DOCUMENT RESUME

ED 390 716 SE 057 711

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TITLE An Integrated Science and Technology Undergraduate Curriculum.
PUB DATE Jan 96
NOTE 20p.
PUB TYPE Guides - Non-Classroom Use (055)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Course Descriptions; Demonstration Programs; Higher Education; *Interdisciplinary Approach; *Science Curriculum; *Technology Education; *Undergraduate Study

ABSTRACT

The College of Integrated Science and Technology (CISAT) at James Madison University was founded to educate and graduate a well-rounded science student, one educated in science and technology but in a very different way than traditional programs. This document contains information about mission and objectives, curriculum, faculty, and students of this program. The curriculum is broad-based multidisciplinary exhibiting the natural connections among science, mathematics, and technology, and using expertise from the fields of modern communication to present science in the context of real-world global issues and within the complex and disorganized environment of contemporary social issues. The first 2 years of the program consist of courses in four main areas: analytical methods, issues in science and technology, connections, and general education. In the junior year students take courses in six strategic technology sectors: instrumentation and measurement, energy, environment, engineering and manufacturing, knowledge management, and biotechnology. The senior year is continued study of one of the strategic technology sectors or some other concentration. (MKR)

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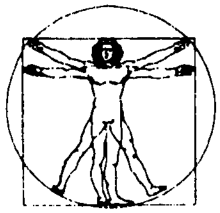

AN INTEGRATED SCIENCE AND TECHNOLOGY UNDERGRADUATE CURRICULUM

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SUMMARY

The College of Integrated Science and Technology (CISAT) at James Madison University was founded to educate and graduate a well-rounded science student, one educated in science and technology but in a very different way than traditional programs.

The Integrated Science and Technology Program (ISAT) is now in its third year, with 45 juniors, 115 sophomores and 155 freshmen, with anticipated growth to 1300 majors by the year 2005. The Commonwealth of Virginia has committed to 55 full-time faculty members for instruction and a $200 million physical plant for the students education.

Particular emphasis in the ISAT program is to educate students as broad-based scientists but with an orientation to application of the sciences to real world problems.

The curriculum is broad-based multidisciplinary, not discipline limited, exhibiting the natural connections among science, mathematics and technology, and using expertise from the fields of modern communication to present science in the context of real world global issues and within the complex and disorganized environment of contemporary social issues.

In their freshman and sophomore years the students study basic science and mathematics, but in integrated, interdisciplinary, team-taught courses; that is chemistry, physics, statistics, and mathematics may be intermixed in the same analytical methods course not taught in the traditional disciplines. In addition, applications are brought into the basic courses so that students immediately see the practical uses of the theories they are studying. At the end of the freshman and sophomore years the student has a broad-based background and common core in all of the sciences and mathematics.

Using this background, as juniors the students study a series of strategic technology sectors. In addition to theory in these sectors, the students apply the material they have learned to the specific application areas. As seniors, the students concentrate in a strategic sector or additional sector and complete a research based group senior thesis.

To educate our students, James Madison University (JMU) has hired a diverse group of faculty members. Their doctorates are in a wide range of disciplines from nuclear engineering to biophysics to toxicology to systems engineering to political science to business. Most of these faculty members have been recruited from industry. All faculty are committed to a collaborative approach, both in their research and in team teaching.

The students recruited to the ISAT program are students who would not normally be attracted to the traditional science and mathematics fields. The students meet the same requirements as other students admitted to James Madison University. While we have no graduates as yet, the students seem most interested in their ability to apply the sciences that they have learned to real world

problems. Their motivation to date has been quite high and the number of students leaving the ISAT program for other majors has been well below the university average.

Although the ISAT program is new, the results to date have been extremely encouraging. The faculty are very pleased with their progress to date, the students seem very pleased with the education they are receiving, and the Commonwealth of Virginia seems pleased with the orientation to application and the use of technology in education.

