering
2018 HH Dow, Tel: (734) 615-3843
avdv@umich.edu
Equilibrium and non-equilibrium materials properties from first-principles

Violi, Angela
Assistant Professor of Mechanical Engineering, Biomedical Engineering, and Chemical Engineering
2150 GGBL, Tel: (734) 615-6448
avioli@umich.edu
Nanoparticle growth and self-assembly, nanoparticle interactions with biomolecular systems, molecular modeling of complex systems using atomistic models, applied chemical kinetics, aerosols

Was, Gary

Professor of Nuclear Engineering and Radiological Sciences and Materials Science and Engineering, Director of Michigan Memorial Phoenix Energy Institute
1921 Cooley, Tel: (734) 763-4675
gsw@umich.edu
Radiation materials science and environmental effects on metals, including stress corrosion cracking, high temperature corrosion and hydrogen embrittlement

Wooldridge, Margaret
Associate Professor of Mechanical Engineering
2156 GGBL, Tel: (734) 936-0349
mswool@umich.edu
Combustion, fluid mechanics and thermodynamics including combustion synthesis; pollution mitigation; reburn and co-firing technologies; reaction kinetics; aerosol sampling and transport; optical diagnostics; gas dynamics

Yang, Ralph
Professor of Chemical Engineering
3316 GGBL, Tel: (734) 936-0771
yang@umich.edu
Hydrogen storage, nanostructured adsorbents, separations, adsorption, catalysis, catalytic NO reduction, fuel desulfurization for fuel cells, carbon

Yocum, Charles
Professor of Biology and Professor of Chemistry
4103A Nat. Sci., Tel: (734) 647-0897
cyocum@umich.edu
Plant Biochemistry, Photosynthesis

APPENDIX D – Coursework at UM Pertaining to Energy

D.1 Potential core engineering courses

BiomedE 410. Design and Applications of Biomaterials (MSE 410)
Prerequisites: MSE 220 or 250 or permission of instructor; I; 4 Credits. Biomaterials and their physiological interactions. Materials used in medicine/ dentistry: metals, ceramics, polymers, composites, resorbable smart, natural materials. Material response/degradation: mechanical breakdown, corrosion, dissolution, leaching, chemical degradation, wear. Host responses: foreign body reactions, inflammation, wound healing, carcinogenicity, immunogenicity, cytotoxicity, infection, local/systemic effects.

ChemE 444. Applied Chemical Kinetics
Fundamentals of chemical and engineering kinetics from a molecular perspective. Relationship between kinetics and mechanism. Kinetics of elementary steps in gas, liquid, and supercritical fluid reaction media. Gas-solid and surface reactions. Heterogeneous and homogeneous catalysis. Kinetics and mechanisms of chemcial processes such as polymerization, combustion, and enzymatic reactions.

ChemE 538. Statistical and Irreversible Thermodynamics
The laws of probability and statistics are applied to microscopic matter to yield properties of macroscopic systems. Relations between classical and statistical thermodynamics are developed. Coupling of irreversible processes is treated through the entropy balance and microscopic reversibility.

EECS 414. Introduction to MEMS
Prerequisites: Math 215, Math 216, Physics 240 I; (DL) 4 Credits. Micro electro mechanical systems (MEMS), devices, and technologies. Micromachining and microfabrication techniques, including planar thin-film processing, silicon etching, wafer bonding, photolithography, deposition, and etching. Transduction mechanisms and modeling in different energy domains. Analysis of micromachined capacitive, piezoresistive, and thermal sensors/actuators and applications. Computer-aided design for MEMS layout, fabrication, and analysis.

EECS 528. Principles of Microelectronics Process Technology
Prerequisites: EECS 421, EECS 423; II; 3 Credits. Theoretical analysis of the chemistry and physics of process technologies used in micro-electronics fabrication. Topics include: semiconductor growth, material characterization, lithography tools, photo-resist models, thin film deposition, chemical etching, plasma etching, electrical contact formation, micro-structure processing, and process modeling.

IOE 425. (MFG 426) Manufacturing Strategies
Prerequisites: Senior Standing; I, II; 2 Credits. Review of philosophies, systems, and practices utilized by world-class manufacturers to meet current manufacturing challenges, focusing on "lean production" in the automotive industry, including material flow, plant-floor quality assurance, job design, work and management practices. Students tour plants to analyze the extent and potential of the philosophies.

ME 401. Engineering Statistics for Manufacturing Systems
Prerequisites: Senior or Graduate Standing; I; 3 Credits. Fundamentals of statistics.

Independent t-test and paired t-test. Two-level factorial design. Fractional factorial designs. Matrix algebra and canonical analysis. Regression analysis (Least Squares Method). Response Surface methodology. Probability. Binomial and Poisson distributionss. Single sampling plan. Statistical process control (SPC). Taguchi methods. Introductory time series analysis and Defect Preventive Quality Control.

ME 432. Introduction to Combustion
Introduction to combustion processes; combustion thermodynamics, reaction kinetics and combustion transport. Chain reactions, ignition, quenching, and flammability limits, detonations, deflagrations, and flame stability. Introduction to turbulent premixed combustion. Applications in IC engines, furnaces, gas turbines, and rocket engines.

ME 437. Applied Energy Conversion
Prerequisites: ME 235 and Math 216; I; 3 credits. Quantitative treatment of energy resources, conversion processes, and energy economics. Consideration of fuel supplies, thermodynamics, environmental impact, capital and operating costs. Emphasis is placed on issues of climate change and the role of energy usage. In-depth analysis of automobiles to examine the potential of efficiency improvement and fuel change.

ME 452. Design for Manufacturability
Prerequisites: ME 350; II; 3 Credits. Conceptual design. Design for economical production, Taguchi methods, design for assembly; case studies. Product design using advanced polymeric materials and composites; part consolidation, snap fit assemblies; novel applications.

ME 499. Advanced Energy Systems
This course provides an introduction to the challenges of power generation for a global society. The course starts with an overview of the current and future demands for energy, the various methods of power generation including solar, thermal, wind, nuclear and fossil fuel, and the detrimental byproducts associated with these methods. Advanced strategies to improve power densities, reduce pollutant emissions and improve thermal efficiencies, such as fuel cells for stationary and mobile power generation; synthetic and bio-renewable fuels; and reconfiguring coal-fired power plants to utilize integrated-gasification combined cycle approaches are the primary focus of the second half of the course. The material includes the advantages and technical difficulties associated with a hydrogen economy including production, transport, storage and application. The emphasis is on the application of thermodynamic analysis to understand the basic operating principles and the inherent limitations of the technologies considered.

ME 537. Advanced Combustion
Advanced treatment of fundamental combustion processes. Conservation equations for reacting gas mixtures. The structure of one-dimensional diffusion and premixed flames; introduction to activation energy asymptotics. Two-dimensional Burke-Schumann flames and boundary layer combustion. Flame instabilities and flame stretch; turbulent combustion.

ME 589. Ecological Sustainability in Design and Manufacturing
A scientific basis for understanding and reducing the environmental impact of engineering design and manufacturing decision for a life cycle perspective. Environmental impact principles: air/water pollution, ozone depetion, global warming, resource sustainability. Life cycle assessment and environmentally conscious manufacturing of metals, plastics, and electronics

products. Systems design metrics, disassembly, remanufacturing, recycling, policy considerations. Case studies include sustainable mobility, alternative energy sources, tooling and machining, refrigeration, electronics remanufacturing.

ME 599-1. Fundamentals of Energy Conversion
This course covers fundamentals of thermodynamics and chemistry as applied to energy systems. Topics include analysis of energy conversion with an emphasis on efficiency and environmental impact. The course will focus on the engineering fundamentals and chemical processes, as applied particularly in the current topics of interest such as combustion, fuel cells and other direct conversion systems, but encompassing also future forms of traditional systems.

MSE 501. Structure and Processing of Electrical Materials*Prerequisites*: MSE 440 or EECS 314; 2 Credits. The role of chemistry, structure, and processing in determining the properties of electrical materials.

NERS 442. Nuclear Power Reactor
Analysis of nuclear fission power systems including an introduction to nuclear reactor design, reactivity control, steady-state thermal-hydraulics and reactivity feedback, fuel cycle analysis and fuel management, and environmental impact and plant siting, and the student.

D.2 Potential systems engineering courses

CE 460. Design of Environmental Engineering Systems
Prerequisites: CEE 360; I; 3 Credits. Design and theoretical understanding of environmental processes; biological, physical, and chemical processes, and reactor configurations commonly used for water quality control; applications to the design of specific water and wastewater treatment operations; discussion of pollution prevention and green engineering options.

Econ 435. *Financial Economics*
Prerequisites: Econ 401 and 405 or equivalent. This course introduces the economic analysis of financial markets and financial decision-making. Topics covered include asset pricing theory (the valuation of stocks, bonds and options), net present value analysis, portfolio management, and financial market organization and behavior. The course develops the capacity to analyze investment strategies and policy issues from the standpoint of economic theory (as often opposed to conventional wisdom). Our main objectives are to understand why the financial markets work the way they do, to develop useful tools for the analysis of investment opportunities, and to use economic methods to think critically about policy issues such as government regulation of financial markets and the taxation of investment returns.

Econ 574. Forecasting and Modeling
Prerequisites: Econ 503.This course investigates various economic forecasting techniques, with a primary focus on econometric modeling. A sequence of modeling topics is addressed, including model specification, data issues, model estimation and evaluation, simulation of model systems and policy simulation experiments. Special attention is given to preparing, generating, and adjusting forecasts. Alternative forecasting techniques (e.g., leading indicators, time series models, and judgment) are also briefly considered. Other topics include comparative forecasting performance, forecast services, and the current outlook. This course requires individual projects which emphasize on-line experience with modeling and forecasting techniques. (replaced by ME

563)

FIN 580. Options and Futures in Corporate Decision Making
Prerequisites: F551 or F552; 2.25 credits. This course introduces the student to options and futures and illustrates their use in the context of corporate decision making. Companies increasingly issue securities with features that resemble options or futures. Options and futures also play an important role in risk management. Many corporate decisions have built-in strategic options which need to be evaluated. Credit is granted for F580/F618 OR F619.

IOE 452. Corporate Finance
Prerequisites: IOE 301/201 - Economic Decision Making, IOE 365/265 - Probability and Statistics for Engineers, IOE 310 - Introduction to Optimization Methods or Instructor's consent. This course provides you with an understanding of financial valuation, investments, risk-return tradeoffs, and capital structure decisions. Learn about NPV and it applications, risk and return, market efficiency and financial securities, dividend policies and capital structure, options and their applications. This course is helpful to understand what is driving financial choices in your company. The course emphasizes corporate policies through fundamental financial principles applicable to personal finances as well.

IOE 453. Derivative Instruments
Prerequisites: IOE 201 - Economic Decision Making, IOE 365/265 - Probability and Statistics for Engineers or IOE 366 - Linear Statistical Models, IOE 310 -- Introduction to Optimization Methods or Instructor's consent.This course provides you with a thorough understanding of the theory of the arbitrage-free derivatives pricing and to introduce you to the mathematical and numerical tools necessary for that. By the end of the semester you will learn about: 1. the basics of derivative securities and derivative securities markets; 2. mathematical and numerical tools required for implementing theoretical derivatives pricing models; 3. the use of derivative instruments for financial risk management and for financial engineering.

IOE 533. Human Factors in Engineering Systems I
Prerequisites: IOE 365, IOE 333, IOE 433 (EIH 556); I; 3 Credits. Principles of engineering psychology applied to engineering and industrial production systems. Visual task measurement and design, psychophysical measurements, signal detection theory and applications to industrial process control. Human information processing, mental workload evaluation human memory and motor control processes.

NRE 527. Social Institutions for Energy Production
The goal of this course is to give students a solid grasp of the environmental and social impacts of, and the institutions that govern, energy use, so that you can play a more effective role in shaping future policy or business decisions. We will begin with basic scientific and technological facts regarding the major uses for and sources of energy. We will then study energy markets (including spot and future markets), and what they are capable of accomplishing; we will also study the ways energy markets may fail. This will lead into an overview of the role of government in influencing energy decisions, starting with a high-level perspective, and then working with a series of case studies that examine in depth what government has accomplished in the area of energy policy. The course will wrap up with several current policy/business issues such as renewable portfolio standards, markets for renewable energy credits, and integrating the transportation sector into a cap-and-trade system for greenhouse gas emisisions.

NRE 574. Sustainable Energy Systems (same as Public Policy 519)
This course examines the production and consumption of energy from a systems perspective. Sustainability is examined by studying global and regional environmental impacts, economics, energy efficiency, consumption patterns and energy policy. First, the current energy system that encompasses resource extraction, conversion processes (e.g. electricity generation) and end-uses (transportation, residential and commercial buildings, industrial sectors), is covered. Responses to current challenges such as declining fossil fuels, carbon sequestration, emerging technologies (e.g., renewable sources: biomass, wind and photvoltaics; fuel cells) and end-use efficiency and conservation. This is a cross-disciplinary course that draws students from across campus including (but not limited to) SNRE, Engineering, Business, LS&A, RC, Architecture and Public Policy.

D.3 Potential Energy specialization courses

Aero 464. (AOSS 464) (ENSCEN 464) The Space Environment
Prerequisite: senior or graduate standing in a physical science or engineering. I (3 credits).
An introduction to physical and aeronomical processes in the space environment. Discussion of theoretical tools, the Sun, solar spectrum, solar wind, interplanetary magnetic field, planetary magnetosphere, ionospheres and upper atmospheres. Atmospheric processes, densities, temperatures, and wind.

Aero 533. (ENSCEN 533) Combustion Processes
*Prerequisite: Aero 225. (3 credits).*This course covers the fundamentals of combustion systems, and fire and explosion phenomena. Topics covered include thermochemistry, chemical kinetics, laminar flame propagation, detonations and explosions, flammability and ignition, spray combustion, and the use of computer techniques in combustion problems.

Aero 535. Rocket Propulsion
Analysis of liquid and solid propellant rocket powerplants; propellant thermochemistry, heat transfer, system considerations. Low-thrust rockets, multi-stage rockets, trajectories in powered flight, electric propulsion.

Aero 536. Electric Propulsion
Introduction to electric propulsion with an overview of electricity and magnetism, atomic physics, non-equilibrium flows and electrothermal, electromagnetic, and electrostatic electric propulsion systems.

Aero 633. Advanced Combustion
Thermodynamics of gas mixtures, chemical kinetics, conservation equations for multi-component reacting gas mixtures, deflagration and detonation waves. Nozzle flows and boundary layers with reaction and diffusion.

Auto 563. Dynamics and Controls of Automatic Transmissions.
Prerequisites: Graduate Standing or permission of instructor. IIIa, III. (3 credits).
(Distance Learning).
Automatic transmission is a key element of automotive vehicles for improved driving comfort. This course will introduce the mechanisms, design and control of modern transmissions systems. The emphasis will be on the dynamic control design, analysis and

synthesis problems.

Chem 567. Chemical Kinetics
Chemical Kinetics is the study of the rates and mechanisms of systems undergoing chemical change. The extraction of rate data from reacting systems and the utilization of such data in other reacting systems is central to chemistry in the laboratory and in the practical worlds of combustion science, atmospheric science, and chemical synthesis. This course introduces the treatment of complex chemical systems and fundamental ideas about chemical reaction rates in gases and in solutions. Computer software is utilized to treat complex reaction systems.

ChemE 528. Chemical Reactor Engineering
Analysis of kinetic, thermal, diffusive, and flow factors on reactor performance. Topics include batch, plug flow, backmix reactors, empirical rate expressions, residence time analysis, catalytic reactions, stability, and optimization.

ChemE 628. Industrial Catalysis
Theoretical and experimental aspects of heterogeneous catalysis and surface science. Design, preparation, and characterization of catalysts. Kinetics of heterogeneous catalytic reactions, thermal and diffusional effects in catalytic reactors. Case studies of important industrial catalytic processes.

EECS 411. Microwave Circuits I
Prerequisites: EECS 330; I; 4 Credits. Transmission-line theory, microstrip and coplanar lines, S-parameters, signal-flow graphs, matching networks, directional couplers, low-pass and band-pass filters, diode detectors. Design, fabrication, and measurements (1-10GHz) of microwave-integrated circuits using CAD tools and network analyzers.

EECS 423. Solid-State Device Laboratory
Prerequisites : EECS 320; I ; 4 Credits. Semiconductor material and device fabrication and evaluation: diodes, bipolar and field-effect transistors, passive components. Semiconductor processing techniques: oxidation, diffusion, deposition, etching, photolithography. Lecture and laboratory. Projects to design and simulate device fabrication sequence.

EECS 425. Integrated Microsystems Laboratory
Prerequisites: EECS 320, EECS 427; II; 4 Credits. Integrated circuit fabrication; mask design, photographic reduction; photoresist application, exposure, development, and etching; oxidation; diffusion; metal film deposition by evaporation and sputtering; die bonding, wire bonding, and encapsulation; testing of completed integrated circuits.

EECS 427. VLSI Design I
Prerequisites: EECS 270 and EECS 311; I, II; 4 Credits. Design techniques for rapid implementations of very large-scale integrated (VLSI) circuits, MOS technology and logic. Structured design. Design rules, layout procedures. Design aids: layout, design rule checking, logic, and circuit simulation. Timing. Testability. Architectures for VLSI. Projects to develop and lay out circuits.

EECS 514. Advanced MEMS Devices and Technologies
Prerequisites: EECS 414. II; 4 credits. Advanced micro electro mechanical systems (MEMS)

devices and technologies. Transduction techniques, including piezoelectric, electrothermal, and resonant techniques. Chemical, gas, and biological sensors, microfluidic and biomedical devices. Micromachining technologies such as laser machining and microdrilling, EDM, materials such as SiC and diamond. Sensor and actuator analysis and design through CAD.

EECS 515. Integrated Microsystems
Prerequisites: EECS 414. I; 4 credits. Review of interface electronics for sensors and drive and their influence on device performance, interface standards, MEMS and circuit noise sources, packaging and assembly techniques, testing and calibration approaches, and communication in integrated microsystems. Applications, including RF MEMS, optical MEMS, bioMEMS, and microfluidics. Design project using CAD and report preparation.

EECS 529. Semiconductor Lasers and LEDs
Prerequisites: EECS 429; I; 3 Credits. Optical processes in semiconductors, spontaneous emission, absorption gain, stimulated emission. Principles of light-emitting diodes, including transient effects, spectral and spatial radiation fields. Principles of semiconducting lasers; gain-current relationships, radiation fields, optical confinement and transient effects.

ME 438. Internal Combustion Engines
Prerequisite: ME 336 or permission of instructor. I; 4 credits. Analytical approach to the engineering problem and performance analysis of internal combustion engines. Study of thermodynamics, combustion, heat transfer, friction and other factors affecting engine power, efficiency, and emissions. Design and operating characteristics of different types of engines. Computer assignments. Engine laboratories.

ME 458. Automotive Engineering
Prerequisites: ME 350. I, II; 3 credits. (Distance Learning). Emphasizes systems approach to automotive design. Specific topics include automotive structures, suspension steering, brakes, and driveline. Basic vehicle dynamics in the performance and handling modes are discussed. A semester team based design project is require.

ME 559. Smart Materials and Structures
Prerequisites: EECS 210 or equivalent; I alternate years; 3 Credits *(Technical Breadth*). This course will cover theoretical aspects of smart materials, sensors and actuator technologies. It will also cover design, modeling and manufacturing issues involved in integrating smart materials and components with control capabilities to engineering smart structures.

ME 631. Statistical Thermodynamics
by Prof. Kevin Pipe
Introduction to statistical methods for evaluating thermodynamic and transport properties. Elements of quantum mechanics, statistical mechanics, and kinetic theory, as applied to engineering thermodynamics.

MSE 693. Nanostructured Materials for Energy Conversion and Storage.
By Professor Rachel Goldman
The course will focus on nanomaterials design and processing approaches to enhanced performance photovoltaics, thermoelectrics, and fuel cells. Fall 2006

D.4 Required Courses

ESP 503. Seminars on Energy Science, Technology and Policy
Leaders in policy and energy science discuss cutting-edge technologies, and critical barriers in their disciplines. The aim of the seminar series is to provide a view at multiple scales, of challenges in developing and implementing new technologies. The impact of energy policy is also a topic of interest, along with the need to create sustainable energy systems.

