CIM – Week 6

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| **Lesson 2.3 Product Development** |

**Preface**

Machines have changed the face of manufacturing. From the first conveyor system used by Henry Ford over a hundred years ago to the laser engraver and 3-D printers of today, machines have simplified the manufacturing process and have given us unlimited potential for creativity. Technology has allowed the evolution of manufacturing to explode in the last century. The quality, speed, and durability of products have reached new heights. The profit margin for companies has also benefited from the advancement of machines and technology. Imagine where we would be if the technology were the same now as it was when mass production first began.

In this lesson students will learn about the various machines used in the real world and in the classroom. They will learn how to read and write code and apply their knowledge to the creation of a simple assembled product. Students will also learn how jigs and fixtures factor into manufacturing and will simulate their creation. Students will ultimately follow the engineering process to create an assembled product of their choice, utilizing their knowledge as applicable.

**Concepts**

1.    Many machines exist to perform manufacturing processes.

2.    Machine code is an essential tool used to communicate with some machines.

3.    Jigs and fixtures are essential in maintaining consistency and quality control.

4.    Computer Aided Manufacturing (CAM) programming tools make it possible to manufacture physical models using Computer Aided Design (CAD) programs.

5.    Products manufactured today have been greatly influenced by the advancement of machines and technology.

6.    Several variables in machining operations affect the final product in manufacturing.

7.    Profit margins are essential to a company’s survival in a competitive market.

8.    Prototyping is a major step in the design cycle of manufactured goods and has been greatly advanced with the advent and use of rapid prototyping processes.

**Standards and Benchmarks Addressed**

***Standards for Technological Literacy***

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| **Standard 2:** | Students will develop an understanding of the core concepts of technology. |
| **BM AA:** | Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.  |
| **BM CC:** | New technologies create new processes.  |
| **BM DD:** | Quality control is a planned process to ensure that a product, service, or system meets established criteria.  |
| **Standard 4:** | Students will develop an understanding of the cultural, social, economic, and political effects of technology. |
| **BM I:** | Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.  |
| **Standard 8:** | Students will develop an understanding of the attributes of design. |
| **BM J:** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. |
| **BM K:** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. |
| **Standard 9:** | Students will develop an understanding of engineering design. |
| **BM K:** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.   |
| **BM L:** | The process of engineering design takes into account a number of factors. |
| **Standard 11:** | Students will develop abilities to apply the design process.  |
| **BM P:** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.   |
| **BM R:** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. |
| **Standard 17:** | Students will develop an understanding of and be able to select and use information and communication technologies. |
| **BM M:** | Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. |
| **BM O:** | Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage retrieval and destination. |
| **Standard 19:** | Students will develop an understanding of and be able to select and use manufacturing technologies. |
| **BM N:** | Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.   |
| **BM P:** | The interchangeability of parts increases the effectiveness of manufacturing processes.   |

***National Science Education Standards***

**Unifying Concepts and Processes Standard K-12:**  As a result of activities in grades K-12, all students should develop

         **Systems, order, and organization**

         **Evidence, models, and explanation**

         **Change, constancy, and measurement**

         **Form and function**

**Science as Inquiry Standard A:** As a result of activities in grades 9-12, all students should develop

         **Abilities necessary to do scientific inquiry**

         **Understandings about scientific inquiry**

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop

         **Abilities of technological design**

         **Understandings about science and technology**

**Science in Personal and Social Perspectives Standard F:** As a result of activities in grades 9-12, all students should develop understanding of