INTRODUCTION

In its 1988 session, Virginia's General Assembly formed the Commission on the University of the 21st Century. This Commission was created to develop a vision of higher education responsive to the needs of the next century. The Commission's initial task was to address the question of growth in Virginia's institutions of higher education. It became apparent however, that of equal importance was how universities should proceed in preparing students for the dramatic impact of rapidly changing economic and social orders in the world.

This Commission recommended that each university in Virginia be directed to develop a plan of action in response to the mission of preparing students for the changing world. James Madison University's response to this mission was to propose the establishment of a College of Integrated Science and Technology.

The need for university educated students with a background in science and technology different from that of most current graduates has been documented by many articles and studies. As one example, in a recent article, Dr. Roy P. Vagelos, Chairman of Merck and Company, offered this perspective: "it is disturbing that the men and women who will be the country's leaders in the 21st Century are not equipped to think intelligently about the environment, energy, space, defense and biotechnology. Unless we take action, other countries will reap the human economic and cultural benefits of tomorrow's breakthrough products."

Thus the goal of the College of Integrated Science and Technology at James Madison University is to produce a well rounded science graduate; one educated in science and technology but in a very different way than traditional programs.

Since this vision was first articulated by JMU's president, Dr. Ronald E. Carrier, JMU has moved forward to meet the challenge. The College of Integrated Science and Technology was created in 1991 and the first freshman class of students was accepted in the fall of 1993. 1994 and 1995 showed additional groups of students entering the ISAT program, and in November, 1995 there were 45 juniors, 115 sophomores and 155 freshmen majoring in Integrated Science and Technology. To serve this group of students, the Commonwealth of Virginia is building a new campus at James Madison University. By 2005, the number of Integrated Science and Technology majors will increase from the current 315 to 1,300. They will be served by a complex of new cutting-edge technology designed and furnished academic classroom buildings. The first of these buildings is currently under construction and will be completed in March, 1997. Thereafter, a new academic building will be added approximately every two years as well as supporting dormitory, food and recreational facilities. It is anticipated that the cost of the new campus to serve the College of Integrated Science and Technology will be approximately $200 million by the year 2005.

As of November, 1995, twenty-four full time faculty have been hired to instruct students in the Integrated Science and Technology program. Faculty should increase to approximately 55 individuals by the year 2005. In addition to the normal support activities given to faculty, CISAT has a substantial multimedia laboratory, a research faculty member in instructional technology is on staff, and a staff technician is available in this multimedia laboratory to aid faculty in development of instructional technology packages to educate students.

MISSION AND OBJECTIVES OF THE ISAT PROGRAM

The mission of the College of Integrated Science and Technology at James Madison University is to prepare men and women to recognize and understand scientific and technical developments and to apply them creatively to issues facing contemporary society. The curriculum, offering a strong liberal arts foundation and an integrated core in science and mathematics, has been designed to prepare individuals for a productive life in an economy which is both technologically demanding and global in perspective. The new College's unique mission focuses on:

- helping to redress the critical shortage of people in scientific and technical fields;
- attracting a significant number of minorities and women to the sciences;
- establishing programs to enable students to study the integration of scientific disciplines;
- providing the opportunities for students to engage in the study of contemporary issues involving science and technology;
- developing strong communication and decision making skills in students;
- producing graduates who are sensitive to the political, social and ethical context of technology;
- strengthening ties between the Commonwealth of Virginia's elementary and secondary schools; and
- integrating the use of technology in the curriculum to support decision making, information gathering and communication.

The ISAT undergraduate curriculum is characterized by global perspective and technological competence in the context of an increasingly multi-cultural, multi-racial, and multi-ethnic society. Rather than being discipline specific, the focus of the curriculum is on extensive interdisciplinary exposure and training that:

- encourages familiarity with science, business and technology principles;
- provides a strong new initiative for recruiting and preparing students for careers in science, technology, health and engineering related fields;
- promotes knowledge of the computer as a problem solving tool;
- produces graduates that are comfortable with a collaborative (team) approach to problem solving;
- prepares students for the real world of complex multi-disciplinary decisions and actions;

- encourages a strong engagement of science and technology within the public sector in general; and
- develops a capacity for intellectual coherence in the midst of specialization in science and technology.