ME599-04 Energy Technologies
Energy and power densities previously thought unattainable in electrochemical, photovoltaic, wind and other environmentally-friendly energy technologies have been achieved through use of novel materials. Insertion of new materials, particularly nanoarchitectured systems, into such power supplies, has changed the landscape of modern power options. Our main focus will be on microelectronic and automotive batteries, though we will discuss some novel approaches, including biological batteries and power supplies. Emerging technologies stemming from materials design for energy storage and generation are rooted not only in traditional engineering disciplines, but also in chemistry, biology and interfaces among engineering and science fields. Thus, this course will cover not only basic electrochemistry, but also mechanics of battery degradation, design of hybrid systems, and an introduction to atomistic and multiscale methods in modeling battery behavior and performance. Performance limiters in key technologies will be discussed. Finally, design strategies for power systems requiring batteries will be described, as will the future of these technologies in the context of growing global demand for power.

MICHIGAN MEMORIAL
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Gary S. Was, Director

March 15, 2007

Professor Ann Marie Sastry
Mechanical Engineering

Dear Ann Marie:

On behalf of MMPEI, I am pleased to endorse the creation of a new M.Eng program in Energy Science. Your proposal for education of graduate students in key application areas is clearly supported by the wealth of course offerings at UM in related areas. The strong faculty interest in energy research clearly supports the idea that more graduate offerings in energy science and technologies are expected, as our research continues to grow.

The existing framework provided by Interpro will likely enable a quick start to this program, and I am personally delighted to see that UM will take a leadership role, not only in research, but in graduate education. Part of our mission at MMPEI is to speed transfer of energy science and technology in order to have the greatest societal impact, and an educated workforce is absolutely essential to this effort.

I look forward to helping create visibility and support for the ESP through the MMPEI, and wish you every success in launching this initiative.

Sincerely yours,

Gary S. Was

Gary S. Was

Sample Schedule

B.S.E./M.S. Biomedical Engineering

B.S.E. (Biomedical Engineering)

	Credit Hours	Terms 1	2	3	4	5	6	7	8	9	10
Subjects required by all programs (51-53 hrs.)											
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-		
Engr 100, Intro to Engineering	4	4	-	-	-	-	-	-	-		
Engr 101, Intro to Computers	4	-	4	-	-	-	-	-	-		
Chemistry 130[1]	3	3	-	-	-	-	-	-	-		
Physics 140/141, 240/241[2]	10	5	5	-	-	-	-	-	-		
Humanities and Social Sciences	16	-	4	4	4	4	-	-	-		
Advanced Science and Math (17-18 hrs.)											
Biology ~~162~~, Introduction to Biology 172	4 ~~5~~	-	-	-	4 ~~5~~	-	-	-	-		
Chemistry 210/211, Structure & Reactivity I	5	-	-	5	-	-	-	-	-		
Biology 310, Intro to Biol Chem	4	-	-	-	-	-	4	-	-		
IOE 265, Probability & Statistics for Engrs	4	-	-	-	-	4	-	-	-		
Required Program Subjects (28 hrs.)											
BiomedE 211, Circuits & Systems for Biomedical Engineers	4	-	-	-	-	4	-	-	-		
BiomedE 221, Biophysical Chemistry	4	-	-	-	-	4	-	-	-		
BiomedE 231, Intro to Biomechanics	4	-	-	-	4	-	-	-	-		
MatSci 250, Prin. of Engr. Materials	4	-	-	4	-	-	-	-	-		
BiomedE 418, Quantitative Cell Biology	4	-	-	-	-	-	4	-	-		
BiomedE 419, Quantitative Physiology	4	-	-	-	-	-	-	4	-		
BiomedE 450, Biomedical Design	4	-	-	-	-	-	-	-	4		
BiomedE 458, Biomedical Instrumentation & Design	4	-	-	-	-	-	-	4	-		
B.S.E. Concentration Requirements and Electives[3] (20 hrs.)	16	-	-	-	-	-	4	4	8		
Unrestricted Electives (9-11 hrs.)	10 ~~9-11~~	-	-	-	-	-	4 ~~3~~	3	3	-	-
Total	128	16	17	17	~~17~~ 16	16	15	15	15	-	-

M.S. Biomedical Engineering

	Credit Hours	Terms 1	2	3	4	5	6	7	8	9	10
Required Program Subjects M.S. (14-15 hrs.)											
Advanced Math	3	-	-	-	-	-	-	-	-	-	3
Advanced Statistics	4	-	-	-	-	-	-	-	-	4	-
BME 500, Seminar	1	-	-	-	-	-	-	-	-	1	-
BME 550, Ethics & Enterprise	1	-	-	-	-	-	-	-	-	1	-
BME 590, Directed Study	2-3	-	-	-	-	-	-	-	-	-	2-3
Life Science	3	-	-	-	-	-	-	-	-	3	-
M.S. Concentration Requirements[3] (8 hrs.)	8	-	-	-	-	-	-	-	-	4	4
M.S. Total Hours	22-23	-	-	-	-	-	-	-	-	13	9-10

Candidates pursuing a five-year Sequential Graduate/Undergraduate Studies Program in BME leading to a Bachelor of Science in Engineering degree (BME) - B.S.E. (BME) - and the Master of Science (BME) - M.S. (BME) - must complete the program listed above.

Students interested in pursuing the five-year Sequential Graduate/Undergraduate Studies Program in BME should consult with a Program Advisor.

Notes:

[1] If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130 you will have met the Chemistry Core Requirement for CoE.

[2] If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and/or 240/241 you will have met the Physics Core Requirement for CoE.

[3] Concentration requirements and electives: A list of approved courses is available on the department web site and in 1111 Gerstacker.

At the undergraduate level students may pursue three concentration areas: biochemical, bioelectrics, and biomechanics. Specific course requirements for the undergraduate concentrations are available on the department web site and in 1111 Gerstacker.

The undergraduate degree program provides a strong foundation in the life sciences and engineering and flows smoothly into graduate studies in BME through the S.G.U.S. program. The three undergraduate concentrations are linked to the six graduate concentrations: biomaterials and biotechnology (undergraduate biochemical), bioelectrics and biomedical imaging (undergraduate bioelectrics), biomechanics and rehabilitation engineering and ergonomics (undergraduate biomechanics).

Sample Schedule

B.S.E. (NAVAL ARCHITECTURE & MARINE ENGINEERING)

	Credit Hours	Terms 1	2	3	4	5	6	7	8
Subjects required by all programs (55 hrs.)									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Engr 100, Intro to Engineering. .	4	4	-	-	-	-	-	-	-
Engr 101, Intro to Computers	4	-	4	-	-	-	-	-	-
Chemistry 125/126 and 130 or Chemistry 210 and 211	5	5	-	-	-	-	-	-	-
Physics 140 with Lab 141; Physics 240 with Lab 241	10	-	5	5	-	-	-	-	-
Humanities and Social Sciences	16	4	4	-	-	-	-	4	4
Related Technical Core Subjects (11 hrs.)									
ME 211, Intro. to Solid Mechanics	4	-	-	4	-	-	-	-	-
ME 240, Intro. to Dynamics	4	-	-	-	4	-	-	-	-
ME 235, Thermodynamics I	3	-	-	-	3	-	-	-	-
Program Subjects (45 hrs.)									
NA 270, Marine Design	4	-	-	4	-	-	-	-	-
NA 260, Marine Systems Manufacturing	3	-	-	-	3	-	-	-	-
NA 310, Marine Structures I	4	-	-	-	-	4	-	-	-
NA 320, Marine Hydrodynamics I	4	-	-	-	-	4	-	-	-
NA 321, Marine Hydrodynamics II	4	-	-	-	-	-	4	-	-
NA 331, Marine Engineering I	3	-	-	-	-	3	-	-	-
NA 332, Marine Electrical Engineering	3	-	-	-	-	-	3	-	-
NA 340, Marine Dynamics I	4	-	-	-	-	-	4	-	-
NA 387, Prob. & Stats. for Marine Engin.	3	-	-	-	-	-	3	-	-
NA 470, Foundations of Ship Design	4	-	-	-	-	-	-	4	-
NA 475, Marine Design Team Project	4	-	-	-	-	-	-	-	4
NA 491, Marine Engr. Laboratory I	3	-	-	-	-	-	-	3	-
NA 492, Marine Engr. Laboratory II	2	-	-	-	-	-	-	-	2
Technical Electives (7-8 hrs.)	7-8	-	-	-	-	-	-	4	4

Choose two from the following list. At least one must come from the 1st four on the list:

NA 410, Marine Structures II (F)
NA 420, Environmental Ocean Dynamics (F)
NA 431, Marine Engineering II (W)
NA 440, Marine Dynamics II (W)
NA 401, Small Craft Design (F)
NA 403, Sailing Craft Design Principles (W)
NA 416, Theory of Plates and Shells (W, alt.yrs.)
NA 455, Nearshore Environmental Dynamics (W)
NA 562, Marine Systems Production Strategy and Operations Management (F)
Advanced Mathematics: Math450, Math454, or Math471 (F/W)

	Credit Hours	1	2	3	4	5	6	7	8
Unrestricted Electives (9-10 hrs.)	9-10	-	-	-	3	4	2	-	-
Total	128	17	17	17	17	15	16	15	14

The University of Michigan
College of Engineering
Nuclear Engineering and Radiological Sciences

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MEMORANDUM

TO: College of Engineering
Curriculum Committee

FROM: James P. Holloway James Paul Holloway
Chair, NERS Curriculum Committee

DATE: March 12, 2007

RE: NERS Curriculum Changes

Attached is a request for changes in the NERS Undergraduate Curriculum. These changes are being made in order to provide space in the curriculum for students to take both NERS 441 and 484 as required courses in the senior year. The effective date for the program change will be Fall 2007 and the effective date for the course changes will be Winter 2008 to allow for the transition of students currently enrolled in NERS 250. The proposed changes have been approved by the NERS faculty.

If you have any questions or need additional information, please do not hesitate to contact me.

Proposal on NERS Curriculum Changes

This document describes a proposed change to the NERS BSE curriculum.

- For students electing the program starting in Fall 2007, the required NERS courses will include both NERS 441, Nuclear Reactor Theory 1, and NERS 484, Radiological Health Engineering Fundamentals.
- Current students entering their senior year will also be advised to take both NERS 441 and NERS 484.
- The NERS Core, comprising NERS 250 (Fundamentals of Nuclear Engineering & Radiological Sciences), NERS 311 & 312 (Elements of Nuclear Engineering & Radiological Sciences I and II), will be changed as described below. These changes will be effective Winter 2008. This effective date is to allow students currently in NERS 250 to learn special relativity in NERS 311 in Fall 2007.

Revisions of NERS Core

Broad overview of changes:

- NERS 311 & 312 are changed to 3 credit hours, and NERS 250 remains at 4 credit hours in order to accommodate the introduction to special relativity while still providing a broad overview of nuclear applications.
- Special relativity is moved from NERS 311 into NERS 250, review of classical physics and some mathematical review is removed from NERS 311, and review of quantum mechanics is removed from NERS 312.
- Duplication of alpha decay coverage between 311 and 312 is removed. Duplication of coverage between NERS 312 & 250 on radioactive dating and units for measuring radioactivity is eliminated.
- The NERS 312 description no longer includes radiation transport.

These changes are made in order to provide space in the curriculum for students to take both NERS 441 and 484 as required courses in the senior year.

Individual course descriptions and outcomes follow:

NERS 250 – Fundamentals of Nuclear Engineering and Radiological Sciences
4 credit hours
Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Special relativity, basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.
Text: Shultis & Faw, *Fundamentals of Nuclear Science and Engineering*

Students will:

1. Derive relativistic transformations of length, time, velocity and momentum (Lorentz transformations), expression for relativistic energy. Derive the relativistic Doppler effect. Use these to solve problems. Explain apparent twin paradox. (Einstein's postulates, Michelson-Morley experiment)
2. Derive the Compton scattering formula from conservation of energy & momentum, describe annihilation and pair production, and describe the photoelectric effect.
3. Understand basic nomenclature of nuclear physics, including how to find information on the Chart of the Nuclides, X(a,b)Y reaction notation, and will compute Q values for given reactions

4. Compute decay constants from half-life and vice versa. Solve decay equation, decay with production, and solve the Bateman equations for decay chains. Demonstrate the analysis of basic radiometric dating techniques.
5. Describe the natural decay chains and environmental radiation
6. Define basic nuclear terminology and describe the breadth of current and potential nuclear applications. including fission power, medical diagnostic systems and cancer treatment. and industrial and medical uses of radionuclides.
7. Define the concept of cross-section. and define the concept of probability of interaction per unit path length (macroscopic cross section). Compute mean-free-path from cross section. Compute macroscopic cross section of mixtures.
8. Define scalar flux as path-length rate density. Compute scalar flux in vacuum and pure absorbers.
9. Describe the fundamentals of sustained neutron chain reactions. fission reactor design. and fission products. Derive the 4-factor formula from basic balance arguments; explain the importance of fuel lumping in fission reactors. Define and describe BWR & PWR and enumerate the basic systems of each reactor type. Describe potential advanced reactor types. including VHTR.
10. Identify some health risks and environmental concerns associated with ionizing radiation and radioactive materials. Define absorbed dose and dose equivalent. Define stopping power.
11. Read the ANS and HPS code of Ethics.
12. Write about nuclear technology.

NERS 311 – Elements of Nuclear Engineering and Radiological Sciences I
3 credit hours
Photons. electrons. neutrons. and protons. Particle and wave properties of radiation. Introduction to quantum mechanics. Properties and structure of atoms.
Text: Krane. *Modern Physics*

Students will:

1. Describe the particle properties of EM Radiation including the Photoelectric effect. the Compton effect. and describe what a photon is.
2. Describe wave-like properties of particles. including De Broglie's Hypothesis. Uncertainty relationships for classical waves. Heisenberg Uncertainty Relationships. Probability and randomness. the probability amplitude. Derive the relation between the energy, frequency. wavelength and momentum of a photon. Derive expressions for interference of waves. Apply De Broglie's hypothesis to interference of particles. learning the Heisenberg uncertainty relationships and the properties of wave packets.
3. Justify the Schrodinger equation. describe the probability interpretation, solve problems using the Schrodinger equation in one-D. describe parity in the square well potential. moments and interpretation of results. Show orthonormality of wavefunctions for different energy states. describe superposition of wavefunctions. describe plane waves, normalization and currents, the vector current. Be able to solve problems for potential barriers and wells. the impenetrable barrier. finite length barriers. steps and wells. and the "simple" harmonic oscillator. Obtain discrete energy levels for confined particles. Compute expectation values. Use Hermite polynomials and Dirac's bra-ket notation. Describe and estimate relative transition probabilities. Solve problems for the finite potential well including unbound states and bound states. Solve the Schrodinger equation in 2- and 3-D. describe degeneracy
4. Describe the Rutherford-Bohr atomic model, including Basic properties of atoms. The Rutherford nuclear atom. Describe the Rutherford scattering distribution. Carry out center of mass transformation in classical mechanics, and classical cross section calculations including the Rutherford cross section. Describe line spectra and

deficiencies of the Bohr Model. Derive the scattering angle for an electron as a function of the impact parameter. Derive the Rutherford scattering formula, compare result to experiment.

5. Solve problems involving the hydrogen atom in wave mechanics. Solve the Schrodinger equation in spherical coordinates, describe spherical harmonics, derive the hydrogen atom wavefunctions, describe radial probability densities. Describe and use Angular momentum in quantum mechanics. Describe tntrinsic spin, atomic Energy levels and spectroscopic notation, State the Pauli Exclusion Principle. Write expression for the quantum-mechanical angular momentum, allowed values of its z-component. Understand the concept of the spin. Express the magnetic moment in terms of the angular momentum.
6. Analyze problems in many electron atoms, Electronic states in many-electron atoms. Connect this analysis to The Periodic Table and Properties of the Elements including x-ray spectra.

NERS 312 – Elements of Nuclear Engineering and Radiological Sciences II
3 Credit hours
Nuclear properties. Radioactive decay. Alpha, beta and gamma decays of nuclei. Nuclear fission and fusion. Radiation interactions and reaction cross-sections.
Krane, *Introductory Nuclear Physics*

Students will:

1. Demonstrate knowledge of Introductory terminology for nuclei, nuclear properties, units and dimensions
2. Know the magnitude of nuclear radius and how it varies with A, find data on mass and abundance of nuclides, describe nuclear binding energy, describe nuclear angular momentum and parity, nuclear electromagnetic moments, and excited states. Read energy level diagrams.
3. Describe the shell model, the significance of even-even nuclei, collective structure, rotations/vibrations, and more realistic nuclear models
4. Solve the decay law, list the types of decay, describe the quantum theory of radioactive decay, solve decay problems with production, solve for growth of daughter activities, and describe the natural radioactivity chains. Describe the physical mechanisms of alpha, beta and gamma decay, and the properties that strongly impact the decay constant.
5. Explain why alpha decay occurs, alpha decay processes, alpha decay systematics, solve problems in the theory of alpha emission, qualitatively describe the influence of angular momentum and parity in alpha decay
6. Describe the Energy release in beta decay, and the Fermi theory of beta decay. Describe the classical experimental tests of Fermi theory. Describe the angular momentum and parity selection rules, comparative half-lives and "forbidden" decays
7. Describe the energetics of gamma decay, read energy level diagrams, describe classical electromagnetic radiation and transition to quantum mechanics, and the influence of angular momentum and parity selection rules. Describe angular distribution and polarization measurements. Describe Internal emissions and lifetimes for gamma emission
8. Enumerate types of reactions and relevant conservation laws, describe the energetics of nuclear reactions. Describe the concept of Isospin. Define the concept of reaction and scattering cross sections and compute kinematic relationships based on conservation of energy and mass. Describe Fission and Fusion. Describe why nuclei fission.

CURRENT

B.S.E.(NERS) CURRICULUM

		F 1	W 2	F 3	W 4	F 5	W 6	F 7	W 8
Subjects required by all programs (52-55 hrs.)									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Intro Comp (Eng 100)	4	4	-	-	-	-	-	-	-
Computing Course (Eng 101)	4	-	4	-	-	-	-	-	-
Chemistry 130 & 125 or 210 & 211[1]	5	5	-	-	-	-	-	-	-
Physics 140/141, 240/241[2]	10	-	5	5	-	-	-	-	-
Humanities and Social Sciences	16	4	4	-	4	-	-	4	-
Advanced Science (4 hrs.)									
Math 450, Adv Math for Eng I	4	-	-	-	-	4	-	-	-
Related Technical Subjects (19 hrs.)									
MSE 250, Princ of Eng Material or MSE 220, Intro to Materials and Manf	4	-	-	4	-	-	-	-	-
CEE 211,Statics and Dynamics	4	-	-	-	4	-	-	-	-
ME 235, Engr Thermodyn	3	-	-	-	-	3	-	-	-
EECS 314, Cct Analy and Electronics or EECS 215, Intro to Circuits	4	-	-	-	-	4	-	-	-
CEE 325, Fluid Mechanics or ME 320, Fluid Mechanics I[3]	4	-	-	-	-	-	4	-	-
Program Subjects (37 hrs.)									
NERS 250, Funda of Nuclear Eng and Rad Sci	4	-	-	-	4	-	-	-	-
NERS 311, Ele of Nuclear Eng I	4	-	-	-	-	4	-	-	-
NERS 312, Ele of Nuclear Eng II	4	-	-	-	-	-	4	-	-
NERS 315, Nuclear Inst Lab	4	-	-	-	-	-	4	-	-
NERS 441, Nucl Reac Theory I or NERS 484, Rad Hlth Eng Fundamentals	4	-	-	-	-	-	-	4	-
Senior Laboratory (above NERSS 315)[4]	4	-	-	-	-	-	-	-	4
Design Course[5]	4	-	-	-	-	-	-	-	4
NERS Electives	9	-	-	-	-	-	-	6	3
Technical Electives	3	-	-	-	-	-	-	3	-
Free Electives	10-13	-	-	3	-	-	3	-	4
Total	**128**	**17**	**17**	**16**	**16**	**15**	**15**	**17**	**15**

Candidates for the Bachelor of Science degree in Engineering (Nuclear Engineering and Radiological Sciences) — B.S.E. (N.E.R.S.) —must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

Notes:

[1]If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for CoE.

