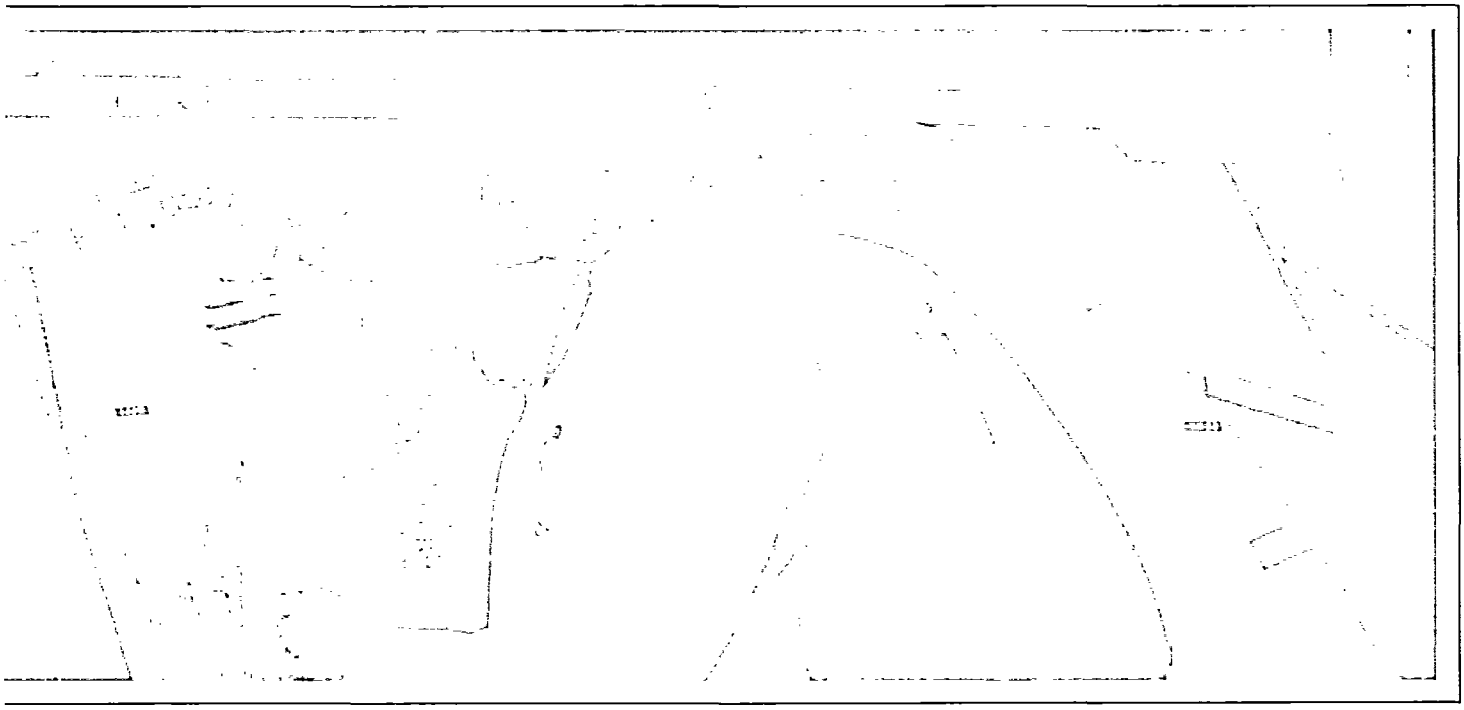
TECHNOLOGY EDUCATION
PRODUCT DESIGN AND ENGINEERING

GRADES 9-12
ELECTIVE



The University of the State of New York
The State Education Department
Bureau of Home Economics
and Technology Education Programs
Division of Occupational Education
Albany, New York 12234

3. Assign a partner for the duration of a unit to a student as an additional resource to facilitate clarification of daily assignments, timelines for assignments, and access to daily class notes.

4. When assigning long-term projects or reports, provide a timeline with benchmarks as indicators for completion of major sections. Students who have difficulty with organizational skills and time sequence may need to see completion of sections to maintain the organization of a lengthy project or report.

Infusing Awareness of Persons with Disabilities Through Curriculum

In keeping with the concept of integration, the following subgoal of the Action plan was established.

In all subject areas, revisions in the syllabi will include materials and activities related to generic subgoals such as problem solving, reasoning skills, speaking, capacity to search for information, the use of libraries and increasing student awareness of and information about the disabled.

