Amp It Up! Engineering/Technology and Industry Lesson Extension

Teacher Name(s), School and District: Denise Yelle, Danvers High School

Course Name: Honor's Calculus

Lesson/Unit Name: Careers in manufacturing / Optimization/ Marginal Cost

Science or Education Topic(s): Locating, evaluating and interpreting information.

Engineering Technology Industry Related Field/Activity: Manufacturing / career

When Taught: Spring 2017

Abstract: This lesson will expose students to the different career opportunities in manufacturing. They will discover the skills and education needed to attain such a career. They will also learn the importance of knowledge and use of technology in this career. They will see how math skills are applied in the manufacturing field by solving some optimization and marginal cost problems related to the manufacturing done at Innovent Technologies.

Objectives and assessment: Using the table below, identify at least 3-5 learning objectives (content and/or pedagogical) and describe how each will be assessed.

Objectives *By the end of this lesson/unit, the students will be able to:*	**Assessment** *How was the objective assessed? List the example of formative or summative assessment.*
Identify various items in the classroom that were and were not manufactured.	Written lists, sticky notes on the items in the classroom
Describe the different careers available in manufacturing.	Written assignment
Research different career opportunities.	Project (attached)
Identify educational and skill requirements for a career in manufacturing.	Project (attached)
Apply optimization and marginal cost formulas to manufacturing problems	Manufacturing math problems

Engineering/Technology Link: Please check the appropriate box(es) in question 1. And provide a brief answer to question 2.:

1. How did you *introduce* engineering/ technology concepts or the company/industry focus in your course? Check the appropriate box(es) or choose Other.

XX Defined terms (manufacturing, engineering, technology)

XX Described the engineering design process

XX Overview of the company

XX Other: _Informational sheets on manufacturing and careers in manufacturing given to students at the start of the lesson

2. After introducing the concepts, what did/will the students do to explore and apply the engineering/technology and industry specific concepts?

-find objects in the classroom that were and were not manufactured
-each group will come up with the steps needed to make one of the objects in the room including; idea, materials, design, test, market, distribute
-groups will also list what types of careers are available
-students will think about what type of company they would like to work for
-students will individually chose 2 or more careers from the handout that they would like to know more about
-students will be given a worksheet with 4 manufacturing problems in which they will use the optimization and marginal cost formulas
-for homework they will research the careers they chose
-each student will then select ONE career and complete a project (the project must include; Job title, companies, educational and skill requirements, and a diagram explaining their career path)

Level of Inquiry: Which of the following best describes the level of inquiry (adapted from Bell 2005) you used for this lesson/unit? Check the appropriate level.

XX *Structured inquiry*: Instructor provides question and procedure. Students determine the results based on given procedures.

XX *Guided inquiry*: Instructor provides question. Students design procedure and determine the results.

Lesson Extension Plan:

Title/Topic: Careers in manufacturing
Time (minutes): 50 minutes plus a homework assignment
Company Name and brief Description: Innovent Technologies. A company that provides some of the industries leading companies with contract manufacturing, engineering and assembly services.
Overview of the Lesson: Students will identify items that were manufactured, discuss the process, think about different careers involved, research those careers and the requirements needed to attain such a career. They will also solve a manufacturing problem applying the "rate of change" formula.
Standard(s)/Unit Goal(s) to be addressed in this lesson: *Develop skills to locate, evaluate and interpret information. *Problem-solving, organizational skills, and working in groups. *Demonstrate knowledge of technology.
Essential Question(s) addressed in this lesson: What types of careers are available in manufacturing and what skills/education are needed to attain that career? When do we use mathematics in the field of manufacturing?
Objectives: Students will: • Identify various items in the classroom that were and were not manufactured. • Describe the different careers available in manufacturing. • Research different career opportunities. • Identify educational and skill requirements for a career in manufacturing. * Solve a optimization and marginal cost problems about manufacturing
Link to Industry: Manufacturing, engineering.
What students should know and be able to do before starting this lesson: Students should be able to work in groups, research online and share their findings. They should also know the optimization and marginal cost formulas.

Instructional Materials/Resources/Tools: "Manufacturing Process From Start to Finish", "Manufacturing Sectors and Careers" informational sheets, applied problems worksheet and instructions for the project.
Lesson Delivery
Lesson Opening: In groups of 2, students will make a list of 3 items, in the classroom, that were and 3 items that were not manufactured. They will put their names on sticky notes and put the sticky notes on the items.
During the Lesson (activities/labs/challenges): Each group will explain, in writing, why they chose the items they chose and how they think each item was made. Each group will then chose 1 item from their list. They will be given the handouts; "The Manufacturing Process from Start to Finish" and "Some Manufacturing Sectors and Careers." Each group will write down the steps needed to make the item they chose, what types of careers are available and what type of company they could work for. Students will then be given a worksheet with 4 manufacturing problems, which they will solve using the optimization and marginal cost formulas previously learned.
Lesson Closing: Whole class discussion about what they learned and what they will take away from the class. (hopefully they will see where math is used in the real world) Students will be given the project instructions and due date.
Assessment
Student Assessment: Students will be graded on teamwork skills, research ability, the correct solving of the application problems and on the quality and creativity of their projects.
Delivery Assessment: Teamwork, class discussions.