[2]If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and/or 240/241 you will have met the Physics Core Requirement for CoE

[3]If ME 320 (3 hrs) is elected, students will have an additional hour of unrestricted electives.

[4]Laboratory Course (above NERS 315) select one from the following: NERS 445, 575, 586. (NERS 575 and NERS 586 need program advisor's consent.)

[5]Design Course select one: NERS 442, 554.

REQUESTED CHANGE

B.S.E. (NERS) CURRICULUM

		F 1	W 2	F 3	W 4	F 5	W 6	F 7	W 8
Subjects required by all programs (52-55 hrs.)									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	-	-	-	-
Intro Comp (Eng 100)	4	4	-	-	-	-	-	-	-
Computing Course (Eng 101)	4	-	4	-	-	-	-	-	-
Chemistry 130 & 125 or 210 & 211[1]	5	5	-	-	-	-	-	-	-
Physics 140/141, 240/241[2]	10	-	5	5	-	-	-	-	-
Humanities and Social Sciences	16	4	4	4	~~4~~	-	4	~~4~~	-
Advanced Science (~~4~~3 hrs.)									
~~Math 450, Adv Math for Engineers I~~	~~4~~	-	-	-	-	~~4~~	-	-	-
Math 454, Boundary Val Probl for Partial Dif Equ	3	-	-	-	-	3	-	-	-
Related Technical Subjects (~~19~~18 hrs.)									
MSE 250, Princ of Eng Material or MSE 220, Intro to Materials and Manf	4	-	-	~~4~~	-	-	4	-	-
CEE 211, Statics and Dynamics	4	-	-	-	4	-	-	-	-
ME 235, Engr Thermodyn	3	-	-	-	-	3	-	-	-
EECS 314, Cct Analy and Electronics or EECS 215, Intro to Circuits	4	-	-	-	-	4	-	-	-
~~CEE 325, Fluid Mechanics or~~ ME 320, Fluid Mechanics I[3]	~~4~~3	-	-	-	-	-	-	~~4~~3	-
Program Subjects (~~37~~39 hrs.)									
NERS 250, Funda of Nuclear Eng and Rad Sci	4	-	-	-	4	-	-	-	-
NERS 311, Ele of Nuclear Eng I	3	-	-	-	-	~~4~~3	-	-	-
NERS 312, Ele of Nuclear Eng II	3	-	-	-	-	-	~~4~~3	-	-
NERS 315, Nuclear Inst Lab	4	-	-	-	-	-	4	-	-
NERS 441, Nucl Reac Theory I ~~or~~	4	-	-	-	-	-	-	4	-
NERS 484, Rad Hlth Eng Fundamentals	4	-	-	-	-	-	-	4	-
Senior Laboratory (above NERSS 315)[~~4~~3]	4	-	-	-	-	-	-	-	4
Design Course[~~5~~4]	4	-	-	-	-	-	-	-	4
NERS Electives	9	-	-	-	-	-	3	~~6~~3	3
Technical Electives	3	-	-	-	-	-	-	~~3~~	3
Free Electives	10~~10-13~~	-	-	~~3~~4	-	3	~~3~~-	3	~~4~~
Total	**128**	**17**	**17**	**~~16~~ 17**	**16**	**~~15~~ 16**	**~~15~~ 14**	**17**	**~~15~~ 14**

Candidates for the Bachelor of Science degree in Engineering (Nuclear Engineering and Radiological Sciences) — B.S.E. (N.E.R.S.) —must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

Notes:

[1]If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 130/125/126 you will have met the Chemistry Core Requirement for CoE.

[2]If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and/or 240/241 you will have met the Physics Core Requirement for CoE

~~[3]If ME 320 (3 hrs) is elected, students will have an additional hour of unrestricted electives.~~

[~~4~~3]Laboratory Course (above NERS 315) select one from the following: NERS ~~445~~425, 575, 586. (NERS 575 ~~and NERS 586~~ needs program advisor's consent.)

[~~5~~4]Design Course select one: NERS 442, 554.

Sample Schedule

- NERS 441 and 484 as required courses
- Reduce NERS 311/312 from 4 cr to 3 cr
- Change Math requirement from Math 450 to Math 454

Fall - 1st term		Winter - 2nd term	
Chem 130/125/126 (lab)	5	Phys 140/141 (lab)	5
Engr 100	4	Engr 101	4
Math 115	4	Math 116	4
HU/SS	4	HU/SS	4
	17		17
Fall - 3rd term		Winter - 4th term	
Phys 240/241 (lab)	5	NERS 250	4
Math 215	4	Math 216	4
HU/SS	4	MSE 220/250	4
Unrestricted Elective	4	CEE 211	4
	17		16
Fall - 5th term		Winter - 6th term	
NERS 311	3	NERS 312	3
EECS 314 (lab)	4	NERS 315 (lab)	4
Math 454	3	HU/SS	4
Unrestricted Elective	3	NERS Elective	3
ME 235	3		
	16		14
Fall - 7th term		Winter - 8th term	
NERS 441	4	NERS 442/554 (design)	4
NERS 484	4	NERS 425/586 (lab)	4
NERS Elective	3	NERS Elective	3
ME 320	3	Tech Elective	3
Unrestricted Elective	3		
	17		14

Summary

Required NERS courses

250	4	
311	3	
312	3	
315	4	
441	4	
484	4	
442/554	4	
425/586	4	
	30	required
NERS Elec	9	
	39	NERS program courses

Required technical courses

CEE 211	4	
MSE 220/250	4	
ME 235	3	
EECS 314	4	
ME 320	3	
	18	Total

Required Math (beyond Math 216)

Math 454	3

Required Technical Elective

Math, Physics or Engr course 300L+	3

Unrestricted Elective	10

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1814

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/6/2007
Effective Winter 2008

A. CURRENT LISTING

Home Department: | Div #: | Course Number:

Cross Listed Course Information:

Course Title:

TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): | Transcript (Max = 20 Spaces):

☒ Course Description
Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle. Additional topics and guest lectures.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit
☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl

Credit Hours: Min ___ Max ___
Contact Hrs/Wk ___ Number of Wks ___

B. REQUESTED LISTING

Home Department	Div #	Course Number
NERS	288	250

Cross Listed Course Information:

Course Title: Fundamentals of Nuclear Engineering and Radiological Sciences

TITLE ABBREVIATION	
Time Sched (Max = 19 Spaces)	Fund Nuc Eng/Rad Sci
Transcript (Max = 20 Spaces)	Fund Nuc Eng/Rad Sci

Course Description for Official Publication (Max = 50 words)
Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Special relativity, basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.

PROGRAM OUTCOMES:
☒ a ☐ b ☐ c ☐ d ☒ e ☐ f ☒ g ☒ h ☐ i ☒ j ☐ k

Degree Requirements ◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites: preceded or accompanied by Math 216 and Physics 240
○ Enforced ◉ Advised

Credit Restrictions:

Level of Credit
☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 4 Max 4
Contact Hrs/Wk 4 Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ◉ No

Printing Information (Optional) ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Class Type(s) ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading ☐ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III ☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years
Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: James Holloway **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm. ___
☐ Faculty ___
☐ Rackham ___
☐ Cross listed Unit 1 ___
☐ Cross listed Unit 2 ___

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. [signature]
Cross-listed Dept(s). ___

Form Number

1814

SUPPORTING STATEMENT

Modifications are required to accommodate NERS program changes. A more formal introduction to special relativity is introduced (move from NERS 311) to replace what used to be a brief introduction. time to achieve this is gained by eliminating the expectation of guest lectures. Teaching special relativity at the sophomore level is not unusual in physics curricula and can be done with algebra and calculus, so formalizing this content will introduce no learning difficulty for the student.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

COURSE PROFILE

Degree Program: Nuclear Engineering and Radiological Sciences **Date:** March, 2007

Prepared by: James P. Holloway

COURSE #: NERS 250	**COURSE TITLE:** Fundamentals of Nuclear Engineering and Radiological Sciences
TERMS OFFERED: Winter	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: J. Kenneth Shultis & Richard E. Faw, *Fundamentals of Nuclear Science and Engineering* Dekker, 2002	**PREREQUISITES:** Preceded or accompanied by Math 216 and Phys 240 (A)
INSTRUCTOR(S): Wehe	**COGNIZANT FACULTY:** Holloway
CoE BULLETIN DESCRIPTION: Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.	**COURSE TOPICS:** Modern physics concepts. Atomic & Nuclear Models, Nuclear Energetics, Radioactivity, Nuclear Reactions, Radiation Interactions with Matter, Radiation Dose and Hazards, Nuclear Reactors & Nuclear Power, Medical Applications of Nuclear Technology
COURSE STRUCTURE/SCHEDULE Lecture: 2 per week @ 80 minutes; Discussion: 1 per week @ 50minutes	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1. To teach students fundamental physics that applies to a broad range of nuclear technology [1] 2. To begin to introduce students to the analytical methods used in nuclear engineering and radiological science [1,2,3] 3. To introduce students to environmental impacts of nuclear technology, and the physical and biological effects of ionizing radiation [8,9] 4. To expose students to engineering applications career opportunities in nuclear engineering and radiological sciences [12] 5. To introduce students to nuclear engineering and radiological sciences and their impact on contemporary societal issues [9,10.11,12] 6. To provide practice in technical communication [7]
COURSE OUTCOMES For <u>each</u> course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1. Derive relativistic transformations of length, time, velocity and momentum (Lorentz transformations), expression for relativistic energy. Derive the relativistic Doppler effect. Use these to solve problems. Explain apparent twin paradox. [1,2] 2. Derive the Compton scattering formula from conservation of energy and momentum, describe annihilation and pair production, and describe the photoelectric effect. [1,2] 3. Understand basic nomenclature of nuclear physics, including how to find information on the Chart of the Nuclides, X(a,b)Y reaction notation, and will compute Q values for given reactions. [1,2] 4. Compute decay constants from half-life and vice versa. Solve decay equation, decay with production, and solve the Bateman equations for decay chains. [1,2,4] 5. Describe the natural decay chains and environmental radiation. [3] 6. Define basic nuclear terminology and describe the breadth of current and potential nuclear applications, including fission power, medical diagnostic systems and cancer treatment, and industrial and medical uses of radionuclides. [4,5] 7. Define the concept of cross-section, and define the concept of probability of interaction per unit path length (macroscopic cross section). Compute macroscopic cross-section of mixtures. [1,2] 8. Define scalar flux as path-length rate density. Compute scalar flux in vacuum and pure absorbers. [1,2] 9. Describe the fundamentals of sustained neutron chain reactions, fission reactor design, and fission products. Derive the 4-factor formula from basic balance arguments; explain the importance of fuel lumping in fission reactors. Define and describe BSR and PWR and enumerate the basic systems of each reactor type. Describe potential advanced reactor types, including VHTR. [1,2,4,5]

	10. Identify some health risks and environmental concerns associated with ionizing radiation and radioactive materials. Define absorbed dose and doe equivalent. Define stopping power. [3] 11. Read the ANS and HPS Code of Ethics. [3] 12. Write about nuclear technology. [6]
ASSESSMENT TOOLS For <u>each</u> assessment tool, links to the course outcomes are identified.	1. A combination of during-term test(s) and/or final examination will be used to measure outcomes [1-5] for individual students under a time constraint 2. Problem sets measure outcomes [1-5] under less time pressure and allow student collaborations 3. In class discussion establishes [6] at a class-wide level 4. In-class oral presentation establishes outcome [7] 5. Term paper measures outcome [8] 6. Course evaluation by each student at the end of the course provides self-assessment data on all outcomes

Revision History: March, 2002; May, 2005; August, 2005; March, 2007

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1815

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/6/2007

Effective Winter 2008

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department: — Div #: — Course Number: —	Home Department: NERS Div #: 288 Course Number: 311
Cross Listed Course Information:	Cross Listed Course Information:
Course Title:	Course Title: Elements of Nuclear Engineering and Radiological Sciences I
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Ele Nucl Engr/Rad Sci I
TITLE ABBREVIATION — Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Transcript (Max = 20 Spaces): Ele Nucl Engr/Rad Sci I
☒ Course Description: Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics and special relativity. Properties and structure of atoms and nuclei. Introduction to interactions of radiation with matter.	Course Description for Official Publication (Max = 50 words): Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics. Properties and structure of atoms.
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k	**PROGRAM OUTCOMES:** ☒ a ☒ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
Prerequisites: ○ Enforced ○ Advised	Prerequisites: ○ Enforced ⊙ Advised
Credit Restrictions:	Credit Restrictions:
☒ Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 4 Max 4; Contact Hrs/Wk 4; Number of Wks 14	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 3 Max 3; Contact Hrs/Wk 3; Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☒ I ☐ II ☐ IIIa ☐ IIIb ☐ III — ☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term: ☐ 1st ☐ 2nd

Cognizant Faculty Member: Alex Bielajew **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ____
- ☐ Faculty ____
- ☐ Rackham ____
- ☐ Cross listed Unit 1 ____
- ☐ Cross listed Unit 2 ____

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. [signature]
Cross-listed Dept(s). ____

Form Number

1815

SUPPORTING STATEMENT

Modifications are required to accommodate NERS program changes. Special relativity was covered in both NERS 250 and NERS 311. The reduction in credit hours to NERS 311 is accomplished by removing special relativity from NERS 311 along with removing discussion of alpha decay (covered already in NERS 312). Class time spent reviewing classical physics will be minimized.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

COURSE PROFILE

Degree Program: Nuclear Engineering and Radiological Sciences **Date:** May, 2005

Prepared by: Alex Bielajew

COURSE #: NERS 311	COURSE TITLE: Elements of Nuclear Engineering and Radiological Sciences I
TERMS OFFERED: Fall	For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.
TEXTBOOKS/REQUIRED MATERIAL: Krane, *Modern Physics*, Wiley, 2nd Edition	PREREQUISITES: NERS 250 and Phys 240, preceded or accompanied by Math 454 (A)
INSTRUCTOR(S): Alex Bielajew	COGNIZANT FACULTY: Alex Bielajew
CoE BULLETIN DESCRIPTION: Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics and special relativity. Properties and structure of atoms.	COURSE TOPICS: 1. The special theory of relativity 2. The particle-like properties of radiation 3. The wave-like properties of particles 4. The Rutherford-Bohr model of the atom 5. The Schrödinger equation 6. One-electron atoms 7. Multi-electron atoms and the periodic table
COURSE STRUCTURE/SCHEDULE Lecture: 2 per week @ 80 minutes each	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1. Teach the students the concepts and methodology of modern physics.[1] 2. Teach the students to use theoretical results to make quantitative predictions.[1] 3. Apply the concepts learned in class to experimental problems. [5]
COURSE OUTCOMES For each course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1. Describe the particle properties of EM Radiation including the Photoelectric effect, the Compton effect, and describe what a photon is. [1] 2. Describe wave-like properties of particles, including De Broglie's Hypothesis, Uncertainty relationships for classical waves, Heisenberg Uncertainty Relationships, Probability and randomness, the probability amplitude. Derive the relation between the energy, frequency, wavelength and momentum of a photon. Derive expressions for interference of wave. Apply DeBroglie's hypothesis to interference of particles, learning the Heisenberg uncertainty relationships and the properties o f wave packets. [1,2] 3. Justify the Schrodinger equation, describe the probability interpretation solve problems using the Schrodinger equation in one-D, describe parity in the square well potential, moments and interpretation of results. Show orthonormality of wavefunctions for different energy states, describe superposition of wavefunctions, describe plane waves, normalization and currents, the vector current. Be able to solve problems for potential barriers and wells, the impenetrable barrier, finite length barriers, steps and wells, and the "simple" harmonic oscillator. Obtain discrete energy levels for confined particles. Compute expectation values. Use Hermite polynomials and Dirac's bra-ket notation,. Describe and estimate relative transition probabilities. Solve problems for the finite potential well including unbound states and bound states. Solve the Schrodinger equation in 2- and 3-D, describe degeneracy. [1,2] 4. Describe the Rutherford-Bohr atomic model, including basic properties of atoms, the Rutherford nuclear atom. Describe the Rutherford scattering distribution. Carry out center of mass transformation in classical mechanics, and classical cross section calculations including the Rutherford cross section. Describe line spectra and deficiencies of the Bohr Model. Derive the scattering angle for an electron as a function of the impact parameter. Derive the Rutherford scattering formula, compare result to experiment. [1,2,3] 5. Solve problems involving the hydrogen atom in wave mechanics. Solve the Schrodinger equation in spherical coordinates, describe spherical harmonics, derive the hydrogen atom wavefunctions, describe radial probability densities. Describe and use Angular momentum in quantum mechanics. Describe intrinsic spin, atomic Energy levels and spectroscopic notation. State the Pauli Exclusion Principle. Write expression for the quantum-mechanical angular momentum, allowed values of its z-component. Understand the concept of the spin. Express the magnetic moment in terms of the angular momentum. [1,2,3] 6. Analyze problems in many electron atoms, electronic states in many-electron atoms. Connect this analysis to the Periodic Table and Properties of the Elements including x-ray spectra. [1,2,3]
ASSESSMENT TOOLS For each assessment tool, links to the course outcomes are identified.	1. Exams measure all outcomes for individual students under time constraint. 2. Weekly assigned problem sets measure all outcomes under less time pressure and with collaboration between students and assistance from instructor.

