NYSCATE MODULE GUIDE
Drying by Design

I. INTRODUCTION AND OVERVIEW

ABSTRACT
This module, the first of 13 NYSCATE modules, features the integration of mathematics, science and technology (MST) through an emphasis on design in the context of dehydration. In response to a challenge, groups of students consider specifications and work within constraints as they design, construct, and test a dehydrator. The device they construct is expected to dry fruit in as short a time as possible while maintaining the quality of the foodstuff.

Rather than proceed by trial and error, students are expected to make design decisions based on mathematical and scientific principles that they consciously apply. The module features mathematical, scientific, and technological Knowledge and Skill Builder (KSB) activities that groups complete in order to be informed as they design, construct, and test. Topics included in the KSBs are informed design, dehydration techniques, investigations of factors affecting dehydration, linear and curvilinear relationships, data treatments, microbes and spoilage, humidity, and food appearance changes.

GRADE LEVEL
This module can serve as an introduction to the process of informed design and is appropriate for use in high schools and community colleges, grades 9-14.

TIME ALLOCATION IN 45-MINUTE PERIODS: 23 periods

EXISTING COURSES ENHANCED BY THE MODULE

- High school technology education
- Pre-engineering
- Family and Consumer Science

SOURCES (To be maintained until final version)
II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction
A local elementary school group is planning a weekend hike during which they must carry everything, including their food and clothing. They are concerned about the heavy load each person will have to carry. Unable to think of ways to substantially reduce the weight of their backpacks, they have turned to your class for advice.

Design challenge
As part of a group, you will design, construct, and test a dehydrator that dries fruit in as short a time as possible while maintaining the quality of the foodstuff.

Specifications
Dehydrate 250 grams of apple slices to 20% or less of the initial weight.

Constraints
You may use only approved materials and tools. In addition, the drying surface your group uses must have an area no greater than 144 square inches.
MODULE GUIDE
GENETIC TESTING

I. INTRODUCTION AND OVERVIEW

ABSTRACT

In recent decades, scientists have made amazing strides in understanding the molecular basis of heredity and explaining many human genetic diseases. By the beginning of the 21st century, scientists had mapped the entire human genome, laying the groundwork for even more spectacular advances to come.

Biotechnology, the use of living organisms to create products or processes that help improve our quality of life, has undergone rapid development as a result. Molecular geneticists have developed new ways to identify and treat people who have genetic diseases.

Biotechnology has begun to affect many areas of our lives and DNA is in the headlines almost daily. Although biotechnology has great potential for improving human life, it also brings tremendous ethical and environmental challenges that will test the ability of humankind to use the power of biotechnology wisely. Students need to understand this new technology and, in order to do so, they must have a basic knowledge of molecular genetics.

By completing this module, students learn concepts and principles of molecular genetics through a focus on biotechnology. They learn how molecular genetics explains many human diseases and how molecular genetics is being applied to test for and cure human genetic diseases. They further their understanding of biotechnology and demonstrate their knowledge of molecular genetics by designing:

- an information booklet on a human genetic disease;
- a simulated test for a genetic disease, using gel electrophoresis; and
- a counseling session for patients and their families on a genetic disease.

GRADE LEVEL

This module is appropriate for biology and advanced biology courses in grades 9–12 and for college-level biology courses for nonmajors.

TIME ALLOCATION IN 45-MINUTE PERIODS: 23 periods

EXISTING COURSES ENHANCED BY THE MODULE

This module introduces molecular biology and biotechnology concepts to students in the context of informed design. It could be used as part of a Regents biology or Advanced Placement biology course, an MST course following
Regents biology, or a college-level introductory biology/human genetics course for nonmajors.

**SOURCES**
- Tasks 1, 5, 6, 7, and 8 in KSB #4 (Portrait of a Genetic Disease: From Genotype to Phenotype) have been adapted and used, with permission, from Boston University School of Medicine's CityLab program and “How Many CATS,” by Anthony Bertino, Cornell Institute of Biology Teachers.

**II. DESIGN CHALLENGE OVERVIEW**

**SETTING THE CONTEXT FOR STUDENTS**

[The design challenges for this module are presented to students in three related parts. As an overview for these challenges, the students are told the following:]  

**Introduction**
You will work, as part of a team, to develop materials needed to establish a genetics clinic that specializes in counseling and testing people who suspect that they might have or be carriers for *(an assigned genetic disease).* The team needs to design an integrated program that provides patients with pretesting counseling, genetic testing, and posttesting counseling.

**Design Challenge**
Your team will need to design the following products:
- An information booklet that explains the cause, diagnosis, prevention, and treatment of the genetic disease.
- A simulated diagnostic test that uses gel electrophoresis to analyze a patient’s deoxyribonucleic acid (DNA) and a simulated genetic counseling session for patients who are receiving the results of the genetic test.