Additional resources and assessments: List the attachments here.

"The Manufacturing Process From Start to Finish"
"Some Manufacturing Sectors and Careers"
Application problems worksheet.
Project instructions.

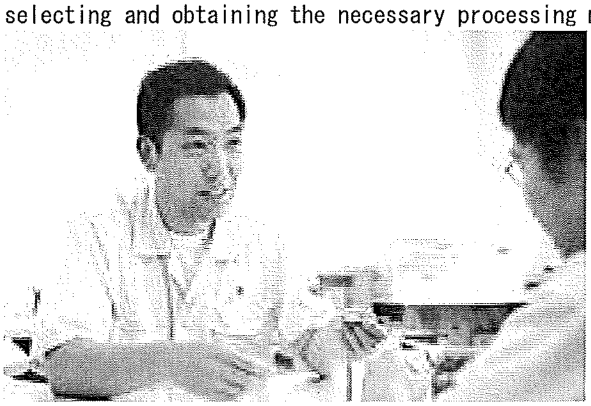
The Manufacturing process from start to finish

01/ Initial planning stage

We receive product plans and quality specifications from the customer, draw up a proposal for the manufacturing method and overall schedule, and based on this information calculate a rough cost estimate. After doing this and dealing with any other issues, we consider the feasibility of manufacturing the proposed product on a commercial scale.

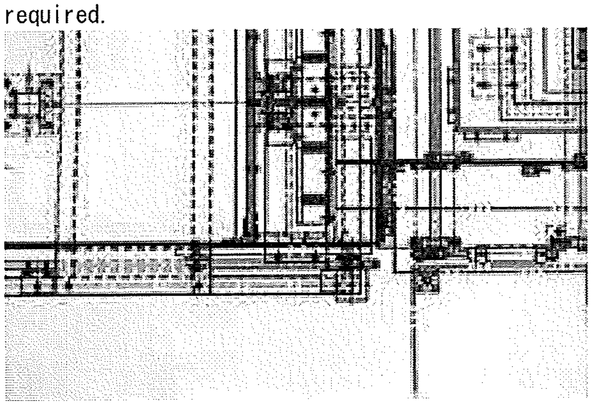
02/ Product Development Phase

After establishing the feasibility of the project, we determine the specifications of the product in more detail by working on the design and manufacture of the dies, as well as selecting and obtaining the necessary processing machinery and tools etc.



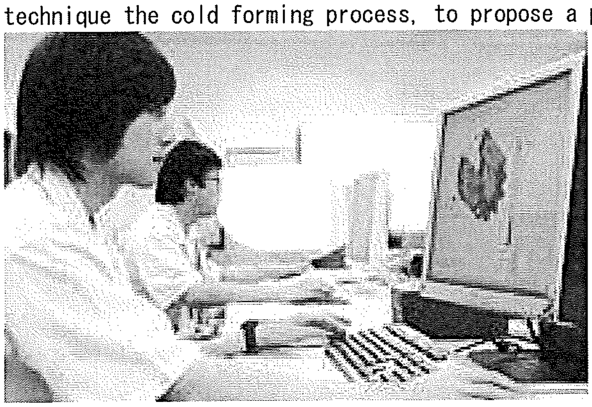
03/ Prototype production/evaluation

Based on the product plans and quality specifications received from the customer, and the product specifications and product manufacturing plans determined in the Product Development Phase, we produce a prototype. We then work with the customer to establish whether the product meets the required quality standards. We repeat this process of product development, prototype production and prototype evaluation until the prototype reaches the standard of quality required.



04/ Commercial prototype production planning

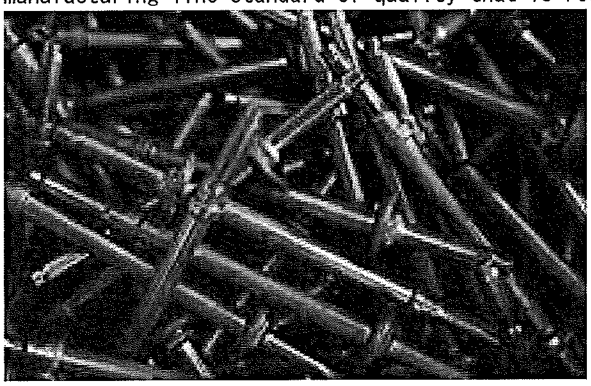
In order to build a manufacturing line that can efficiently produce high quality products, we carry out a forging simulation using the CAE system, which supports the design of our core technique the cold forming process, to propose a pertinent manufacturing design and layout.