Revision History: September, 1998; March, 2002; January, 2004;March, 2007

Alex Bielajew, Cooley 2927, bielajew@umich.edu Last modified: November 9, 2006

NERS311 Schedule Fall 2006

Introduction to Nuclear Engineering and Radiological Sciences I

Relativity, E&M Waves, and Particles

Date started	Topics introduced	Reference material K/B: Krane/Bielajew "book"
	Introduction	K:1, B:1
09/06	Course philosophy, honor code, class policy	web docs
	Introduction to the course	K:1, B:1
	Review of Classical Physics	K:1.1, B:1.1
	Units and dimensions (not covered, but read!)	K:1.2
	Significant figures	K:1.3, B:1.3
	Theory, experiment, law (not covered, but read!)	K:1.4
09/08	2-body scattering	K:1.1, B:1.1
09/11	Taylor series (by popular demand)	
09/13	Basic error estimation	B:1.5
	The special theory of relativity	K:2, B:2
09/13	Classical relativity	K:2.1, B:2.1
	The Michelson-Morley experiment	K:2.2, B:2.2
	Einstein's postulates	K:2.3, B:2.3
09/15	Consequences of Einstein's postulates	K:2.4
	The Twin Paradox	K:2.6
	The Lorentz transformation	K:2.5, B2.5
	The Doppler effect	K:2.4
09/22	Relativistic dynamics	K:2.7, B:2.7
09/27	Lorentz transformation of E and $\vec{p}$	B:2.7
	Particle-like properties of E&M radiation	K:3
09/25	Classical E&M waves	K:3.1
09/27	The Photoelectric effect	K:3.2
	Blackbody radiation	K:3.3
	The Compton effect	K:3.4
09/29	What is a photon?	K:3.6
	Conservation law violation in scattering	notes
	Conservation laws and scattering processes	notes
10/04	Quantum Electrodynamics!	notes
	A catalogue of $e^{\pm}\gamma$ processes	notes
	Other photon processes	K:3.5
	Wave-like properties of particles	K:4
10/04	De Broglie's Hypothesis	K:4.1
	Uncertainty relationships for classical waves	K:4.2
	Heisenberg Uncertainty Relationships	K:4.3
	Probability and randomness	K:4.4
	The probability amplitude	K:4.5
10/17	**Exam 1—Chapters 1–2 incl.**	In class

⇒ material not covered in a 3 credit version

Schrödinger equation, atomic models

	The Schrödinger equation	K:5
10/06	Justifying the Schrödinger equation	K:5.1
	The probability interpretation	K:5.3
	Application - the square well potential	K:5.4
10/09	Moments, and interpretation of results	notes
	Orthonormality of wavefunctions	notes
	Superposition of wavefunctions	notes
10/18	Plane waves, normalization and currents	notes
	The vector current	notes
	Potential barriers and wells	notes
	The impenetrable barrier	notes
10/20	Finite length barriers, steps and wells	notes
10/23	Parity, in the square-well potential	notes
10/25	The "simple" harmonic oscillator	K:5.5
	Hermite polynomials	notes
	Dirac's bra-ket notation	notes
	Relative transition probabilities	notes
10/27	The finite potential well, unbound states	notes
10/30	The finite potential well, bound states	notes
11/01	2- and 3-D solutions to the Schrödinger equation	notes, K5.4
	Degeneracy	notes, K5.4
	Energy-level degeneracies	notes
11/03	A model of α-decay	notes
	The Rutherford-Bohr atomic model	K:6
11/03	Basic properties of atoms	K:6.1
	The Thomson Model	K:6.2
11/06	The Rutherford nuclear atom	K:6.3
	The Rutherford scattering distribution	K:6.3
11/08	Center of mass transformation in classical mechanics	notes
	Classical cross section calculations	notes
	The Rutherford cross section	notes
	Solid sphere cross sections	notes
11/10	Line spectra	K:6.4
	The Bohr model	K:6.5
	The Franck-Hertz experiment	K:6.6
	The Correspondence Principle	K:6.7
	Deficiencies of the Bohr Model	K:6.8
11/17	**Exam 2—Chapters 3–6**	In class

move up

The hydrogen atom, many-electron atoms

	The hydrogen atom in wave mechanics	K:7
	The Schrödinger equation in spherical coordinates	K:7.1
	Spherical harmonics	notes
	~~Spherical harmonics~~	~~notes~~
	The hydrogen atom wavefunctions	K:7.2
	Radial probability densities	K:7.3
	The hydrogen atom wavefunctions	K:7.2
	Angular momentum and probability densities	K:7.4
	Intrinsic spin	K:7.5
	Energy levels and spectroscopic notation	K:7.6
	The Zeeman effect	K:7.7
	Fine structure	K:7.8
	The Pauli Exclusion Principle	K:8.1
	Many electron atoms	K:8
	Electronic states in many-electron atoms	K:8.2
	The Periodic Table	K:8.3
	Properties of the Elements	K:8.4
	X-Rays	K:8.5
	Optical spectra	K:8.6
	Lasers	K:8.8
12/15	**Exam 3—Chapters 7,8**	**13:30 - 15:30, Location TBD**

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1816

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/6/2007

Effective Winter 2008

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department: / Div #: / Course Number:	Home Department: NERS / Div #: 288 / Course Number: 312
Cross Listed Course Information:	Cross Listed Course Information:
Course Title:	Course Title: Elements of Nuclear Engineering and Radiological Sciences II
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): / Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Ele Nucl Engr/Rad Sci II / Transcript (Max = 20 Spaces): Ele Nucl Engr/Rad Sci II
☒ Course Description: Production and use of nuclear radiation. Alpha-, beta- and gamma-decay of nuclei. Neutrons. Reactions. Elementary radiation interactions and transport.	Course Description for Official Publication (Max = 50 words): Nuclear properties. Radioactive decay. Alpha-, beta-, and gamma-decays of nuclei. Nuclear fission and fusion. Radiation interactions and reaction cross-sections.
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l	PROGRAM OUTCOMES: ☒ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective	Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective
Prerequisites: ○ Enforced ○ Advised	Prerequisites: ○ Enforced ⊙ Advised
Credit Restrictions:	Credit Restrictions:
☒ Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 4 Max 4; Contact Hrs/Wk 4; Number of Wks 14	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 3 Max 3; Contact Hrs/Wk 3; Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____
Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other
Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y
Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Alex Bielajew **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ______________
- ☐ Faculty ______________
- ☐ Rackham ______________
- ☐ Cross listed Unit 1 ______________
- ☐ Cross listed Unit 2 ______________

Submitted By: ☒ Home Dept ☐ Cross-listed Dept
Name, Signature & Department
Home Dept. ______________
Cross-listed Dept(s). ______________

Form Number

1816

SUPPORTING STATEMENT

Modifications are required to accommodate NERS program changes. Review of quantum mechanics is removed. Transport theory is removed.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

COURSE PROFILE

Degree Program: Nuclear Engineering and Radiological Sciences **Date:** March, 2007

Prepared by: Alex Bielajew

COURSE #: NERS 312	**COURSE TITLE:** Elements of Nuclear Engineering and Radiological Sciences II
TERMS OFFERED: Winter	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: Krane, *Introductory Nuclear Physics*	**PREREQUISITES:** NERS 311 (A)
INSTRUCTOR(S): Bielajew	**COGNIZANT FACULTY:** Bielajew
CoE BULLETIN DESCRIPTION: Nuclear properties. Radioactive decay. Alpha, beta and gamma decays of nuclei. Nuclear fission and fusion. Elementary radiation interactions and transport. Reaction cross-sections	**COURSE TOPICS:** Elements of Quantum Mechanics, basic nuclear properties, Radioactive decay , alpha, beta and gamma decays, nuclear reactions and cross-sections, fission
COURSE STRUCTURE/SCHEDULE Lecture: 2 per week @ 80 minutes each	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1. Teach students key nuclear properties (radius, spin, binding energy, separation energies, decay energetics, Q values). [1] 2. Teach students decay systematics (decay laws, decay chains). [1] 3. Teach students the fundamentals of alpha, beta and gamma decays (nuclear decays and physics). [1] 4. Teach students the fundamentals of nuclear reactions, including fission and fusion [1] 5. Prepare students for higher level courses involving the applications of radiation. [1, 12]
COURSE OUTCOMES For <u>each</u> course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1. Demonstrate knowledge of introductory terminology for nuclei, nuclear properties, units and dimensions. [1,5] 2. Know the magnitude of nuclear radius and how it varies with A, find data on mass and abundance of nuclides, describe nuclear binding energy, describe nuclear angular momentum and parity, nuclear electromagnetic moments, and excited states. Read energy level diagrams. [1,5] 3. Describe the shell model, the significance of even-even nuclei, collective structure, rotations/vibrations, and more realistic nuclear models. [1,5] 4. Solve the decay law, list of the types of decay, describe the quantum theory of radioactive decay, solve decay problems with production, solve for growth of daughter activities, and describe the natural radioactivity chains. Describe the physical mechanisms of alpha, beta and gamma decay, and the properties that strongly impact the decay constant.[2,5] 5. Explain why alpha decay occurs, alpha decay processes, alpha decay systematics, solve problems in the theory of alpha emission, qualitatively, describe the influence of angular momentum and parity in alpha decay. [2,3,5] 6. Describe the energy release in beta decay, and the Fermi theory of beta decay. Describe the classical experimental tests of Fermi theory. Describe the angular momentum and parity selection rules, comparative half-lives and "forbidden" decays. [2,3,5] 7. Describe the energetics of gamma decay, read energy level diagrams, describe classical electromagnetic radiation and transition to quantum mechanics, and the influence of angular momentum and parity selection rules. Describe angular distribution and polarization measurements. Describe internal emissions and lifetimes for gamma emission. [2,3,5] 8. Enumerate types of reactions and relevant conservation laws, describe the energetics of nuclear reactions. Describe the concept of Isospin. Define the concept of reaction and scattering cross-sections and compute kinematic relationships based on conservation of energy and mass. Describe fission and fusion. Describe why nuclei fission. [4,5]
ASSESSMENT TOOLS For <u>each</u> assessment tool, links to the course outcomes are identified.	1. A combination of mid-term test and final examination will be use to measure all outcomes for individual students under a time constraint. 2. Problem sets measure all outcomes under less time pressure and with student collaborations 3. Course evaluation by each student at the end of the course assesses all outcomes.

Revision History: September, 1998; March, 2002;April, 2006; March, 2007

Alex Bielajew, Cooley 2927, bielajew@umich.edu

Last modified: September 28, 2006

NERS312 Schedule Winter 2007

Introduction to Nuclear Engineering and Radiological Sciences II

Quantum Mechanics and Fundamentals of Nuclei and Radioactivity

Lecture/date started	Topics introduced	Reference material K: Krane's "book"
	Basic Concepts and Fundamentals	K:1
	Introduction to the course	
	Course philosophy, honor code, class policy	See web
	What the course is really about	
	How to succeed and be happy	
	History and overview	K:1.1
	Some introductory terminology	K:1.2
	Nuclear properties	K:1.3
	Units and dimensions	K:1.4
	Elements of Quantum Mechanics	K:2
	Quantum behavior	K:2.1
	Principles of Quantum Mechanics	K:2.2
	Problems in one dimension	K:2.3
	Problems in three dimensions	K:2.4
	Quantum theory of angular momentum	K:2.5
	Parity	K:2.6
	Quantum statistics	K:2.7
	Transition between states	K:2.8
	Nuclear Properties	K:3
	The nuclear radius	K:3.1
	Mass and abundance of nuclides	K:3.2
	Nuclear binding energy	K:3.3
	Nuclear angular momentum and parity	K:3.4
	Nuclear electromagnetic moments	K:3.5
	Nuclear excited states	K:3.6
	Nuclear Models	K:5
	The shell model	K:5.1
	Even-Z, Even-N Nuclei	K:5.2
	Collective structure, rotations/vibrations	K:5.2
	More realistic nuclear models	K:5.3
	Radioactive Decay	K:6
	The radioactive decay law	K:6.1
	Quantum theory of radioactive decays	K:6.2
	Production and decay of radioactivity	K:6.3
	Growth of daughter activities	K:6.4
	Types of decays	K:6.5
	Natural radioactivity	K:6.6
	Radioactive dating	K:6.7
	Units for measuring radiation	K:6.8

α, β, and γ Radioactive Decays

———————	**Alpha Decay**	K:8
	Why alpha decay occurs	K:8.1
	Basic alpha decay processes	K:8.2
	Alpha decay systematics	K:8.3
	Theory of alpha emission	K:8.4
	Angular momentum and parity in alpha decay	K:8.5
———————	**Beta Decay**	K:9
	Energy release in beta decay	K:9.1
	Fermi theory of beta decay	K:9.2
	The "classical" experimental tests of the Fermi theory	K:9.3
	Angular momentum and parity selection rules	K:9.4
	Comparative half-lives and forbidden decays	K:9.5
———————	**Gamma Decay**	K:10
	Energetics of gamma decay	K:10.1
	Classical electromagnetic radiation	K:10.2
	Transition to quantum mechanics	K:10.3
	Angular momentum and parity selection rules	K:10.4
	Angular distribution and polarization measurements	K:10.5
	Internal emissions	K:10.6
	Lifetimes for gamma emission	K:10.7

Nuclear Reactions, Fission and Fusion

———————	**Nuclear Reactions**	K:11
	Types of reactions and conservation laws	K:11.1
	Energetic of nuclear reactions	K:11.2
	Isospin	K:11.3
	Reaction cross sections	K:11.4
	Scattering and reaction cross sections	K:11.8
	The optical model	K:11.9
	Heavy ion collisions	K:11.13
———————	**Nuclear Fission**	K:13
	Why nuclei fission	K:13.1
	Fission explosives	K:13.9
———————	**Nuclear Fusion**	K:14
	Thermonuclear explosives	K:14.5

COURSE APPROVAL FORMS

For March 20, 2007 CoE CC Meeting

CEE 230	Modification—Changing Title from: Thermodynamics ***to: Energy and Environment***; changing Descriptiion; Changing Outcomes; Changing Credit hours from: 4 ***to: 3***
CEE 431	Modification—Changing Prerequisites from: Junior Standing ***to: Senior Standing***; Changing Credit hours from: 3 ***to: 4***
CEE 528(/X-Listed with ENSCEN 528	Deletion
CEE 585(X-Listed with ENSCEN 585	Deletion
CEE 625(X-Listed with SNRE 625)	Deletion
CEE 628	Deletion
CEE 638	New Course
CEE 646(X-Listed with ENSCEN 646	Deletion
ME 350	Modification—Changing Description (re-submitting with outcomes sheet)
ME 360	Modification—Changing Description (re-submitting with outcomes sheet)
NAME 491	Modification – Changing title from: Marine Engineering Laboratory ***to: Marine Engineering Laboratory I*** ;Changing Description; changing credit hours from: 4 ***to: 3***.
NAME 492	New Course
NERS 250	Modification – Changing Description
NERS 311	Modification – Changing Description; Changing Credit Hours from 4 ***to: 3***.
NERS 312	Modification – Changing Description; Changing Credit Hours from: 4 ***to: 3***.

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1812

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/21/2007
Effective Fall 2007

	A. CURRENT LISTING	B. REQUESTED LISTING
☐	Home Department: — Div #: — Course Number: —	Home Department: Civil and Environmental Engineering — Div #: 248 — Course Number: 230
	Cross Listed Course Information:	Cross Listed Course Information:
X	Course Title: Thermodynamics	Course Title: Energy and Environment
	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Thermodynamics; Transcript (Max = 20 Spaces): Thermodynamics	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Energy & Environment; Transcript (Max = 20 Spaces): Energy & Environment
X	Course Description: Engineering thermodynamics. First and second law applications for closed and open systems. Heat and refrigeration cycles. Physical properties of fluids and equations of state. Phase equilibria for pure fluids and fluid mixtures. Chemical reaction equilibria and aqueous-phase chemistry. Combustion processes. Vapor-liquid and solid-liquid equilibria.	Course Description for Official Publication (Max = 50 words): The laws of thermodynamics are presented and applied to energy technologies used for electric power generation, transportation, heating, and cooling. Physical properties of fuels and materials used in energy production are discussed. The environmental impacts, resource constraints, and economic factors governing conventional and alternative energy technologies are considered.
X	PROGRAM OUTCOMES: ☒ a ☐ b ☒ c ☐ d ☒ e ☐ f ☐ g ☐ h ☐ i ☐ j ☒ l	PROGRAM OUTCOMES: ☒ a ☐ b ☒ c ☐ d ☒ e ☐ f ☐ g ☒ h ☐ i ☒ j ☒ k
	Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective	Degree Requirements: ○ Degree Requirement ○ Tech Elective ◉ Core Course ○ Other ○ Free Elective
☐	Prerequisites: ○ Enforced ○ Advised	Prerequisites: Chem 125 & 130 or Chem 210 & 211; Math 116 ○ Enforced ◉ Advised
☐	Credit Restrictions:	Credit Restrictions:
X	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl — Credit Hours Min 4 Max 4 — Contact Hrs/Wk 4 — Number of Wks	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work — Credit Hours Min 3 Max 3 — Contact Hrs/Wk 3 — Number of Wks 14

C. Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional): ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

☐ Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___
Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other
Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y
Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☒ I ☒ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Christian Lastoskie — Title: Associate Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm. ___
- ☐ Faculty ___
- ☐ Rackham ___
- ☐ Cross listed Unit 1 ___
- ☐ Cross listed Unit 2 ___

Submitted By: ☐ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Roman D. Hryciw, Interim Chair & Professor
Cross-listed Dept(s). ___

Form Number

1812

SUPPORTING STATEMENT

The supply of energy to meet rapidly the rising demands of growing domestic and global populations is one of foremost challenges confronting scientists, engineers and policymakers. Accordingly, the civil engineering thermodynamics course is being modified to focus upon energy infrastructure, and the processes and technologies that are used for electric power generation, vehicular transportation, refrigeration, and heating and air conditioning of buildings. System design and analysis of process efficiency will be discussed in the context of the First and Second Laws of thermodynamics, and the physical properties of fuels and other materials that are used in energy production will be reviewed. The environmental impacts of energy consumption will be noted, and alternative energy technologies that reduce environmental emissions, or that supply energy in a more sustainable fashion, will be discussed and compared with conventional energy technologies in regard to economic factors and commitment of resources.

Presently, CEE 230 (Thermodynamics) is a four-credit course with four lecture contact hours. The modified three-credit CEE 230 course, renamed Energy and Environment, will have three lecture contact hours. A corresponding reduction in the scope of the CEE 230 course content will be accomplished by removing coverage of phase equilibria and chemical equilibria, which comprised approximately one-quarter of the four-credit CEE 230 course syllabus. There is sufficient coverage of these concepts in other CEE courses, namely CEE 260 and CEE 360, such that this content may be deleted from CEE 230. This will allow the new three-credit CEE 230 course to focus more exclusively upon applications of thermodynamics to engineering processes that produce and utilize energy in civil infrastructure systems

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

CEE 230: Energy and Environment
Fall 2007
Course Information

Instructor:	Prof. Christian M. Lastoskie, Dept. of Civil and Environmental Engineering 180 EWRE, (734) 647-7940, cmlasto@umich.edu	
Lectures:	MWF 11:30-12:30	@ 1024 FXB
Office Hours:	W 12:30-1:30 F 4:00-5:00	@ 180 EWRE
Course Text:	*Thermodynamics: an Engineering Approach*, 6[th] edition, by Y.A. Cengel and M.A. Boles (McGraw-Hill, 2008)	
Grading:	Midterm 1 (20%), Midterm 2 (20%), Final Exam (27%), Homework (33%)	

Objectives:

1. Formulate energy and entropy balances for the analysis of engineering process units in flow and nonflow systems. [a,e]

2. Apply knowledge of the physical properties and phase behavior of fluids to determine required heat and work inputs and outputs for engineering devices such as turbines, compressors, and heat exchangers. [a,c,e,k]

3. Perform design calculations for engineering processes used for power generation, refrigeration, engine combustion, heating, and air conditioning. [a,c,e,k]

4. Gain an awareness of the sources of energy that are used for heat, motive power and electricity, and the environmental impacts associated with consumption of these resources [h,j]

5. Develop an understanding of present and proposed energy production technologies, and the benefits and costs associated with these technologies [a,c,e,h,j].