CURRICULUM

Introduction

In addition to integrating the topics of science and technology in an innovative way, the basic ISAT pedagogical approach is broad-based and multi-disciplinary, not discipline limited, exhibiting the natural connections among science, mathematics and technology and using expertise from the fields of modern communication to present science in the context of real world global issues and within the complex and disorganized environment of contemporary social issues.

The ISAT instructional techniques have a number of distinct characteristics:

- integrated instruction of science and technology in the context of technology, business and social issues;
- team teaching by interdisciplinary faculty;
- sensitivity to non-technological considerations;
- application of collaborative learning and student self learning;
- instruction supported by modern pedagogical methods (multimedia, student participation);
- intrinsic use of the computer; and
- development of motivational content to capture student interest.

An Overview of the Four Years

To receive a Bachelors Degree at James Madison University, a student must complete a total of 120 semester credit hours. Typically, each credit hour is one hour of class contact time for a traditional lecture course and three hours of contact time for a traditional laboratory course per week for a semester. The university requires a general education component of all students that consists of 30 credit hours. Freshman and sophomore ISAT students will take 12 credit hours of Analytical Methods, 12 credit hours of Issues in Science and Technology, and 4 credit hours of Connections in addition to their General Education courses. As juniors, ISAT students will take four of six strategic technology sectors to gain a well rounded background in a number of science and technology areas. As seniors, they will concentrate in a specific area of science and technology and also complete a senior thesis. A pictorial description of this four-year program is shown in figure 1.

The Freshman and Sophomore Years

The student's first two years in the ISAT program focuses on four main areas.

1. Analytical Methods
2. Issues in Science and Technology
3. Connections
4. General Education

As shown in figure 2, Analytical Methods is a four semester sequence completed throughout the freshman and sophomore years. Issues in Science and Technology is also a four semester sequence. In the first semester students study living systems, the second semester, the environment, the third semester, modern production, and the fourth semester, energy. Connections between science, technology, economics and social and political considerations are covered in a year-long course during the freshman year.

Figure 3 shows the topics covered in the Analytical Methods sequence. In Analytical Methods, students study the scientific method, mathematical models, statistics, project management, mechanics, calculus, vectors, integration, introduction to electricity and magnetism, logic, intelligent systems, knowledge based systems, expert systems, and many other topics.

Figures 4.1 and 4.2 show the topics covered in the Issues in Science and Technology sequence. The living systems course focuses on genetic engineering, the hierarchy of life, and technology management and infectious diseases. The environment course focuses on air pollution and ozone depletion, global warming, acid rain, ecosystems, and solid waste management. The modern production course focuses on an overview of the manufacturing enterprise, product life cycle, product design, energy efficiency, equipment justification, quality, dimensioning and tolerances, and biomanufacturing. The energy course concentrates on the basis of chemical engineering, temperature scales, gas laws, heat transfer, solar energy, endothermic reactions, electrochemistry, nuclear energy, etc. Each of the energy sources are discussed thoroughly, specifically in terms of their efficiency and conservation and their renewability.

The Connections courses are detailed in figure 5. The emphasis in these courses include the history of discovery in innovation, public perceptions of science and technology, science technology and social justice, competing values and social dilemmas over science and technology, and an integrated view of social controversies and society impacts.

At the completion of their freshman and sophomore years students in the ISAT program will have a sound foundation in all of the areas of mathematics, science and technology necessary to begin a more in-depth study of the particular strategic technology sectors.

The Junior and Senior Years

The junior year finds the student building from the integrated common core program at the freshman and sophomore years. Developed from the list of national critical technologies, the ISAT faculty have determined six strategic technology sectors for which there will be a demand for educated students in the future. These sectors include: instrumentation and measurement, energy, environment, engineering and manufacturing, knowledge management, and biotechnology. Each of these technologies is covered in courses spread over two semesters. Each student must complete the instrumentation and measurement sector and three other strategic technology sectors in their junior year. The specific courses that make up these strategic technology sectors are shown in figure 6.