**Specifications**
It is important that the information that your team provides to the client be complete, up-to-date, and biologically accurate. You must consider how to communicate this information effectively so patients with little background in biology can understand the genetic disease. Because the knowledge gained from genetic testing will impact the patient and family members, you will also need to inform patients of possible psychological, social, economic, ethical, and legal implications of genetic testing.
**Constraints**

Your team needs to have the counseling service established by *(your date)*. To complete the project by the deadline, you will need to work together both during and after class. Background research needs to be done outside of class unless your teacher tells you otherwise. You should use class time for sharing information gained from background research and for the design of your products. Each member of the team will be required to maintain a laboratory notebook as a record of both individual and team contributions to work.
NYSCATE MODULE GUIDE
Pure Peptides

I. INTRODUCTION AND OVERVIEW

ABSTRACT
This module, one of 14 NYSCATE modules, features the integration of mathematics, science, and technology (MST) through the design of a process to isolate and purify a protein from a mixture of proteins. In response to a challenge, groups of students consider specifications and work within constraints as they design, construct, and test their protocol. They use the SDS-PAGE technique to test the effectiveness of their two-step purification process.

Rather than proceed by trial and error, students are expected to design a purification process based on mathematical and scientific principles that they apply consciously. To assist students in using informed design, as opposed to trial and error, this module includes a number of activities that are Knowledge and Skill Builders (KSBs). Topics included in the KSBs are informed design, methods for protein purification, bioinformatics, preparation of solutions and media, cloning, screening of bacterial cultures, chromatography, testing for purity, and bioethics.

GRADE LEVEL
This module is most appropriate for general biology, biochemistry, genetics, and biotechnology courses at a second-year college level.

TIME ALLOCATION
In a course with three hours of class time and a two-hour lab per week, this module would require four to six weeks to complete. It is assumed that all classroom and laboratory time will be devoted to this module for a period of four to six weeks. The time may vary depending on how much presentation/review you provide for students on basic protein structure and function. Some classroom time will need to be allocated to prepare students for the laboratory work they will be doing each week.

EXISTING COURSES ENHANCED BY THE MODULE
This module could be used for general biology, biochemistry, genetics, or biotechnology courses, especially at a second-year college level.

CURRICULUM PARTNER
This curriculum is a modified version of the Secrets of the Rainforest Kit, which is produced by Bio-Rad Laboratories as part of their Biotechnology Explorer Series. The Secrets of the Rainforest curriculum was adapted and placed into the context of the scenario in the design challenge of this curriculum module. Information on the Explorer Series can be found at www.bio-rad.com.
II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction
At a recent conference sponsored by the pharmaceutical industry, you and your research partners attended a presentation in which you learned of an effective folk remedy that is used for the prevention of fungal diseases in humans. During the presentation you learned that there is evidence that, among the people who take this remedy, there is a lower incidence of breast cancer and heart disease. To explore this further, you have obtained a sample of this folk remedy and determined that it contains the following ingredients:

1. Water
2. Salt (NaCl)
3. A prepared extract from pigeon feathers
4. Muskemelon seeds
5. Southern copperhead snake venom

A chemical analysis of the material reveals that the remedy contains three proteins that may be responsible for the beneficial effects that you learned about at the conference. You and your partners have decided to start a new biotechnology company that will identify the protein that may be responsible for reducing the risk of breast cancer and heart disease. Your company will then clone the gene for this protein into bacteria. By growing these bacteria in nutrient culture, your company expects to produce large quantities of the protein that can be purified and then tested on humans in clinical trials.

Design Challenge
As part of a group, you will design a way to purify a protein in large quantities for use in clinical trials. You will purify this protein from a bacterial culture through a two-step purification process.

Specifications
Purify Green Fluorescent Protein (GFP) from a bacterial culture lysate and use SDS–PAGE technique to test the effectiveness of the purification protocol that you designed.

Constraints
You will be provided with a variety of materials used to purify proteins that will improve your design solution. The materials will come from many of the currently applied methods used in protein purification (ion exchange, affinity chromatography, size exclusion, etc.). The following constraints will be imposed:

- The design will be constrained by the materials supplied for use in protein purification.
- The design must be limited to a two-step chromatographic purification process.
ABSTRACT
This module features the integration of mathematics, science and technology (MST) through an emphasis on design in the context of solutions and dilutions. Groups of students will design, construct, and test an iron testing kit to be used in third world countries. The kit will include directions (SOP), small volume measuring devices, limited distilled water, and will have a required % error for the iron determination.

Rather than proceed by trial and error, students are expected to make design decisions based on mathematical and scientific principles. The module features mathematical, scientific, and technological Knowledge and Skill Builder (KSB) activities that groups complete in order to informed as they experiment, design, and construct. Topics included in the KSBs are informed design, scientific method, significant figures, statistics, graphing, concentrations, dilutions, and spectroscopy.

GRADE LEVEL
This module is appropriate for use in community colleges and advanced high school science courses.

TIME ALLOCATION IN 50-MINUTE PERIODS: 20

EXISTING COURSES ENHANCED BY THE MODULE
This module was designed for chemical and biological technology courses. It also fits well into Freshmen Chemistry, Analytical Chemistry and could be used in advanced chemistry and biology courses in high school.

SOURCES

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction.
A small African country has become concerned with a recent increase in African siderosis. African siderosis is condition of iron overload thought to be associated with a diet high in iron and may be a result of a genetic mutation similar to HFE gene mutations associated with hemochromatosis in Caucasians.
Design challenge
A representative from the health ministry has approached your laboratory to develop a kit, which could be used to measure iron in their drinking water and food supply. The country that is using this kit is very poor and also has limited access to water and distilled water. Therefore the methodology must be on a small scale.