Course Topics:

1. Energy Today: a Look at the U.S. and Global Energy Portfolio
2. Energy Transformations: the First Law of Thermodynamics
3. Fuels and Energy Transporters: the Physical Properties of Substances
4. Energy in Motion: Pistons, Turbines and Compressors
5. Energy Traders: Boilers, Condensers and Heat Exchangers
6. The Cost of Work: Thermodynamic Efficiency and the Second Law
7. When Waste Isn't Wasted: Entropy, Heat Engines and the Carnot Principle
8. The Need for Speed: Internal Combustion and Automotive Transportation
9. Power to the People: Thermoelectric and Hydroelectric Power Generation
10. Cool Runnings: Refrigeration and That Patched-Up Hole in the Ozone Layer
11. Creature Comforts: Heating, Air Conditioning, and Indoor Climate Control
12. Action Reaction: Synthetic Fuel Processing and Chemical Equilibrium
13. All Fuels are Not Created Equal: Renewable Energy and the Hydrogen Conundrum
14. Energy 2050: the Roadmap to a Sustainable Energy Infrastructure

CEE 230: Energy and Environment
Fall 2007
Lecture Syllabus

Week	Date	Topic	Assigned Reading
1	W 09/05	The U.S. and Global Energy Portfolio	C&B Chp. 1, p.1-17
	F 09/07	Heat, Motive Power, and Electricity	C&B Chp. 1, p.17-39
2	M 09/10	Energy Transformations	C&B Chp. 2, p.51-70
	W 09/12	The First Law	C&B Chp. 2, p. 70-86
	F 09/14	Wind Energy and Hydropower	C&B Chp. 2, p. 86-97
3	*M 09/17*	Energy Conveyers: Fuels and Fluids	C&B Chp. 15, p. 773-787
		Homework Set 1 due	
	W 09/19	Properties of Pure Substances	C&B Chp. 3, p. 111-126
	F 09/21	Property Tables & Equations of State	C&B Chp. 3, p. 126-139; p. 149-153
4	*M 09/24*	Energy in Motion: Piston Devices	C&B Chp. 4, p. 165-173
		Homework Set 2 due	
	W 09/26	Energy Balances for Closed Systems	C&B Chp. 4, p. 173-188
	F 09/28	Specific Heats and Latent Heats	C&B Chp. 4, p. 189-201
5	*M 10/01*	Energy Traders: Boilers & Condensers	C&B Chp. 5, p. 221-231
		Homework Set 3 due	
	W 10/03	Energy Balances for Open Systems	C&B Chp. 5, p. 232-240
	F 10/05	Turbines, Pumps and Mixers	C&B Chp. 5, p. 241-248
6	*M 10/08*	Heat Engines and Thermal Efficiency	C&B Chp. 6, p. 283-303
		Homework Set 4 due	
	W 10/10	The Carnot Cycle	C&B Chp. 6, p. 303-307; p. 309-319
	F 10/12	Review for Midterm 1	
7	M 10/15	FALL BREAK - NO LECTURE	
	W 10/17	**Midterm 1**	
	F 10/19	Waste Heat and Entropy	C&B Chp. 7, p. 337-349
8	*M 10/22*	Reversible Processes	C&B Chp. 7, p. 349-368
		Homework Set 5 due	
	W 10/24	Compression Work	C&B Chp. 7, p. 368-373; p. 397-406
	F 10/26	Isentropic Efficiency	C&B Chp. 7, p. 376-381; p. 383-396

Bold text denotes exam dates
Italics denote homework due dates

CEE 230: Energy and Environment
Fall 2007
Lecture Syllabus

Week	Date	Topic	Assigned Reading
9	*M 10/29*	Internal Combustion Engines	C&B Chp. 9, p. 497-509
		Homework Set 6 due	
	W 10/31	Otto and Diesel Cycles	C&B Chp. 9, p. 510-513
	F 11/02	Gas Turbines	C&B Chp. 9, p. 517-525; p. 540-548
10	M 11/05	Thermoelectric Power Generation	C&B Chp. 10, p. 565-578
	W 11/07	Feedwater Heating and Regeneration	C&B Chp. 10, p. 578-590
		Homework Set 7 due	
	F 11/09	Combined Gas-Vapor Cycles	C&B Chp. 10, p. 592-600
11	M 11/12	Review for Midterm 2	
	W 11/14	**Midterm 2**	
	F 11/16	Refrigeration Cycles	C&B Chp. 11, p. 623-634
12	M 11/19	Cascade Refrigeration	C&B Chp. 11, p. 634-642
	W 11/21	Absorption Refrigeration	C&B Chp. 11, p. 647-650
		Homework Set 8 due	
	F 11/23	THANKSGIVING - NO CLASS	
13	M 11/26	Gas Mixtures	C&B Chp. 13, p. 701-705; p. 710-713
	W 11/28	Humidity and Dew Points	C&B Chp. 14, p. 737-747
		Homework Set 9 due	
	F 11/30	Air Conditioning	C&B Chp. 14, p. 747-754
14	M 12/03	Evaporative Cooling	C&B Chp. 14, p. 754-760
	W 12/05	Reactive System Energy Balances	C&B Chp. 15, p. 787-792
		Homework Set 10 due	
	F 12/07	Reaction Equilibrium	C&B Chp. 16, p. 817-823
15	M 12/10	Coal Gasification and Integrated Cycles	C&B Chp. 16, p. 823-831
	W 12/12	Energy 2050: A Look Ahead	
		Homework Set 11 due	
	F 12/14	Review for Final Exam	
16	**W 12/19**	**Final Exam (10:30 a.m.-12:30 p.m.)**	

Bold text denotes exam dates
Italics denote homework due dates

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1562

Action Requested

- ○ New Course
- ⦿ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/21/2005
Effective Fall 2007

	A. CURRENT LISTING	B. REQUESTED LISTING
☐	Home Department / Div # / Course Number:	Home Department: Civil and Environmental Engineering; Div #: 248; Course Number: 431
	Cross Listed Course Information:	Cross Listed Course Information:
☐	Course Title:	Course Title: Construction Contracting
	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Constr Contracting
	TITLE ABBREVIATION — Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Transcript (Max = 20 Spaces): Constr Contracting
☐	Course Description:	Course Description for Official Publication (Max = 50 words): Construction contracting for engineers, contractors, architects, owners. (1) Organization and administration; industry structure; construction contracts, bonds, insurance, dispute resolution. (2) Planning, estimating, and control; quantity takeoff and pricing; labor and equipment estimates; estimating excavation and concrete; proposal preparation; scheduling; accounting and cost control. Students use contract documents to prepare detailed estimate.
	PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k	PROGRAM OUTCOMES: ☒ a ☒ b ☒ c ☒ d ☒ e ☒ f ☒ g ☒ h ☒ i ☒ j ☒ k
	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
X	Prerequisites: junior standing — ○ Enforced ⦿ Advised	Prerequisites: senior standing — ○ Enforced ⦿ Advised
☐	Credit Restrictions:	Credit Restrictions:
X	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl; Credit Hours Min 3, Max 3; Contact Hrs/Wk 3; Number of Wks 14	Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☒ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 4, Max 4; Contact Hrs/Wk 4; Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ○ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional) ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

X **Class Type(s)**: ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⦿ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ■ I ■ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Photios G. Ioannou — **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Roman D. Hryciw, Interim Chair and Professor
Cross-listed Dept(s).

Form Number

1562

SUPPORTING STATEMENT

CEE431 perhaps covers the most topics in the CEE undergraduate program and is the only course that contributes (maps) to every one of the 13 Program Outcomes of the CEE Curriculum.

Student evaluations indicate that they learn the material and most of them feel that they have achieved a strong level of mastery in every one of the course's 5 objectives. This comes at a price. Formal and informal feedback from students indicates that, given the amount of work in CEE431 relative to other courses, students should definitely earn 4 credit hours for the effort they put into the course. This should be taken into account for Fall 2005.

CEE431 includes a term-long project that has been taught as a lab. Traditionally, the material needed for the project has been interspersed with regular lectures in class as needed. Students have also indicated that they would prefer additional formal instruction time for the project. Making CEE431 a 4-hour course will allow us to dedicate 3 hours to lectures and have 1 hour of lab time for the project and other assignments.

From a resource standpoint, CEE431 has always had a GSI to handle the term project and help the students one-on-one in the Construction Lab where students spend many hours working without earning credit for the work. So, no additional resources will be needed.

Moreover, CEE431 is the only required Program Subjects course in the CEE Curriculum that is a 3-hour course. All other required Program Subjects courses are 4-hour courses. Making it a 4-hour course will achieve parity so that students will earn equal credit for equal work.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

B.S.E. (Civil Engineering) **Proposed Schedule starting Fall 2007**

	Credit Hours	Terms 1	2	3	4	5	6	7	8
Subjects required by all programs (55 hrs.)									
Mathematics 115, 116, 215, and 216	16	4	4	4	4	–	–	–	–
Engr 100, Intro to Engr	4	4	–	–	–	–	–	–	–
Engr 101, Intro to Computers +	4	–	4	–	–	–	–	–	–
Chemistry 125/126 and 130 or Chemistry 210 and 211[1]	5	5	–	–	–	–	–	–	–
Physics 140/141, Physics 240/241[2]	10	–	5	5	–	–	–	–	–
Humanities and Social Sciences *(includes one 3 or 4 credit economics course)*	16	4	4	–	–	4	–	–	4
Advanced Mathematics (8 hrs.)[3]									
CEE 270, Engr Probability and Statistics	4	–	–	–	4	–	–	–	–
CEE 303, Computational Methods	4	–	–	–	–	–	4	–	–
Technical Core Subjects (19 hrs.)[3]									
CEE 230, Energy and Environment	3	–	–	3	–	–	–	–	–
CEE 211, Statics and Dynamics	4	–	–	4	–	–	–	–	–
CEE 212, Solid and Structural Mechanics	4	–	–	–	4	–	–	–	–
CEE 260, Environmental & Sustainable Eng Principles	4	–	–	–	4	–	–	–	–
CEE 325, Fluid Mechanics	4	–	–	–	–	4	–	–	–
Program Subjects (28 hrs.)									
CEE 445, Engineering Properties of Soil	4	–	–	–	–	4	–	–	–
CEE 412, Structural Engineering	4	–	–	–	–	4	–	–	–
CEE 351, Civil Engineering Materials	4	–	–	–	–	–	4	–	–
CEE 360, Environmental Process Engineering	4	–	–	–	–	–	4	–	–
CEE 421, Hydrology and Hydraulics	4	–	–	–	–	–	–	4	–
CEE 431, Construction Contracting	4	–	–	–	–	–	–	4	–
CEE 402, Professional Issues & Design	4	–	–	–	–	–	–	–	4
Technical Electives (9 hrs.) [4]	9	–	–	–	–	–	–	6	3
Construction: CEE 534, 536, 537, 538 (any two) [5]									
Hydrology: CEE 526 and CEE 428, 521 or 590[5]									
Environmental: CEE 460 and CEE 581 or 582[5]									
Materials: CEE 547, CEE 554[5]									
Geotechnical: CEE 542, 545, 546[5] (any two)									
Structural: CEE 413, 415 and CEE 512[5]									
Unrestricted Electives (9 hrs.)	9	–	–	–	–	–	3	3	3
Total	128	17	17	16	16	16	15	17	14

Notes:

Candidates for the Bachelor of Science degree in Engineering (Civil Engineering) — B.S.E. (C.E.) — must complete the program listed above. This sample schedule is an example of one leading to graduation in eight terms.

[1]Chemistry: 125/126, 130 or 210, 211 will count for 5 total credits, 1 of which will be applied according to individual program directives.

[2]Physics: 140, 141; 240, 241 will count for 10 total credits, 2 of which will be applied according to individual program directives.

[3]CEE will accept equivalent courses offered by other departments in the College of Engineering.

[4]Students choose a focus area and take two technical electives in this focus area from the above list. The third technical elective may be taken in the same focus area (except for Materials). Alternatively, any course listed in another focus area may be selected as the third technical elective. For the Hydrology focus area, CEE 526 is required. For the Environmental focus area, CEE 460 is required. For the Structural focus area, CEE 413 and CEE 415 are required.

[5]The following CEE courses are 3 credit hours: all technical electives and CEE 230.

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1803

Action Requested

- ◯ New Course
- ◯ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/20/2007

Effective Fall 2007

A. CURRENT LISTING

Home Department	Div #	Course Number
Civil and Environmental Engineering	248	528

Cross Listed Course Information

ENSCEN	260	528

Course Title: Flow and Transport in Porous Media

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	Por Med Fl & Trans
	Transcript Max = 20 Spaces	Por Med Flow

Course Description
Basic principles governing flow and transport in porous media; development of mathematical models at pore and continuum levels; single and multiphase flow; solute transport and dispersion theory; parameter estimation; application to saturated and unsaturated groundwater flow, flow in fractured media, petroleum reservoirs, saltwater intrusion and miscible and immiscible subsurface contamination.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites CEE 428 or equivalent ◯ Enforced ◯ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☒ All Credit types ☐ Rckhm Grad w/add'l Worl

Credit Hours: Min 3, Max 3

Contact Hrs/Wk 3; Number of Wks 14

B. REQUESTED LISTING

Home Department	Div #	Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

Course Description for Official Publication (Max = 50 words)

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites ◯ Enforced ◯ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min, Max

Contact Hrs/Wk; Number of Wks

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ◯ Yes ⊙ No
Maximum Hours? Maximum Times?
Can it be repeated in the same term? ◯ Yes ◯ No

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ◯ Rec ◯ Sem ◯ Lab ◯ Dis ◯ Ind ◯ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Linda Abriola **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm.
☐ Faculty
☐ Rackham
☐ Cross listed Unit 1
☐ Cross listed Unit 2

Submitted By: ☒ Home Dept ☐ Cross-listed Dept.
Name, Signature & Department Roman D. Hryciw 2/26/07
Home Dept. Roman D. Hryciw, Interim Chair and Professor
Cross-listed Dept(s). Phillip Savage, Professor P. E. Savage

Form Number

1803

SUPPORTING STATEMENT

This course has been inactive for several years, and no offerings of the course are planned in the near future. Therefore, the course is being deleted from the CoE Bulletin.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number
1805

Action Requested

- ○ New Course
- ○ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/20/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department	Div #	Course Number
Civil and Environmental Engineering	248	585

Cross Listed Course Information

ENSCEN	260	585

Course Title
Solid Waste Management

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	Solid Waste Manage
	Transcript Max = 20 Spaces	Solid Wat Mn

Course Description
The study of methods for managing the solid wastes generated by urban communities, evaluating alternatives and design of disposal facilities. Methods for minimizing adverse effects on the human health and environment are included.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
- ☐ Undergrad only
- ☐ Rackham Grad
- ☐ Non-Rckhm Grad
- ☒ Ugrad or Rckhm Grad
- ☐ Ugrad or Non-Rckhm Grad
- ☐ All Credit types
- ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ___ Max ___
Contact Hrs/Wk ___
Number of Wks ___

B. REQUESTED LISTING

Home Department	Div #	Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

Course Description for Official Publication (Max = 50 words)

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
- ☐ Undergrad only
- ☐ Rackham Grad
- ☐ Non-Rckhm Grad
- ☐ Ugrad or Rckhm Grad
- ☐ Ugrad or Non-Rckhm Grad
- ☐ All Credit types
- ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ___ Max ___
Contact Hrs/Wk ___
Number of Wks ___

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional)
- ☐ Print the course in the Bulletin
- ☐ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☐ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III
Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Eugene A. Glysson Title Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm. ________
- ☐ Faculty ________
- ☐ Rackham ________
- ☐ Cross listed Unit 1 ________
- ☐ Cross listed Unit 2 ________

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department: Roman D. Hyrciw 2/26/07
Home Dept. Roman D. Hyrciw, Interim Chair and Professor
Cross-listed Dept(s). Phillip Savage PESavage

Form Number

1805

SUPPORTING STATEMENT

This course has been inactive for several years, and no offerings of the course are planned in the near future. Therefore, the course is being deleted from the CoE Bulletin.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1807

Action Requested

- ○ New Course
- ○ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/20/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department	Div #	Course Number
Civil and Environmental Engineering	248	625

Cross Listed Course Information

SNRE	711	625

Course Title: Geostatistical Modeling of Uncertainty

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	Geostat Modeling
	Transcript Max = 20 Spaces	Geostat Modeling

Course Description
Risk assessment: parametric and non-parametric approaches. Optimal estimates. Decision making in the face of uncertainty. Classification of categorical attributes. Stochastic spatial simulation: continuous and categorical environmental attributes. Propagation of uncertainty. Soil and water pollution data will be analyzed using geostatistical software.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ◉ Free Elective

Prerequisites CEE 570 ○ Enforced ◉ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only
☒ Rackham Grad
☒ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad
☐ All Credit types
☐ Rckhm Grad w/add'l Work

Credit Hours: Min 3 Max 3
Contact Hrs/Wk 3
Number of Wks 14

B. REQUESTED LISTING

Home Department	Div #	Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

Course Description for Official Publication (Max = 50 words)

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites ○ Enforced ○ Advised

Credit Restrictions

Level of Credit
☐ Undergrad only
☒ Rackham Grad
☒ Non-Rckhm Grad
☐ Ugrad or Rckhm Grad
☐ Ugrad or Non-Rckhm Grad
☐ All Credit types
☐ Rckhm Grad w/add'l Work

Credit Hours: Min Max
Contact Hrs/Wk
Number of Wks

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? Maximum Times?
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s): ☐ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other

Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☐ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III
Half term ☐ 1st ☐ 2nd
☐ Yearly ☒ Alter Years ☒ Even Years ☐ Odd Years

Cognizant Faculty Member: Pierre Goovaerts **Title** Assistant Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm.
☐ Faculty
☐ Rackham
☐ Cross listed Unit 1
☐ Cross listed Unit 2

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department: Roman D. Hryciw 2/26/07
Home Dept. Roman D. Hryciw, Interim Chair and Professor
Cross-listed Dept(s). James Diana

Form Number

1807

SUPPORTING STATEMENT

This course has been inactive for several years, and no offerings of the course are planned in the near future. Therefore, the course is being deleted from the CoE Bulletin.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1808

Action Requested

- ○ New Course
- ○ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/20/2007

Effective Fall 2007

A. CURRENT LISTING

Home Department	Div #	Course Number
Civil and Environmental Engineering	248	628

Cross Listed Course Information

Course Title: Numerical Modeling of Subsurface Flow

TITLE ABBREVIATION		
Time Sched Max = 19 Spaces	Num Mod Subs Flow	
Transcript Max = 20 Spaces	Num Mod Subs	

Course Description
Application of numerical solution methods, including finite differences, finite elements, boundary elements, and method of characteristics to various subsurface flow problems: saturated isothermal flow, solute transport, multiphase flow, geothermal reservoirs, use and modification of existing models in addition to new code development.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ◉ Free Elective

Prerequisites: CEE 528 or CEE 593 and Math 471
○ Enforced ◉ Advised

Credit Restrictions

Level of Credit
- ☐ Undergrad only
- ☒ Rackham Grad
- ☒ Non-Rckhm Grad
- ☐ Ugrad or Rckhm Grad
- ☐ Ugrad or Non-Rckhm Grad
- ☐ All Credit types
- ☐ Rckhm Grad w/add'l Worl

Credit Hours: Min 3, Max 3
Contact Hrs/Wk: 3
Number of Wks: 14

B. REQUESTED LISTING

Home Department	Div #	Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION	
Time Sched Max = 19 Spaces	
Transcript Max = 20 Spaces	

Course Description for Official Publication (Max = 50 words)

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites
○ Enforced ○ Advised

Credit Restrictions

Level of Credit
- ☐ Undergrad only
- ☐ Rackham Grad
- ☐ Non-Rckhm Grad
- ☐ Ugrad or Rckhm Grad
- ☐ Ugrad or Non-Rckhm Grad
- ☐ All Credit types
- ☐ Rckhm Grad w/add'l Work

Credit Hours: Min, Max
Contact Hrs/Wk
Number of Wks

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? Maximum Times?
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☒ I ☐ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Linda Abriola — **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department: Roman D. Hryciw 2/26/07
Home Dept. Roman D. Hryciw, Interim Chair and Professor
Cross-listed Dept(s).

Form Number

1808

SUPPORTING STATEMENT

This course has been inactive for several years, and no offerings of the course are planned in the near future. Therefore, the course is being deleted from the CoE Bulletin.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1801

Action Requested

- (●) New Course
- ( ) Modification of Existing Course
- ( ) Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/16/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department	
Div #	
Course Number	
Cross Listed Course Information	
Course Title	
TITLE ABBREVIATION – Time Sched (Max = 19 Spaces)	
TITLE ABBREVIATION – Transcript (Max = 20 Spaces)	
Course Description	

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl

Credit Hours: Min ___ Max ___

Contact Hrs/Wk ___ Number of Wks ___

B. REQUESTED LISTING

Home Department	Civil and Environmental Engineering
Div #	248
Course Number	638
Cross Listed Course Information	
Course Title	Sensing for Civil Infrastructure Development
TITLE ABBREVIATION – Time Sched (Max = 19 Spaces)	Infrastruct Sensing
TITLE ABBREVIATION – Transcript (Max = 20 Spaces)	Infrastruct Sensing

Course Description for Official Publication (Max = 50 words)

Civil infrastructure sensors for spatial data acquisition and analysis. Introduction to multi-dimensional signal processing for pattern recognition in sensor data with a focus on constructions materials, personnel and equipment. Segmentation, clustering, and filtering techniques. 3D reconstruction of civil infrastructure elements. Defects detection and system health monitoring.

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other (●) Free Elective

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit: ☐ Undergrad only ☒ Rackham Grad ☒ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 3 Max 3

Contact Hrs/Wk 3 Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes (●) No
Maximum Hours? Maximum Times?
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section: (●) Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Ioannis K. Brilakis **Title** Assistant Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ___
- ☐ Faculty ___
- ☐ Rackham ___
- ☐ Cross listed Unit 1 ___
- ☐ Cross listed Unit 2 ___

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department: Roman D. Hryciw 3/2/2007
Home Dept. Roman D. Hryciw, Interim Chair and Professor
Cross-listed Dept(s). ___

Form Number

1801

SUPPORTING STATEMENT

This graduate course is being created to teach CEE students the basics of Sensing for Civil Infrastructure development. The great research accomplishments in this area during the past decade and the increasing popularity of sensors and sensor networks in construction sites indicate that interested CEE graduate students should be introduced to this topic. The goal is to familiarize students with the existing on-site sensing technologies and explain the underlying mechanics. This includes introducing related sensing technology and its applications throughout the life-cycle of Civil Infrastructure development. This course was taught as a prototype in Winter 2005 and Winter 2006 and was well received by the students. (Q1 and Q2 scores = 4.25).

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

SYLLABUS
CEE 630: Directed Studies -
Visual Pattern Recognition in Civil Engineering

Instructor: Ioannis Brilakis
2356 G.G. Brown Building
Tel: 764-9420
Email: brilakis@umich.edu

Text: (Recommended)
* Handbook of Image and Video Processing (Hardcover) by Bovik, ISBN: 0-12-119790-5

* Computer Vision – A Modern Approach (Hardcover) by Forsyth and Ponce, ISBN: 0-13-085198-1

* Robot Vision (Hardcover) by Horn, ISBN: 0-26-208159-8

* Class notes will be provided when necessary.