         **Natural resources**

         **Environmental quality**

         **Natural and human-induced hazards**

         **Science and technology in local, national, and global challenges**

***Principles and Standards for School Mathematics***

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| **Number Operations:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand numbers, ways of representing numbers, relationships among numbers, and number systems; understand meanings of operations and how they relate to one another; compute fluently and make reasonable estimates. |
| **Algebra:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to represent and analyze mathematical situations and structures using algebraic symbols; use mathematical models to represent and understand quantitative relationships; analyze change in various contexts. |
| **Geometry:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to [**analyze characteristics**](file:///D%3A%5CStandards%5Cdocument%5Cchapter3%5Cgeom.htm#bp1#bp1) and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; specify locations and describe spatial relationships using coordinate geometry and other representational systems; apply transformations and use symmetry to analyze mathematical situations; use visualization, spatial reasoning, and geometric modeling to solve problems. |
| **Measurement:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to understand measurable attributes of objects and the units, systems, and processes of measurement; apply appropriate techniques, tools, and formulas to determine measurements. |
| **Data Analysis and Probability** | Instructional programs from pre-kindergarten through grade 12 should enable all students to formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; select and use appropriate statistical methods to analyze data; develop and evaluate inferences and predictions that are based on data; understand and apply basic concepts of probability. |
| **Problem Solving:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; monitor and reflect on the process of mathematical problem solving. |
| **Communication:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others. |
| **Connections:**  | Instructional programs from pre-kindergarten through grade 12 should enable all students to recognize and use connections among mathematical ideas; understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics. |
| **Representation:** | Instructional programs from pre-kindergarten through grade 12 should enable all students to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; model and interpret physical, social, and mathematical phenomena. |

***Standards for English Language Arts***

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| **Standard 4:** | Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.  |

**Performance Objectives**

*It is expected that students will:*

    Identify machines when given a process and identify the process that a given machine performs.

    Determine the appropriate speed rate for a given material using a tool with a given diameter.

    Determine the feed rate for a given material using a tool with a given diameter.

    Read and interpret G & M codes.

    Transfer the drawings made in CAD to a CAM program.

    Create numerical code using a CAM program.

    Verify the creation of a part using a simulation software.

    Create parts using the machines demonstrated by the instructor.

    Create a product on the computer using knowledge of manufacturing processes.

**Assessment**

*Explanation*

1.    List machines used to perform manufacturing processes.

2.    Explain the difference between jigs and fixtures.

*Interpretation*

3.    Interpret G & M codes.

*Application*

4.    Calculate cutter speeds and tool rates.

5.    Create an assembly using the manufacturing processes.

6.    Write G & M codes to perform given functions.

7.    Create jigs and fixtures to aid in the construction of an assembly.

8.    Students will apply one or more of the manufacturing processes to a product they will create on the computer.

*Self-knowledge*

9.    Students will analyze a part and plan the most efficient milling method  among the several methods they know.

**Essential Questions**

1.    What types of machines exist to perform manufacturing processes?

2.    Why is it important for a design engineer to learn about programming codes?

3.    What are jigs and fixtures? How are they the same? How are they different?

4.    How has the advancement of technology and machines affected the global market?

5.    What are some ways that manufacturers can verify how a part will be created without producing it physically?

6.    How do machines receive data from a computer?

7.    How are manufacturing companies affected by the way a product is created?

**Key Terms**

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| **Absolute** | System in which positions are given with respect to a fixed point, usually the origin. |
| **Address Character** | A letter used in G & M code programming to designate a class of functions. |
| **Block** | A single line of code in an NC part program. |
| **Bench Grinder** | A grinding machine that has been mounted to a bench or table. The grinding wheels mount directly onto the motor shaft. Normally one wheel is coarse, for roughing, and the other is fine, for finishing. |
| **Computer Aided Manufacturing (CAM)** | The use of computers in converting engineering designs into finished products. |
| **Computer Numerical Control (CNC)** | A numerical control method in which one computer is linked with one machine tool to perform NC functions. |
| **Feed** | The distance advanced by the cutting tool along the length of the work for every revolution of the spindle.  |
| **Fixture** | A device designed and built for holding a particular piece of work for machining operations. |
| **G & M Codes** | Programming code used to control CNC machines. |
| **Incremental** | A system in which each position is taken from the one prior. Also called relative. |
| **Jig** | A device that holds and locates a piece of work and guides the tools that operate upon it. |
| **Laser** | An acronym for Light Amplification by Stimulated Emission of Radiation. Some common uses for lasers are cutting, measuring, and guidance systems. |
| **Lathe** | A machine tool used for turning cylindrical forms on work pieces. Modern lathes are often equipped with digital readouts and numerical controls. |
| **Machinability** | The ease or difficulty of machining as it relates to the hardness of a material to be cut. |
| **Milling Machine** | A machine that removes material from work by means of a rotary cutter. |
| **Modal** | Information that is retained by the system until new information is obtained. |
| **Numerical Control (NC)** | Any controlled equipment that allows an operator to program its movements through a series of coded instructions consisting of numbers, letters, symbols, etc. |
| **Parameter** | Attribute of a feature, such as a dimension, that can be modified. |
| **Part Program** | The instructions written by the programmer to produce a workpiece. |
| **Preparatory Code** | Codes that carry out machining operations or establish machine settings; G-codes. |
| **Spindle Speed** | The number of revolutions per minute (RPM) that is made by the cutting tool of a machine. |
| **Tolerance** | The amount of interference required for two or more parts that are in contact. The amount of variation, over or under the required size, permitted on a piece of machined work. |
| **V-Block** | A square or rectangular steel block with a 90 degree V-groove through the center, provided with a clamp for holding round stock for drilling, milling, and laying out operations. |
| **Word** | The programming expression formed when a letter (address) is combined with a number. |

