Manufacturing Systems II, Advanced

8427 36 weeks

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Office of Career, Technical, and Adult Education
Virginia Department of Education

Course Description

Suggested Grade Level: 11 or 12
Prerequisites: 8425

Students develop an in-depth understanding of automation and its applications in manufacturing. Activities center on flexible manufacturing processes and computer integrated manufacturing (CIM). Students work in teams to solve complex interdisciplinary problems that stem from the major systems in automated manufacturing.

As noted in Superintendent's Memo #058-17 (2-28-2017), this Career and Technical Education (CTE) course must maintain a maximum pupil-to-teacher ratio of 20 students to one teacher, due to safety regulations. The 2016-2018 biennial budget waiver of the teacher-to-pupil ratio staffing requirement does not apply.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	8427	Tasks/Competencies
Practicing Safety		
39	⊕	Use required personal protective equipment (PPE).
40	⊕	Implement a safety plan.
41	⊕	Maintain safe working practices in the production laboratory.
42	⊕	Operate lab equipment according to instructor guidelines.
Understanding Manufacturing		
43	⊕	Explain the goals of lean manufacturing.
44	⊕	Describe manufacturing as a technological system.
45	⊕	Use manufacturing terminology.
46	⊕	Project future trends in manufacturing.

47	⊕	Investigate careers in manufacturing.	
Designing for Manufacturing			
48	⊕	Apply problem-solving strategies.	
49	⊕	Design with computer-aided design (CAD).	
50	⊕	Use computer-assisted engineering (CAE).	
Applying Automation Technology to Manufacturing			
51	⊕	Explain the key components of automated systems in the manufacturing environment.	
52	⊕	Explain numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), and computer-assisted manufacturing (CAM).	
53	⊕	Apply CAM in additive and subtractive processes.	
54	⊕	Communicate through examples the importance of flexibility in computer-integrated manufacturing (CIM) production systems.	
55	⊕	Demonstrate an understanding of industrial control systems and the role they play in synchronizing and controlling the operation of work cells in the plant.	
56	⊕	Program a PLC.	
Exploring Mechatronics			
57	⊕	Define *mechatronics*.	
58	⊕	Explain the role of fluid power in mechatronic systems.	
59	⊕	Explain the role of electricity and electronics in mechatronics systems.	
60	⊕	Explain the role of mechanics in mechatronics systems.	
61	⊕	Explain the role of computer systems in mechatronics systems.	
Applying Business Concepts			
62	⊕	Describe the effect of labor and human resources issues on manufacturing.	

63	⊕	Create a marketing plan.	
64	⊕	Explain the effect of supply and demand on manufacturing.	
65	⊕	Explain fiscal and fiduciary responsibilities associated with running a successful enterprise.	
Using Advanced Manufacturing Systems Processes			
66	⊕	Explain supply chain management.	
67	⊕	Describe philosophies of continuous improvement.	
68	⊕	Plan for production.	
69	⊕	Design the manufacturing process.	
70	⊕	Implement the manufacturing process.	
71	⊕	Evaluate the process.	
72	⊕	Modify the process according to specific measures.	
Examining Product Quality			
73	⊕	Explain product quality.	
74	⊕	Apply root-cause analysis to identify problems in product quality.	
75	⊕	Implement a continuous improvement plan.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Practicing Safety

Task Number 001

Use required personal protective equipment (PPE).

Definition

Use should include

- identifying potential hazards
- identifying safety data sheets (SDS)
- describing equipment that protects against each hazard
- wearing necessary equipment when performing hazardous tasks.

Process/Skill Questions

- What are the names and purposes of five pieces of PPE?
- When would it be necessary to wear PPE?
- When should an SDS be used? How does an SDS benefit the response to a spill or another incident or injury?
- How does facial hair affect the use of some PPE?

ITEEA National Standards

Use and Maintain Technological Products and Systems

Task Number 002

Implement a safety plan.

Definition

Implementation should include

- completing a safety proficiency test with 100% pass rate
- demonstrating safe use of each tool and machine
- adhering to basic safety rules.

Process/Skill Questions

- Why do you have to pass the safety test with 100%?
- What could happen if you don't follow **every** safety rule?
- Why is it important to always have teacher supervision in the lab?

ITEEA National Standards

Use and Maintain Technological Products and Systems

Task Number 003

Maintain safe working practices in the production laboratory.

Definition

Maintenance should include

- locating and using laboratory safety equipment
- identifying potential hazards in the laboratory
- demonstrating safe work habits with each type of equipment and material
- adhering to Occupational Safety and Health Administration (OSHA) standards as required by the teacher.

Process/Skill Questions

- What are the risks of unsafe behavior in the laboratory?
- How would safety rules help prevent these risks?
- How should one respond to an emergency in the laboratory?

ITEEA National Standards

Use and Maintain Technological Products and Systems

Task Number 004

Operate lab equipment according to instructor guidelines.

Definition

Operation should include

- following posted safety rules for each piece of equipment
- using guards as required
- passing a proficiency demonstration with the instructor.

Process/Skill Questions

- How are the posted safety rules for any two pieces of equipment in your room similar and different?
- Why are guards necessary?
- How would you know if you are using a piece of equipment improperly?
- What should always be done to the electrical service prior to performing maintenance on a machine?

ITEEA National Standards

Use and Maintain Technological Products and Systems

Understanding Manufacturing

Task Number 005

Explain the goals of lean manufacturing.

Definition

Explanation should include

- improving on-time deliveries
- reducing product cycle time
- reducing total product cost
- reducing customer lead time
- reducing inventories
- reducing waste.

Process/Skill Questions

- What effect does a reduction in inventory have on a company's bottom line?
- How has manufacturing evolved in the last decade?
- How has technology made manufacturing more efficient?

Economics and Personal Finance Standards of Learning

EPF.2

The student will demonstrate knowledge of the role of producers and consumers in a market economy by

a. describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
b. explaining how businesses respond to consumer sovereignty;
c. identifying the role of entrepreneurs;
d. comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;
e. describing how costs and revenues affect profit and supply;
f. describing how increased productivity affects costs of production and standard of living;
g. examining how investment in human capital, capital goods, and technology can improve productivity;
h. describing the effects of competition on producers, sellers, and consumers;
i. explaining why monopolies or collusion among sellers reduces competition and raises prices; and
j. illustrating the circular flow of economic activity.

ITEEA National Standards

Assess the Impact of Products and Systems

Manufacturing Technologies

TSA Competitive Events

Prepared Presentation

Task Number 006

Describe manufacturing as a technological system.

Definition

Description should include

- inputs
- processes
- outputs
- goals

- feedback.

Process/Skill Questions

- What is automation? What is mechatronics?
- What are the key aspects of a manufacturing environment?
- How has technology influenced products/processes, and vice versa?
- What is the universal system model and how does it work?

ITEEA National Standards

Manufacturing Technologies

TSA Competitive Events

Essays on Technology

Prepared Presentation

Task Number 007

Use manufacturing terminology.

Definition

Use of terminology should include letter-terms and terms used in proper context throughout the course in written and oral communication.

Process/Skill Questions

- What are the consequences of failure to understand manufacturing terminology?
- What is PPE?
- What are the differences and similarities among primary and secondary processes?
- What is EPA, DFE, OSHA, and CAD?

Design Briefs

Manufacturing Terminology

Design Briefs

Manufacturing Terminology

Context
You are a recruiter for a car manufacturing company. Part of your job is to go to college campuses and interview graduating seniors for positions with your company. As part of the interview process, you need to screen candidates for their ability to communicate with others in the manufacturing industry. Key words that your company thinks candidates should know are listed below:

assembly line	conditioning	primary processes
batch production	efficiency	quality control
CAD	forging	separating
calipers	forming	supply
casting	job shop	template

Challenge
Develop an activity that assesses knowledge of manufacturing terminology. Because interviews usually are limited by time, the activity should take no longer than 10 minutes to complete. You will have 30 minutes to develop the activity.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Define manufacturing vocabulary terms.
- Develop activities that support studying for vocabulary tests.
- Explain the importance of preparing for interviews.
- Describe the importance of sharing information and ideas.