The purpose of this subgoal is to ensure that appropriate activities and materials are available to increase student awareness of disabilities.

This curriculum, by design, includes information, activities, and materials regarding persons with disabilities. Teachers are encouraged to include other examples as may be appropriate to their classroom or the situation at hand.

STUDENT LEADERSHIP SKILLS

Development of leadership skills is an integral Part of occupational education in New York State. The New York State Education Department states that, "Each education agency should provide to every student the opportunity to participate in student leadership development activities. All occupational education students should be provided the opportunity to participate in the educational activities of the student organization(s) which most directly relate(s) to their chosen educational program."

Leadership skills should be incorporated in the New York State occupational education curricula to assist students to become better citizens with positive qualities and attitudes. Each individual should develop skills in communications, decision making/problem solving, human relations, management, and motivational techniques.

Leadership skills may be incorporated into the curricula as competencies (Performance Objectives) to be developed by every student or included within the Suggested Instructional Strategies. Teachers providing instruction through occupational educational curricula should familiarize themselves with the competencies. Assistance may be requested from the State advisor of the occupational student organization related to the program area.

Students who elect to become active members of one of the student leadership organizations chartered by the New York State Education Department have the advantage of the practical forum to practice leadership skills in an action oriented format and have the potential for recognition of their achievements at the local, State, and national level.

SYLLABUS OBJECTIVES

Through the implementation of this syllabus, the student will:

1. Participate in a manufacturing enterprise to research, design, develop, produce, and assure quality of a manufactured product.

2. Participate as a member of a team to reach a common goal.

3. Develop collaborative and social skills necessary to be a productive member of a working group.

4. Use computer programmable controls and mechanisms.

5. Use tools, equipment, and materials in the development and production of a product.

6. Learn how products, materials, processes, and information are conceived, improved, and applied in a manufacturing enterprise.

7. Use the systems approach, problem-solving and analytical skills to solve engineering problems within the context of laboratory activities.

8. Identify current trends in manufacturing and the possible associated impacts.

PERFORMANCE OBJECTIVES

The performance objectives of the syllabus are intended to clearly present what students are expected to know, do and be like, following instruction in a given topic. The knowledge (K), skills (S) and attitudes (A) that students should acquire are identified for each topic, under "competencies to be developed".

COURSE TITLE: Product Design and Engineering

SYLLABUS OUTLINE
Table of Contents

Estimated Learning Time

SEMESTER ONE

I. MODULE: **Product Engineering** **30 Hours**

Topics:

A. Product Selection and Specifications
B. Product Development
C. Prototype and Testing

II. MODULE: **Production Engineering** **24 Hours**

Topics:

A. Management
B. Capital
C. Process Selection
D Plant Layout
E. Personnel Selection and Training
F. Quality Assurance Program

SEMESTER TWO

III. MODULE: **Traditional Manufacturing** **25 Hours**

Topics:

A. Precision Measurement and Inspection
B. Principles of Machine Set-up and Operation

V. MODULE: **Computer Aided Manufacturing** **25 Hours**

Topics:

A. Computer Numerical Control
B. Robotics
C. Communication and Integration

VI. MODULE: **Trends and Impacts** **4 Hours**

Topic:

A: Trends and Impacts

TOTAL LEARNING TIME: 108 Hours

SYLLABUS COMPONENT

SEMESTER ONE

I. Module: **Product Engineering**

A. Topic: **Product Selection and Specifications**

Performance Statement:

Upon satisfactory completion of this topic, the student will select and specify a product.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Role play the part of both the customer and the manufacturer. (S) (K)

b. Demonstrate an ability to develop specifications to meet the needs of both the customer and the manufacturer. (S)

Suggested Instructional Strategies:

1. Provide several common products to be evaluated on the basis of customer appeal, ergonomics, gender bias, etc.

2. Have students view a videotape of an engineer describing the concerns of the manufacturer, and contrast these with those of a videotape of a customer.

3. Divide the class into teams of four with two members playing the role of the customer and two members playing the role of the manufacturer. Repeat strategy one with students reversing roles. Synthesize the results of steps one and two.