Gear analysis
Set bolt analysis

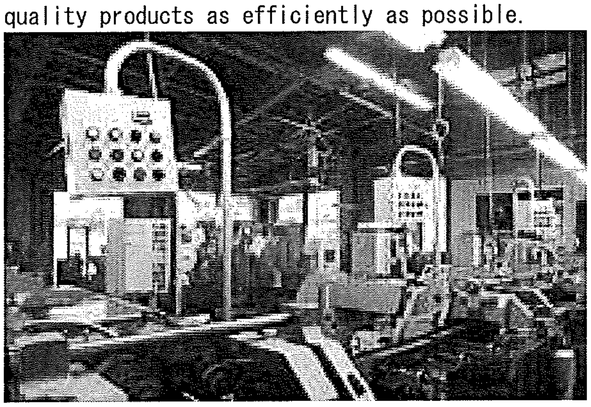
05/ Commercial Prototype Production/Evaluation

Based on the manufacturing design and layout proposed in the Commercial prototype production planning stage, we build a manufacturing line and produce a commercial prototype. We then work with the customer to establish whether the product meets the required commercial manufacturing line quality standards. We repeat this process of commercial-scale prototype development, prototype production and prototype evaluation until the prototype reaches the commercial manufacturing line standard of quality that is required.



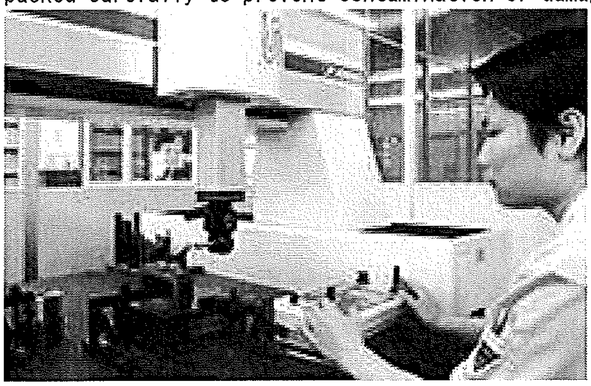
06/ Commercial Production

When all the preparations are complete, commercial production begins. Even at this stage, modifications and improvements are made to the manufacturing line, and our engineers are continually trying to improve their work. The whole team actively cooperates to make high quality products as efficiently as possible.



07 Inspection, Shipment, Delivery

The completed goods are closely inspected manually and by machine to make sure there are no defects or flaws. Only those goods that pass the inspection are delivered to the customer, packed carefully to prevent contamination or damage.



Now that we have learned a bit about manufacturing and the jobs in manufacturing, let's take a look at some applications of derivatives in the manufacturing world. For the most part these are really applications that we've already looked at, but they are now going to be approached with an eye towards the manufacturing world.

Let's start things out with an optimization problem. We've already looked at more than a few of these in previous sections so there really isn't anything all that new here except for the fact that it is coming out of the manufacturing world.

Problem 1

A production facility is capable of producing 60,000 bicycle tires in a day and the total daily cost of producing x tires in a day is given by;

$$C(x) = 250{,}000 + 0.08x + \frac{200{,}000{,}000}{x}$$

How many tires per day should they produce in order to minimize production costs?

We shouldn't look at the previous example and think that the only applications to manufacturing are just applications we've already looked at but with a business "twist" to them.

There are some very real applications to calculus that are in the manufacturing world and at some level that is the point of this section. We're just going to scratch the surface and get a feel for some of the actual applications of calculus from the manufacturing world.

Let's start off by looking at some examples.

Problem 2:

The production costs per week for producing x wafers is given by,

$$C(x) = 500 + 350x - 0.09x^2, \quad 0 \le x \le 1000$$

Answer each of the following questions.

(a) What is the cost to produce 301 wafers?

(b) What is the rate of change of the cost at $x = 300$?

Problem 3:

The production costs per day for producing machine parts is given by,

$$C(x) = 2500 - 10x - 0.01x^2 + 0.0002x^3$$

What is the marginal cost when $x = 200$, $x = 300$ and $x = 400$?