Materials
Pen, pencil, paper

References
Aquilano, Nicholas, and Richard Chase. *Production and Operations Management: Manufacturing and Services.* Chicago: Irwin, 1995.
Daiber, Robert, and Thomas Erekson. *Manufacturing Technology: Today and Tomorrow.* New York: Glencoe/McGraw-Hill, 1991.
Ostwald, Phillip, and Jairo Munoz. *Manufacturing Processes and Systems.* New York: John Wiley & Sons, 1996.

Evaluation
After the time is up for activity development, students should exchange activities with each other. Students should try each other's activities and evaluate them based on the following:

- correct spelling and definitions
- ability to understand directions

- likelihood of completing activity in 10 minutes
- creativity

After the peer evaluation, review all manufacturing terms with students.

TSA Competitive Events

Essays on Technology

Prepared Presentation

Technology Bowl

Task Number 008

Project future trends in manufacturing.

Definition

Projection should include

- international influence
- environmental emphasis and regulation
- use of electronic commerce (e-commerce)
- causes of changes.

Process/Skill Questions

- How is technology changing manufacturing?
- What role does e-commerce play in manufacturing?
- What effect do consumers have on manufacturing trends?
- How is 3D printing affecting manufacturing?
- How do enterprise resource planning (ERP) systems create a lean and competitive advantage?

ITEEA National Standards

Assess the Impact of Products and Systems

The Influence of Technology on History

TSA Competitive Events

Webmaster

Task Number 009

Investigate careers in manufacturing.

Definition

Investigation of careers in manufacturing should include examining various jobs/careers by

- job/career title
- training and education required
- nature of work
- difficulty of work
- future outlook of job/career
- advantages and disadvantages associated with the job/career.

Sources for investigation include

- Occupational Outlook Handbook
- job-analysis chart.

Process/Skill Questions

- What are some local industries that offer manufacturing career opportunities?
- What levels of education are required for various manufacturing occupations?
- What is a lifelong learner?
- What career fields relate to green energy and medical technology?

ITEEA National Standards

The Cultural, Social, Economic, and Political Effects of Technology

The Influence of Technology on History

TSA Competitive Events

Prepared Presentation

Technology Bowl

Designing for Manufacturing

Task Number 010

Apply problem-solving strategies.

Definition

Application may include strategies to

- improve on-time deliveries
- reduce product cycle time
- reduce total product cost
- reduce customer lead time
- reduce inventories
- reduce waste.

Process/Skill Questions

- What effect does total product cost have on retail prices?
- How does product cycle time affect total product cost?
- What is customer lead time?
- What factors are considered in total product cost?
- What issues are caused by excessive inventory?
- What strategies are companies using to reduce waste?

ITEEA National Standards

The Attributes of Design

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

TSA Competitive Events

Engineering Design

Technology Problem Solving

Task Number 011

Design with computer-aided design (CAD).

Definition

Design should involve

- sketching a design
- modelling a design from sketches
- creating a working drawing
- creating assemblies.

Process/Skill Questions

- What are assemblies?
- What is scale?
- What is on a working drawing?
- What are advantages and disadvantages of CAD?
- What is parametric modeling?
- What are geometric constraints?
- What are some examples of CAD software?

Design Briefs

CADD Drawings

Design Brief

CADD Drawings

Context
You are a CADD specialist who works for XYZ Plastics, a company that specializes in plastic injection molding. The company has just been hired by Sweet Soap to make plastic soap dishes that will be given out free to any customer who buys three or more bars of soap at one time. Before Klann Plastics can begin making the soap dish, they must have a dimensioned drawing of what the mold will look like.

Challenge
Using 1/4" grid paper and a ruler, sketch a multiview drawing to scale of a soap dish design. Your drawing should include the front, right side, and top views of the soap dish. Views should

be labeled and dimensioned. After you have used grid paper to sketch a multiview drawing, transfer your drawing to the computer using CADD software. Make sure to use the ASME line conventions shown below. You will have one hour to complete this portion of the design brief.

Source: *Fundamentals of Drafting with AutoCAD LT*. 2d ed.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Sketch a dimensioned multiview drawing using 1/4" grid paper.
- Use CADD software to transfer a sketch onto the computer.
- Use ASME line conventions.

Materials
Pencil, ruler, 1/4” grid paper, computer with CADD software

References
Fane, Bill. *AutoCAD Essentials: An Unintimidating Introduction to AutoCAD and AutoCAD LT*. Addison Wesley Longman, Inc., 1994.
Kalameja, Alan J. *The AutoCAD Tutor for Engineering Graphics R14 Windows with CD-ROM*. Albany: Delmar Publishers, 1997.
Walker, John R. *Exploring Drafting.* Tinley Park, Ill.: Goodheart-Willcox Company, 1996.
Wallach, Paul, et al. *Fundamentals of Drafting with AutoCAD LT*. 2d ed. Detroit: Autodesk Press, 1998.

Evaluation
After the time is up, students should print their CADD drawings and exchange both the sketch and the CADD drawing with someone else for peer evaluation. Students should assess drawings based on the following criteria:

- views labeled
- consistency of dimensions among the three views
- accuracy of dimensions
- similarity between grid paper sketch and computer drawing
- proper line conventions used

Based on the peer evaluations, students should make any necessary corrections and hand in their drawings. Use the above criteria to evaluate student drawings. Review multiview drawings and line conventions.

ITEEA National Standards

Manufacturing Technologies

TSA Competitive Events

Computer-Aided Design (CAD), Architecture

Computer-Aided Design (CAD), Engineering

Task Number 012

Use computer-assisted engineering (CAE).

Definition

Use of CAE should include

- efficiency modeling using calculations to determine effectiveness of intended criteria and functionality
- analysis of model testing for material stress.

Process/Skill Questions

- What are the similarity and differences between CAD and CAE?
- How has CAE decreased time to production?
- What are some examples of CAE software?
- What is the value of running software simulations vs. making and testing prototypes?
- What is computational fluid dynamics (CFD)?

Design Briefs

Cellular Manufacturing

Design Brief

Cellular Manufacturing

Context
You are a manufacturing consultant and have recently been hired by the River City Jeans Company to analyze their jeans manufacturing plant layout. The manufacturing process, in order, for all of their jeans is: dyeing, fabric cutting, sewing, button assembly, zipper assembly, inspection, and boxing. The company is currently experiencing bottlenecks at its button assembly area because of a recent increase in the demand for button fly jeans. The plant operates for 16

hours a day 7 days a week. The company feels that switching from a cluster to a cellular layout could alleviate this bottleneck.

Challenge
Working with a partner, use CADD software to design a cellular layout for the Levi Strauss Company that will decrease the bottleneck at the button assembly station. Specify the type of jeans that will be produced in each cell, as well as the number of each type of machine in each work cell. Also show any part of the process that may not be part of a cell. Use a spreadsheet to show how much time can be saved with your new layout.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Differentiate between cluster and cellular layouts.
- Determine a cellular layout solution to a cluster layout problem.
- Use spreadsheet software to prove that a cellular layout is more efficient than a cluster layout for a given problem.
- Use CADD software to design a shop floor layout.

Materials
CADD software, spreadsheet software

References
Irani, Shahrukh A., ed. *Handbook of Cellular Manufacturing Systems.* New York: John Wiley & Sons, Inc., 1999.
Kamrani, Ali, ed., *Planning, Design, and Analysis of Cellular Manufacturing Systems*. New York: Elsevier Science, 1995.
Kamrani, Ali K., and Rasarathnam Logendran. *Group Technology and Cellular Manufacturing: Methodologies and Applications,* Vol. 1. Gordon & Breach Publishing Group, 1998.
Wallach, Paul, et al. *Fundamentals of Drafting with AutoCAD LT*. 2d ed. Detroit: Autodesk Press, 1998.