Specifications
A large corporation in the United States has donated spectrophotometers to the labs but the labs do not have access to many lab supplies. Equipment in the kit should include a small-scale (micro) pipetter or micro pipets, volumetrics, and all other required equipment and materials. A set of directions (SOP) for making the reagents and the laboratory procedure must also be included. A translator will be used to translate to the appropriate languages.

Constraints
- A minimum precision of 2 %.
- Volumetrics must be 10 mL or smaller.
- The entire kit should be under $30. (Check this amount out.)
Introduction to Polymers

I. INTRODUCTION AND OVERVIEW

ABSTRACT
This module features the integration of mathematics, science and technology (MST) through an emphasis on design in the field of polymer products. In response to a challenge, groups of students consider specifications and work within constraints as they design, construct, and test a new composite polymer material.

The students are challenged to work as a team to design a new composite material to be used for a recreational product line. The emphasis will be on understandings of the structure and function of the organic molecules that make up polymers and the properties that make polymers the right choice for a specific application. The students will perform a series of knowledge and skill building activities (KSBs) to prepare them for the informed design process. This informed design enables them to create using the knowledge and skills developed rather than by trial-and-error. The KSBs include the chemistry of polymer synthesis, research about both natural and synthetic polymers, and activities to test material for their polymer layers and the glues and adhesives to make the composite.

GRADE LEVEL- 11-12

TIME ALLOCATION IN 45-MINUTE PERIODS: 22

EXISTING COURSES ENHANCED BY THE MODULE:
- Regents Chemistry
- Local Chemistry
- Materials Science Technology

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction
Your group is part of the research and development unit for a large recreational equipment and supply company. Your group has been assigned to design and test a new polymer composite for use in one of the company’s new products, a new fully outfitted snowmobile.

Design challenge
Design and test a composite of multiple layers of polymer material bonded together to form a material suitable for use in the body of the snowmobile, in the protective cover storage/transport shell, or matching snowmobile suit.
**Specifications**
Your group will submit one sample of the polymer composite along with individual reports of test results to support claims that this composite is right for the intended application on the snowmobile.

**Constraints**
The composite must have a minimum of 5 layers. The composite must use at least one synthetic and one natural polymer. The adhesive(s) and coating(s) may be natural and/or synthetic and are not considered layers. If you decide on a polymer or glue or adhesive not tested in the KSBs then you must justify its use by test results before using it in your composite. The sample is to be 10 cm x 30 cm.

Thickness requirements:
- Snowmobile body material – 0.5 cm
- Snowmobile storage/transport shell – 1.0 cm
- Snowmobile suit – 2.0 cm

The sample may be under the thickness maximum.
Each composite should be waterproof or highly water resistant.
The composite’s flexibility should be appropriate for the intended use.
NYSCATE MODULE GUIDE
Automated Control

I. INTRODUCTION AND OVERVIEW

ABSTRACT

This module is one of 14 NYSCATE modules that feature the integration of mathematics, science, and technology (MST) through an emphasis on design. The module introduces the concepts that are central to automated control systems by challenging students to design and build an automated control system to accomplish a simple task.

The design challenge charges students with building an automated system for delivering a predetermined amount of product to a package for distribution and sale. Students are given latitude in determining the exact methods they will employ for addressing this challenge. To simulate the challenges that would exist in similar situations in an industrial setting, students are asked to work within a set of external constraints placed upon the final design.

Rather than proceed by trial and error, students are expected to make design decisions based on mathematical and scientific principles that they consciously apply. The module features mathematical, scientific, and technological Knowledge and Skill Builder (KSB) activities that design teams complete in order to be informed as they design, construct, and test their solutions.

GRADE LEVEL
This module is appropriate for students enrolled in community college technology programs.

TIME ALLOCATION IN 45-MINUTE PERIODS
The work that is recommended for the basic module should take approximately 13 class periods of 55 minutes each. However, individual teachers may choose to consolidate the work into fewer periods by using lab periods that are longer than 55 minutes each, or by assigning some of the work to be done outside the usual class or lab periods.

EXISTING COURSES ENHANCED BY THE MODULE
This module has been specifically designed to facilitate student learning in a college freshman-level electrical technology course.

Since this is a module that emphasizes the design process, it may also fit well or be adapted to fit well into most community college technology education or
introductory engineering design courses. Opportunities also abound for team teaching the module in these subject areas.

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

The design challenge charges students with building an automated system for delivering a predetermined amount of product to a package for distribution and sale. Students are given latitude in determining the exact methods they will employ for addressing this challenge. To simulate the challenges that would exist in similar situations in an industrial setting, students are asked to work within a set of external constraints placed upon the final design.

Note: Information in this section is also provided to students within this document (see Student Handout #1 in the Student Handout section).

Introduction

Your local marble company has experienced an increase in sales over the last few years. This increase in sales has resulted in pressure on the packaging facility. Currently, an employee packages marbles manually. The employee counts out the number of marbles required for each package. The owner of the company has decided to automate this process. Her goal is a fully automated packaging system, but, understanding the need to start slowly, she wants to test a simple version of the system in which the empty package may be manually placed on the packaging device and the product source may be manually stocked.