The purpose of the strategic technology sectors is to not only give the students a broad background in science and technology, but a background in the context of applications to these specific areas. While the students continue to study the basic theories of the sciences and mathematics, they are constantly applying these theories to these strategic sectors. In addition, the students are continuously working in team projects throughout their junior year to further their broad scientific base.

As seniors, the students take a concentration of twelve hours, six hours each semester and complete a six hour senior thesis spread out over the year. For most students, the concentration at their senior year will be a continuation of one of the strategic technology sectors studied at their junior year. It is possible, however, for a student to develop their own concentration, perhaps in conjunction with another science department or the computer science department. In addition to the concentrations that further strategic technology sectors, we have identified in advance a health systems strategic sector based upon student demand.

The titles of the courses making up each of the concentrations are shown in figure 7. As of November, 1995, we have not taught any of the senior level courses. Our first class has reached the junior level. We are currently developing the details of the concentrations and the senior thesis for implementation in the fall of 1996.

The senior year will bring together teams of students who have developed individual expertise based upon specialized work in their research efforts. It is anticipated that most senior theses will be a group effort on a real world research project sponsored by a private company or government organization. Thus students will practice the team building collaborative approach throughout their entire four years.

While taking their junior and senior level major course work in integrated science and technology, the students also have free electives to complete their undergraduate degree. Students may use these free electives for additional courses in strategic sectors or in a concentration, or they can be used to minor in any other subject offered at the university, or to take individual courses in other disciplines that may interest them.

THE FACULTY

To educate the integrated science and technology students James Madison University has hired a diverse group of faculty members. As of November, 1995, there are 24 full-time faculty members in this program and it is anticipated this will grow to 55 faculty by the year 2005. With a desire to hire faculty members who were interdisciplinary, collaborative, and innovative, it was felt that a mixture of faculty from a number disciplines would be the desired approach. Accordingly, the existing group of faculty, all of whom have appropriate doctorate degrees, have their degrees in areas such as nuclear engineering, electrical engineering, chemical engineering, biophysics, toxicology, computer science, systems engineering, political science, environmental engineering, production/operations management, management systems and business. The majority of these faculty have been recruited to the ISAT program directly from industry. Thus, the faculty are a blend of many disciplines, coming from both academia and industry.

All of the courses in the freshman and sophomore years are taught by teams of faculty members. Thus, all of the faculty hired are committed to a collaborative team approach to instruction and to an interdisciplinary approach to presentation of all materials in all classes. In particular, all faculty are extremely sophisticated in their use of the computer and computer applications, both in terms of teaching technology and in terms of its application to applied science and technology. Since the first faculty for this program were hired in 1991, no faculty member has been involved for more than four years. It remains to be seen if the motivation of the faculty and the ability to work in teams will continue for longer periods of time. So far, however, the results have been very very successful. The faculty learn from each other and enjoy working together and the students benefit from the interdisciplinary approach of a variety of faculty members.

In particular, ISAT is attempting to develop a new role for faculty members, to develop faculty who have the ability to explore new teaching methodologies using advanced communication vehicles across disciplines. ISAT faculty have already begun to:

- Invert the learning progression of traditional sciences and technology by moving context and applications topics to early courses;
- Integrate issues of global commerce, government studies, and business and economics through instructional modules developed by faculty of many disciplines;
- Define new bachelor of science degrees to integrate the areas of science, engineering, computer science, knowledge-based studies, management, analytical methods and liberal studies; and
- Identify the importance of science and technology in the context of social needs and issues throughout the curriculum.

As the ISAT program continues to grow and as we offer the first senior concentrations and senior thesis, it is expected that we will add faculty members who are perhaps more specialized. It is also anticipated that the senior concentration or more specific courses may not be taught by as large or as interdisciplinary a team as the freshman or sophomore courses.