Prerequisites: Permission of instructor. Recent programming experience in C++ or Java will be helpful. A willingness to spend long hours for the term projects.

Lectures: Tuesday, Thursday - 9:00 - 10:30 AM (classes start at 9:10)
1363 G.G. Brown Building

Office Hours: 10:30 – 11:50 (After class) and by appointment

Grading: In-class midterm and two projects in addition to multiple weekly assignments. The distribution is: Homework, 30%; Midterm, 20%; Project, 50%.

Objectives: An introduction to the basic principles of image and video processing required to crop and detect interesting patterns within the content of construction images, such as materials, shapes, objects, personnel and equipment. Development of specific advanced skills in rasterizing, clustering, filtering and other processing tools sufficient to design, implement and test large-scale visual pattern recognition and 3D building model generation tools in civil engineering. Introduction to construction site image content, material, and multi modal based indexing and retrieval, as well as motion segmentation, epipolar, trifocal and analytical Euclidean geometry at a level to understand the impact and applicability of such tools in civil engineering.

Course Outline:
1. Intro – Signal Processing for Images
1.1 Fourier analysis and transforms
1.2 Convolution
1.3 Wavelets

2. Basic vision: Single image
2.1 Building materials and shapes segmentation
2.2 Building materials and equipment recognition
2.3 Shape and object recognition
2.4 Personnel recognition
2.5 Building images indexing and retrieval

3. Mid-level vision: Multiple Images and Video
3.1 Equipment and personnel segmentation
3.2 Automated building model generation

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1809

Action Requested

- ○ New Course
- ○ Modification of Existing Course
- ◉ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/20/2007
Effective Fall 2007

A. CURRENT LISTING

Home Department	Civil and Environmental Engineering, Div # 248, Course Number 646
Cross Listed Course Information	ENSCEN 260 646
Course Title	Geophysical Techniques in Environmental Geotechnology
TITLE ABBREVIATION – Time Sched (Max = 19 Spaces)	Geophy Envir Geotec
TITLE ABBREVIATION – Transcript (Max = 20 Spaces)	Geophy Techns

Course Description
Introduction to geophysical techniques currently available for use in environmental geotechnology. Principles on which methods are based. Site characterization, pore fluid identification, buried object location by these non-intrusive, non-destructive tests. AI programming for selection of appropriate methods. Case studies in use of geophysical methods.

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Core Course ◉ Free Elective ○ Tech Elective ○ Other

Prerequisites: CEE 445 ○ Enforced ◉ Advised

Credit Restrictions:

Level of Credit: ☐ Undergrad only ☒ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 3, Max 3

Contact Hrs/Wk: 3; Number of Wks: 14

B. REQUESTED LISTING

Home Department: Div #: Course Number:

Cross Listed Course Information:

Course Title:

TITLE ABBREVIATION – Time Sched (Max = 19 Spaces):
Transcript (Max = 20 Spaces):

Course Description for Official Publication (Max = 50 words):

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min Max
Contact Hrs/Wk: Number of Wks:

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? Maximum Times?
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____
Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other
Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y
Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional): ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III; Half term ☐ 1st ☐ 2nd
☐ Yearly ☒ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Richard Woods **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
☐ Curriculum Comm. ____
☐ Faculty ____
☐ Rackham ____
☐ Cross listed Unit 1 ____
☐ Cross listed Unit 2 ____

Submitted By: ☐ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Thomas W. Hayes 2/26/07
Cross-listed Dept(s). P E Savage

Form Number

1809

SUPPORTING STATEMENT

This course has been inactive for several years, and no offerings of the course are planned in the near future. Therefore, the course is being deleted for the CoE Bulletin.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1574

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/28/2007
Effective Fall 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department: / Div #: / Course Number:	Home Department: Mechanical Engineering / Div #: / Course Number: 350
Cross Listed Course Information:	Cross Listed Course Information:
Course Title:	Course Title: Design and Manufacturing II
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Des & Mfg II
Transcript (Max = 20 Spaces):	Transcript (Max = 20 Spaces): Des & Mfg II
[X] Course Description: Principles of mechanical design; synthesis and selection of machine components. Design project. Three hours of lecture and one lab.	Course Description for Official Publication (Max = 50 words): Principles of mechanical design and manufacturing. Analysis, synthesis and selection of mechanisms, machine components and associated manufacturing processes. Design projects. Three hour lecture and one two-hour lab.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	PROGRAM OUTCOMES: ☐a ☒b ☒c ☐d ☒e ☐f ☐g ☐h ☐i ☐j ☒k
Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	Degree Requirements: ○ Degree Requirement ○ Free Elective ○ Other ◉ Core Course ○ Tech Elective
Prerequisites: ○ Enforced ○ Advised	Prerequisites: ME211, ME240, ME250:P/A ME382 ○ Enforced ◉ Advised
Credit Restrictions:	Credit Restrictions:
Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min: Max: ; Contact Hrs/Wk: ; Number of Wks:	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min: 4 Max: 4; Contact Hrs/Wk: 4; Number of Wks: 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional) ☐ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ■ I ■ II ☐ IIIa ☐ IIIb ☐ III; Half term ☐ 1st ☐ 2nd
■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: D. Brei **Title** Assoc. Prof.

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm. ____
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Mechanical Engineering [signature]
Cross-listed Dept(s). ____

Form Number

1574

SUPPORTING STATEMENT

The course topics/objectives are being updated to reflect the new course structure.

Are any special resources or facilities required for this course? ☒ Yes ☐ No

Detail the Special requirements

machine shop

ME350 COURSE PROFILE

DEGREE PROGRAM: Mechanical Engineering

<table>
<tr><td>COURSE NUMBER: ME350</td><td>COURSE TITLE: Design and Manufacturing II</td></tr>
<tr><td>REQUIRED COURSE OR ELECTIVE COURSE: Required</td><td>TERMS OFFERED: Fall, Winter</td></tr>
<tr><td>TEXTBOOK / REQUIRED MATERIAL: Mechanical Engineering Design by Shigley & Mischke</td><td>PRE / CO-REQUISITES: ME 211: Introduction to Solid Mechanics, ME 240: Introduction to Dynamics and Vibrations, ME 250: Design and Manufacturing, preceded or accompanied by ME 382: Mechanical Behavior of Materials</td></tr>
<tr><td>COGNIZANT FACULTY: D. Brei</td><td rowspan="2">COURSE TOPICS:
1. Review of the design process and relevant design principles
2. Application of basic materials and mechanics to mechanical design
3. Analysis and synthesis with focus on selection methods for basic off-the-shelf mechanical components which may incude gears, bearings, springs, power screws, fasteners
4. Basic kinematic and kinetostatic analysis of mechanisms such as four bar linkages and cams
5. Selection and application of motors based upon predictive models and motor curves
6. Design of mechanical systems for given motion/power requirements
7. Analysis of load and power flow through transmission systems such as gears, linkages, cams
8. Preparation of engineering instructions (tolerance drawing and text) by selecting the appropriate materials and manufacturing processes based upon geometry, loading and tolerances
9. Build and assemble mechanical systems using standard machine shop tools (manual/CNC mill, lathe, drill and laser cutter)
10. Test and evaluate simple machine systems and components for performance and failure behavior using physical and virtual prototypes</td></tr>
<tr><td>BULLETIN DESCRIPTION: Principles of mechanical design and manufacturing. Analysis, synthesis and selection of mechanisms, machine components and associated manufacturing processes. Design projects. Three hour lecture and one two-hour lab.</td></tr>
<tr><td colspan="2">COURSE STRUCTURE/SCHEDULE: Lecture: 1 day per week at 2.0 hours</td></tr>
</table>

COURSE OBJECTIVES: for each course objective, links to the Program Outcomes are identified in brackets.	1. To teach students how to formulate the design and manufacturing problem for simple systems and mechanical components [3, 5] 2. To teach students how to apply the general mechanical engineering sciences in analyses specific to the design of mechanical components and systems [1, 2, 3, 5, 9, 11, 12] 3. To teach students in a laboratory setting how to generate concepts, conduct analyses to size components, construct and assemble a prototype of a system and test its function [1, 2, 3, 5, 11] 4. To reinforce students' team skills through team projects, including problem formulation, problem solution and written and oral reporting of results [4, 5, 7, 11] 5. To reinforce students' visualization and hands-on skills through project virtual prototyping and/or physical construction exercises [2, 4, 11]
COURSE OUTCOMES: for each course outcome, links to the Course Objectives are identified in brackets.	1. Given functional and manufacturing requirements, utilize concept generation methods within a team setting to achieve a consensus for a product concept [1, 3, 4] 2. Weigh tradeoffs in concept and detail design from the perspectives of function, manufacture, design effort and available resources [1, 3] 3. Apply basics of conservation and constitutive laws from the mechanical engineering sciences to understand the basic nature of a posed problem [2, 3] 4. Compile reference (catalog, handbook and textbook) resources to formulate an analysis for a specific mechanical component addressed within those resources [1, 2, 3] 5. Conduct failure analyses, including stiffness, static strength and fatigue strength, appropriate for sizing common components, such as belt drives, rolling contact bearings, gears, and shafts [1, 2, 3] 6. Make decisions regarding buy or build for individual components of a design [3] 7. Use basic machines and hand tools to manufacture a simple part from wood and/or metal to reasonable tolerances sufficient for the part's function [3, 5] 8. Formulate, in a team setting or independently, a test plan that encompasses all failure modes that may be present per the analyses conducted during the design stage [3, 4, 5] 9. Translate, in a team setting or independently, test results into redesigns that will eliminate catastrophic failures and/or improve on marginal performance [3, 4, 5]
ASSESSMENT TOOLS: for each assessment tool, links to the course outcomes are identified	1. Regular homework problems 2. One design project with report and built prototype 3. Optional additional design project with written and/or oral report 4. One in-class midterm exam or additional design project 5. One two-hour final exam or one final project

PREPARED BY: D. Brei
LAST UPDATED: March 16, 2007

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1575

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 2/28/2007
Effective Fall 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number:	Home Department: Mechanical Engineering / Div #: / Course Number: 360
Cross Listed Course Information:	Cross Listed Course Information:
Course Title:	Course Title: Modeling, Analysis and Control of Dynamic Systems
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): ; Transcript (Max = 20 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): ; Transcript (Max = 20 Spaces):
[X] Course Description: Unified approach to abstracting real mechanical, fluid, and electrical systems into proper models in graphical and state equation form to meet engineering design and control system objectives. Introduction to system analysis (eigenvalues, time and frequency response) and linear feeback control. Synthesis and analysis by analytical and computer methods. Four lectures per week.	Course Description for Official Publication (Max = 50 words): Developing mathematical models of dynamic systems, including mechanical, electrical, electromechanical, and fluid/thermal systems, and representing these models in transfer function and state space form. Analysis of dynamic system models, including time and frequency responses. Introduction to linear feedback control techniques. Synthesis and analysis by analytical and computer methods. Four hours of lecture per week.
PROGRAM OUTCOMES: ☐a ☐b ☐c ☐d ☐e ☐f ☐g ☐h ☐i ☐j ☐k	**PROGRAM OUTCOMES:** ☒a ☐b ☐c ☐d ☒e ☐f ☐g ☐h ☐i ☐j ☒k
Degree Requirements ○ Degree Requirement ○ Free Elective ○ Other ○ Core Course ○ Tech Elective	**Degree Requirements** ○ Degree Requirement ○ Free Elective ○ Other ◉ Core Course ○ Tech Elective
Prerequisites: ○ Enforced ○ Advised	Prerequisites: ME240 ○ Enforced ⊙ Advised
Credit Restrictions:	Credit Restrictions:
Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min: Max: ; Contact Hrs/Wk: ; Number of Wks:	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min: 4 Max: 4; Contact Hrs/Wk: 4; Number of Wks: 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional) ☒ Print the course in the Bulletin ☐ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ■ I ■ II ☐ IIIa ☐ IIIb ☐ III; ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years
Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: D.Tilbury **Title** Assoc Prof

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Mechanical Engineering
Cross-listed Dept(s).

Form Number

1575

SUPPORTING STATEMENT

Modification made to more accurately reflect the material taught in the course.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

ME360 COURSE PROFILE

DEGREE PROGRAM: Mechanical Engineering

COURSE NUMBER: ME360	**COURSE TITLE:** Modeling, Analysis and Control of Dynamic Systems
REQUIRED COURSE OR ELECTIVE COURSE: Required	**TERMS OFFERED:** Fall, Winter
TEXTBOOK / REQUIRED MATERIAL: Dynamic Modeling & Control of Engineering Systems by Shearer, Kulakowski and Gardner	**PRE / CO-REQUISITES:** ME 240: Introduction to Dynamics and Vibrations
COGNIZANT FACULTY: D. Tilbury **BULLETIN DESCRIPTION:** Developing mathematical models of dynamic systems, including mechanical, electrical, electromechanical, and fluid/thermal systems, and representing these models in transfer function and state space form. Analysis of dynamic system models, including time and frequency responses. Introduction to linear feedback control techniques. Synthesis and analysis by analytical and computer methods. Four hours of lecture per week.	**COURSE TOPICS:** 1. MODELING: Mechanical, Electrical, Hydraulic and mixed-domain systems (e.g. DC Motors) / 7 lectures 2. MODELING: State space system equations; Numerical integration / 2 lectures 3. ANALYSIS: Linearity (superposition) and linearization / 1 lecture 4. ANALYSIS: Laplace transforms and transfer functions; block diagrams / 3 lectures 5. ANALYSIS: Free and forced responses (impulse, step) of first and second order LTI systems / 3 lectures 6. ANALYSIS: Frequency response; Bode plots / 4 lectures 7. CONTROL: System performance measures in the time and frequency domains: time constant, natural frequency, damping ratio, steady-state behavior / 2 lectures 8. CONTROL: Feedback control: P, PI, PD control; reference tracking and disturbance rejection / 4 lectures 9. Mixed domain systems 10. Introduction to feedback control
COURSE STRUCTURE/SCHEDULE: Lecture: 2 days per week at 2 hours	

COURSE OBJECTIVES: **for each course objective, links to the Program Outcomes are identified in brackets.**	1. To teach students elementary tools of modeling of mechanical, electrical, fluid, and thermofluid systems [1, 5, 11] 2. To teach a basic understanding of behavior of first- and second-order linear time-invariant differential equations [1, 12, 13] 3. To teach basic concepts of Laplace transforms, transfer functions, and frequency response analysis [12] 4. To introduce the concept of stability and the use of feedback control to actively control system behavior [1, 3, 5] 5. To provide examples of real-world systems to which modeling and analysis tools are applied (e.g., DC Motor) for the purpose of design [11] 6. To introduce an appreciation for decision-making skills needed to devise models that adequately represent relevant behaviors yet remain simple [1, 5] 7. To teach basic concepts in numerical integration and computer simulation of mathematical models
COURSE OUTCOMES: **for each course outcome, links to the Course Objectives are identified in brackets.**	1. Given a description of a real-world system, make educated decisions about how to model it in terms of idealized, lumped elements [1, 5, 6, 7] 2. Given a simple system containing some combination of mechanical, electrical, and/or thermofluid elements, write a differential equation describing its input/output behavior [1] 3. Given a first- or second-order LTI differential equation, predict its step response or free response [2] 4. Given a LTI differential equation and a sinusoidal input, predict the gain and phase of the steady-state output as a function of input frequency [3] 5. Given certain desired performance characteristics for a system (such as maximum overshoot due to a step input), translate specifications into design parameters (such as the dimensions of a coil spring) necessary to provide those characteristics [4, 5, 7] 6. Given a physical description of a system and a graphical representation of its time-domain response (step, frequency, etc.), estimate system parameters (i.e. friction or damping coefficient, spring constant) [3, 4, 5] 7. Given a LTI differential equation and an arbitrary input composed of steps, ramps, and other simple functions, set up the solution using Laplace transforms [3] 8. Describe basic applications of proportional, integral, and derivative feedback in control systems to improve performance or stability [4] 9. Given a system composed of mixed mechanical/electrical/thermofluid components, write the transfer function describing input-output behavior [1, 3] 10. Given a system with given performance, describe (qualitatively) how behavior can be improved according to specifications such as overshoot and settling time, using some combination of parameter tuning and feedback control [2, 4, 5, 7] 11. Describe how changes in parameter values will affect damping ratio and natural frequency for a system, and how these characteristics are manifested in the system's behavior [2, 3, 7] 12. Implement a mathematical model into commercial simulation software, and exercise the model to make engineering assessments [2, 5, 6, 7]
ASSESSMENT TOOLS: **for each assessment tool, links to the course outcomes are identified**	1. Regular homework problems 2. Exams

PREPARED BY: D. Tilbury
LAST UPDATED: March 16, 2007

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1795

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 1/26/2007

Effective Fall 2007

A. CURRENT LISTING	B. REQUESTED LISTING
Home Department / Div # / Course Number:	Home Department: Naval Architecture and Marine Engineering; Div # 284; Course Number 491
Cross Listed Course Information:	Cross Listed Course Information:
[X] Course Title: Marine Engineering Laboratory	Course Title: Marine Engineering Laboratory I
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Marine Engin Lab	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Marine Engin Lab I
Transcript (Max = 20 Spaces): Marine Engin Lab	Transcript (Max = 20 Spaces): Marine Engin Lab I
[X] Course Description: Instruction in laboratory techniques and instrumentation. Use of computers in data analysis. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.	Course Description for Official Publication (Max = 50 words): Instruction in laboratory techniques and instrumentation. Use of computers in data analysis and understanding the fast Fourier transform and frequency domain. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.
PROGRAM OUTCOMES: ☒ a ☒ b ☒ c ☒ d ☒ e ☐ f ☒ g ☐ h ☒ i ☐ j ☒ l	PROGRAM OUTCOMES: ☒ a ☒ b ☐ c ☐ d ☒ e ☐ f ☒ g ☐ h ☒ i ☐ j ☒ k
Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective	Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective
Prerequisites: ○ Enforced ⊙ Advised	Prerequisites: NA 310, NA 320, NA 321, NA 331, NA 332, NA 340 ○ Enforced ⊙ Advised
Credit Restrictions:	Credit Restrictions:
[X] Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work
Credit Hours: Min 4, Max 4; Contact Hrs/Wk 5.5; Number of Wks 14	Credit Hours: Min 3, Max 3; Contact Hrs/Wk 4.5; Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ■ I ☐ II ☐ IIIa ☐ IIIb ☐ III — ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: Marc Perlin **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ____
- ☐ Faculty ____
- ☐ Rackham ____
- ☐ Cross listed Unit 1 ____
- ☐ Cross listed Unit 2 ____

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. Dale G. Karr [signature] NA&ME
Cross-listed Dept(s). ____

Form Number

1795

SUPPORTING STATEMENT

The existing NA491 at four credits is to be replaced in the curriculum with NA491 at three credits and NA492 at two credits.

NA 491 currently includes 10 laboratory sessions, offered in the fall semester. The workload for the course has been considered too high for four credits. A review of the course content by the student advisory board and the faculty concluded that the 10 laboratories should remain in the curriculum and that, accordingly, the total credits should be five rather than four credits. Major senior design projects are required in NA470 (fall semester) and NA475 (winter semester). To maintain high standards in the laboratory requirements and to more evenly distribute course demands over the senior year, a two course sequence for the Marine Engineering Laboratory is proposed. Of the existing ten laboratories, six will remain in NA491, four will be in NA492.

NA 491 Marine Engineering Laboratory I is to be modified from four credits to three credits and offered in the fall semester. This change will be accomnpanied by a new required 2 credit course, NA492.

Are any special resources or facilities required for this course? ☒ Yes ☐ No

Detail the Special requirements

Use of Marine Hydrodynamics Laboratory in West Hall.