Design challenge

You are asked to design and build a prototype system to demonstrate that 1) marbles can be delivered automatically to a package from a source and that 2) the system will detect and stop filling the package when a specified amount of the product has been delivered.

1. For the first part of the challenge, designing the delivery subsystem, you will work as a whole class. With the stock and container components provided, you will design a class strategy for transferring marbles continuously from the larger stock container to the smaller packaging container.

2. For the second part of the challenge, designing the packaging subsystem, you will work as a member of an assigned design team; you will design a subsystem to control the transfer of a specified number of marbles to the package. Working in your team, you will document the specifications, circuitry, and performance for your portion of the system.

Specifications
1) *The packaging container must hold 20 marbles.*
2) The marbles are obtained automatically from a larger bin designated as the source bin.
3) Upon receiving a generated signal, marbles begin moving from the source bin toward the package.
4) The packaging container, which may be manually placed into position, begins receiving marbles. The system must determine when the appropriate number have been transferred.
5) A stop signal is automatically generated to halt the flow of marbles from the source bin.
6) When the next empty packaging container is in the receiving position, the process repeats.
7) The system must cycle successfully five consecutive times.

**Constraints**

Success is defined as five repetitions at not more than 5% error.
NYSCATE MODULE GUIDE
Remote Sensing

I. INTRODUCTION AND OVERVIEW

ABSTRACT

This module is one of 14 NYSCATE modules that feature the integration of mathematics, science, and technology (MST) through an emphasis on design. It introduces the concepts that are central to maps and map making. It does this by challenging students to use basic remote sensing technology. Specifically, they use tethered balloons to take a set of aerial photographs and design an accurate scale map of the area around their school.

The module emphasizes traditional Earth science topics such as maps, map making, topology, and land features. In addition, the more modern topic of remote sensing technology is introduced.

In this module, the teacher:

- provides an engaging design challenge;
- fosters cooperative learning as students work in design teams;
- facilitates student acquisition of skills and knowledge in maps and map making, and in the science and mathematics principles related to this content;
- prompts scientific inquiry and mathematical analysis;
- guides students as they identify and explore factors relevant to design performance;
- provides opportunities for improving communication skills through the use of the Design Journal or Design Folio; Design Report; and group presentation of student work; and
- works with groups as they cooperatively compose, construct, test, improve, and present their design solutions.

Rather than proceed by trial and error, students are expected to make design decisions based on mathematical and scientific principles that they consciously apply. The module features mathematical, scientific, and technological Knowledge and Skill Builder (KSB) activities that groups complete in order to be informed as they design, construct, and test.

GRADE LEVEL

This module is appropriate for students in high schools and community colleges, grades 9–14.
TIME ALLOCATION IN 45-MINUTE PERIODS:

It should take about 21 periods to complete all of the work recommended in the basic module. However, the number of periods can be reduced by eliminating certain activities identified as optional, or expanded by completing some suggested applications of the student products.

EXISTING COURSES ENHANCED BY THE MODULE

This module has been specifically designed to facilitate student learning in an existing high school Earth science course.

Since this is a module that emphasizes the design process, portions of it may also be adapted to fit into high school or community college technology education courses.

SOURCES (To be maintained until final version)


EarthKAM Project, http://www.earthkam.ucsd.edu

M. Kerr, National Air and Space Museum, Smithsonian Institution, Cosmic Voyage, http://www.nasm.edu

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

The design challenge asks students to make a composite aerial photograph of their school property from separate photographs that they take from a helium-filled balloon. The challenge is broken into three parts: 1) developing a strategy for taking the separate photos, 2) constructing the composite photograph, and 3) developing an overlay map to place on the composite photo.

The full challenge should be completed in about 21 days, but dropping nonessential activities can shorten this time considerably. Specific ways to reduce the time include:

- focusing student effort solely on the challenge and the Knowledge and Skill Builders (KSBs) that are essential for completing the challenge;
• omitting design and preparation of the overlay map;
• omitting identification of GPS coordinates;
• omitting the additional application activities presented after the challenge in the timeline; and
• omitting the student presentations or using a less time-consuming poster session to display student work.

In the presentation below, items that can be dropped easily are labeled “Optional.”

Note: Information in this section is also provided to students later in the document (see Student Handout #1).

Introduction

The planning board of your local government is interested in mapping your community in order to plan for the future. Your school administration has been asked to provide an up-to-date aerial photograph and overlay map of the property on which the school resides and the area immediately surrounding it. Your class has been assigned the project of providing the aerial photograph and developing a labeled transparent overlay map to help interpret the photograph.

Design challenge

You will design a composite aerial photograph and transparent overlay map of your school property and its immediate surroundings. This design challenge has three parts:
• Working as a class and using the balloon and camera system provided, you will design a class strategy for taking several photos that together show the entire area of the school property and its immediate surroundings.
• Working in an assigned group, you will use copies of these photos to design a single composite photograph of the property.
• (Optional) Working in your group, you will design a map that can be superimposed on the composite photograph to identify major features of the photo such as buildings, athletic fields, parking lots, and adjoining streets.

