Summary:
The purpose of these lessons is to introduce students to additive manufacturing and its applications in medical engineering. In the first lesson, students will explore the general principles of additive manufacturing and how it is unique. The second lesson will introduce the idea of using physical models to make scientific observations. Student should have a baseline familiarity with the scientific method before starting this lesson.

Learning Objectives:
After completing these lessons, students will have:
- Understood the general principles of additive manufacturing and its limitations
- Listed advantages and disadvantages of creating 3D models
- Sharpened problem solving skills
- Improved their ability to work with a partner to accomplish a goal
- Practiced the skill of critical thinking

Lesson Plan:

Lesson 1 – Additive Manufacturing
Time: 45 minutes
Activity Materials: Cardboard, glue, scissors
Prep time: 15 minutes
Prepare an example object for the activity. Any simple solid should be sufficient.
Connection (5 min):
Ask the students to think of their favorite object in their rooms at home. After they have thought of items, ask them how they think those items were made. Have them talk to the person next to them about their item and ideas. After some brief theorizing, move on to the lecture.

Lecture (10 min):
Begin the lecture by explaining the idea of physical dimensions (one dimension vs two dimensions vs three dimensions). Continue the lecture by asking the students if they have ever heard about 3D printing. Explain that 3D printing is one method for quickly producing objects. Emphasize that 3D printing works by adding layer upon layer until a solid object is completed. Make sure to touch on the different materials and different methods for delivering those materials (plaster/paper 3D printers vs.
SLS vs. FDM vs. LOM. Make sure to mention how they are being used in manufacturing and engineering for creation of prototypes and parts.

Activity (25 min):
Have the students divide into partners. Give them instructions to cut out layers that can be stacked to create the object that they had thought of earlier in the lesson. Explain that the layers will be stacked to make said object. If the object that they had thought of earlier is too complex, then suggest a simple shape such as a pyramid or a sphere. These layers should be glued together to create a solid 3D shape. Students will need time to plan with their partner and complete the activity. Additionally, if time permits, have the students add details with markers, pens, etc. Have an example model for the students to visually solidify the idea of what they are doing.

Discussion (5 min):
Discuss the process that the students just went through. The following questions can help get a discussion started.
What was hard about building an object using this technique?
How do you think a 3D printing could make building an object easier?
What do you think are some of the limitations of 3D printing?

Lesson 2
Time: 45 minutes
Activity Materials:
Pool noodles, scissors, duct tape, an image of a simple winding river or stream, a space where water can be spilled and/or cleaned up, buckets of water.
Prep time: 20 minutes
The pool noodles will need to be cut lengthwise. You should end up with long “half pipes”. The noodles can be reused for future classes to minimize prep time.

Connection (5 min):
Talk to your students about the last lesson and refresh them on some of the applications of 3D printing that they came up with.

Lecture (10 min):
Begin by introducing the idea of using computer software to create simulations for real life problems such as figuring out how air flows past an airplane as it flies through the air. Touch on how many of these programs use digital 3D models (such as a plane) and simulated situations (the air) to accomplish this task. Next, talk to them about how physical models can also be used to make observations about their real world counter parts. Because of the increased access to the technology, 3D printed models specifically are becoming more and more common for this same purpose. Some examples include: Prototypes for mechanical parts, prototypes of prosthetic parts for people with disabilities, and flow through models for fluid dynamics tests (aerodynamics for vehicle models and flow through models of anatomical structures). These physical models allow scientist and engineers to test how these things behave in a real life setting.
Activity (25 min):
Split the class into several small groups of three or four. Display your image of a river and instruct your students to try to recreate the path of the river as accurately as they can using the noodles and tape. Once they have finished, pour water down their “river” to see what happens!

Discussion (5 min):
Discuss the process that the students just went through. The following questions can help get a discussion started.
How well do you think that you recreated your river?
What would happen if you used a 3D printed replica of the river? Which one would be more similar to a real river? How so?

Wisconsin academic standards covered in this lesson plan:
A.8.7 Design real or thought investigations to test the usefulness and limitations of a model
A.8.2 Describe limitations of science systems and give reasons why specific science themes are included in or excluded from those systems
B.8.3 Explain how the general rules of science apply to the development and use of evidence in science investigations, model-making, and applications