Evaluation
Once students have completed their CADD layouts and spreadsheets, each group should share its design with the rest of the class and discuss the following:

- number of cells and what their focus is
- number of each type of machine in each cell
- any process not in a cell
- amount of time saved with new layout
- solution thought process
- any problems encountered.

After each group has had an opportunity to share its cellular layout, select the layout that saves the most time and compare it with the original diagram. Review the advantages and disadvantages of a cellular layout.

Computer Aided Engineering (CAE)

Design Brief

Computer Aided Engineering (CAE)

Context
You work as an engineer for Span Engineering, a bridge design and building corporation.

It is part of your job to determine if bridge designs created by CADD technicians are durable enough to withstand traffic load and wind forces.

A CADD technician has just provided you with a design to analyze for maximum weight load and maximum wind speed.

You have CAE software that has analyzed the bridge and determined the volume to be 34,000 ft3 and the weight to be 1000 N.

Challenge
Verify the volume calculation of the bridge performed by the computer.
Calculate the amount of weight that the bridge can hold assuming an efficiency of 150%.
Determine the maximum wind speed that the bridge can withstand by interpreting the data outputted by your CAE program shown below. The computer reports that the maximum lateral stress load that the bridge can handle before it breaks is 2000 N. You will have 30 minutes to complete this portion of the design brief.

Wind Test Results

Wind Velocity (m/s)	Exposure Time (s)	Air Mass (kg)
7	10	429
15	10	333
25	10	400
30	10	467
40	10	438
50	10	400
60	10	383
70	10	386

80	10	375
100	10	350

Helpful Formulas
Efficiency = (Load / Weight) x 100
Acceleration = Velocity / Time
Force = Mass x Acceleration

Objectives
Upon completion of this design brief, students will be able to do the following:

- Describe features of CAE programs.
- Perform structural efficiency calculations.
- Define *Newton's second law*.
- Verify CAE volume and force calculations.

Materials
12" ruler, pencil, calculator

References
Chang T.C., et al. *Computer Aided Manufacturing.* Englewood Cliffs, N.J.: Prentice Hall, 1997.
Lee, Kunwoo. *Principles of CAD/CAM/CAE Systems*. Addison Wesley Longman, Inc., 1999.
Lewis, Jack W. *Modeling Engineering Systems: PC-Based Techniques and Design Tools*. High Text Publications, Inc., 1993.
McMahon, Chris. *CADCAM: Principles, Practice and Manufacturing Management.* Addison Wesley Longman, Inc., 1998.

Evaluation
After students have verified the volume calculation and determined the maximum lateral wind speed that the bridge can handle, they should exchange papers and check each other's work. Review the problem solution with the class and discuss other applications for Computer Aided Engineering software

CAE Solution

1. Substructure Volume

- a. Center Rectangle: Roadbed (20) x Height (10) x Length (40) = 8000
- b. End Triangles Added: Roadbed (20) x Height (10) x Length (10) = 2000
- c. Total Volume = 10,000 ft3

2. Superstructure Volume

- a. Center Rectangle: Roadbed (20) x Height (20) x Length (50) = 20,000
- b. End Triangles Added: Roadbed (20) x Height (20) x Length (10) = 4000
- c. Total Volume = 24,000 ft3

Final Volume = 10,000 + 24,000 = 34,000 ft3

Efficiency = (Load / Weight) x 100
150 = (Load/1000) x 100
Load = 1500 N

Max Wind Speed = 50 m/s

Wind Velocity (m/s)	Exposure Time (s)	Air Mass (kg)	Stress Force
7	10	429	300.3
15	10	333	499.5
25	10	400	1000
30	10	467	1401
40	10	438	1752
50	10	400	2000
60	10	383	2298
70	10	386	2702
80	10	375	3000
100	10	350	3500

Computer Aided Process Planning (CAPP)

Design Brief

Computer Aided Process Planning (CAPP)

Context
You work as a process planner for Logical Manufacturing. Recently, due to a sudden increase in business, your workload has become overwhelming. Therefore, you have decided to implement a CAPP system to help relieve some of your workload. You now must decide whether to purchase a Variable CAPP system or a Generative CAPP system. Variable systems create new plans by retrieving and modifying a standard process plan for a given part family. Generative systems include database and decision logic and automatically generate a process plan from graphical and textual information on the part. Logical Manufacturing uses a Group Technology approach to manufacturing.

Challenge
Use Force Field Analysis to help determine which type of CAPP system to purchase. Use the information below to help make your decision.

Variant Process Planning

- Most successful variant systems depend on Group Technology.
- The basic variant approach to process planning with GT is as follows:
    1. Go through normal GT setup procedures.
    2. After part families have been identified, develop standard process plans for each.
    3. When a new product has been designed, get a GT code for each part.
    4. Use the GT system to look up which part family is the closest match, and retrieve the standard plan for that part family.
    5. Edit the standard plan so that values now match the new design parameters, and add or delete steps as required.
- Some benefits of the GT system are as follows:
    1. It is well suited to medium to low product mixes.
    2. It can be developed quickly for most companies.
    3. It can be used with other CIM.
    4. One program can be used in radically different industries.
- Disadvantages are as follows:
    1. GT codes can become obsolete quickly.
    2. While it is fast to set up, it is slower for planning than generative systems.
    3. It is more prone to error than generative systems.
- These systems tend to get exact matches 2% to 7% of tries. A standard plan is used about 50% of time.

Generative Process Planning

- Each plan is made from scratch.
- The generative systems are poorly developed at this point in time and tend to be research systems, or of very limited domain.
- These systems rely heavily on the methods of Artificial Intelligence, or very complex algorithms.
- An example of a generative system is the development of rules to decide which machines to use.
- Possible sources of input vary from system to system, but essentially,
    1. They interpret designs from CAD directly (very difficult).
    2. The user defines features then answers questions about them.
    3. The user does design directly on the CAPP system.
    4. The users create a special product description file.
- An example for a CAPP system called XPS-2 is shown below:
  0010 EXECUTE MILL_HOLE FOR EACH BLIND_HOLE IF
  BLIND_HOLE.DIAMETER GT 25.,
  BLIND_HOLE.DEPTH LT 50. !
- This rule identifies the operation, the feature it is used on, and the two conditions for it to be used. When rules are used, the number of rules in the system becomes very large.
- The advantage is that it runs faster when planning.
- The disadvantage is that it requires a more extensive setup.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Describe how automation can make process planning increase productivity, reduce time to production, and improve rationalization and standardization of plans.
- Describe how process planning takes place in Variable and Generative CAPP systems.
- List advantages and disadvantages of Variable and Generative CAPP systems.
- Perform a Force Field Analysis to decide between implementation of a Variable or Generative CAPP system.

Materials
Paper, ruler, pencil or pen

References
Bedworth, David. *Computer Integrated Design and Manufacturing*. New York: McGraw Hill, 1991.
Groover, Mikell. *Automation, Production Systems, and Computer Integrated Manufacturing.* New York: Prentice Hall, 1987.
Mehra, Pankaj, and Benjamin Wah. *Load Balancing: Automated Learning Approach*. World Scientific Publishing Company, 1995.
Nolen, James. *Computer-Automated Process Planning for World-Class Manufacturing*. New York: John Wiley & Sons, Inc., 1999.
Ullman, D.G. *The Mechanical Design Process.* New York: McGraw-Hill, 1997.

Evaluation
After completing the Force Field Analysis, students should meet in groups of four or five to discuss their recommendations. Call on a few students to share their Force Field Analysis with the entire class. Next, take a class survey to determine which type of CAPP system should be implemented. Review the advantages and disadvantages of CAPP systems and have the class think of ways to speed up the process planning time without CAPP implementation.