Specifications

1) The photo and transparent overlay map of your school property and surrounding area must show a rectangular region at least 200 meters on one side. The photo and map must have a scale indicating the relationship between the distances in meters on the ground and the corresponding distances on the photo and map.
2) The photo and map must show a level of detail much greater than the 30-meter pixel resolution offered by satellite photos. One must at least be able to
distinguish objects the size of a car from other objects.

3) (Optional) The map overlay that you produce must show the GPS coordinates of the photo so that the photographed area’s precise location on the globe is known. The coordinates should also permit accurate identification of that area on other local maps.

4) The composite photo and map must be easily transported, stored, and used. They must be in a form that permits their viewing by groups of people; two large posters, overhead transparencies, and computer projections (PowerPoint) are examples of acceptable formats.

**Constraints**

The composite photo (mosaic) must be developed from separate aerial photographs taken by each of the working groups in your class. These photographs must be taken using the balloon lift system described in KSB T3: Construction of Aerial Camera Support.
Using Liquid Crystals to Create a Practical Device

Some alternative titles:
1) Liquid Crystals for Design
2) Making Liquid Crystals Useful through Design
3) Designing Useful Liquid Crystal Devices
( 9/24/01)

1. INTRODUCTION AND OVERVIEW

ABSTRACT

As we examine the world around us, many common devices we use each day are being replaced by more advanced items that draw from our ever expanding knowledge of science and technology. This module integrates mathematics, science, and technology (MST) through the design and development of a liquid crystal device. Students will be challenged to develop knowledge and skills necessary to design, construct, and test an object that demonstrates an effective use for a liquid crystal device in the form of a thermotropic display.

Students, working in design teams, will be expected to make their design decisions based upon mathematical and scientific principles in an informed design process rather than proceed through trial and error. Mathematical, scientific, and technological Knowledge and Skill Builder (KSB) activities are completed by the groups to provide the needed information to guide them as they design, construct, and test the device. Topics in the KSBs include: the informed design cycle; electrical circuits; voltage, current, resistance, and power; series and parallel circuits; voltage divider circuits; liquid crystal properties; thermotropic concepts; use and combination of chemicals; and factor studies that relate temperature and color changes of thermotropic displays.

PEDAGOGICAL FRAMEWORK REFERENCE

A separate document, the NYSCATE Pedagogical Framework, provides an in-depth understanding of the NYSCATE challenge statements, the FOCUS on Informed Design pedagogical model for teachers, student Knowledge and Skill Builders (KSBs), the informed design loop for students, and more.

GRADE LEVEL

This module is designed for the 11th- or 12th-grade high school student.

TIME ALLOCATION IN 45-MINUTE PERIODS: 20-25 periods
EXISTING COURSES ENHANCED BY THIS MODULE

This module is intended for use in chemistry, physics, and technology education courses that address the MST learning standards of New York State. This module could be taught as part of a high school stand-alone chemistry course, physics course, or technology education course; or it could be team taught as an interdisciplinary course. Completing this module will enhance mathematical skills as well.

Chemistry students, in addition to developing skill in experimental design, will gain knowledge in the areas of chemical properties, mixtures of chemicals, and the effects of temperature change on these chemicals.

Physics students, in addition to developing skill in experimental design, will gain knowledge in the areas of energy transfer and conversion, electrical concepts and applications, and optical properties of liquid crystal displays and thermotropic substances.

Technology students, in addition to developing skill in engineering design, will gain knowledge in the areas of electrical concepts and applications, electrical circuit design and application, use of tools and materials, and design and construction of a practical device utilizing this material.

SOURCES

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction

Those who invent a device by taking a basic technology and putting it to use in a new way often improve our lives. The ability to design a new device by applying an existing technology is an important, creative engineering skill. Think of basic technological inventions such as Velcro, lasers, LEDs, or CRTs — each has been put to so many uses. Can you name some of these uses? In this module, you will be challenged to take a basic technology, liquid crystals, and use it to design a new device.

Each day we come into contact with many things for which temperature is important.

- Some things, such as a cup of coffee, should be a certain temperature. Can you think of others?
• Some things, such as a person’s forehead, indicate a problem when they are too hot or cold. Can you think of others?
• Measuring the temperature of something can indirectly measure something that may be difficult to measure directly. Measuring the temperature of a wire can indicate the amount of current flowing through it. Can you think of other examples?

A device providing a quick and inexpensive means of monitoring temperature visually could be used in many ways in today’s world. This module challenges you to create such a device.

**Design Challenge**

As part of a team, you are to design, construct, and test a device that will demonstrate a practical use for liquid crystals in the form of a thermotropic display.

**Specifications**

The device constructed must incorporate the ability to detect heat and to visually display temperature (or a temperature range, or changes in temperature).

**Constraints**

Each team must use only approved materials. The display created should be no larger than 1 inch by 2 inches.
ABSTRACT
By exploring the best way to manufacture an item, this module provides students with the opportunity to learn at a variety of levels about design for manufacturing.

- At the first, most obvious, level, students learn about different manufacturing technologies, materials, assembly techniques, finishing, and packaging.