B. Topic: **Product Development**

Performance Statement:

Upon satisfactory completion of this topic, the student will design and develop a product that meets given specifications.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Role play the part of various engineers in the development of a product. (S) (K)
b. Demonstrate an ability to develop a product that meets the needs of both the customer and the manufacturer. (S)
c. Follow a systematic design/problem-solving process. (S) (K) (A)

Suggested Instructional Strategies:

1. Provide several common products to be evaluated on the basis of manufacturability.

2. Have students view a videotape which illustrates the concept of design for manufacturability.

3. Divide the class into teams with members playing the roles of the industrial design, mechanical, electrical, computer and manufacturing engineers as well as cost analysis personnel. Repeat strategy one with students changing groups and assuming new roles. Synthesize the results of steps one and two.

4. Using traditional and/or computer-assisted design methods, design and develop an aesthetically pleasing product.

5. Have students prepare a list of questions to ask various people during a visit to a local manufacturing concern. Have students postulate the expected answers. Contrast and compare the two.

C. Topic: **Prototype and Testing**

Performance Statement:

Upon satisfactory completion of this topic, the student will develop a product prototype and test procedures.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Role play the part of engineers, model makers, and potential customers in building and evaluating the prototype. (S) (K)
b. Fabricate a product and modify it so that it meets the needs of the customer. (S)
c. Demonstrate various techniques for making mock-ups and prototypes. (K)
d. Enjoy the satisfaction of building a product to the customer's satisfaction. (A)
e. Demonstrate manual skills in using various tools and machines to build a mock-up or prototype. (S)

Suggested Instructional Strategies:

1. Have student teams build a mock-up of a simple manufactured product.

2. Have student teams build a prototype of the company's product.

3. Divide the class into teams to evaluate and test the prototype by using market survey techniques.

4. Divide the class into teams and plan to modify the product based on market survey results.

II. Module: **Product Engineering**

A. Topic: Management

Performance Statement:

Upon satisfactory completion of this topic, the student will participate in the management of a manufacturing enterprise.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Construct a management line of authority chart. (S)
b. Describe the procedures for decision making. (K)
c. Appreciate the role that a manager plays in the manufacturing enterprise. (A)
d. Demonstrate the ability to accomplish goals with the help of other people. (S)

e. Contrast the concept of lean management with that of the older, more traditional concepts of management. (K) (A)

Suggested Instructional Strategies:

1. Allow students to establish a manufacturing company.

2. Have students collectively establish goals for the manufacturing enterprise.

3. Divide the class into teams of three or four and allow each group to plan a management system and style. Have each group give a presentation to the class and combine the best ideas for a final plan for a management system.

B. Topic: **Capital**

Performance Statement:

Upon satisfactory completion of this topic, the student will participate in the financing decisions of a manufacturing enterprise.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Describe the roles of various members of a corporate organization. (K)
b. Name the resources for investment capital. (K)
c. Enjoy the experience of being a stockholder in a free enterprise economy. (A)
d. Estimate income, expenses, and profits for a company. (S)

Suggested Instructional Strategies:

1. Have students prepare and establish a legal company and elect a board of directors.

2. Instruct students to obtain money for investment capital by selling stock to other students in class, approaching a local bank, or other means.

3. Divide the class into teams of three or four and allow each group to prepare company budgets. Have each group give a presentation to the class and combine the best ideas for a final financial plan.

4. Arrange a visit from a local banker or investment specialist.

C. Topic: **Production Planning**

Performance Statement:

Upon satisfactory completion of this topic, the student will participate in process selection, planning and scheduling of manufacturing operations of the company's product(s).

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Select processes appropriate to the manufacture of a product. (K) (S)
b. Construct operation process charts, operation methods sheets, and flow process charts. (K)
c. Describe the job responsibilities of a methods engineer. (K)
d. Value the role of a methods engineer. (A)
e. Break down the manufacturing of an item into a list of sequential events. (S)

Suggested Instructional Strategies:

1. Pair students to construct operation process charts showing the sequence of operations in the manufacture of a part.

2. Pair students to construct flow process charts showing all steps in the manufacture of a product.

3. Pair students to construct a method sheet which elaborates a single operation in the manufacturing process.

4. Pair students to develop and/or select tooling for a simple manufactured product.

5. Have teams defend the rationale of their production plan in a class presentation.

6. Divide the class into teams of three or four and allow each group to prepare a production plan for the company's product. Have each group give a presentation to the class and combine the best ideas for approval of company management.