Force Field Analysis
Source: http://www.psywww.com/mtsite/forcefld.html

Force Field Analysis is a method used to get a whole view of all the forces for or against a plan so that a decision can be made which takes into account all interests. In effect, this is a specialized method of weighing pros and cons.

Where a plan has been decided on, force field analysis allows you to look at all the forces for or against the plan. It helps you to plan or reduce the impact of the opposing forces, and strengthen and reinforce the supporting forces.

Carrying Out a Force Field Analysis
To carry out a force field analysis, use the following steps:

1. List all forces for change in one column, and all forces against change in another column.
2. Assign a score to each force, from 1 (weak) to 5 (strong).
3. Draw a diagram showing the forces for and against, and the size of the forces.

Once you have carried out an analysis, you can decide on the viability of the project.

Where you have decided to carry out a project can help you analyze how to push through a project that may be in difficulty. Here you have two choices:

- to reduce the strength of the forces opposing a project
- to increase the forces pushing a project.

ITEEA National Standards

Manufacturing Technologies

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Applying Automation Technology to Manufacturing

Task Number 013

Explain the key components of automated systems in the manufacturing environment.

Definition

Explanation should include

- where and how computers are used in manufacturing
- input devices

- software that directs hardware to complete tasks
- components of the automated hardware system (e.g., robots, actuators, sensors).

Process/Skill Questions

- What are some examples of automated systems?
- What careers are associated with automated systems?
- What jobs have been eliminated over the past 50 years by automation?
- What are examples of input devices? How can they be used to track a product?

ITEEA National Standards

Manufacturing Technologies

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Prepared Presentation

Task Number 014

Explain numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), and computer-assisted manufacturing (CAM).

Definition

Explanation should include

- differentiating among NC, CNC, and DNC
- identifying components of CAM system
- identifying M and G codes controlling various machining operations: M = machine codes—i.e., provide instruction to the machine for its operation; G = geometric codes—i.e., provide instruction for position, such as change of contour, speed, and direction.

Process/Skill Questions

- What is the Cartesian Coordinate System?
- How did Descartes come up with the coordinate system?
- How does G code use the Cartesian Coordinate System?

- Where are modeling and simulation applied in CAM?

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Task Number 015

Apply CAM in additive and subtractive processes.

Definition

Application should include

- generating M and G codes to control various machining operations
- operating NC/CNC/DNC equipment.

Process/Skill Questions

- What equipment is used for additive processing? For subtractive processing?
- What is the trade-off between resolution and speed in automated additive and subtractive processing?
- What factors affect the resolution of a product manufactured via an additive or subtractive process?
- How are commands different in additive vs. subtractive methods? How are they similar?

ITEEA National Standards

Manufacturing Technologies

Task Number 016

Communicate through examples the importance of flexibility in computer-integrated manufacturing (CIM) production systems.

Definition

Communication should include

- the organization, purpose, function, and material-handling requirements of individual automated stations
- flexible manufacturing systems (FMS)
- modular manufacturing systems (MMS)
- islands of automation
- computer-integrated manufacturing (CIM) as combinations of flexible manufacturing cells that create systems.

Process/Skill Questions

- What are islands of automation?
- How is material transferred among islands of automation?
- What types of inputs are used in CIM systems?
- How can inputs for different components be a detriment to CIM?

Design Briefs

Computer Integrated Manufacturing (CIM)

Design Brief

Computer Integrated Manufacturing (CIM)

Context
You have received a consulting contract from the Duggan CD Group, LTD to help them integrate automation into its production process. The small company has been awarded the contract to produce the new compact disc (CD) from the largest music group in the nation and needs to upgrade its manufacturing facility to increase production efficiency and reduce costs.

Challenge
Your job is to research the equipment used in CD production and create a floor plan that will meet the needs of the Duggan CD Group, LTD. The production plan must contain automated material-handling devices and robotics to create flexible manufacturing systems (FMS) and use a controller to manage CIM cells.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Describe the machinery and equipment in the production of compact discs.
- Describe the function and purpose of different automated material-handling devices.
- Demonstrate a successful line flow to accomplish efficient production.
- Draw a CIM cell that contains various islands of automation and a flow chart of operations among them.

Materials
Internet access, paper, writing and drawing tools

Evaluation
After each team is finished researching and drawing its floor plan, students should orally present the sketch to the class. The presentation should demonstrate student understanding of

- the steps involved in CD production
- the proper islands of automation required to produce the interim steps in the production process
- appropriate automated material-handling devices
- the need for a controller to manage the interaction among the separate islands of automation and the importance of timing each step of production for line flow.

ITEEA National Standards

Manufacturing Technologies

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Task Number 017

Demonstrate an understanding of industrial control systems and the role they play in synchronizing and controlling the operation of work cells in the plant.

Definition

Demonstration of understanding should include

- the purpose of sensors and actuators
- the purpose of programmable logic controllers (PLC)
- a comparison of PLCs to other computer systems
- a list of applications that use PLCs
- use of PLCs to control a process.

Process/Skill Questions

- Why is a PLC preferable over a PC in certain manufacturing applications?
- What is the importance of using control systems?
- What is the run cycle of a PLC?
- How does an actuator work?

Design Briefs

Industrial Control Systems

Design Brief

Industrial Control Systems

Context
You are the mechanical engineer of the GoodEarth Recycling Plant, a partnership that has recently contracted with the city of Toms River to take over the recycling effort in the city. Yours is a for-profit company, and the current system of manual separation is too slow to show profit. You have contractual agreements with SoftFlush, Inc. a recycled toilet paper company; Green Furniture, a company that makes lawn furniture from recycled plastics; and Fly Upright, LTD, the only company that makes airplanes from recycled metals. These companies have agreed to buy your recycled materials if you can process them quickly enough to meet their raw material requirements.

Challenge
Your job is to update the manual separation system with an automated system that uses human power only at the receiving and distribution ends of the process. The automated process must be fast and efficient to maximize profits.

Objectives
Upon completion of this design brief, students should be able to do the following:

- List and describe the benefits of the different types of conveyance systems that will be used in the recycling plant.
- Define the purpose and functioning of the different sensors that will be used in the recycling plant.
- Describe the purpose and function of any actuators that will be necessary to process the recycled items.
- Choose an appropriate programmable logic controller (PLC) to meet the needs of controlling the plant in terms of inputs/outputs, and create a sketch of the relationship between the controller and the equipment it is managing.

Materials
Internet, paper, drawing and writing implements

Evaluation
After each team is finished researching and drawing its automated recycling plant, students should be able to do the following:

- Describe various conveyance systems and justify the choice in each situation on the plant design.
- Explain how sensors and actuators interact with a programmable logic controller in automated systems.
- Explain how a PLC works and what its role is in an automated manufacturing system.

ITEEA National Standards

Manufacturing Technologies

Use and Maintain Technological Products and Systems

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Transportation Modeling

Task Number 018

Program a PLC.

Definition

Programming may include

- ladder logic
- structured text
- function block diagram
- sequential function chart
- instruction list (IL).

Process/Skill Questions

- What are common inputs and outputs of a PLC?
- How is ladder logic incorporated in a PLC?
- How does structured text compare to a function block diagram?

- What is a scan cycle?

ITEEA National Standards

Manufacturing Technologies

Exploring Mechatronics

Task Number 019

Define *mechatronics*.

Definition

Definition should include the concept that mechatronics is a balance of mechanical structure with electronic and software-controlled technology.

Process/Skill Questions

- What branches of engineering does mechatronics include?
- What options are available for further education in mechatronics?
- What local or regional employers are hiring for jobs in mechatronics?
- What is an example of a mechatronic product?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

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Task Number 020

Explain the role of fluid power in mechatronic systems.

Definition

Explanation should include

- pneumatics
- hydraulics
- demonstration of the use of fluid power.