As a new group of faculty, the ISAT faculty are currently working out their own criteria for promotion and tenure. They are finding that the criteria often used by the traditional departments are not adequate for a department where the emphasis is on collaborative effort among different disciplines and upon applications of subject material. It is expected, however, that the criteria developed for promotion and tenure within this program will be a well defined set of activities that recognize the uniqueness of the program while maintaining rigorous academic standards for compe ence.

THE STUDENTS

The Integrated Science and Technology Program is attracting students who would normally not be attracted to the traditional science and mathematics fields. In fact, surveys of the students in our current sophomore and junior classes have revealed that almost none of these students would have gone into a traditional natural science field as a major. The Integrated Science and Technology Program is thus an expansion of science education beyond the traditional programs. If anything, the very early data has suggested that ISAT students are more likely to shift to a major in chemistry or biology, for example, than a student who started out majoring in those disciplines shifting to become an ISAT major.

The quality of ISAT students is the same as that of other students at James Madison University. All students are admitted to JMU meeting exactly the same admissions standards. Students may then select their major and, in fact, change majors frequently. The average JMU student ranks in the upper 20% of their high school class and has an average SAT score of 1100 (before the scores were revised upward).

Student response to this new program has been much greater than expected. This can be shown by the fact that we have over 300 majors without ever having a graduate. Students appear very motivated by their ability to see the applications of science and mathematics in all of their courses, even those at the freshman level. Student clubs and organizations are forming, the students have developed their own mentoring program, and the students are very active in recruiting new students into the program. Because of the approach to student learning and integrated subject material, by the time they complete the undergraduate program, our students will have served as traditional students, teachers to each other, colleagues on projects and mentors to younger students. They will have conducted original research and will have had experience in problem solving as part of a multi-disciplinary team spanning the academic community, corporate world and the public sector. The students will have the self-confidence that comes with having mastered real world problems. Because of the availability of summer jobs, internships and practicums, the students will have had the opportunity to not only understand the real world outside of academia, but also to apply the subject material they are learning in a professional job.

Upon graduation, students will have blended learning with doing, and individual work with collaboration, and they will have come to understand the challenges and rich context of contemporary science and technology.

In developing the ISAT curriculum, indeed in setting up the program in the first place, numerous surveys were conducted of executives in industry and government to determine if these students would fill worthwhile professional jobs upon graduation. The curriculum was designed with the idea that these graduates would have a practical ability to apply science and technology to real world problems. In fact, one goal was clearly that the graduates of this program would be able to join an industrial company or government and be an effective employee in that organization faster than other graduates.

In surveys of industries to determine who would be likely to hire a graduate of this program, the list became longer and longer. Some examples of industries that would be looking at ISAT graduates for entry level positions include: biotechnology, many aspects of business administration, engineering management, environmental science, law, public policy, ecology, industrial management, and health administration. While job titles do not have specific meanings, some examples of job titles taken from newspaper classified advertisements that ISAT graduates might fill include: program/project manager, plans/programs staff specialist, health systems analyst, technical representative, marketing representative, environmental specialist, information systems consultant, foreman, manufacturing superintendent, and computer information specialist. These industries and job titles are not intended to be all inclusive but to give a feel for the breadth of background for which students will be prepared. In particular, it is felt that by the emphasis on internships and practicums and by e ability of students to gain concentration at the senior level, the students will be able to develop their own interests while tailoring their program with the insider knowledge they have gained from practical work experience in industry