- At a higher, more important level, students gain an understanding of learning-by-doing and learning-by-necessity. These important concepts are used in the real-world working environment.

- The big picture is that students learn the important, fundamental concept of what engineering is. They learn about evaluating different parameters and making trade-offs to determine the best way to accomplish specific goals.

Students accomplish these learning objectives by designing a product to be mass-produced. To solve this design challenge, students need to learn about materials and manufacturing methods. Then they need to evaluate design options and make decisions based on information about manufacturing methods and considerations.

Knowledge and Skill Builders (KSBs) are completed to support the design challenge. Some KSBs provide background information while others provide opportunities to apply the information. For instance, students are asked to “reverse engineer” a product and to speculate about how a product might be manufactured. They then tour a manufacturing facility to test their speculations.

GRADE LEVEL
Second year of community college

TIME ALLOCATION IN 45-MINUTE PERIODS
Stretched over one semester, roughly two weeks of time:

Four to six one-hour class periods
Two lab periods of two to three hours each
EXISTING COURSES ENHANCED BY THE MODULE
Any basic engineering or engineering exploration courses

SOURCES
For an idea of what is out there:
   Assembly magazine (www.assemblymag.com)
   PHD Automation products (www.phdinc.com)
   Basics of manufacturing technology (www.ee.washington.edu/conselec/CE/kuhn/manufact/95x2.htm)
   Manufacturing Center (www.manufacturingcenter.com)

II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction
Your team of three to four people has been charged with designing a product that is ready for manufacturing. Since the product must be produced in large quantities, you are to evaluate and select different materials and manufacturing techniques that optimize the mass production process.

After learning about and evaluating the parameters, and comparing at least two different product styles, you are to make a model of the item. The model does not have to be made of the same materials or by the same methodologies you proposed, but it should illustrate the key features you evaluated and selected.

Design challenge

You are to design a desktop CD holder, taking into account factors to optimize its manufacture.

Prepare a written report. In the report, your team is to compare and contrast at least two product styles. For example, you might look at a drawer-type CD holder versus a flip-lid style. Your report should include an evaluation of the possibilities presented in the list of methodologies below. In addition, you should defend the design decisions you made.

Manufacturing Methodologies and Considerations:
   Plastic: injection molding, blow molding, sheet forming
   Metal: casting, sheet forming, stamping, bending
   Cloth: cutting, stamping, sewing, riveting
   Wood: cutting, shaping, fastening, finishing
   Glass: cutting, blowing, hardening, finishing
   Construction elements: hinges, glides, closures
Assembly: snap-together, fasteners, screws, pop-rivets, glue, welding (metal or plastic)
Assembly automation: Reconfigurable work cells, dedicated equipment
Coating: painting, stamping, decals, silk screening
Packaging: boxing, shrink-wrapping, bagging, blister packing
Environmental (“green”) considerations: production of waste; hazardous waste; reclamation, reworking, and recycling of unused materials; environmentally friendly packaging.

Build a model of one of the styles you have analyzed. Obviously, the model does not have to be made of the same materials or use the same methodologies recommended in your report, but it should illustrate some of the major decisions you made and defended. This model might be a physical model or, if you already have adequate skills, a 3-D virtual model.

Specifications
The CD holder must have the capacity to hold at least 20 standard-sized CDs on a desktop.

Plan to produce a lot of these; using as much automation as possible during the manufacturing process is likely to pay off.

Constraints
Do not over concern yourself with features of the CD holder. Assume that there is a large demand for containers, and any reasonable features you choose will sell in the marketplace. The holder can be a drawer style, stackable, open style, flip style, etc. It can be cheap, expensive, purely functional, or decorative. Do not focus on features that are important to you personally. Your main concern should be to design a quality holder that can be manufactured in quantity at a reasonable cost.
NYSCATE MODULE GUIDE

Introduction to Networking: Getting Wired

I. INTRODUCTION AND OVERVIEW

ABSTRACT
This high school concentration-level module introduces students to computer networks. Students will be introduced to computer networks in a variety of experiences including:

- Applying components of the NYSCATE design process and using appropriate tools and materials to design a solution to a given problem. The design and redesign must be based upon scientific and mathematical concepts;
- Completing Knowledge and Skill Builder activities;
- Developing a timeline describing the history of computer networking;
- Installing a network interface card and driver software;
- Determining OSI model and attributes;
- Generating a computer simulation of network topology; and
- Developing a proposal for a new computer system designed for a small business.

GRADE-LEVEL APPROPRIATENESS
This is a concentration-level high school module appropriate for use in grades 11–12.

TIME ALLOCATION IN 45-MINUTE PERIODS: 30 periods

EXISTING COURSES ENHANCED BY THE MODULE
For a concentration-level HS module, students are expected to have a measure of computer literacy. Some knowledge of computer system hardware would be helpful as well, but is not required. This module can be delivered through a variety of computer applications, or through technology education courses such as: Digital Electronics, Computer Electronics, AC & DC Electronics, or Principles of Engineering.