D. Topic: **Plant Layout**

Performance Statement:

Upon satisfactory completion of this topic, the student will participate in the layout planning of a safe and efficient manufacturing facility.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Describe significant health and safety requirements. (K) (A)
b. Construct a plant flow diagram. (K)
c. Describe the job responsibilities of plant layout personnel. (K)
d. Enjoy the designing of a manufacturing facility. (K)
e. Describe the characteristics of a good plant layout. (S)

Suggested Instructional Strategies:

1. Have pairs of students research health and safety requirements (e.g., OSHA) for plant operation.

2. Have students prepare a list of significant health and safety requirements.

3. Have teams of students role play the part of an OSHA or insurance safety inspector, plant manager, and other employees.

4. Pair students to devise a plant layout for the manufacture of a simple product.

5. Divide the class into teams of three or four and allow each group to prepare a plant design. Ensure plant is handicapped accessible, as appropriate. Have each group give a presentation to the class and combine best ideas for approval of company management.

E. Topic: **Personnel Selection and Training**

Performance Statement:

Upon satisfactory completion of this topic, the student will participate in a decision-making process of identifying, selecting, and determining training needs of workers needed to manufacture the company's product(s).

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Complete a job application. (S)
b. List the major steps in the process of hiring workers. (K)
c. Value the contributions of a personnel manager to a manufacturing enterprise. (A)
d. Write a job description. (S)
e. Describe training necessary for a given job description and applicant. (S)

Suggested Instructional Strategies:

1. Pair students to list the job requirements for the manufacture of a simple product.

2. Have each student fill our a job application listing personnel skills and education background (courses taken in school).

3. Divide the class into teams of three or four. Have each group determine employees' needs in manufacturing the company's product. Have each group give a presentation to the class and combine the best ideas for a final needs assessment.

4. Pair students to list the job safety requirements needed for each job identified.

F. Topic: **Quality Assurance Program**

Performance Statement:

Upon satisfactory completion of this topic, the student will participate in a decision-making process in the establishment of a quality control system.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Complete a job quality inspection chart. (S)
b. Be familiar with and employ statistical process control methods, such as Grasby, Taguchi, and Total Quality Management. (K) (A) (S)
c. Appreciate the importance of doing the best job that can be done. (A)
d. Set quality goals for the company's product. (S)
e. Describe the brainstorming process. (K)

Suggested Instructional Strategies:

1. Pair students to list the quality standards needed for the manufacture of a simple product.

2. Pair students to identify at least one quality problem that could occur at each step of a given operation flow sheet.

3. Divide the class into production teams (quality circles) of four or five students and allow each group to brainstorm ideas to increase product quality and production efficiency. Have each group generate a list of quality and production goals.

4. Pair students and have each pair develop a list of ideas on how to reward production teams who reach quality goals.

5. Have production teams construct and use a quality control inspection sheet.

SEMESTER TWO

III. Module: **Traditional Manufacturing**

A. Topic: **Precision Measurement and Inspection**

Performance Statement:

Upon satisfactory completion of this topic, the student will use precision measurement tools to inspect a manufactured item.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Use common measuring tools to an accuracy of 1/100th of an inch. (S) (K)
b. Explain the difference between absolute and incremental positioning. (K)
c. Distinguish between parts that are within tolerance, and those that are rejects or in need of remanufacture. (S)
d. Enjoy using precision measuring equipment and appreciate its role in manufacturing. (A)

Suggested Instructional Strategies:

1. Divide the students into groups of two to four. Provide a working drawing of a given part, complete with tolerances and several of the actual parts with some out of tolerance. Have students measure the parts and separate them into acceptable, rejects, and remanufacturable bins. Compare the actions of different groups with the same selection of parts. Discuss the consequences of the actions of the groups and recommendations.

2. Have each group of students design and build a measuring machine. Have each group demonstrate their machine.

3. Divide the students into groups of three. On a tile floor or other such geometric pattern, establish a point (X O, Y O). Provide each group with a simple program with several steps. Have one student from each group follow the program using an incremental system. The third student will read the program as the other two move the required number of steps. Ask each student who develops the last step in the program to return to the starting point.

B. Topic: **Principles of Machine Set-up and Operation**

Performance Statement:

Upon satisfactory completion of this topic, the student will select and use traditional machines in the production of a product.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Set up a machine for a given operation.
b. Define such terms as lathe, mill, grinder, etc.
c. Experience satisfaction by using traditional machines in the production of a product. (A)
d. Use a traditional machine in the production of a product. (S)
e. Use a common machine in the production of a product.