Process/Skill Questions

- How does thermodynamics factor into fluid systems?
- When would a hydraulic system be chosen over a pneumatic system, and vice versa?
- How do pressure and temperature affect fluid-power systems?
- What fluids are used in pneumatic and hydraulic systems?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

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Task Number 021

Explain the role of electricity and electronics in mechatronics systems.

Definition

Explanation should include

- AC and DC electricity
- Ohm's Law and the power equation
- use of a multimeter.

Teacher resource:
PhET Interactive Simulations (University of Colorado, Boulder)

Process/Skill Questions

- What electrical components are used in mechatronics?
- What are the differences between AC and DC systems in mechatronics?

- How is a multimeter used to troubleshoot a circuit?
- What do various components accomplish in the system?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

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Task Number 022

Explain the role of mechanics in mechatronics systems.

Definition

Explanation should include

- simple machines
- transmissions
- gear systems
- drive systems
- cams
- use of mechanics in a mechatronic system.

Process/Skill Questions

- What is the equation for calculating mechanical advantage?
- How are speed and torque related in a mechanical drive system?
- What are the six simple machines?
- What is a compound machine?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Transportation Modeling

Task Number 023

Explain the role of computer systems in mechatronics systems.

Definition

Explanation should include

- hardware
- software
- interfaces
- networking.

Process/Skill Questions

- How does software control hardware in mechatronics systems?
- What software programs are currently used in mechatronics systems?
- Why is it important to budget for upgrades in computer systems?
- What will the networks of mechatronics systems look like in the future?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Software Development

Applying Business Concepts

Task Number 024

Describe the effect of labor and human resources issues on manufacturing.

Definition

Description should include

- benefits
- unions
- hiring practices
- training
- labor costs.

Process/Skill Questions

- What is the purpose of a union?
- What does it mean to be an equal opportunity employer?
- Why are benefits important?
- What aspects of a geographic region, municipality, or community might be desirable to a manufacturer looking to locate a new facility?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

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Task Number 025

Create a marketing plan.

Definition

Creation should include

- product
- price
- promotion

- distribution
- service.

Process/Skill Questions

- What factors go into determining product price?
- How do companies promote their products?
- What are some effective marketing strategies?
- What are the four or five marketing Ps?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Promotional Design

Task Number 026

Explain the effect of supply and demand on manufacturing.

Definition

Explanation should include effects on

- product pricing
- product availability
- labor.

Process/Skill Questions

- How does price vary with availability?
- How does demand affect production?
- How does supply affect production?
- What is just-in-time inventory?
- Can a company create demand? Explain.

Economics and Personal Finance Standards of Learning

EPF.3
The student will demonstrate knowledge of the price system by

a. examining the laws of supply and demand and the determinants of each;
b. explaining how the interaction of supply and demand determines equilibrium price;
c. describing the elasticity of supply and demand; and
d. examining the purposes and implications of price ceilings and price floors.

ITEEA National Standards

Manufacturing Technologies

The Role of Society in the Development and Use of Technology

TSA Competitive Events

Essays on Technology

Task Number 027

Explain fiscal and fiduciary responsibilities associated with running a successful enterprise.

Definition

Explanation should include

- capital requirements
- determining financial overhead
- stock price
- break-even charts
- maintaining records
- income statement
- cash-flow statement
- balance sheet.

Process/Skill Questions

- Why are break-even charts important?
- What is the purpose of startup capital?

- What are the consequences of not keeping and maintaining accurate records?
- What actions do publicly traded manufacturing companies take to protect the valuation of their stock?
- What software is useful in creating a break-even chart?

Economics and Personal Finance Standards of Learning

EPF.2
The student will demonstrate knowledge of the role of producers and consumers in a market economy by

a. describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
b. explaining how businesses respond to consumer sovereignty;
c. identifying the role of entrepreneurs;
d. comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;
e. describing how costs and revenues affect profit and supply;
f. describing how increased productivity affects costs of production and standard of living;
g. examining how investment in human capital, capital goods, and technology can improve productivity;
h. describing the effects of competition on producers, sellers, and consumers;
i. explaining why monopolies or collusion among sellers reduces competition and raises prices; and
j. illustrating the circular flow of economic activity.

ITEEA National Standards

Manufacturing Technologies

The Cultural, Social, Economic, and Political Effects of Technology

The Role of Society in the Development and Use of Technology

Using Advanced Manufacturing Systems Processes

Task Number 028

Explain supply chain management.

Definition

Explanation of supply chain management should include the four decisions made in the supply chain procedure:

- location
- production
- inventory
- transportation.

Process/Skill Questions

- How can improvements in supply chain management lead to increased profits?
- What is a lead time?
- What is the negative effect of maintaining a large inventory of materials or products?
- How do automated storage and retrieval systems affect supply chain flow?

TSA Competitive Events

Essays on Technology

Transportation Modeling

Task Number 029

Describe philosophies of continuous improvement.

Definition

Description should include

- total quality management (TQM)
- lean manufacturing (e.g., Lean 3P, Toyota Production Systems)
- Six Sigma
- just-in-time (JIT) manufacturing.

Process/Skill Questions

- On what percentage of defects is Six Sigma focused?
- How has continuous improvement changed manufacturing?
- What is the benefit of JIT manufacturing?

ITEEA National Standards

The Cultural, Social, Economic, and Political Effects of Technology

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Task Number 030

Plan for production.

Definition

Planning for production should include

- basic components of production planning: company's capacity for production, production rate, production strategies
- demonstration of technical writing skills in development of a product plan
- rapid prototyping
- ability to calculate output capacity
- use of spreadsheet to graphically display a monthly production schedule.

Process/Skill Questions

- What is an example of rapid prototyping?
- Why is production planning necessary?
- What are some common methods of generating a production schedule?
- How is a time study conducted for a process?

Design Briefs

Planning for Production

Design Briefs

Planning for Production

Context
You are a member of a production planning team for Sound Tech, a new stereo manufacturing company. As a member of this team, it is your job to create a production plan for the first year of stereo production. It is now November, and the company intends to start production in December

so that stereos can be shipped to stores at the beginning of the new year. Since you are a new company, there is no existing inventory. The Sound Tech Manufacturing Plant operates 8 hours per day five days a week. The average daily lead-time for production set up is 30 minutes, and the average daily clean-up time is 15 minutes. The plant has an output of 4 stereos per hour. According to market surveys, your estimated monthly demands are as follows:

January	200	July	300
February	200	August	500
March	200	September	300
April	250	October	300
May	400	November	900
June	400	December	1000

Challenge
Working with two other production team members, write a 2- to 3-page production plan for the upcoming year. The president of Sound Tech would like to emphasize to your team that monthly storage costs are $2.00 per stereo, so keep required storage to a minimum when developing your production plan. The plan should include the following:

- purpose of plan
- explanation of maximum monthly output (assuming 20 working days per month)
- explanation of intended monthly production using a monthly demands graph and monthly production table and graph as evidence
- monthly storage requirements and storage costs
- concluding remarks

Your group will have 45 minutes to complete this portion of the design brief.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Apply technical writing skills to the development of a production plan.
- Calculate the output capacity of a manufacturing plant given production requirements.
- Use spreadsheet software to graphically display a monthly production schedule.
- Explain the importance of minimizing excessive spending when developing a production plan.

Materials
Computer with word processing and spreadsheet software

References
Anderson, David. *Design for Manufacturability: Optimizing Cost, Quality, and Time-to-Market*. CIM Press, 1990.

Bacon, Frank, and Thomas Butler. *Achieving Planned Innovation: A Proven System for Creating Successful New Products and Services*. New York: Simon & Schuster, 1998.
Drexl, Andreas. *Beyond Manufacturing Resource Planning: Advanced Models and Methods for Production Planning.* New York: Springer-Verlag, 1998.