SOURCES
II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction
Computers have come a long way since the time when a single computer filled an entire room. In the early days of computer use, and up through the mid-1970s, remote access was the only viable method of connecting to a computer. People usually worked on a terminal wired to a computer that might have been in the next room or many miles away. Dedicated telephone lines typically served as the common link between the user’s terminal and the “mainframe” computer. This situation changed with the development of integrated circuits (microchips) and the microcomputer in the late '70s. For the first time, people were able to work on a stand-alone computer on their desktop, independently of any other system. This independence, however, has brought certain disadvantages. Many desktop computers lack the capacity to store and access the large amounts of data associated with typical business applications, and they often require needless duplication of resources that can (and should) be shared.

As a result, the need today is for networks that enable computers to share data, software, devices, and other resources. One might say that computers have come full circle over the past two decades: We are now all getting connected again. As much as we like our independence, we often need the benefits of connectivity.

DESIGN CHALLENGE (Growing Company)
Student teams will design a system for a business that is modernizing its computer system. They will be upgrading their 386 Novell Server–based accounting system that used 4-mps token rings to network six computers, and replacing it with a new state-of-the-art integrated system that will put terminals at every point in this warehouse-based business and connect to the Internet. Optionally, a small dot.com will be created, allowing eCommerce with an additional router(s), switch(es), and servers. Each team will analyze the operation of the company and then design a system that best matches their current and future (projected) needs. Each team will submit a formal proposal describing their recommended system.

SPECIFICATIONS
The recommended system will be based on a needs assessment that students develop by analyzing the operation of the company. Their solution will include the following items:

- A sales proposal indicating the name, model, quantity, and cost of all devices and materials. Each team’s proposal will include prices of hardware, software (OS and office suite), and installation. A one-page spreadsheet summarizing prices and a one-page summary of the reasoning behind this proposal will comprise the first two pages of the proposal.
■ A computer simulation describing the topology of the connected hardware. This simulation will confirm that all of the network components work together. Cisco’s ConfigMaker will be used for this.
■ A wiring diagram (cut sheets) illustrating the layout and connections for all network wiring.

CONSTRAINTS
Students must meet the needs of the new network in regard to bandwidth, security, reliability, and speed. In addition, their prices must be competitive. Presentations should be professional.
PAVING THE WAY TO THE INTERNET

I. INTRODUCTION AND OVERVIEW

ABSTRACT
This NYSCATE module provides second year community college students with an opportunity to investigate various Internet addressing protocols and schemes. The design challenge requires students to design a network that will provide full Internet access for several clients/companies that have different network requirements. Routing fundamentals are investigated by students as are the data (routing tables) that they generate. Students optimize network design with the use of newer, more efficient addressing schemes such as variable length subnet mask (VLSM) and classless interdomain routing (CIDR). Students design networks using a variety of IP Internet addresses and classes, and use the TCP/IP communications protocol.

GRADE LEVEL
Third semester community college.

TIME ALLOCATION
8 to 9 class/lab sessions; class/lab sessions as described run for two class/lab hours; each class/lab hour is 50 minutes long. Total approximate time is 16 to 18 class/lab hours in a setting where computers are available for student use.

EXISTING COURSES ENHANCED BY THE MODULE
Examples of course offerings enhanced by this module at New York City Technical College are provided here:

Computer Systems Technology Department, Microcomputer Business Systems program:
- MS 307 Local Area Networks
- MS 405 Microcomputer Operating Systems

Electromechanical Technology Department, Computer Engineering Technology program:
- EM 360 Data Communications
II. DESIGN CHALLENGE OVERVIEW

SETTING THE CONTEXT FOR STUDENTS

Introduction
The “information superhighway” is by no means the smoothly paved road we all hoped it would be. We regularly encounter bumps and sharp curves along the way in our travels through cyber space. It is the access to the multitudes of information available on the Internet that makes the process entirely worthwhile.

Much of our active time on the Internet is spent searching for information that we either need, or for which we just have a passing interest. Time spent in the library 20 years ago can now be used more efficiently by accessing the same sources through the Internet. The same can be said for online purchasing (e-commerce), email and personal finance as well.

Although we're very interested in the location of the information we are looking for, we never seem to be concerned about the path the information takes to reach us. If not for the ability to locate a remote information source, and initiate a data transfer from this source, we could not have an Internet as we know it today.

The Internet can only work if it has a method (or protocol) which enables it to identify users and directs information accordingly. The Internet protocol (IP) accomplishes this by assigning a unique address to each user. This process, which is similar in concept to the manner in which the US Postal Service directs mail to locations, can suffer from the same bottlenecks and congested resources. Although there are no ZIP codes (or ZIP + 4) on the Internet, strategies have been developed to optimize the process and to increase the efficiency of data transfer.
Design Challenge
You and the members of your team will design a network that will provide full Internet access for four clients/companies. You will determine the requirements of each company and then design an optimal addressing scheme to serve them.

Specifications
• Full Internet access will be provided for the following four clients/companies:
  • Small company (Real Estate Office): 50 nodes
  • Medium company (Department Store): 200 nodes
  • Medium-large company (University): 1500 nodes
  • Large company (Local ISP): 5000 nodes
• The designed network must increase data performance (decrease router table size) of a traditional single class B address network.