Problem 4:

The weekly cost to produce x wafers is given by

$$C(x) = 75,000 + 100x - 0.03x^2 + 0.000004x^3 \qquad 0 \le x \le 10000$$

and the demand function for the wafers is given by,

$$p(x) = 200 - 0.005x \qquad 0 \le x \le 10000$$

Determine the marginal cost, marginal revenue and marginal profit when 2500 wafers are sold and when 7500 wafers are sold. Assume that the company sells exactly what they produce.

Solutions;

Problem 1

Here we need to minimize the cost subject to the constraint that *x* must be in the range. Note that in this case the cost function is not continuous at the left endpoint and so we won't be able to just plug critical points and endpoints into the cost function to find the minimum value.

Let's get the first two derivatives of the cost function;

C'(x) = .08 – 200,000,000 / x^2   C" (x) = 400,000,000 / x^3

The critical points of the cost function are,

.08 – 200,000,000 / x^2   = 0

so, x = 50,000 and x = -50,000 are our critical points

The negative value doesn't make any sense in this setting and so we have a single critical point in the range of possible solutions: 50,000.

The function is always concave up and so producing 50,000 tires will yield the absolute minimum production cost.

Problem 2

(a) We are looking for the actual cost of producing the 301st wafer.

C (301) – C(300) = 97,695.91 – 97,400.00 = 295.91

The cost of producing the 301st wafer is $295.91

(b) In this part all we need to do is get the derivative and compute.

c'(x) = 350 - .18x
c'(300) = $296.00

Problem 3

We need the derivative and then we'll need to compute some values of the derivative.

C'(x) = -10 - .02x +.0006x^2

C'(200) = 10

C'(300) = 38

C'(400) = 78

In order to produce the 201st machine part it will cost approximately $10. To produce the 301st machine part will cost about $38. Finally, to produce the 401st machine part it will cost approximately $78.

Problem 4; The first thing we need to do is get all the various functions that we'll need. Here are the revenue and profit functions.

$R(x) = x\,(200 - .0005x) = 200x - .0005x^2$

$P(x) = 200x - .005x^2 - (75{,}000 + 100x - .03x^2 + .000004x^3)$

$\quad = -75{,}000 + 100x + .025x^2 - .000004x^3$

The marginal functions are:

$C'(x) = 100 - .06x + .000012x^2$

$R'(x) = 200 - .01x$

$P'(x) = 100 + .05x - .000012x^3$

The marginal functions at 2500 are;

$C'(2500) = 25$

$R'(2500) = 175$

$P'(2500) = 150$

The marginal functions at 7500 are;

$C'(7500) = 325$

$R'(7500) = 125$

$P'(7500) = -200$

When producing and selling the 2501^{st} wafer it will cost the company approximately \$25 to produce the wafer and they will see an added \$175 in revenue and \$150 in profit.

When they produce and sell the 7501^{st} wafer it will cost an additional \$325 and they will receive an extra \$125 in revenue, but lose \$200 in profit.

The company that I visited was Innovent Technologies (Innoventtech) in Peabody, Massachusetts. Their design team enhances existing designs, while their manufacturing team produces finished products to each companies specifications. They manufacture and assist in the design of substrate handling components. There is a cleanroom, where contamination sensitive products are manufactured. Innoventtech also does inventory control, precision assembly, custom packaging, and shipping to the end customer. Innoventtech is a precision machining center that does manufacturing, engineering and failure analysis/product redesigns. They have grown from a company of 24 employees, just 6 years ago, to a current employee count of 70. The plant is 50,000 square feet. Employee salaries range from minimum wage up to more than $100,000 per year. Responsibilities range from basic manufacturing to engineering and a multitude of jobs in between. The engineers typically need a bachelor's degree, but are sometimes promoted from manufacturer to engineer, even without a degree.

I spent the day there with John Flinn, the vice-president/general manager. After answering all of my questions and telling me about the company, he took me on a tour of the plant. I saw people making bicycle tires, cooling panels, wafers and assembling full machines. I observed the clean room and the quality control room. It was a very interesting and enlightening experience.

Some Manufacturing Sectors

*Aviation and Aerospace
*Medical devices
*Electronic devices
*Food/beverage
*Paper
*Cosmetics
*Printing
*Entertainment
*Metals
*Plastics
*Mining
*Systems engineering
*Transportation

Sample Manufacturing Careers

*Product design
*Production
*Engineering
*Manufacturing operation
*Facilities maintenance
*Automation and controls
*Robotics
*Materials handling
*Quality assurance
*Packaging design
*IT (information technology)
*Sales/marketing
*Finances
*Customer service

Careers in Manufacturing Project

Research the career(s) you chose in class, select 1 career and complete the following;

1. Job title and a brief description of what the job entails
2. Companies you could work for
3. Skills required
4. Educational requirements –(high school, Associate's Degree, Bachelor's Degree, Master's Degree, etc.)
5. Diagram showing your career path