Evaluation
Once all groups have completed their production plans, have them exchange plans for peer review. They should make any corrections to their plans based on suggestions. Next, each group should share their monthly production table and annual storage costs with the class. The group with the lowest storage costs should share its entire production plan with the class. Review each plan and provide feedback on the following:

- clarity of production plan purpose
- monthly production output calculation
- accuracy and readability of graphs
- calculation of storage costs
- supporting evidence for explanations
- valid conclusions
- grammar and report layout

ITEEA National Standards

Engineering Design

Manufacturing Technologies

The Attributes of Design

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Engineering Design

Transportation Modeling

Task Number 031

Design the manufacturing process.

Definition

Design should include

- standard operating procedures (SOP)
- plant layout or workflow
- production teams
- flowchart or process control chart
- operation process chart
- desired outcome.

Process/Skill Questions

- What symbols are commonly used in a manufacturing flow chart?
- How is the layout of equipment determined?
- How are human resource levels determined for a process? How are their tasks determined?
- How might the process influence the design?

Design Briefs

Job Shops and Batch Processes

Design Brief

Job Shops and Batch Processes

Context
You work for a company that builds furniture for local businesses. A new school is scheduled to open in three days, and the school system has hired your company to manufacture teacher desks. The school needs 20 computer desks, 30 standard teacher desks, and 15 laboratory demonstration desks. Your company has two buildings, a warehouse designed for machine clusters, and a building set up with four work cells. The company shop manager would like to know whether it is going to be more cost effective to use a job shop or batch process. The shop manager would also like to know whether to use work cells or clusters. The table below summarizes materials and other project costs.

Warehouse building	$50/hr	Table saws	4
Work cell building	$60/hr	Drill presses	4
Computer desk materials	$100	Routers	6
Standard desk materials	$75	Planers	4
Lab desk materials	$125	Lathes	4
Lathe	$6/min	Employees	28

Table saw	$2/min	*Employees may only work 8-hour days.
Router	$3/min	
Drill press	$1/min	
Planer	$2/min	
Each employee	$10/hr	

Computer desk process: Cut wood on table saw (10 min); run wood through planer (5 min); use router on desk top (3 min); drill holes to attach legs (2 min); assemble desk (20 min); apply finish (60 min).

Standard desk process: Cut wood on table saw (12 min); run wood through planer (5 min); use lathe on table legs (4 min); use router on desk top (4 min); drill holes to attach legs (2 min); assemble desk (25min); apply finish (60 min).

Lab desk process: Cut wood on table saw (10 min); run wood through planer (5 min); use router on desk top (5 min); drill holes to attach legs (3 min); assemble desk (20 min); apply finish (60 min).

Challenge
Determine the most cost-effective method of producing teacher desks for the new school. Present your decision in the form of an executive summary. The executive summary should include the following:

- brief introduction summarizing the problem
- explanation of factors that are being weighed
- explanation of decision to use a job shop or batch process
- explanation of decision to use work cells or clusters
- final production cost explained in spreadsheet format

Objectives
Upon completion of this design brief, students will be able to do the following:

- Differentiate between job shops and batch processes.
- Perform a cost comparison to decide which manufacturing process is the most cost effective for the production of desks.
- Explain the advantages and disadvantages of work cells and clusters.
- Design a manufacturing environment for desks.

Materials
Computer with spreadsheet and word processing software

References
Ghosh, Ashish. *Batch Process Automation: Theory and Practice*. Chapman and Hall, 1987.
Hardman, William. *Basic Machine Shop Theory: All You Need to Know about Tools and*

Processes — Instructor's Guide. National Tooling & Machining Association, 1980.
Sawyer, Paul. *Computer-Controlled Batch Processing.* Institute of Chemical Engineers, 1992.
Sharrat. *Handbook of Batch Processing Technology.* Kluwer Academic Publishers, 1997.

Evaluation
After the time is up for calculation and executive summary writing, have students read their summaries to the class and respond to the following:

- How did you determine whether a job shop or batch process should be used?
- How did you determine whether to use work cells or clusters?
- What is the final production costs for all of the desks?
- How long will it take to manufacture all of the desks?

Once each group has shared its executive summary, the groups with the cheapest production costs and shortest production time should use chart paper or a white board to diagram the manufacturing process in detail to the class. Review each of the executive summaries and make suggestions for improving the process for next time.

ITEEA National Standards

Engineering Design

Manufacturing Technologies

The Attributes of Design

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Engineering Design

Transportation Modeling

Task Number 032

Implement the manufacturing process.

Definition

Implementation should include safe operation of equipment to perform production processes as part of a production team.

Process/Skill Questions

- What is a production team?
- Who is responsible for safety?
- What is the benefit of positive criticism?
- How is the process documented and managed?

ITEEA National Standards

Engineering Design

Manufacturing Technologies

The Attributes of Design

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Engineering Design

Task Number 033

Evaluate the process.

Definition

Evaluation should include

- representation of schedule using a spreadsheet
- identification of problem areas
- measurement of output quantity relative to production plan
- application of statistical process control (SPC).

Process/Skill Questions

- What is a bottleneck?
- What is a time study?
- What tools are used to measure these processes?
- How can use of a step diagram help evaluate a process?

Design Briefs

Design Brief

Just-in-Time

Context
You are a line supervisor for BDM, a bookshelf manufacturing company. The line consists of three work cells, each equipped with a table saw, planer, router, drill press, assembly area, and finishing area. Your company has just implemented Just-in-Time manufacturing in order to minimize waste in all areas of bookshelf production. It is your job to set all of the schedules for machines, material ordering, and shipment to stores based on orders taken. You have received orders for 100 bookshelves to be delivered within the next 54 hours. You currently have none of the materials in stock. The tables below describe required machining time, material delivery times, and shipping times for each order.

Machine Process	**Time (min)**
Table saw	4
Planer	3
Router	6
Drill press	3
Assembly	10
Finishing	34

Material	**Delivery Time (hrs)**	**Step Needed for**
Wood	8	Table saw
Screws	4	Drill press
Dowels	6	Assembly
Glue	2	Assembly
Polyurethane	3	Finishing
Stain	3	Finishing

Order #	**Bookshelves Ordered**	**Shipping Time (hrs)**
1	20	2
2	35	10
3	15	22
4	10	5
5	20	15

Challenge
Just-in-Time manufacturing requires that materials arrive as they are needed and orders are shipped upon completion, not stored. Using the information provided in the tables above, work with a partner to develop a time schedule which includes the following:

- material ordering times for each order number

- work cell utilization times organized by order number
- shipping departure times

Objectives
Upon completion of this design brief, students will be able to do the following:

- Describe the components of Just-in-Time manufacturing.
- List factors that must be weighed when developing a manufacturing schedule for a Just-in-Time system.
- Use a spreadsheet program to develop a time schedule for a Just-in-Time manufacturing system.

Materials
Computer with spreadsheet software

References
Hay, Edward. *The Just-in-Time Breakthrough: Implementing the New Manufacturing Basics.* John Wiley & Sons, 1987.
Jansen, R. *Just-in-Time Manufacturing.* New York: Springer-Verlag, 1988.
Viale, David. *JIT Forecasting and Master Scheduling.* Crisp Publisher, 1997.

Evaluation
After students complete the JIT scheduling activity, have each pair print out their schedule. Discuss the following with the class:

- how to set up the schedule
- where to start when creating a JIT schedule
- how to balance work cell usage
- ways to maintain zero inventory
- difficulties encountered in creating the schedule

Provide each group with the solution to the problem that allows for the least amount of overall waste.

ITEEA National Standards

Engineering Design

Manufacturing Technologies

The Attributes of Design

TSA Competitive Events

Engineering Design

Task Number 034

Modify the process according to specific measures.

Definition

Modification should include demonstration of knowledge of flow lines and continuous improvement by

- designing those processes
- eliminating bottlenecks and other problem areas
- readjusting the schedule
- reallocating workforce.

