<table>
<tr><td>STEM Week</td><td>I'd Like to Be a Cardiothoracic Surgeon</td><td>Biomedical Engineering</td></tr>
<tr><td>Topic</td><td colspan="2">Blocked Artery Activity</td></tr>
<tr><td>Learning Outcomes</td><td colspan="2">Through completing the blocked artery activity, students will design and test a method for successfully clearing a blocked artery in a model of the heart.</td></tr>
<tr><td>ISTE Student Standards</td><td colspan="2">1.4 Innovative Designer - Students use a variety of technologies within a design process to identify and solve problems by creating new, useful, or imaginative solutions
1.4a Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
1.4b Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
1.4c Students develop, test and refine prototypes as part of a cyclical design process.
1.4d Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.</td></tr>
<tr><td>MA STE Frameworks</td><td colspan="2">The Science and Engineering Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking
6. Constructing explanation and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

ETS1. Engineering Design
4.3-5-ETS1-3. Plan and carry out tests of one or more design features of a given model or prototype in which variables are controlled and failure points are considered to identify which features need to be improved. Apply the results of the tests to redesign a model or prototype.
4.3-5-ETS1-5(MA) Evaluate relevant design features that must be considered in building a model or prototype of a solution to a given design problem.
6.MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. Include potential impacts on people and the natural environment that may limit possible solutions.
6.MS-ETS1-5(MA) Create visual representations of solutions to a design problem. Accurately interpret and apply scale and proportion to visual representations.
6.MS-ETS1-6(MA). Communicate a design solution to an intended user, including design features and limitations of the solution.
7.MS-ETS1-2. Evaluate competing solutions to a given design problem using a decision matrix to determine how well each meets the criteria and constraints of the problem. Use a model of each solution to evaluate how variations in one or more design features, including size, shape, weight, or cost, may affect the function or effectiveness of the solution.</td></tr>
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	7.MS-ETS1-4. Generate and analyze data from interactive testing and modifications of a proposed object, tool, or process to optimize the object, tool, or process for its intended purpose. **7.MS-ETS1-7(MA)** Construct a prototype of a solution to a given design problem. ***ETS2. Materials, Tools, and Manufacturing*** **6.MS-ETS2-2(MA)**. Given a design task, select appropriate materials based on specific properties needed in the construction of a solution.
Targeted Academic Language	**balloon catheter**: A catheter with an inflatable tip that can be expanded by the passage of gas or liquid; used especially to expand a partly closed or obstructed bodily passage or tube (such as an artery). Also called balloon-tipped catheter. **bioengineering**: The use of artificial tissues, organs or organ components to replace damaged or absent body parts, such as artificial limbs and heart pacemakers. **biomedical engineer**: A person who blends traditional engineering techniques with the biological sciences and medicine to improve the quality of human health and life. Biomedical engineers design artificial body parts, medical devices, diagnostic tools and medical treatment methods. **brainstorming**: A method of shared problem solving in which all members of a group contribute many ideas. **catheter**: A hollow, flexible tube for insertion into a body cavity, duct or vessel to allow the passage of fluids or expand a passageway. **coronary artery bypass surgery**: A surgery that uses a piece of a vein from the leg, or artery from the chest or wrist. The surgeon attaches this to the coronary artery above and below the narrowed area or blockage so blood can bypass the blockage. Some people need more than one bypass. **engineer**: A person who applies an understanding of science and math to creating things for the benefit of humanity and our world. **engineering design process**: A decision-making process used by engineers to make something that meets a need or solves a problem. Steps include: brainstorm, design, plan, create, test, improve. **heart attack**: Damage to heart muscle that is deprived of oxygen via blood flow, usually due to blockage of a coronary artery. Typically accompanied by chest pain. Often life threatening. Also called myocardial infarction. **model**: (noun) A representation of something, sometimes on a different scale. (verb) To simulate, make or construct something to help visualize or learn about something else (such as a living human body, process or system) that cannot be directly observed or experimented upon. **plaque**: A deposit of fatty material on the inner lining of an arterial wall. prototype: A first attempt or early model of a new product, device or creation. Typically revised many times. **stent**: A small, expandable tube used for inserting in a blocked vessel.

	stroke: When a blockage of a blood vessel to the brain causes inadequate oxygen supply, leading to weakness, paralysis, speech difficulties, loss of consciousness and/or death.
Materials	Chromebook and/or iPad Each group needs: ● 2 model "blocked arteries" made from about 4 inches (10 cm) of flexible tubing (~1.5-in [3.8-cm] diameter) clogged with play dough ● 2 long thin balloons ● Balloon air pump ● 2 straws ● 2 paper clips ● thin wire ● 1 pipe cleaner ● 4 rubber bands ● tape ● 1 square of aluminum foil, about 3 x 3 inches [7.6 x 7.6 cm] ● (optional) strip of metal mesh screen, about 4 x 1 inch [10 x 2.54cm] ● Clearing Blocked Arteries Measurements Worksheet, one per student For the entire class to share: ● water source ● 2 liter pitcher ● timer ● Three Treatment Methods Images
Resources	Cardiovascular System Clear a Path to the Heart Activity Deck Design Sheet
Essential Question	How can we prevent a Heart Attack?
Pre Guiding Questions	What function(s) does our heart perform in the body? What causes a heart attack? How can we prevent a heart attack? If arteries become blocked, how can we efficiently fix the problem? How are new medical tools developed?
Instructional Procedure	**Introduction (30 minutes)** ● Begin the lesson by having a class discussion using the Pre-Guiding questions. No correct answers are needed at this time - students should simply be sharing their current knowledge. Questions will be answered throughout the lesson. ● Use the Cardiovascular System Deck to introduce students to how cancer affects the body