**Day-by-Day Plans**

*Time: 10 Days*

**Day 1:**

    The teacher will present **Concepts,** **Key Terms**, and **Essential Questions** in order to provide a lesson overview.

    The teacher will present **Machines.ppt****.**

    Students will take notes using **Activity 2.3.1 Introduction to Machines****.**

    Students will work on **Activity 2.3.1 Introduction to Machines**.

    The teacher will present **Speeds and Feeds.ppt****.**

    Students will take notes in their journals.

    The teacher will distribute **Activity 2.3.2 Speeds & Feeds****.**

    Students will work on **Activity 2.3.2 Speeds & Feeds****.**

    The teacher will present **Milling Machine Setup.ppt****.**

    Students will take notes in their journals.

    The teacher will demonstrate setup and use of the milling machine.

    **NOTE:** Because there are different milling machines being used, the teacher may want to create a startup checklist outlining the steps to take in the successful use of the milling machine.

**Day2:**

    The teacher will distribute **G & M Code Reference**.

    The teacher will present **G & M Codes.ppt****.**

    Students will take notes in their journal.

    **NOTE:** If students need instruction or a review of trigonometry then present **Trigonometry.ppt**.

    The teacher will distribute and explain **Project 2.3.3 G & M Codes****.**

    Students will complete up to page four using prior knowledge gained during the last lesson.

    The teacher will assess understanding with **G & M Codes Quiz**.

    Students will work on and complete **Project 2.3.3 G & M Codes**.

    Students will verify their parts in CNC simulation software.

    **NOTE:** The teacher may want to present the **CNC Motion Setup and Operation.ppt** to aid students in the completion of their part verification using the CNC simulation software. The teacher should distribute **Tool Attribute Worksheet** to assist students to document tool selection.

    Students will machine their parts using the hand code they created from **Project 2.3.3 G & M Codes**.

    The teacher will assess student progress and assign homework pertaining to the project as necessary.

**Day 3-5:**

    The teacher will present **Introduction to CAM software.ppt****.**

    Students will take notes in their journal.

    **NOTE:** This presentation is long and is intended to be shown in intervals. The teacher should present only the slides necessary for student success during the next two projects.

    The teacher will demonstrate how to use the CAM software and the commands needed to complete the next two projects.

    The teacher will distribute **Project 2.3.4 Practice Machining**.

    Students will work on **Project 2.3.4 Practice Machining**individually or teams, documenting their progress in their engineer’s notebooks.

    Students will complete **Project 2.3.4 Practice Machining**.

**Day 6-10:**

    The teacher will distribute **Project 2.3.5 Container Design****.**

    Students will work on **Project 2.3.5 Container Design**, documenting progress in their engineer’s notebooks.

    Students will complete **Project 2.3.5 Container Design**.

**Instructional Resources**

Presentations

**Machines**

**Milling Machine Setup**

**Speeds and Feeds**

**G & M Codes**

**Trigonometry**

**Jigs and Fixtures**

**CNC Motion Setup and Operation**

**Introduction to CAM software**

Word Documents

**Activity 2.3.1 Introduction to Machines**

**Activity 2.3.2 Speeds and Feeds**

**G & M Codes Quiz**

**G & M Code Reference**

**Project 2.3.3 G & M Codes**

**Project 2.3.4 Practice Machining**

**Project 2.3.5 Container Design**