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| **Lesson 2.2 How We Make Things - Roemer** |

**Preface**

The end of a violin appears to be a scrolled piece of wood. How is that created? For some products, the method of construction may be obvious. A cereal box, for example, is simply a pattern cut from cardboard and folded. But what about more complex products, such as a violin? How about the lamp in your bedroom? How was it manufactured? Were the violin and the lamp created in the same manner? Products that are used by consumers on a daily basis are all created using different  manufacturing processes. As emerging technologies develop, the speed, quality, and durability of the products also improve.

In this lesson students will investigate a process for a common product and apply that knowledge by creating the product using solid modeling software.

**Concepts**

1.    Prototyping is part of a design process where a physical model can be evaluated to refine the design.

2.    Before raw material can be used in manufacturing, it must undergo primary processing.

3.    The separating process is one of the oldest manufacturing processes.

4.    Milling and shearing utilize the subtractive process to create products.

5.    ECM, EDM, water-, and laser-cutting are using newer technologies to enhance the accuracy and efficiency of material removal.

6.    Metals, plastics, and ceramics are types of materials that are well suited to the manufacturing process.

7.    The way in which a product is made is dependent upon the properties of the material that will be used.

**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 BB:** | Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. |
| **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.  |
| **BM EE:** | Management is the process of planning, organizing, and controlling work. |
| **BM FF:** | Complex systems have many layers of controls and feedback loops to provide information. |
| **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 5:** | Students will develop an understanding of the effects of technology on the environment. |
| **BM H:** | When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.   |
| **BM K:** | Humans devise technologies to reduce the negative consequences of other technologies.                  |
| **BM L:** | Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. |
| **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 J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **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 12:** | Students will develop the abilities to use and maintain technological products and systems. |
| **BM L:** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. |
| **BM O:** | Operate systems so that they function in the way they were designed. |
| **Standard 16:**  | Students will develop an understanding of and be able to select and use energy and power technologies.   |
| **BM M:** | Energy resources can be renewable or nonrenewable. |
| **BM N:** | Power systems must have a source of energy, a process, and loads. |
| **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 P:** | There are many ways to communicate information, such as graphic and electronic means. |
| **BM Q:** | Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. |
| **Standard 19:** | Students will develop an understanding of and be able to select and use manufacturing technologies.   |
| **BM L:** | Servicing keeps products in good operating condition. |
| **BM M:** | Materials have different qualities and may be classified as natural, synthetic, or mixed.   |
| **BM Q:** | Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.    |

***National Science Education Standards***

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

         **Natural resources**

***Standards for English Language Arts***

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| **Standard 1:** | Students read a wide range of print and nonprint texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. |
| **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. |
| **Standard 5:** | Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. |
| **Standard 8:** | Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. |
| **Standard 12** | Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). |

**Performance Objectives**

*It is expected that students will:*

         Explain the difference between primary and secondary manufacturing processes.

         Analyze a product to propose the manufacturing processes used to create it.

         Explore manufacturing processes via research.

         Explore prototyping processes.

**Assessment**

*Explanation*

1.    Students will explain the difference between primary and secondary manufacturing processes.

2.    Students will explain the secondary manufacturing processes studied.

3.    Students will explain different methods of prototyping and why they are important.

4.    Students will identify products created by each of the processes studied.

*Application*

5.    Students will determine the manufacturing processes required to produce a product.

*Perspective*

6.    Students will compare and contrast how objects recently created could have been produced during a specific era in the past.