Constraints
• ISP (Internet service provider) has access to a single "class B" IP address.
• Solution must use VLSM (Variable Length Subnet Mask) and CIDR (Classless Inter-Domain Routing) in the addressing scheme.
I. INTRODUCTION AND OVERVIEW

ABSTRACT
This high school foundation-level module introduces students to the PC and its applications. In this module the teacher introduces students to PCs through a variety of experiences including:

- designing a “virtual PC” on the Internet to introduce students to the design process and provide an engaging design challenge;
- completing Knowledge and Skill Builders to obtain just-in-time information;
- formatting a hard disk and installing an operating system (OS) and applications;
- troubleshooting and correcting faults on a PC;
- developing flowcharts; and
- generating a computer presentation.

GRADE-LEVEL APPROPRIATENESS
This is an introductory, foundation-level high school module appropriate for use in grades 9-10.

TIME ALLOCATION IN 45-MINUTE PERIODS: 25 periods

EXISTING COURSES ENHANCED BY THE MODULE
As an introductory module on PCs, the package can be delivered in a variety of computer applications courses, or in technology education courses such as Digital Electronics, AC & DC Electronics, and Principles of Engineering.

SOURCES

II. DESIGN CHALLENGE OVERVIEW
SETTING THE CONTEXT FOR STUDENTS

Introduction
For any given human-made device there are times when the device isn’t working properly. Computers are no different; they will inevitably have problems that need to be addressed and remedies that need to be found. Many of us have experienced the frustration of trying to troubleshoot a problem ourselves and then trying to find someone who can fix the problem for us. In this module, you become a troubleshooter of computer problems.

Design Challenge
As part of a group, you will design a flowchart for troubleshooting common errors in a computer and then implement that design using presentation software (i.e., PowerPoint, Corel Suite, Lotus Suite, etc.). Your “Help Desk” will meet quality specifications both when you test it and when your group formally presents it to the class.

Specifications
Use presentation software with variable slide sequencing to navigate through a troubleshooting procedure. Slides must include graphics, text, and digital photos.

Constraints
Entire presentation must fit on a single 1.4 MB floppy disk.
Gatekeeper to the Internet

ABSTRACT
This NYSCATE module provides second-year community college students with an opportunity to explore various methods used to implement security on the Internet. The design challenge requires students to design a solution that will enable an e-commerce company that was recently hacked to be secured from unauthorized access, but at the same time will permit full remote access to its traveling salespeople.

Students develop a security proposal for the company and then test their designed security system to ensure that it fulfills the intent of their proposal.

GRADE LEVEL
Third or fourth semester of community college. Students will need prerequisite course work and a working knowledge of computer networks.

TIME ALLOCATION
8 to 9 class/lab sessions; class/lab sessions run for two class/lab hours; each class/lab hour is 50 minutes long. Approximate total time is 16 to 18 class/lab hours in a setting where computers are available for student use.

EXISTING COURSES ENHANCED BY THE MODULE
Examples of course offerings enhanced by this module at New York City Technical College are provided here:

Computer Systems Technology Department
Microcomputer Business Systems program:
  MS 307 Local Area Networks
  MS 405 Microcomputer Operating Systems
  CS 507 Advanced Single LAN Concepts
  CS 607 Interconnectivity
  CS 707 LAN-Internet Connection

Electromechanical Technology Department
Computer Engineering Technology program:
  EM 360 Data Communications
  EM 973 Microcomputer Interfacing

Electrical Engineering Technology Department
Telecommunications Technology program:
  TC 570 Computer Systems
  TC 620 Data Networks and Traffic Control
SETTING THE CONTEXT FOR STUDENTS

Introduction
Security has always been an important issue. Recorded history has shown that humans were developing technological solutions regarding their security long before the Internet came into being.

In medieval times, security involved a feudal lord’s needing to hold back attacks from legions of armored warriors on horseback. To do this, castles were built increasingly larger with higher and thicker stone walls. As potential invaders acquired more skill, the lords had to respond with increased security measures such as moats, bridges, and multiple levels of security using gates and guard towers. Invaders eventually found it so difficult to storm a castle that they developed technological tools of their own, namely the trebuchet (catapult), which hurled 200-pound stone “missiles” at the castle walls, and eventually the cannon, which all but destroyed the castle unless it was surrendered to its attackers first. With all of the measures used to secure such a castle, authorized access became more difficult as well. Allowing any authorized access while the castle was under attack was virtually impossible.

The modern Internet has many similar security issues. It must be secure from attack (which is considered to be ongoing), but at the same time it must have the capacity to permit complete access when an authorized user requests it. In medieval times the castle walls were built to hold back the attack of armored warriors on horseback and archers traveling by foot. Today, we use firewalls to secure our networks and servers, and the attackers are often hackers using such modern weapons as viruses (hostile programs) that can cripple our systems if they gain access to our resources.

Design Challenge
A website of a well-known company involved in e-commerce has been hacked. Passwords have been accessed and confidential information has been compromised. You and the members of your team will design a solution to secure both the website and the company resources (data).

Specifications
• The website and network need to be secured to prevent all unauthorized access.
• The website and network must permit full remote access to three (3) traveling salespeople who need access to all network resources and internal data.

Constraints
• Dial-up solutions cannot be used since large-scale direct-dial access is unavailable.
• Internal data must be accessed through the Internet (an ISP account) using VPN.