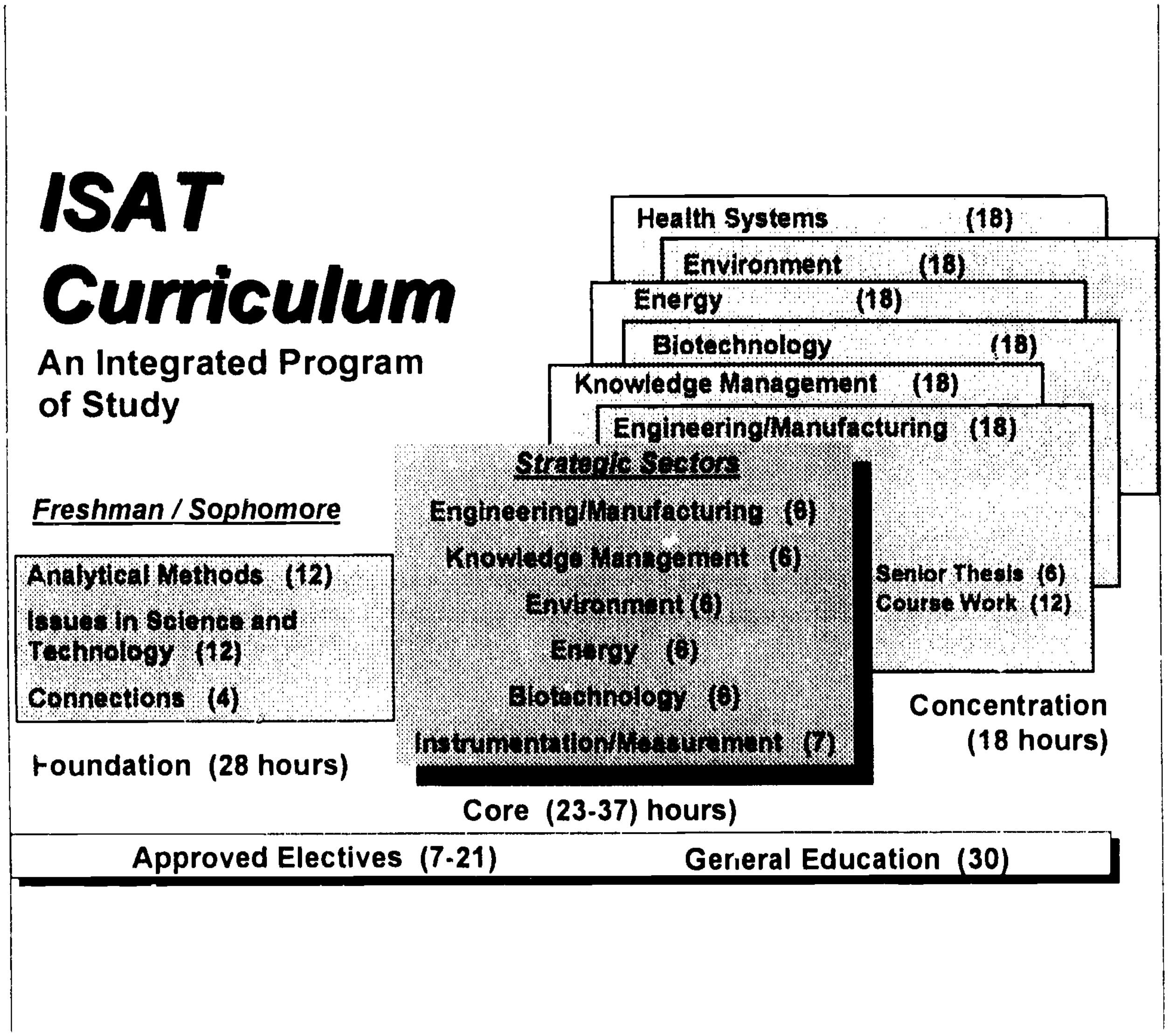
ISAT
Curriculum
An Integrated Program of Study
Freshman / Sophomore
Analytical Methods (12)
Issues in Science and Technology (12)
Connections (4)
Foundation (28 hours)
Strategic Sectors
Engineering/Manufacturing (6)
Knowledge Management (6)
Environment (6)
Energy (6)
Biotechnology (6)
Instrumentation/Measurement (7)
Core (23-37) hours)
Health Systems (18)
Environment (18)
Energy (18)
Biotechnology (18)
Knowledge Management (18)
Engineering/Manufacturing (18)
Senior Thesis (6)
Course Work (12)
Concentration (18 hours)
Approved Electives (7-21)
General Education (30)

