Casting

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Subject: Physics

Grade Level: Middle School

Standards: Next Generation Science Standards (www.nextgenscience.org)

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Schedule: Two 1-hour classes

CCMR Lending Library Connected Activities:

Objectives: Students will learn about the manufacturing process of casting. They will create their own casts, test them for strength, and analyze different factors to see which is most practical. They will learn some concepts associated with casting and the various ways this process is used. Students will also reconcile competing design and engineering principles to understand that the majority of engineering problems require an assessment of tradeoffs.	**Vocabulary:** Casting Mold Density Viscosity
Students Will: * Learn the basics of casting and see some examples of what it is used for. * Understand and define the concepts of density and viscosity. * Cast Plaster of Paris into molds. * Take measurements to calculate the density of the mold. * Demonstrate their findings in writing. * Analyze different variables to see which mold is the most practical to use. * Perform an assessment of design tradeoffs to choose the best casting procedure.	**Materials:** **For Each Group (2-4 students)** Popsicle Stick Measuring Cylinder 3 Cookie Cutters Aluminum Foil **For Class** Plaster of Paris Balance Scale ***Provided by Teacher:*** Rulers Metersticks Beakers or Cups
Safety	There are no safety concerns with this activity. Be sure to throw away any excess plaster in the garbage. Do not pour down sink as it will solidify in drain.

Science Content for the Teacher:

Casting is a common industrial method used for producing objects for many different industries. Casting is a processing technique where the desired material is melted or suspended in liquid, then poured into a mold and allowed to solidify. Casting is used to produce many different objects including jewelry, candy, mugs, and even engine blocks in cars. Metals, are often cast by melt casting, which requires very high temperatures, ~1000-3000˚F, much higher temperatures than many materials can be exposed to (ovens can only reach temperatures of ~900˚F). Ceramics are also frequently cast but usually by cold casting (the process that will be used in this lab). This technique involves suspending a powder of the ceramic material in a liquid (usually water) and pouring it into the mold. As the suspension sits in the mold, water evaporates out, and the ceramic particles are pulled together. Once the cast has dried, it is often heated to allow the particles to fuse together into a stronger structure. However, some materials, such as Plaster of Paris, do not require this heating step and will produce a strong structure at room temperature. The ability of a material to be cast, is largely based on its viscosity. Viscosity is a measure of a liquid's ability to "flow." In the case of ceramic suspensions, the viscosity is related to the ratio of solid:liquid in the mixture. If too little water is added to the mixture, the suspension will be too viscous to fill the mold it is poured into. If too much water is added to the mixture, the ceramic particles have farther to move as they are pulled together during the evaporation of the water, resulting in a structure with a lower density. Density is measured in terms of mass per unit volume. Often, we think of the density of a material as the weight of the atoms in material divided by the area they take up. However, at larger scales, an object's density can be a function of the amount of empty space contained within the structure as pores. In this lab, the second definition describes the density we have control over. In particular, the density can affect the strength of the object in question.

In this activity, the students will cast different mixes of Plaster of Paris into a cookie cutter mold as a small-scale example of casting.

Preparation:

Set out materials for groups to prepare casts.
Choose which analysis you want to use with your class ('challenging' analysis requires your students to calculate the density of the casts).

Classroom Procedure:

Engage
Explain casting to students and show video of slip casting, which is similar to what they will be doing (https://www.youtube.com/watch?v=FZzOTX9Ihqs or https://www.youtube.com/watch?v=eEWIuyeNp2k). Explain the concept of density if this is new to the students. Be sure to differentiate between material density and object density. Explain the concept of viscosity. Perhaps perform a demonstration using liquids of different viscosity's (honey, syrup, water). Discuss engineering as a concept (problem solving-based science). **(Time: 15 mins)**

Explore
Hand out lab sheet and have students review it. Students will prepare their 3 mixtures and pour into the molds. They will let the molds sit for 1 or more days before taking them out and testing them. NOTE: The 25 mL mixture will be very hard to pour. It may need to be scooped in, tapped down, etc. **(Time: 45 mins)**

Perform drop testing after molds have dried. Record results. Perform calculations and make conclusions using analysis sheet. **(Time: 45 mins)**

Explain
Allow students time to discuss casting and viscosity concepts at end of class. Students must also demonstrate their understanding of the presented concepts on the activity sheet. You can show a video on metal casting that shows other applications. **(Time: 15 mins)**

Resources:

"How it's made: Ceramic Slip Casting - YouTube." 2013. 3 Nov. 2015 <https://www.youtube.com/watch?v=FZzOTX9Ihqs>

"Liquid Fire" to Metal Sword in minutes! - A ... - YouTube." 2011. 3 Nov. 2015 <https://www.youtube.com/watch?v=eEWIuyeNp2k>

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Assessment:

The following rubric can be used to assess students during each part of the activity. The term "expectations" here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

	Engage	Explore	Explain
1	Shows leadership in the discussion and an understanding of casting and viscosity.	Completes work accurately while providing an explanation for what is observed. Works very well with group.	Provides an in depth explanation of findings. Fills out worksheet clearly.
2	Participates in the discussion and shows an understanding of casting and viscosity.	Completes work accurately and works cooperatively with group.	Provides clear explanation of findings. Fills out worksheet clearly.
3	Contributes to the discussion, but shows little understanding of casting or viscosity.	Works cooperatively with partner, but makes some mistakes with the procedure.	Provides a limited explanation of findings. Fills out some of the worksheet.
4	Does not participate in discussion. Shows no understanding of casting or viscosity.	Has trouble working with partner. Does little to complete the procedure.	Is not clear in explanation of findings. Does not fill out worksheet.