Course Title:	NA 491 Marine Engineering Laboratory
Course Function:	Required course; fourth year; laboratory experience
Cognizant Faculty:	Marc Perlin
Credit Hours:	3 credits
Schedule:	Fall Semester
Pre/corequisites:	Prerequisites NA 310, NA 320, NA 321, NA 331, NA 332, NA 340
Short Description:	Instruction in laboratory techniques and instrumentation. Use of computers in data analysis that includes Fast Fourier transforms. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.
Texts:	Course pack: <u>Marine Engineering Laboratory Manual</u> Dally, *Instrumentation for Engineering Measurements* Lewis, *Principles of Naval Architecture Vol. II*

Outline and Time Allocation

Week	Lecture Topic (2 x 1.5 hr.)		Laboratory (1 x 2.0 hr.)	Report	hours
I.	Orientation and Introduction		N/A		1.5+0
II.		1	Transducers & Signal Processing	Informal	3+2
III.		2	Column Buckling	Informal	3+2
IV.	Technical Communications Introduction to Test Reports & Individual Sessions				3
V.					
VI.		3	Beam Bending and Vibration	Informal - Group	3+2
VII.	Technical Communications				3
VIII		4	Pump System Performance	Informal	3+2
IX.					
X.		5	Foil Lift and Boundary-Layer Separation	Informal - Group	3+2
XI.					
XII.		6	Planing Boat Hydrodynamics	Informal - Group	3+2
XIII.					
	Total:			25.5 lecture + 12 lab	

ABET Categories:	Engineering Science 2.5; Engineering Design 0; Other 0.5
Threads Served:	Written and Oral Communications; Teams, Teamwork and Team Leadership; Dealing with Uncertainty and Error. Understanding the frequency domain.
Computing:	Use of WORD and EXCEL required; graphing packages strongly encouraged.

COURSE PROFILE

Degree Program: Naval Architecture and Marine Engineering **Last Revision Date: 1/9/2007**

Prepared by: Marc Perlin

COURSE #: NA 491 **3 credits**	**COURSE TITLE:** Marine Engineering Laboratory
TERMS OFFERED: Fall	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: Dally, *Instrumentation for Engineering Measurements*. Lewis, *Principles of Naval Architecture Vol. II.* Course pack: Marine Engineering Laboratory Manual	**PREREQUISITES:** **A** NA 310, **A** NA 320, **A** NA 321, **A** NA 331, **A** NA 332, **A** NA 340
INSTRUCTOR(S): Perlin	**COGNIZANT FACULTY: Perlin**
CoE BULLETIN DESCRIPTION: Instruction in laboratory techniques and instrumentation. Use of computers in data analysis and understanding the fast Fourier transform and frequency domain. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.	**COURSE TOPICS:** 1. Transducers, data acquisition, & signal processing 2. Column buckling 3. Introduction to writing reports on experiments 4. Beam bending and vibration 5. Pump system performance 6. Foil lift, drag, and boundary-layer separation 7. Planing boat dynamics
COURSE STRUCTURE/SCHEDULE: One 3-hr lecture per week, and 6 2-hour labs	

COURSE OBJECTIVES	1. Familiarize students with standard industry practices 2. Extract information for engineering analysis from measured data 3. Develop an understanding of the importance of statistics and error bars 4. Develop written communication skills 5. Exercise skills learned in sophomore and junior level NA&ME classes 6. Frequency domain understanding and application 7. Introduction to NONLINEAR least squares analysis and reinforcement of linear least squares analysis

COURSE OUTCOMES For each course outcome, the following links are identified: •links to **course objectives** in square brackets [ ]; •links to **program educational outcomes** in parentheses ( ); •links to **ABET criteria** (a-k) in curly brackets { }.	1. Learn and perform model extrapolation techniques [Course Obj.: 1-7], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,c,e,i} 2. Verify Newton's law from measured data [Course Obj.: 2-6], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,i} 3. Verify Moody diagram from measure data [Course Obj.: 2-5], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,i} 4. Verify 2-D linear foil theory from measured data [Course Obj.: 2-5], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,i} 5. Apply Gaussian statistics [Course Obj.: 2-5], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,e,i} 6. Apply variance from multiple measurements [Course Obj.: 2-5], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,e,i} 7. Understand and produce error estimates [Course Obj.: 2-4], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,e,i} 8. Identify three kinds of errors and learn to quantify them [Course Obj.: 2-4], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,e,i} 9. Write short memorandum style report [Course Obj.: 4), (Program Educ. Out.: V,VI,VII,X), {ABET Crit.: g,i} 10. Write long formal reports [Course Obj.: 4], (Program Educ. Out.: V,VI,VII,X), {ABET Crit.: g,i} 11. Use summaries, tables, and graphs effectively [Course Obj.: 2-7], (Program Educ. Out.: V,VI,VII,X), {ABET Crit.: g,i} 12. Use computer programs for word processing and Excel spreadsheets for data processing [Course Obj.: 1-7], (Program Educ. Out.: V,VI,VII,X), {ABET Crit.: g,i} 13. Illustrate basic rational mechanics concepts taught in NA 310, 320, 321, 330, 340 [Course Obj.: 2-7], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,c,e,i,k} 14. Exercise computational skills learned in NA 310, 320, 321, 332, 340 [Course Obj.: 2-7], (Program Educ Out. I-IV,IX,XII-XIV), {ABET Crit.: a,b,c,e,i,k} 15. Use analytical skills developed in NA 310, 320, 321, 332, 340 including Fourier analysis [Course Obj.: 2-7], (Program Educ. Out.: I-IV,IX,XII-XIV), {ABET Crit.: a,b,c,e,i,k}
ASSESSMENT TOOLS For each assessment tool, links to the course outcomes are identified.	1. Lab exercises are used to develop skills described in outcomes 1-15. 2. Lab and lab reports measure outcomes 1-15. 3. Course evaluation by each student at the end of the course, used for assessing all outcomes 1-15 of the course.

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1796

Action Requested

- (●) New Course
- ( ) Modification of Existing Course
- ( ) Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 1/26/2007

Effective Winter 2008

A. CURRENT LISTING

Home Department	Div #	Course Number

Cross Listed Course Information:

Course Title:

TITLE ABBREVIATION	
Time Sched Max = 19 Spaces	
Transcript Max = 20 Spaces	

Course Description:

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions:

Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ___ Max ___

Contact Hrs/Wk ___ Number of Wks ___

B. REQUESTED LISTING

Home Department	Div #	Course Number
Naval Architecture and Marine Engineering	284	492

Cross Listed Course Information:

Course Title: Marine Engineering Laboratory II

TITLE ABBREVIATION	
Time Sched Max = 19 Spaces	Marine Engin Lab II
Transcript Max = 20 Spaces	Marine Engin Lab II

Course Description for Official Publication (Max = 50 words):
Instruction in laboratory techniques and instrumentation. Use of computers in data analysis and understanding the fast Fourier transform and frequency domain. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale. Use of the frequency domain.

PROGRAM OUTCOMES:
☒ a ☒ b ☒ c ☐ d ☒ e ☐ f ☒ g ☐ h ☒ i ☐ j ☒ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: NA 310, NA 320, NA 321, NA 331, NA 332, NA 340, NA 491
○ Enforced ⊙ Advised

Credit Restrictions:

Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 2 Max 2

Contact Hrs/Wk 3 Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ○ No

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☒ Lab ☐ Dis ☐ Ind ☐ Other ___

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Terms & Freq. of Offering: ☐ I ■ II ☐ IIIa ☐ IIIb ☐ III — ■ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: Marc Perlin **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ___
- ☐ Faculty ___
- ☐ Rackham ___
- ☐ Cross listed Unit 1 ___
- ☐ Cross listed Unit 2 ___

Submitted By: ■ Home Dept. ☐ Cross-listed Dept.

Name, Signature & Department

Home Dept. Dale G. Karr *Dale G Karr* NA&ME

Cross-listed Dept(s). ___

Form Number

1796

SUPPORTING STATEMENT

The existing NA491 at 4 credits is to be replaced in the curriculum with NA491 at 3 credits and NA492 at 2 credits.

NA 491 currently includes 10 laboratory sessions, offered in the fall semester. The workload for the course has been considered quite high for 4 credits. A review of the course content by the student advisory board and the faculty concluded that the 10 laboratories should remain in the curriculum and that, accordingly the total credits should be five rather than four credits. Major senior design projects are required in NA470 (fall semester) and NA475 (winter semester). To maintain high standards in the laboratory requirements and to more evenly distribute course demands over the senior year, a two course sequence for the Marine Engineering Laboratory is proposed. Of the existing ten laboratories, six will remain in NA491, four will be in NA492.

NA 492 Marine Engineering Laboratory II will be offered as a new 2 credit course to be offered in the winter semester. This change will be accomnpanied by a revised 3 credit course, NA491.

Are any special resources or facilities required for this course? ☒ Yes ☐ No

Detail the Special requirements

Use of Marine Hydrodynamics Laboratory in West Hall

Course Title:	NA 492 Marine Engineering Laboratory
Course Function:	Required course; fourth year; laboratory experience
Cognizant Faculty:	Marc Perlin
Credit Hours:	2 credits
Schedule:	Winter Semester
Pre/corequisites:	Prerequisites NA 310, NA 320, NA 321, NA 331, NA 332, NA 340, NA 491
Short Description:	Instruction in laboratory techniques and instrumentation. Use of computers in data analysis that includes Fast Fourier transforms. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.
Texts:	Course pack: Marine Engineering Laboratory Manual Dally, *Instrumentation for Engineering Measurements* Lewis, *Principles of Naval Architecture Vol. II*

Outline and Time Allocation

Week	Lecture Topic (2 x 1.5 hr.)		Laboratory (1 x 2.0 hr.)	Report	hours
I.	Orientation and Introduction		N/A		1.5+0
II.	Technical Communications Introduction to Test Reports & Individual Sessions				3
III.		1	Effective Power	Formal	3+2
IV.					
V.		2	Sectional Added Mass & Damping	Informal	3+2
VI.					
VII.		3	Open-Water Propeller Test	Formal	3+2
VIII					
IX.		4	Delivered Power Test	Formal - Group	3+2
X.					
XI.					
XII.					
XIII.					
	Total:			16.5 lecture +8 lab	

ABET Categories:	Engineering Science 1.5; Engineering Design 0; Other 0.5
Threads Served:	Written and Oral Communications; Teams, Teamwork and Team Leadership; Dealing with Uncertainty and Error. Understanding the frequency domain.
Computing:	Use of WORD and EXCEL required; graphing packages strongly encouraged.

COURSE PROFILE

Degree Program: Naval Architecture and Marine Engineering **Last Revision Date: 1/9/2007**

Prepared by: Marc Perlin

COURSE #: NA 492 **2 credits**	**COURSE TITLE:** Marine Engineering Laboratory II
TERMS OFFERED: Winter	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: Dally, ***Instrumentation for Engineering Measurements.*** **Lewis,** ***Principles of Naval Architecture Vol. II.*** **Course pack: Marine Engineering Laboratory Manual**	**PREREQUISITES:** **A** NA 310, **A** NA 320, **A** NA 321, **A** NA 331, **A** NA 332, **A** NA 340, **A** NA 491
INSTRUCTOR(S): Perlin	**COGNIZANT FACULTY: Perlin**
CoE BULLETIN DESCRIPTION: Instruction in laboratory techniques and instrumentation. Use of computers in data analysis and understanding the fast Fourier transform and frequency domain. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale. Use of the frequency domain.	**COURSE TOPICS:** 1. Effective power test 2. Sectional added mass and damping 3. Open water propeller test 4. Delivered power test
COURSE STRUCTURE/SCHEDULE: 1 2-hr lecture per week; 4 2-hour labs	

COURSE OBJECTIVES	1. Familiarize students with standard industry practices 2. Extract information for engineering analysis from measured data 3. Develop an understanding of the importance of statistics and error bars 4. Develop written communication skills 5. Exercise skills learned in sophomore and junior level NA&ME classes 6. Frequency domain understanding and application

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1814

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/6/2007
Effective Winter 2008

A. CURRENT LISTING

Home Department | Div # | Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION: Time Sched Max = 19 Spaces; Transcript Max = 20 Spaces

☒ Course Description
Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle. Additional topics and guest lectures.

PROGRAM OUTCOMES:
☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions

Level of Credit: ☐ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min ___ Max ___
Contact Hrs/Wk ___
Number of Wks ___

B. REQUESTED LISTING

Home Department	Div #	Course Number
NERS	288	250

Cross Listed Course Information

Course Title
Fundamentals of Nuclear Engineering and Radiological Sciences

TITLE ABBREVIATION	
Time Sched Max = 19 Spaces	Fund Nuc Eng/Rad Sci
Transcript Max = 20 Spaces	Fund Nuc Eng/Rad Sci

Course Description for Official Publication (Max = 50 words)
Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Special relativity, basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.

PROGRAM OUTCOMES:
☒ a ☐ b ☐ c ☐ d ☒ e ☐ f ☒ g ☒ h ☐ i ☒ j ☐ k

Degree Requirements: ◉ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: preceded or accompanied by Math 216 and Physics 240
○ Enforced ◉ Advised

Credit Restrictions

Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 4 Max 4
Contact Hrs/Wk 4
Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? ___ Maximum Times? ___
Can it be repeated in the same term? ○ Yes ◉ No

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ___
Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other
Grading: ☐ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y
Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III
Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: James Holloway
Title: Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm. ______
- ☐ Faculty ______
- ☐ Rackham ______
- ☐ Cross listed Unit 1 ______
- ☐ Cross listed Unit 2 ______

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. [signature]
Cross-listed Dept(s). ______

Form Number

1814

SUPPORTING STATEMENT

Modifications are required to accommodate NERS program changes. A more formal introduction to special relativity is introduced (move from NERS 311) to replace what used to be a brief introduction. time to achieve this is gained by eliminating the expectation of guest lectures. Teaching special relativity at the sophomore level is not unusual in physics curricula and can be done with algebra and calculus, so formalizing this content will introduce no learning difficulty for the student.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

COURSE PROFILE

Degree Program: **Nuclear Engineering and Radiological Sciences** **Date:** **March, 2007**

Prepared by: **James P. Holloway**

COURSE #: NERS 250	**COURSE TITLE:** Fundamentals of Nuclear Engineering and Radiological Sciences
TERMS OFFERED: Winter	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: J. Kenneth Shultis & Richard E. Faw, *Fundamentals of Nuclear Science and Engineering* Dekker, 2002	**PREREQUISITES:** Preceded or accompanied by Math 216 and Phys 240 (A)
INSTRUCTOR(S): Wehe	**COGNIZANT FACULTY: Holloway**
CoE BULLETIN DESCRIPTION: Technological, industrial and medical applications of radiation, radioactive materials and fundamental particles. Basic nuclear physics, interactions of radiation with matter. Fission reactors and the fuel cycle.	**COURSE TOPICS:** Modern physics concepts, Atomic & Nuclear Models, Nuclear Energetics, Radioactivity, Nuclear Reactions, Radiation Interactions with Matter, Radiation Dose and Hazards, Nuclear Reactors & Nuclear Power, Medical Applications of Nuclear Technology
COURSE STRUCTURE/SCHEDULE Lecture: 2 per week @ 80 minutes; Discussion: 1 per week @ 50minutes	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1. To teach students fundamental physics that applies to a broad range of nuclear technology [1] 2. To begin to introduce students to the analytical methods used in nuclear engineering and radiological science [1,2,3] 3. To introduce students to environmental impacts of nuclear technology, and the physical and biological effects of ionizing radiation [8,9] 4. To expose students to engineering applications career opportunities in nuclear engineering and radiological sciences [12] 5. To introduce students to nuclear engineering and radiological sciences and their impact on contemporary societal issues [9,10,11,12] 6. To provide practice in technical communication [7]
COURSE OUTCOMES For <u>each</u> course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1. Derive relativistic transformations of length, time, velocity and momentum (Lorentz transformations), expression for relativistic energy. Derive the relativistic Doppler effect. Use these to solve problems. Explain apparent twin paradox. [1,2] 2. Derive the Compton scattering formula from conservation of energy and momentum, describe annihilation and pair production, and describe the photoelectric effect. [1,2] 3. Understand basic nomenclature of nuclear physics, including how to find information on the Chart of the Nuclides, X(a,b)Y reaction notation, and will compute Q values for given reactions. [1,2] 4. Compute decay constants from half-life and vice versa. Solve decay equation, decay with production, and solve the Bateman equations for decay chains. [1,2,4] 5. Describe the natural decay chains and environmental radiation. [3] 6. Define basic nuclear terminology and describe the breadth of current and potential nuclear applications, including fission power, medical diagnostic systems and cancer treatment, and industrial and medical uses of radionuclides. [4,5] 7. Define the concept of cross-section, and define the concept of probability of interaction per unit path length (macroscopic cross section). Compute macroscopic cross-section of mixtures. [1,2] 8. Define scalar flux as path-length rate density. Compute scalar flux in vacuum and pure absorbers. [1,2] 9. Describe the fundamentals of sustained neutron chain reactions, fission reactor design, and fission products. Derive the 4-factor formula from basic balance arguments; explain the importance of fuel lumping in fission reactors. Define and describe BSR and PWR and enumerate the basic systems of each reactor type. Describe potential advanced reactor types, including VHTR. [1,2,4,5]

	10. Identify some health risks and environmental concerns associated with ionizing radiation and radioactive materials. Define absorbed dose and doe equivalent. Define stopping power. [3] 11. Read the ANS and HPS Code of Ethics. [3] 12. Write about nuclear technology. [6]
ASSESSMENT TOOLS For each assessment tool, links to the course outcomes are identified.	1. A combination of during-term test(s) and/or final examination will be used to measure outcomes [1-5] for individual students under a time constraint 2. Problem sets measure outcomes [1-5] under less time pressure and allow student collaborations 3. In class discussion establishes [6] at a class-wide level 4. In-class oral presentation establishes outcome [7] 5. Term paper measures outcome [8] 6. Course evaluation by each student at the end of the course provides self-assessment data on all outcomes

Revision History: March, 2002; May, 2005; August, 2005; March, 2007

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1815

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/6/2007
Effective Winter 2008

A. CURRENT LISTING	B. REQUESTED LISTING
☐ Home Department: — Div #: — Course Number: —	Home Department: NERS Div #: 288 Course Number: 311
Cross Listed Course Information:	Cross Listed Course Information:
☐ Course Title:	Course Title: Elements of Nuclear Engineering and Radiological Sciences I
TITLE ABBREVIATION — Time Sched (Max = 19 Spaces):	TITLE ABBREVIATION — Time Sched (Max = 19 Spaces): Ele Nucl Engr/Rad Sci I
Transcript (Max = 20 Spaces):	Transcript (Max = 20 Spaces): Ele Nucl Engr/Rad Sci I
☒ Course Description: Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics and special relativity. Properties and structure of atoms and nuclei. Introduction to interactions of radiation with matter.	Course Description for Official Publication (Max = 50 words): Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics. Properties and structure of atoms.
PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k	PROGRAM OUTCOMES: ☒ a ☒ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k
Degree Requirements: ○ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other	Degree Requirements: ◉ Degree Requirement ○ Core Course ○ Free Elective ○ Tech Elective ○ Other
☐ Prerequisites: ○ Enforced ○ Advised	Prerequisites: ○ Enforced ◉ Advised
☐ Credit Restrictions:	Credit Restrictions:
☒ Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 4 Max 4; Contact Hrs/Wk 4; Number of Wks 14	Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work; Credit Hours Min 3 Max 3; Contact Hrs/Wk 3; Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ◉ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional) ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

☐ **Class Type(s)**: ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____
Graded Section: ◉ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other
Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y
Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☒ I ☐ II ☐ IIIa ☐ IIIb ☐ III — Half term ☐ 1st ☐ 2nd
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Cognizant Faculty Member: Alex Bielajew **Title** Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval

- ☐ Curriculum Comm. ____________ ____________
- ☐ Faculty ____________ ____________
- ☐ Rackham ____________ ____________
- ☐ Cross listed Unit 1 ____________ ____________
- ☐ Cross listed Unit 2 ____________ ____________

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. [signature]
Cross-listed Dept(s). ____________

Form Number

1815

SUPPORTING STATEMENT

Modifications are required to accommodate NERS program changes. Special relativity was covered in both NERS 250 and NERS 311. The reduction in credit hours to NERS 311 is accomplished by removing special relativity from NERS 311, along with removing discussion of alpha decay (covered already in NERS 312). Class time spent reviewing classical physics will be minimized.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

COURSE PROFILE

Degree Program: Nuclear Engineering and Radiological Sciences **Date:** May, 2005