Figure 1

ISAT CURRICULUM
Freshman and Sophomore Years

Year	Fall	Spring
1	Analytical Methods I (3) Issues: Living Systems (3) Connections (2)	Analytical Methods II (3) Issues: Environment (3) Connections (2)
2	Analytical Methods III (3) Issues: Modern Production (3)	Analytical Methods IV (3) Issues: Energy (3)

Figure 2

ANALYTICAL METHODS SEQUENCE

Analytical Methods I

- Introduction to science and the scientific method
- Introduction to mathematical models
- Introduction to functions and their applications to modeling
- Using graphical statistics to build empirical models
- Critical evaluation of arguments involving data analysis
- Introduction to project management

Analytical Methods II

- Introduction to mechanics
- Introduction to calculus with applications to modeling 1-dimensional motion
- Numerical (digital) methods for evaluating derivatives and finding maxima/minima
- Further applications of derivatives
- Intro to vectors and tools for modeling 2-D systems (emphasis on 2-D motion)
- Introduction to Riemann integration

Analytical Methods III

- Integration and introduction to differential equations
- Numerical methods to evaluating integrals and solving differential equations
- Applications to modeling work, energy, and power
- Introduction to electricity and magnetism
- Introduction to mechanical waves, with applications to audio systems
- Introduction to optics, with applications to optical disks and fiber optics

Analytical Methods IV

- Introduction to logic and the analysis of language, especially in relation to knowledge-based systems
- Introduction to intelligent systems
- Development of knowledge-based systems, and advanced project management
- Principles of knowledge-acquisition
- Using expert system shells

Figure 3

ISSUES IN SCIENCE AND TECHNOLOGY SEQUENCE

Living Systems

Genetic Engineering: Origins and applications of genetic engineering
- The Human Genome Project
- Structure, functions, and organization of DNA
- Genetic diseases: origins, diagnosis, therapy
- Central dogma: from DNA to RNA to proteins

Putting it Together: The Hierarchy of Life
- From atoms to molecules to macromolecules: the relation of 3-D organization of chemical properties and function
- Building a cell
- Models of living systems

Technology and Medicine: The Rise of Infectious Disease
- Origins and etiology
- Epidemiology
- Antibiotic resistance and its origins
- Prevention, diagnosis, and therapy
- Human gene mutations and infectious disease resistance

Modern Production

- Introduction and overview of the manufacturing enterprise
- Product life cycle - product design and process selection
- Product design and process selection - services
- Engineering economy and equipment justification - time value of money, cost of capital, benefit cost ratio and return on investment
- Design for quality and quality metrics
- Integrating the manufacturing enterprise - integrating islands of automation
- Engineering (technical) drawings, dimensioning and tolerancing
- Process manufacturing and related chemistry concepts - petrochemicals, industrial chemicals, synthetic polymers
- Bio-manufacturing - biotechnology, pharmaceuticals

Environment

Air Pollution and Ozone Depletion
- Atmospheric composition
- Atoms, molecules and matter
- Chemical reactions and equations
- Electromagnetic radiation
- Descriptive and inferential statistics
- Data visualization

Global Warming
- Biochemical cycles
- Energy balance
- Feedback loops

Acid Rain
- Anomalies of water
- Acid base chemistry
- Ecological principles
- Ecosystem impacts and recovery
- Hypothesis testing
- Confidence intervals
- Species diversity

Solid Waste Management
- Management priorities
- Polymer chemistry
- Environmental responsibility