Suggested Instructional Strategies:

1. Use video presentations and field trips to show students the machines used in typical manufacturing operations.

2. Using existing machinery, demonstrate the principles of milling, turning, grinding, etc. Incorporate, and stress, the use of the precision adjustments to maintain accuracy.

3. After a demonstration of the basic machines used in manufacturing, provide a part. Have teams of students select the machine and processes used to make it and defend their choices.

4. Allow students to train on specific machines and use them in the manufacture of a product.

V. Module: **Computer Aided MAnufacturing**

A. Topic: **Computer Numerical Control**

Performance Statement:

Upon satisfactory completion of this topic, the student will select and use CNC equipment in the manufacture of a product.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Describe the common types of CNC machinery. (K)
b. Interpret a simple CNC program. (K)
c. Enjoy using a CNC machine in the production of a product. (A)

d. Load, edit, save, and run a simple CNC program. (S)
e. Prepare a simple CNC program. (S)
f. Appreciate the roles that computers can assume in manufacturing. (A)

Suggested Instructional Strategies:

1. Provide student pairs with graph paper and a completed program sheet and a brief lesson about how a CNC program works. Have the students interpret the program by moving a pencil from square to square following the program. Compare the toolpath developed with a properly prepared toolpath using a transparency or light box.

2. Have students prepare a CNC program to mill their initials in plastic laminate.

3. Use field trips and/or video presentations to show students the use of CNC machines in the manufacturing of a product.

4. Have students use a piece of CNC machinery in the production of a product.

5. Divide the students into groups of three. Have the first student read a prepared CNC program, the second interpret the operations using a conventional machine, and the third act as a backup to be certain that the instructions were read and interpreted correctly.

6. Have students use a computer simulation program of a CNC operation on a personal computer.

B. Topic: **Robotics**

Performance Statement:

Upon satisfactory completion of this topic, the student will select and use a robotic device in the production of a product.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Identify the important components of a robot. (K)
b. Select a robot for a given function. (K)

c. Explain the difference between remote control devices and true robots. (K)
d. Have fun using a robotic device. (A)
e. Program a robot. (S)

f. Analyze the strengths and weaknesses of robotic systems. (K)

Suggested Instructional Strategies:

1. Have students view videotapes showing robots performing various tasks in a manufacturing environment.

2. Have a representative of a robot manufacturer visit the classroom.

3. Have student pairs use catalogs of various robotic devices to select an appropriate unit for a given task.

4. Have the students use a computer simulation of a robotic program.

5. Have student groups use a robot to prepare a simple pick and place operation.

6. Have student groups design and build a simple end effector.

C. Topic: **Communication and Integration**

Performance Statement:

Upon satisfactory completion of this topic, the student will summarize how machines and processes are interfaced.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Describe the relationship of systems such as CAD to CAM. (K)
b. Know the difference between series and parallel communication. (K)
c. Appreciate the fact that a wide variety of computer devices can interface. (A)
d. Connect two devices and have them communicate. (S)

Suggested Instructional Strategies:

1. Have students identify the communication ports on the back of a personal computer, CNC machine, and robotic device.
2. Have students examine an RS232 cable and determine the transmit, receive, and ground pins.
3. Have the students write their own name in ASCII.
4. Have students interface a personal computer with a robotic and/or CNC device to upload, save, and download a program.
5. Have teams of students send a message coded in ASCII to other groups of students to decode.

VI. Module: **Trends and Impacts**

A. Topic: **Trends and Impacts**

Performance Statement:

Upon satisfactory completion of this topic, the student will identify and summarize important past and present trends in manufacturing; and summarize the social, economic, and personal impacts of national and global manufacturing.

Competencies to be Developed:

After studying this topic, the student will be able to:

a. Discuss important trends in manufacturing. (K)
b. Name employment opportunities in manufacturing. (K)
c. Select post secondary programs leading to a career in manufacturing. (S)
d. Identify important social, economic, and personal impacts of shifts in national and global manufacturing. (K)

Suggested Instructional Strategies:

1. Arrange a visit from a representative of a local professional engineering society to discuss employment opportunities.
2. Have students refer to college catalogs to find programs in manufacturing or related fields.

3. Have students research periodicals and/or newspapers for articles on how manufacturing is changing and the impacts of these changes.