**Essential Questions**

1.      What are raw materials and how do we obtain them?

2.      How do we produce industrial materials?

3.      What are common secondary manufacturing processes and how are they applied in manufacturing?

4.      What is the difference between conditioning, assembling, and finishing processes?

5.      What is the difference between forming and molding?

6.      What are some common forms of rapid prototyping, and how has this technique changed the manufacturing process?

**Key Terms**

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| **3D Printing** | 1) Rapid prototyping processes use systems that are low cost, small in size, fast, easy to use, and often suitable for an office environment. 2) Collective term for all rapid prototyping activities. |
| **Additive Process** | Fabrication of a part by adding material. |
| **Assembling** | The process of putting a product together out of separate parts. |
| **Build Time** | Length of time for the physical construction of a rapid prototype, excluding preparation and post-processing time. Also known as run time. |
| **Casting** | The process in which a solid material is made into a liquid, poured into a mold, and allowed to harden in the shape of the mold.  |
| **Ceramics** | Any of various hard, brittle, heat-resistant, and corrosion-resistant materials made by shaping and then firing a nonmetallic mineral, such as clay, at a high temperature.                                                                                             |
| **Concept Model** | Physical model intended primarily for design review and not meant to be sufficiently accurate or durable for full functional or physical testing. |
| **Conditioning Process** | Process in which the properties of a material are changed using mechanical, thermal, or chemical means. |
| **Die Casting** | Similar to permanent mold casting except that the metal is injected into the mold under high pressure. |
| **Electrical Discharge Machining (EDM)** | A process by which an electrode spark is used to erode small amounts of material from a work piece. |
| **Electrochemical Machining (ECM)** | A process in which a stream of electrolyte (typically salt water) is pumped at high pressure through a gap between the positively charged work and the negatively charged tool (electrode). |
| **Exhaustible Resources** | Resources of which there are a limited supply. |
| **Finishing Process** | Machining a surface to size with a fine feed produced in a lathe, milling machine, or grinder. |
| **Forging** | A process by which metal is heated and shaped by plastic deformation by suitably applying compressive force. |
| **Forming Process** | A process that changes the size and shape of a material by a combination of force and a shaped form. |
| **Grinding** | An operation that removes material by rotating an abrasive wheel or belt against the work. |
| **Industrial Material** | Material that has been changed from raw material so that it is ready to be used in manufacturing. Also referred to as standard stock.  |
| **Injection Molding** | A process during which plastic is heated in a machine and forced into a cavity by a screw or ram. The material solidifies and is then ejected. |
| **Metals** | Any of a category of electropositive elements that usually have a shiny surface, are generally good conductors of heat and electricity, and can be melted or fused, hammered into thin sheets, or drawn into wires. |
| **Molding** | A manufacturing process in which the industrial material is made into a liquid. The liquid is then introduced (poured or forced) into a prepared mold of proper design. |
| **Plastics** | Materials that undergo a permanent change in shape or size when subjected to a particular amount of stress. |
| **Photopolymer** | Liquid resin material that utilizes light (visible or ultra-violet) as a catalyst to initiate polymerization, in which the material cross-links and solidifies. This technique is used by various rapid prototyping technologies. |
| **Post Processing** | A common practice that includes clean up and finishing procedures on models after they are removed from the rapid prototyping machine. It may also include mechanical or chemical removal of support structures, powder removal, and surface finishing. |
| **Primary Processing** | The first step in manufacturing where raw materials are processed into a usable form for further manufacture. |
| **Prototype** | A full-scale working model used to test a design concept by making actual observations and necessary adjustments. |
| **Rapid Prototyping** | Computer-controlled additive fabrication. Commonly used synonyms for RP are three-dimensional printing, additive fabrication, freeform fabrication, solid freeform fabrication, and stereolithography. Note that most of these synonyms are imprecise.  |
| **Raw Materials** | Basic substance in its natural, modified, or semi-processed state, used as an input to a production process for subsequent modification or transformation into a finished good. |
| **Renewable Resources** | Biological materials that can be replaced. |
| **Sand Casting** | A process of pressing moist sand around a pattern to make a mold. The pattern is removed, leaving a cavity in the sand. The cavity is the mold that will be filled with liquid metal. The result will be a casting that is identical in shape to the original pattern.  |
| **Separating** | A process that removes excess material to change the size, shape, or surface. |
| **Stereolithography** | A rapid prototyping process that fabricates a part layer-wise by hardening a photopolymer with a guided laser beam. |
| **Subtractive Process** | Processes that remove material to change the size, shape, or surface of a part. There are two groups of separating processes: machining and shearing.  |
| **Vacuum Forming** | Process to heat a thermoplastic sheet until it softens and then force the hot and pliable material against the contours of a mold using vacuum pressure. |
| **Water Jet Cutting** | A process that uses a high speed jet of water emitted from a nozzle under high pressure (10,000-60,000 psi or greater). The advantage of water jet cutting is that it does not create a burr and it is a low temperature process. |

**Day-by-Day Plans**

*Time: 5 Days*

**Day 1 – 3:**

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

    The teacher will present **Creating a Prototype.ppt****.**

    Students will take notes on the processes using **Activity 2.2.1 Creating a Prototype****.**

    Students will complete **Activity 2.2.1 Creating a Prototype**.

**Day 4 – 5:**

    The teacher will present **Manufacturing Processes.ppt****.**

    Students will take notes on the processes using **Activity 2.2.2 Manufacturing Processes****.**

**Instructional Resources**

Presentations

**Creating a Prototype**

**Manufacturing Processes**

Word Documents

**Activity 2.2.1 Creating a Prototype**

**Activity 2.2.2 Manufacturing Processes**