Figure 4.1

Energy

Knowledge Units	Efficiency & Cons.	Renw. Energy Sources	Fossil Energy Comb.	Nuclear & Electrochem.
Temperature Scales	X			
Heat and Thermal Energy	X	X		
Conservation of Energy	X	X		
Ideal Gas Law	X			
Changes of State and Latent Heat	X	X		
Humidification	X			
Heat Transfer	X	X		
Sensible Heat & Specific Heat	X	X		
Vapor Pressure	X			
Kinetic Theory of Gases	X			
Analysis of Alternatives	X			
Energy Economics	X		X	
Thermal Equilibrium	X	X		
Electromagnetic Radiation		X		
Solar Energy		X		
Steady State Concept		X		
Stoichiometry			X	
Oxidation-Reduction Reactions			X	
Enthalphy		X		
Endothermic & Exothermic Reaction			X	
Heat of Reaction			X	
Hydrocarbon Fuels			X	
Electrochemistry				X
Galvanic Cells				X
Fuel Cells				X
Nuclear Binding Energies				X
Radioactivity				X
Radioisotopes				X
Engineering Design & Tradeoffs		X		X
Electric Power Generation			X	

Figure 4.2

CONNECTIONS SEQUENCE

Connections I

History of Discovery and Innovation

- What is science and why do we do it?
- The changing context of research, ancient times to modern
- Social impacts of innovation

Public Perceptions of Science and Technology

- Public literacy and attitudes about science and technology
- "World view" paradigms
- The nature of risk perception
- The role of the media

Science, Technology, and Social Justice

- Concepts of social fairness, equity, and ethics
- Competition between scientific values and social values
- Sociology of science and social consequences

Connections II

Competing Values and Social Dilemmas over Science & Technology

- The nature of values, interests, dilemmas, and controversies
- Competing values and interests at each major level of social organization:
  - individual/family
  - community
  - nation
  - formal organization
  - global system
  - economic system
  - workplace
  - legal system

Social Controversies and Social Impacts: The Integrated View

This module will provide an extended, in-depth look at one or two major controversies to enable students to see how all of the course "building blocks" fit into a unified way of analyzing scientific and technological issues

Figure 5

STRATEGIC TECHNOLOGY SECTOR COURSES

Instrumentation and Measurement Sector
- Foundations of Instrumentation and Measurement (3)

The following four courses are companion laboratory courses for four of the remaining strategic sectors
Instrumentation and Measurement in:
- the Energy Sector (1)
- the Environment Sector (1)
- Engineering/Manufacturing (1)
- Biotechnology (1)

Environment Sector
- Fundamentals of Environmental Science and Technology (3)
- Environmental Projects (3)

Biotechnology Sector
- Biotechnology for the New Millennium I (3)
- Biotechnology for the New Millennium II (3)

Engineering/Manufacturing Sector
- Manufacturing Systems - Techniques and Technologies (3)
- Automation in Manufacturing (3)

Energy Sector
- Energy Fundamentals (3)
- Roles of Energy in Modern Society (3)

Knowledge Management Sector
- Software Development (3)
- Knowledge Management (3)

Figure 6

CONCENTRATION COURSES

Energy Concentration
- Sustainable Energy Development (3)
- Energy Economics and Policy (3)
- Dynamic Control of Energy Systems (3)
- Options for Energy Efficiency (3)

Biotechnology Concentration
- Biotechnology and the Environment (3)
- Biotechnology in Industry and Agriculture (3)
- Medical Biotechnology (3)
- Energy and Living Systems (3)

Engineering/Manufacturing Concentration
- Manufacturing Processes (3)
- Materials Science in Manufacturing (3)
- Two Additional Courses

Environmental Science Concentration
- Waste Management (3)
- Environmental Policy (3)
- Environmental Modeling I (3)
- Environmental Modeling II (3)

Knowledge Management Concentration
- Intelligent Systems (3)
- Information System Design Studio (3)
- Hypermedia Systems (3)
- Seminar in Emerging Information Technologies (3)

Health Systems
- Principles of Community Health (3)
- Funding in Health Care (3)
- Health Care, Economics, Policy, Ethics (3)
- Health Care Strategic Planning (3)

Figure 7