Process/Skill Questions

- How does downtime affect the manufacturing process?
- What is a go/no-go gauge?
- How does inspection affect the process?
- How are acceptable tolerances determined?

Design Briefs

Flow Lines

Design Brief

Flow Lines

Context
Your teacher has decided to have a "Banana Split Day." For sanitary reasons, everyone must wear gloves, and only one person can touch each of the ingredients. The following ingredients are available: one banana per person, 1 scoop per person each of vanilla, chocolate, and strawberry ice cream, chocolate syrup, rainbow sprinkles, whipped cream, and one cherry per person in the class. As in any assembly line production, no talking is allowed.

Challenge
As a class, quickly decide on a way to get a banana split made for each person in the class in the fastest possible way. Remember that only one person is allowed to touch each of the ingredients. Once you have decided on your method, ask your instructor to bring out the ice cream.

Objectives
Upon completion of this design brief, students will be able to do the following:

- Design a flow-line process.
- Use a flow line process to manufacture goods.
- Describe the advantages and disadvantages of using a flow-line process.
- Suggest ways of modifying a flow-line process to allow for small variations in products.

Materials
One banana for each student, enough chocolate, vanilla, and strawberry ice cream for each student to have one scoop, chocolate syrup, rainbow sprinkles, whipped cream, one cherry for each student

References
Robson, George. *Continuous Process Improvement: Simplifying Work Flow Systems*. New York: Free Press, 1991.
Taylor, Sam, and Steven Bolander. *Process Flow Scheduling: A Scheduling Systems Framework for Flow Manufacturing.* American Production & Inventory Control Society, Inc., 1994.
Leymann, Frank. *Production Work Flow: Concepts and Techniques*. New York: Prentice Hall, 1999.

Evaluation
After students finish making the banana splits, allow them to eat while discussing the following:

- difficulties in deciding on the process
- assembly difficulties
- advantages of using an assembly line
- disadvantages of using an assembly line
- modifications to be made for next time

Relate class discussion comments to the use of assembly lines in the real world.

ITEEA National Standards

Engineering Design

Manufacturing Technologies

The Attributes of Design

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Engineering Design

Examining Product Quality

Task Number 035

Explain product quality.

Definition

Explanation of quality should express

- output relative to the design
- form versus function
- product specifications
- customer satisfaction.

Process/Skill Questions

- How can lack of quality affect the bottom line?
- What is the effect of product quality when one manufacturer is supplying products to another manufacturer?
- Who determines product quality?
- How are different stakeholders affected by product quality?

Design Briefs

Definition of Quality

Design Brief

Definition of Quality

Context
You have just graduated from college and received a job offer from a company 15 miles from your apartment. Your college car is not reliable enough to commute twice a day in rush-hour traffic, so you have decided to buy a new car. You need a high-quality car, but because you are just starting out in life, you cannot afford to spend any more than $17,000 for the new car.

Challenge
As a customer, it is your job to judge quality. The table below contains specifications on 10 cars in your price range. Create a table of your own that contains at least five features that you would look for in a quality sub-compact car. Next, rate each of the cars in your price range on a scale of 1 to 10 according to each of your criteria. You may need to use the Internet to find more specification details. Finally, come up with a method of determining which car you would buy based on your ratings. You may want to weigh those features that are most important to you. Write a paragraph below your chart explaining how you made your final decision. You will have 30 minutes to complete this portion of the design brief.

Automobile	Price	Mileage (city)	Cargo Area	Air Cond.	Airbags	PwrWin & Lock	Sunroof
Toyota Corolla	16323	29	12.1 cu.ft.	Y	Y	Y	N
Honda Civic	16145	29	11.9 cu.ft.	Y	Y	Y	Y
Ford Contour	17290	22	13.9 cu.ft.	Y	Y	Y	N
Dodge Neon	12970	28	13.1 cu.ft.	Y	Y	N	N
Chevrolet Cavalier	15315	23	13.6 cu.ft.	Y	Y	Windows Only	N
Pontiac Sunfire	14615	23	13.1 cu.ft.	Y	Y	Y	N
Hyundai Accent	9434	28	11.8 cu.ft.	N	Y	N	N
Volkswagen Beetle	18250	22	12.0 cu.ft.	Y	Y	Y	Y
Nissan Sentra	15519	27	10.7 cu.ft.	Y	Y	Y	N

Objectives
Upon completion of this design brief, students will be able to do the following:

- Explain the concept that the customer defines quality.
- Identify features of an automobile of high quality.
- List criteria used to measure the quality of an automobile.
- Create a personal quality rating system.

Materials
Computer with spreadsheet software, Internet access

References
George, Steven. *Total Quality Management: Strategies and Techniques Proven at Today's Most Successful Companies.* New York: John Wiley & Sons, Inc., 1998.
Hale, Roger, et al. *Quest for Quality: How One Company Put Theory to Work.* Monochrome Press, Inc., 1993.
Kantner, Rob. *QS-9000 Answer Book: 101 Questions and Answers about the Automotive Quality System Standard.* New York: John Wiley & Sons, Inc., 1996.
Kelley Blue Book. http://www.kbb.com. November 22, 1999.

Evaluation
After the time is up, students should print out spreadsheets and paragraphs. Have students share which automobile they thought was of highest quality and why. Hold a class discussion about the variety of quality rating systems used by students in the class. Conclude the class by summarizing the three elements that make up operational definitions.

ITEEA National Standards

Manufacturing Technologies

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

TSA Competitive Events

Prepared Presentation

Task Number 036

Apply root-cause analysis to identify problems in product quality.

Definition

Application should address problems related to

- materials
- measurement
- design

- engineering
- environment
- processes
- personnel
- equipment
- logistics.

Process/Skill Questions

- What is the primary question asked in root-cause analysis?
- How are problem areas prioritized?
- How do unaddressed problems affect the bottom line?
- What are different techniques for root-cause analysis? (e.g., five whys, Ishikawa diagrams)

Design Briefs

Pareto Analysis

Design Brief

Pareto Analysis

Context
You work as a customer-relations associate for a direct mail shipping company. Recently, you have been receiving complaints from customers about packages arriving damaged. There are several steps in the shipping process where this damage could be occurring. You have asked one of your most reliable drivers to observe the entire shipping process for one week and record the number of errors made at each stage in the process. The results of his observations are in the table below.

Step	Monday Errors	Tuesday Errors	Wednesday Errors	Thursday Errors	Friday Errors
Place in box.	5	3	7	9	6
Bubblewrap.	10	6	4	7	8
Fill with peanuts.	7	5	9	11	8
Tape box.	8	11	9	7	7
Take box to loading bay.	17	12	14	10	13
Load box on truck.	20	12	14	17	14
Give box to recipient.	2	3	1	5	4

Challenge
Working with a partner, follow the steps below to complete a Pareto Analysis of the problem to separate the steps in the shipping process into major and minor causes of packages arriving damaged.

1. Transfer the observations table above into a spreadsheet program.
2. Add a column containing the total number of errors in each step for the entire week.
3. Sort the steps in order from most total errors to least total errors.
4. Calculate the total number of errors from all steps.
5. Add a column for the percentage of the total errors that each step represents.
6. Create a bar chart with total number of errors on the y-axis and process step on the x-axis.
7. Print out your bar chart, and follow the steps below to draw the cumulative curve.
    A. Draw a line from where the axes start to the upper right-hand corner of the first bar.
    B. Place a dot here, and next to it write the percentage calculated for that item.
    C. Make a second dot directly above the top-right hand corner of the second bar to represent the cumulative total (i.e., the total of the first and second item added together).
    D. Join it to the first dot and write the cumulative percentage beside it.
    E. Continue until the last cumulative total has been plotted.
    F. On the right-hand side of the diagram, next to the last bar, draw in a second vertical axis that starts at zero and has 100% aligned with the end of the cumulative curve.