Lesson Development (60 minutes)

- Divide the class into groups of three students each. Hand out the worksheets.
- Demonstrate that blocked arteries have different flow than clear arteries by having the class time how long it takes for two liters of water to flow through a clear piece of piping at a 45° angle versus through a blocked piece of piping at the same angle (see Figure 2). Have students record these measurements on their worksheets.

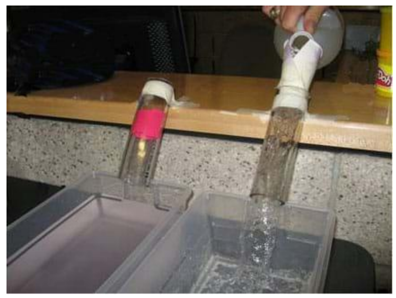

Figure 2. Comparing flow through clogged and unclogged arteries.
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3. Explain the design project to the student teams: Your challenge today is to create a device that could remove or flatten the built-up plaque material inside artery walls. How are you going to go about doing this? What are the steps a design team of engineers would take? (After students have suggested ideas, write on the board the steps all engineers go through in designing and solving problems. These steps are referred to as the engineering design process. Understand the need, brainstorm ideas, design and plan, create and test a prototype, and review and improve.) Well, first engineers must have a problem or a need. Then, they brainstorm creative ideas and solutions to that problem or need. Next, they select the most promising idea and create a design that they can draw or communicate to others. They make a prototype of that design and test it to evaluate whether or not the design is successful.
4. Continue with the project instructions: Today, you and your team are engineers working together to create a device that could remove or flatten the built-up plaque material inside artery walls. Your team has two identical blocked arteries and a set of materials. Use the materials to develop a device to improve the flow in the artery. Remember, you do not have to use all of the materials. The last step of the design process is to review and improve on your design. You have two model arteries to built, test and then redesign with improvements. Keep in mind that you do not want to just knock the plaque off the wall and leave it in the blood stream, and you do not want to hurt the fragile inside wall of the arteries.
5. Ask students: What ideas do you have for how to unblock your model arteries? (As necessary, share the ideas that were mentioned during the Introduction/Motivation section of the activity, such as: dissolve the clot or

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blockage, use a balloon to push the artery open.)

6. Direct students to brainstorm, design (create a drawing with labeled materials), create a prototype and test their designs. Expect the second design to be an improvement of the first.
7. Circulate among the groups as they work, observing and asking questions, as provided in the Assessment section. As students are working, challenge them to think about what happens to the plaque they dislodge, move or scrape away. Remind them that we do not want the treatment to hurt the patient!

With the Students: Communication and Testing

8. Have each team present a description of its two designs and design process to the class.
9. Measure success by timing how fast 2 liters of water flow through a team's cleared arteries after the treatment method. Hold the arteries at 45° angle while the water flows. Have students record these measurements on their worksheets. Compare data. If desired, award prizes for the best team design.
10. Have students complete the questions on their worksheets.

Wrap Up/Closing (20 minutes)

- Discuss the following questions:
    - Our model blocked arteries are, of course, not real arteries. What challenges might an engineering team face when creating a similar technology for real arteries? (Possible answers: The real blocked arteries would be in a human body, so they would be hard to get to, slippery, walls might be more elastic, and the plaque would be different.)
    - While the materials may not be the same, the process that you used to develop your prototype devices is the same used by engineers. And while their devices may be different, they share similarities to your solutions. (Show students the three images of current treatment methods.)
    - Look carefully at the mechanics of the balloon catheter (angioplasty), coronary bypass surgery, and catheter with stent (angioplasty). What similarities and differences do you see?
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<td>Assessments</td>
<td>Flow Rate Data Sheet</td>
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<td>Accommodations/
Differentiation</td>
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- Read-aloud
- Scribing
- Peer support
- Google Translate
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<td>Instructional Tips/</td>
<td>Do the activity yourself, before trying it with students.</td>
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Strategies	Keep the supplies organized throughout the activity Provide students with time checks throughout the activity
Reflection/Next Steps	How will you know if the students retained any of the information presented today? Were the students engaged? If not, what could you do differently next session? If they were engaged, what specific parts of today's lesson worked well? Did you provide enough differentiation so that all students were able to work at their level
Notes	