Prepared by: Alex Bielajew

COURSE #: NERS 311	**COURSE TITLE:** Elements of Nuclear Engineering and Radiological Sciences I
TERMS OFFERED: Fall	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: Krane, *Modern Physics,* Wiley, 2nd Edition	**PREREQUISITES:** NERS 250 and Phys 240, preceded or accompanied by Math 454 (A)
INSTRUCTOR(S): Alex Bielajew	**COGNIZANT FACULTY: Alex Bielajew**
CoE BULLETIN DESCRIPTION: Photons, electrons, neutrons, and protons. Particle and wave properties of radiation. Introduction to quantum mechanics and special relativity. Properties and structure of atoms.	**COURSE TOPICS:** 1. The special theory of relativity 2. The particle-like properties of radiation 3. The wave-like properties of particles 4. The Rutherford-Bohr model of the atom 5. The Schrödinger equation 6. One-electron atoms 7. Multi-electron atoms and the periodic table
COURSE STRUCTURE/SCHEDULE Lecture: 2 per week @ 80 minutes each	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1. Teach the students the concepts and methodology of modern physics.[1] 2. Teach the students to use theoretical results to make quantitative predictions.[1] 3. Apply the concepts learned in class to experimental problems. [5]
COURSE OUTCOMES For each course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1. Describe the particle properties of EM Radiation including the Photoelectric effect, the Compton effect, and describe what a photon is. [1] 2. Describe wave-like properties of particles, including De Broglie's Hypothesis, Uncertainty relationships for classical waves, Heisenberg Uncertainty Relationships, Probability and randomness, the probability amplitude. Derive the relation between the energy, frequency, wavelength and momentum of a photon. Derive expressions for interference of wave. Apply DeBroglie's hypothesis to interference of particles, learning the Heisenberg uncertainty relationships and the properties o f wave packets. [1,2] 3. Justify the Schrodinger equation, describe the probability interpretation solve problems using the Schrodinger equation in one-D, describe parity in the square well potential, moments and interpretation of results. Show orthonormality of wavefunctions for different energy states, describe superposition of wavefunctions, describe plane waves, normalization and currents, the vector current. Be able to solve problems for potential barriers and wells, the impenetrable barrier, finite length barriers, steps and wells, and the "simple" harmonic oscillator. Obtain discrete energy levels for confined particles. Compute expectation values. Use Hermite polynomials and Dirac's bra-ket notation,. Describe and estimate relative transition probabilities. Solve problems for the finite potential well including unbound states and bound states. Solve the Schrodinger equation in 2- and 3-D, describe degeneracy. [1,2] 4. Describe the Rutherford-Bohr atomic model, including basic properties of atoms, the Rutherford nuclear atom. Describe the Rutherford scattering distribution. Carry out center of mass transformation in classical mechanics, and classical cross section calculations including the Rutherford cross section. Describe line spectra and deficiencies of the Bohr Model. Derive the scattering angle for an electron as a function of the impact parameter. Derive the Rutherford scattering formula, compare result to experiment. [1,2,3] 5. Solve problems involving the hydrogen atom in wave mechanics. Solve the Schrodinger equation in spherical coordinates, describe spherical harmonics, derive the hydrogen atom wavefunctions, describe radial probability densities. Describe and use Angular momentum in quantum mechanics. Describe intrinsic spin, atomic Energy levels and spectroscopic notation. State the Pauli Exclusion Principle. Write expression for the quantum-mechanical angular momentum, allowed values of its z-component. Understand the concept of the spin. Express the magnetic moment in terms of the angular momentum. [1,2,3] 6. Analyze problems in many electron atoms, electronic states in many-electron atoms. Connect this analysis to the Periodic Table and Properties of the Elements including x-ray spectra. [1,2,3]
ASSESSMENT TOOLS For each assessment tool, links to the course outcomes are identified.	1. Exams measure all outcomes for individual students under time constraint. 2. Weekly assigned problem sets measure all outcomes under less time pressure and with collaboration between students and assistance from instructor.

Revision History: September, 1998; March, 2002; January, 2004;March, 2007

Alex Bielajew, Cooley 2927, bielajew@umich.edu Last modified: November 9, 2006

NERS311 Schedule Fall 2006

Introduction to Nuclear Engineering and Radiological Sciences I

Relativity, E&M Waves, and Particles

Date started	Topics introduced	Reference material K/B: Krane/Bielajew "book"
	Introduction	K:1, B:1
09/06	Course philosophy, honor code, class policy	web docs
	Introduction to the course	K:1, B:1
	Review of Classical Physics	K:1.1, B:1.1
	Units and dimensions (not covered, but read!)	K:1.2
	Significant figures	K:1.3, B:1.3
	Theory, experiment, law (not covered, but read!)	K:1.4
09/08	2-body scattering	K:1.1, B:1.1
09/11	Taylor series (by popular demand)	
09/13	Basic error estimation	B:1.5
	The special theory of relativity	K:2, B:2
09/13	Classical relativity	K:2.1, B:2.1
	The Michelson-Morley experiment	K:2.2, B:2.2
	Einstein's postulates	K:2.3, B:2.3
09/15	Consequences of Einstein's postulates	K:2.4
	The Twin Paradox	K:2.6
	The Lorentz transformation	K:2.5, B2.5
	The Doppler effect	K:2.4
09/22	Relativistic dynamics	K:2.7, B:2.7
09/27	Lorentz transformation of E and $\vec{p}$	B:2.7
	Particle-like properties of E&M radiation	K:3
09/25	Classical E&M waves	K:3.1
09/27	The Photoelectric effect	K:3.2
	Blackbody radiation	K:3.3
	The Compton effect	K:3.4
09/29	What is a photon?	K:3.6
	Conservation law violation in scattering	notes
	Conservation laws and scattering processes	notes
10/04	Quantum Electrodynamics!	notes
	A catalogue of $e^{\pm}\gamma$ processes	notes
	Other photon processes	K:3.5
	Wave-like properties of particles	K:4
10/04	De Broglie's Hypothesis	K:4.1
	Uncertainty relationships for classical waves	K:4.2
	Heisenberg Uncertainty Relationships	K:4.3
	Probability and randomness	K:4.4
	The probability amplitude	K:4.5
10/17	**Exam 1—Chapters 1–2 incl.**	In class

⇒ material not covered in a 3 credit version

Schrödinger equation, atomic models

	The Schrödinger equation	K:5
10/06	Justifying the Schrödinger equation	K:5.1
	The probability interpretation	K:5.3
	Application - the square well potential	K:5.4
10/09	Moments, and interpretation of results	notes
	Orthonormality of wavefunctions	notes
	Superposition of wavefunctions	notes
10/18	Plane waves, normalization and currents	notes
	The vector current	notes
	Potential barriers and wells	notes
	The impenetrable barrier	notes
10/20	Finite length barriers, steps and wells	notes
10/23	Parity, in the square-well potential	notes
10/25	The "simple" harmonic oscillator	K:5.5
	Hermite polynomials	notes
	Dirac's bra-ket notation	notes
	Relative transition probabilities	notes
10/27	The finite potential well, unbound states	notes
10/30	The finite potential well, bound states	notes
11/01	2- and 3-D solutions to the Schrödinger equation	notes, K5.4
	Degeneracy	notes, K5.4
	Energy-level degeneracies	notes
11/03	A model of α-decay	notes
	The Rutherford-Bohr atomic model	K:6
11/03	Basic properties of atoms	K:6.1
	The Thomson Model	K:6.2
11/06	The Rutherford nuclear atom	K:6.3
	The Rutherford scattering distribution	K:6.3
11/08	Center of mass transformation in classical mechanics	notes
	Classical cross section calculations	notes
	The Rutherford cross section	notes
	Solid sphere cross sections	notes
11/10	Line spectra	K:6.4
	The Bohr model	K:6.5
	The Franck-Hertz experiment	K:6.6
	The Correspondence Principle	K:6.7
	Deficiencies of the Bohr Model	K:6.8
11/17	Exam 2—Chapters 3–6	In class

move up

The hydrogen atom, many-electron atoms

	The hydrogen atom in wave mechanics	K:7
	The Schrödinger equation in spherical coordinates	K:7.1
	Spherical harmonics	notes
	~~Spherical harmonics~~	~~notes~~
	The hydrogen atom wavefunctions	K:7.2
	Radial probability densities	K:7.3
	The hydrogen atom wavefunctions	K:7.2
	Angular momentum and probability densities	K:7.4
	Intrinsic spin	K:7.5
	Energy levels and spectroscopic notation	K:7.6
	The Zeeman effect	K:7.7
	Fine structure	K:7.8
	The Pauli Exclusion Principle	K:8.1
	Many electron atoms	K:8
	Electronic states in many-electron atoms	K:8.2
	The Periodic Table	K:8.3
	Properties of the Elements	K:8.4
	X-Rays	K:8.5
	Optical spectra	K:8.6
	Lasers	K:8.8
12/15	**Exam 3—Chapters 7,8**	**13:30 - 15:30, Location TBD**

THE UNIVERSITY OF MICHIGAN -- COLLEGE OF ENGINEERING
Course Approval Request
College Curriculum Committee, 1420 Lurie Engineering Center Building

Print

Form Number: 1816

Action Requested

- ○ New Course
- ◉ Modification of Existing Course
- ○ Deletion of Course

Complete the following sections:
New Courses - B & C completely
Modifications - A modified information, B & C completely
Deletions - A & C completely

Date 3/6/2007
Effective Winter 2008

A. CURRENT LISTING

Home Department	Div #	Course Number

Cross Listed Course Information

Course Title

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	
	Transcript Max = 20 Spaces	

[x] Course Description
Production and use of nuclear radiation. Alpha-, beta- and gamma-decay of nuclei. Neutrons. Reactions. Elementary radiation interactions and transport.

PROGRAM OUTCOMES: ☐ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ l

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: ○ Enforced ○ Advised

Credit Restrictions

[x] Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Worl

Credit Hours: Min 4 Max 4
Contact Hrs/Wk 4
Number of Wks 14

B. REQUESTED LISTING

Home Department	Div #	Course Number
NERS	288	312

Cross Listed Course Information

Course Title
Elements of Nuclear Engineering and Radiological Sciences II

TITLE ABBREVIATION		
	Time Sched Max = 19 Spaces	Ele Nucl Engr/Rad Sci II
	Transcript Max = 20 Spaces	Ele Nucl Engr/Rad Sci II

Course Description for Official Publication (Max = 50 words)
Nuclear properties. Radioactive decay. Alpha-, beta-, and gamma-decays of nuclei. Nuclear fission and fusion. Radiation interactions and reaction cross-sections.

PROGRAM OUTCOMES: ☒ a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ h ☐ i ☐ j ☐ k

Degree Requirements: ○ Degree Requirement ○ Tech Elective ○ Core Course ○ Other ○ Free Elective

Prerequisites: ○ Enforced ⊙ Advised

Credit Restrictions

Level of Credit: ☒ Undergrad only ☐ Rackham Grad ☐ Non-Rckhm Grad ☐ Ugrad or Rckhm Grad ☐ Ugrad or Non-Rckhm Grad ☐ All Credit types ☐ Rckhm Grad w/add'l Work

Credit Hours: Min 3 Max 3
Contact Hrs/Wk 3
Number of Wks 14

C.

Repeatability (Indi Research, Dir. Study, Dissertation:
Is this course repeatable? ○ Yes ⊙ No
Maximum Hours? ____ Maximum Times? ____
Can it be repeated in the same term? ○ Yes ○ No

Printing Information (Optional): ☒ Print the course in the Bulletin ☒ Print the course in the Time Schedule

Class Type(s): ☒ Lec ☐ Rec ☐ Sem ☐ Lab ☐ Dis ☐ Ind ☐ Other ____

Graded Section: ⊙ Lec ○ Rec ○ Sem ○ Lab ○ Dis ○ Ind ○ Other

Grading: ☒ A-E ☐ CR/NC ☐ S/U ☐ P/F ☐ Y

Location: ☒ Ann Arbor ☐ Biological Station ☐ Camp Davis ☐ Extension

Terms & Freq. of Offering: ☐ I ☒ II ☐ IIIa ☐ IIIb ☐ III
☒ Yearly ☐ Alter Years ☐ Even Years ☐ Odd Years

Half term ☐ 1st ☐ 2nd

Cognizant Faculty Member: Alex Bielajew Title Professor

Grad Course: Attach nomination if Cognizant Faculty is not a regular graduate faculty

Approval
- ☐ Curriculum Comm.
- ☐ Faculty
- ☐ Rackham
- ☐ Cross listed Unit 1
- ☐ Cross listed Unit 2

Submitted By: ☒ Home Dept. ☐ Cross-listed Dept.
Name, Signature & Department
Home Dept. [signature]
Cross-listed Dept(s).

Form Number

1816

SUPPORTING STATEMENT

Modifications are required to accommodate NERS program changes. Review of quantum mechanics is removed. Transport theory is removed.

Are any special resources or facilities required for this course? ☐ Yes ☒ No

Detail the Special requirements

COURSE PROFILE

Degree Program: <u>Nuclear Engineering and Radiological Sciences</u> **Date:** <u>March, 2007</u>

Prepared by: <u>Alex Bielajew</u>

COURSE #: NERS 312	**COURSE TITLE:** Elements of Nuclear Engineering and Radiological Sciences II
TERMS OFFERED: Winter	**For each prerequisite below, "E" denotes Enforced and "A" denotes Advised.**
TEXTBOOKS/REQUIRED MATERIAL: Krane, *Introductory Nuclear Physics*	**PREREQUISITES:** NERS 311 (A)
INSTRUCTOR(S): Bielajew	**COGNIZANT FACULTY: Bielajew**
CoE BULLETIN DESCRIPTION: Nuclear properties. Radioactive decay. Alpha, beta and gamma decays of nuclei. Nuclear fission and fusion. Elementary radiation interactions and transport. Reaction cross-sections	**COURSE TOPICS:** Elements of Quantum Mechanics, basic nuclear properties, Radioactive decay , alpha, beta and gamma decays, nuclear reactions and cross-sections, fission
COURSE STRUCTURE/SCHEDULE Lecture: 2 per week @ 80 minutes each	

COURSE OBJECTIVES	Links shown in brackets are to departmental educational outcomes: 1. Teach students key nuclear properties (radius, spin, binding energy, separation energies, decay energetics, Q values). [1] 2. Teach students decay systematics (decay laws, decay chains). [1] 3. Teach students the fundamentals of alpha, beta and gamma decays (nuclear decays and physics). [1] 4. Teach students the fundamentals of nuclear reactions, including fission and fusion [1] 5. Prepare students for higher level courses involving the applications of radiation. [1, 12]
COURSE OUTCOMES For <u>each</u> course outcome, links to the Program Outcomes are identified.	Links shown in brackets are to course objectives: 1. Demonstrate knowledge of introductory terminology for nuclei, nuclear properties, units and dimensions. [1,5] 2. Know the magnitude of nuclear radius and how it varies with A, find data on mass and abundance of nuclides, describe nuclear binding energy, describe nuclear angular momentum and parity, nuclear electromagnetic moments, and excited states. Read energy level diagrams. [1,5] 3. Describe the shell model, the significance of even-even nuclei, collective structure, rotations/vibrations, and more realistic nuclear models. [1,5] 4. Solve the decay law, list of the types of decay, describe the quantum theory of radioactive decay, solve decay problems with production, solve for growth of daughter activities, and describe the natural radioactivity chains. Describe the physical mechanisms of alpha, beta and gamma decay, and the properties that strongly impact the decay constant.[2,5] 5. Explain why alpha decay occurs, alpha decay processes, alpha decay systematics, solve problems in the theory of alpha emission, qualitatively, describe the influence of angular momentum and parity in alpha decay. [2,3,5] 6. Describe the energy release in beta decay, and the Fermi theory of beta decay. Describe the classical experimental tests of Fermi theory. Describe the angular momentum and parity selection rules, comparative half-lives and "forbidden" decays. [2,3,5] 7. Describe the energetics of gamma decay, read energy level diagrams, describe classical electromagnetic radiation and transition to quantum mechanics, and the influence of angular momentum and parity selection rules. Describe angular distribution and polarization measurements. Describe internal emissions and lifetimes for gamma emission. [2,3,5] 8. Enumerate types of reactions and relevant conservation laws, describe the energetics of nuclear reactions. Describe the concept of Isospin. Define the concept of reaction and scattering cross-sections and compute kinematic relationships based on conservation of energy and mass. Describe fission and fusion. Describe why nuclei fission. [4,5]
ASSESSMENT TOOLS For <u>each</u> assessment tool, links to the course outcomes are identified.	1. A combination of mid-term test and final examination will be use to measure all outcomes for individual students under a time constraint. 2. Problem sets measure all outcomes under less time pressure and with student collaborations 3. Course evaluation by each student at the end of the course assesses all outcomes.

Revision History: September, 1998; March, 2002;April, 2006; March, 2007

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Last modified: September 28, 2006

NERS312 Schedule Winter 2007

Introduction to Nuclear Engineering and Radiological Sciences II

Quantum Mechanics and Fundamentals of Nuclei and Radioactivity

Lecture/date started	Topics introduced	Reference material K: Krane's "book"
________	**Basic Concepts and Fundamentals**	K:1
	Introduction to the course	
	Course philosophy, honor code, class policy	See web
	What the course is really about	
	How to succeed and be happy	
	History and overview	K:1.1
	Some introductory terminology	K:1.2
	Nuclear properties	K:1.3
	Units and dimensions	K:1.4
________	**Elements of Quantum Mechanics**	K:2
	Quantum behavior	K:2.1
	Principles of Quantum Mechanics	K:2.2
	Problems in one dimension	K:2.3
	Problems in three dimensions	K:2.4
	Quantum theory of angular momentum	K:2.5
	Parity	K:2.6
	Quantum statistics	K:2.7
	Transition between states	K:2.8
________	**Nuclear Properties**	K:3
	The nuclear radius	K:3.1
	Mass and abundance of nuclides	K:3.2
	Nuclear binding energy	K:3.3
	Nuclear angular momentum and parity	K:3.4
	Nuclear electromagnetic moments	K:3.5
	Nuclear excited states	K:3.6
________	**Nuclear Models**	K:5
	The shell model	K:5.1
	Even-Z, Even-N Nuclei	K:5.2
	Collective structure, rotations/vibrations	K:5.2
	More realistic nuclear models	K:5.3
________	**Radioactive Decay**	K:6
	The radioactive decay law	K:6.1
	Quantum theory of radioactive decays	K:6.2
	Production and decay of radioactivity	K:6.3
	Growth of daughter activities	K:6.4
	Types of decays	K:6.5
	Natural radioactivity	K:6.6
	Radioactive dating	K:6.7
	Units for measuring radiation	K:6.8

α, β, and γ Radioactive Decays

	Alpha Decay	K:8
	Why alpha decay occurs	K:8.1
	Basic alpha decay processes	K:8.2
	Alpha decay systematics	K:8.3
	Theory of alpha emission	K:8.4
	Angular momentum and parity in alpha decay	K:8.5
	Beta Decay	K:9
	Energy release in beta decay	K:9.1
	Fermi theory of beta decay	K:9.2
	The "classical" experimental tests of the Fermi theory	K:9.3
	Angular momentum and parity selection rules	K:9.4
	Comparative half-lives and forbidden decays	K:9.5
	Gamma Decay	K:10
	Energetics of gamma decay	K:10.1
	Classical electromagnetic radiation	K:10.2
	Transition to quantum mechanics	K:10.3
	Angular momentum and parity selection rules	K:10.4
	Angular distribution and polarization measurements	K:10.5
	Internal emissions	K:10.6
	Lifetimes for gamma emission	K:10.7

Nuclear Reactions, Fission and Fusion

	Nuclear Reactions	K:11
	Types of reactions and conservation laws	K:11.1
	Energetic of nuclear reactions	K:11.2
	Isospin	K:11.3
	Reaction cross sections	K:11.4
	Scattering and reaction cross sections	K:11.8
	The optical model	K:11.9
	Heavy ion collisions	K:11.13
	Nuclear Fission	K:13
	Why nuclei fission	K:13.1
	Fission explosives	K:13.9
	Nuclear Fusion	K:14
	Thermonuclear explosives	K:14.5

– oops, keep