The steps requiring priority action (the major causes of damage) will appear on the left of the diagram where the slope of the curve is steepest. You will have 45 minutes to complete this portion of the design brief.

Objectives
Upon completion of this design brief, students will be able to do the following:

- List the major steps involved in Pareto Analysis.
- Construct a Pareto Diagram.
- Recommend a solution based on Pareto Diagram results.
- Describe what a Pareto Diagram would look like if improvement measures were effective.

Materials
Computer with spreadsheet software, pencil, ruler

References
Chase, Richard B., and Nicholas J. Aquilano. *Production and Operations Management:*

Manufacturing and Services. Chicago: Irwin Press, 1998.
Reynard, Sue. *Pareto Charts Plain and Simple*. Oriel, Inc., 1995.

Evaluation
After the Pareto Analysis is finished, each pair of students should compare their analysis with another pair. They should share what they believe to be the major causes of shipping damage for Direct Mail Shipping Company. Discuss with the class what a Pareto Diagram, developed after improvements were made, would look like if improvements were effective (the curve will be much flatter). Cite other examples of how Pareto Analysis is used in manufacturing.

ITEEA National Standards

Manufacturing Technologies

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

TSA Competitive Events

Transportation Modeling

Task Number 037

Implement a continuous improvement plan.

Definition

Implementation should include an industry standard problem-solving method, such as

- value stream mapping
- waste elimination
- the Five S's (sort, straighten, shine, standardize, and sustain)
- DMAIC (define, measure, analyze, improve, and control)
- Total Productive Maintenance (TPM).

Process/Skill Questions

- What is value stream mapping?
- What are the principles of the 5 S's?
- What is the importance of waste elimination? How can it increase profits?
- Why do manufacturers need continuous improvement?

ITEEA National Standards

Manufacturing Technologies

Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Prepared Presentation

SOL Correlation by Task

39	Use required personal protective equipment (PPE).	English: 11.5, 12.5 History and Social Science: VUS.8, WHII.8 Science: CH.1
40	Implement a safety plan.	English: 11.5, 12.5 History and Social Science: VUS.8, WHII.8
41	Maintain safe working practices in the production laboratory.	History and Social Science: GOVT.7, GOVT.8, GOVT.14, GOVT.15, VUS.8, VUS.13, VUS.14, WHII.8, WHII.14 Science: CH.1
42	Operate lab equipment according to instructor guidelines.	History and Social Science: VUS.8, WHII.8
43	Explain the goals of lean manufacturing.	English: 11.5, 12.5
44	Describe manufacturing as a technological system.	English: 11.5, 12.5
45	Use manufacturing terminology.	
46	Project future trends in manufacturing.	English: 11.5, 12.5 History and Social Science: VUS.1, VUS.13, VUS.14, WG.17, WHII.1, WHII.13, WHII.14

47	Investigate careers in manufacturing.	English: 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.7, GOVT.8, GOVT.14, GOVT.15
48	Apply problem-solving strategies.	
49	Design with computer-aided design (CAD).	English: 11.2, 12.2 Mathematics: G.14
50	Use computer-assisted engineering (CAE).	Mathematics: G.14, AII.3, COM.12
51	Explain the key components of automated systems in the manufacturing environment.	English: 11.5, 12.5 History and Social Science: VUS.1, VUS.13, VUS.14, WG.17, WHII.1, WHII.13, WHII.14 Science: PH.4
52	Explain numerical control (NC), computer numerical control (CNC), direct numerical control (DNC), and computer-assisted manufacturing (CAM).	English: 11.5, 12.5 Mathematics: COM.10, COM.12
53	Apply CAM in additive and subtractive processes.	
54	Communicate through examples the importance of flexibility in computer-integrated manufacturing (CIM) production systems.	English: 11.5, 12.5
55	Demonstrate an understanding of industrial control systems and the role they play in synchronizing and controlling the operation of work cells in the plant.	English: 11.6, 12.6 Mathematics: COM.1, COM.10, COM.11, COM.16
56	Program a PLC.	English: 11.2, 12.2 Mathematics: COM.4, COM.5, COM.8
57	Define *mechatronics*.	English: 11.5, 12.5
58	Explain the role of fluid power in mechatronic systems.	English: 11.5, 12.5
59	Explain the role of electricity and electronics in mechatronics systems.	English: 11.5, 12.5 Mathematics: AII.3
60	Explain the role of mechanics in mechatronics systems.	English: 11.5, 12.5
61	Explain the role of computer systems in mechatronics systems.	English: 11.5, 12.5
62	Describe the effect of labor and human resources issues on manufacturing.	English: 11.5, 12.5

		History and Social Science: GOVT.9, GOVT.15
63	Create a marketing plan.	
64	Explain the effect of supply and demand on manufacturing.	English: 11.5, 12.5 History and Social Science: GOVT.14, GOVT.15
65	Explain fiscal and fiduciary responsibilities associated with running a successful enterprise.	English: 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15
66	Explain supply chain management.	English: 11.5, 12.5
67	Describe philosophies of continuous improvement.	English: 11.5, 12.5
68	Plan for production.	English: 11.1, 11.2, 11.5, 11.6, 12.1, 12.2, 12.5, 12.6 History and Social Science: GOVT.1, GOVT.15 Mathematics: COM.7
69	Design the manufacturing process.	English: 11.1, 12.1 History and Social Science: VUS.14, WG.1, WG.16, WG.17, WHII.14
70	Implement the manufacturing process.	History and Social Science: GOVT.1, GOVT.9, GOVT.15
71	Evaluate the process.	English: 11.5, 12.5 Mathematics: PS.18, PS.10*
72	Modify the process according to specific measures.	English: 11.5, 12.5 Mathematics: COM.4, COM.5, DM.10, DM.3*
73	Explain product quality.	English: 11.5, 12.5
74	Apply root-cause analysis to identify problems in product quality.	History and Social Science: GOVT.1
75	Implement a continuous improvement plan.	

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked “optional.”

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Additive Manufacturing Fundamentals Examination
- Automated Manufacturing Technology Examination
- Business Certificate for Manufacturing Examination
- Certified Production Technician (CPT) Program Examinations
- College and Work Readiness Assessment (CWRA+)
- Manufacturing Specialist Certification Examination
- Manufacturing Technician Level I Certification Examination
- Manufacturing Technology Assessment
- Mechatronic Systems Certification Examinations
- National Career Readiness Certificate Assessment
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Manufacturing Systems I (8425/36 weeks)

Career Cluster: Manufacturing	
Pathway	**Occupations**
Health, Safety, and Environmental Assurance	**Occupational Health and Safety Specialist** **Safety Engineer**
Logistics and Inventory Control	**Dispatcher** **Logistician** **Materials Handler** **Shipping and Receiving Clerk**
Manufacturing Production Process Development	**Electro-Mechanical Technician** **Industrial Engineer** **Industrial Engineering Technician** **Manufacturing Systems Engineer** **Millwright** **Precision Inspector, Tester, or Grader**

Career Cluster: Manufacturing	
Pathway	**Occupations**
	Production Manager **SPC (Statistical Process Control) Coordinator**
Production	**Assembler** **Automated Manufacturing Technician** **Extruding and Drawing Machine Operator** **Tool and Die Maker**
Quality Assurance	**Calibration Technician** **Precision Inspector, Tester, or Grader** **Quality Control Technician** **SPC (Statistical Process Control) Coordinator**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Computer Programmer** **Electrical Engineer** **Electrical Engineering Technician** **Electro-Mechanical Technician** **Electronic Drafter** **Electronics Engineering Technician** **Human Factors Engineer** **Industrial Engineer** **Industrial Engineering Technician** **Manufacturing Systems Engineer** **Materials Engineer** **Mechanical Drafter** **Mechanical Engineer** **Mechanical Engineering Technician** **Power Systems Engineer** **Project Manager** **Quality Engineer** **Quality Technician**