How Do Cartesian Divers Work?

Using the materials available, construct a Cartesian diver. Once you have the Cartesian diver ready, investigate how to make it sink. What did you do to make it sink? What things did not make it sink? Once you have made it sink, try to make it float again.

When you can successfully make it sink and float, draw and label a diagram of the Cartesian diver you created and what it does. Use your scientific reasoning and knowledge to write an explanation about how and why the Cartesian diver works.
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Suggested Grade Span

6–8

Task

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Big Ideas and Unifying Concepts

Cause and effect
Design
Models
Systems

Physical Science Concept

Properties of matter

Mathematics Concepts

Comparison of attributes or effects
Conclusions
Diagrams
Graphs, tables and representations

Time Required for the Task

Approximately one hour.

Context

This task was developed to assess what students understand about sinking and floating. Students have had a number of previous experiences with sinking and floating, working with the concepts of density and buoyancy. This task enabled them to apply their prior knowledge to a
new situation involving the Cartesian divers. This task was also designed to assess their ability to diagram, label and write explanations to describe their understanding of concepts – an ongoing focus for these grade levels.

**What This Task Accomplishes**

This task asks students to show evidence that they understand and can independently apply science concepts to investigate a new situation. It allows the teacher to see what prior experience and understanding a student has of the concepts of sinking and floating that might enhance new understanding. It also assesses their ability to communicate their learning through diagramming, labeling and explaining.

**How the Student Will Investigate**

Cartesian divers are constructed using simple materials. (See Suggested Materials list.) They can also be purchased commercially. Once students construct the divers, they will need to make them sink and float.

Each student was given Cartesian diver materials and a lidded plastic bottle filled with water. Students first will have to get the Cartesian diver to sink. They will need to try things such as squeezing the bottle. If that doesn’t work, they will need to try other possible methods, such as adding more weight to the Cartesian diver.

Students will discover that by adding some water, thus more weight to the diver, they will be able to get it to work. Once the Cartesian diver sinks, they must also be able to bring it back up to the surface and down again. After students are successful at getting the Cartesian diver to work, they need to think about what was happening to the diver as it sank and floated. They will then draw a diagram with labels to help explain what happened and how the divers work.

**Interdisciplinary Links and Extensions**

*Science*
Students can explore other sinking and floating situations, such as placing raisins in ginger ale or seltzer water. The raisins first sink. As they sink, they “collect air bubbles” that then help them to rise again to the surface. At the surface, the air bubbles pop, and the raisins begin to sink again. Students could also further investigate Cartesian divers to find ways of getting them to sink without squeezing the bottle. Tablets of Alka-Seltzer work the same as lid pumps used to keep soda fresh. Students can later design submarines that sink and float as an exercise in design technology and an application of their new knowledge.

*Social Studies*
Have students research submarines and how they work. Students can draw and design blueprints of submarines, using ideas they found in their research. Students may also wish to research famous historical incidents of sinking, such as the *Titanic*, and search for reasons that are both historical and scientific.
Teaching Tips and Guiding Questions

Students may, at first, have some difficulty discovering how to get the Cartesian diver to sink. Provide a model of a Cartesian diver that works and ask students to compare their diver with yours. Ask them what they notice that is different. An easy way to get Cartesian divers out of the water bottles is to lightly squeeze the bottle (without the cap) over the sink. The diver will pop up to the top and can be easily pulled out. Once a Cartesian diver sinks all the way to the bottom and does not float back up, the water must be poured out in order to reach the diver.

Some possible guiding questions to ask students before, during and after they investigate include:

- What do you already know about sinking and floating? How can your knowledge help you with this investigation?
- How can you get the Cartesian diver to sink? How can you get it to float?
- What do you observe happens as the diver sinks to the bottom? rises back up to the top?
- How can you diagram and label your Cartesian diver? What can you include to help others see how the divers work?
- What did you learn about the Cartesian divers? How can you explain the Cartesian divers and how they sink and float?

Concepts to be Assessed

(Unifying concepts/big ideas and science concepts to be assessed using the Science Exemplars Rubric under the criterion: Science Concepts and Related Content)

Scientific Method: Students observe and explain cause-effect relationships, with some justification, using data and prior knowledge, when variables are controlled. Students see that how a model works after changes are made to it may suggest how the real thing would work if the same thing were done to it. Students understand that choosing a useful model (not too simple/not too complex) to explore concepts encourages insightful and creative thinking in science, mathematics and engineering (models).

Physical Science – Properties of Matter: Students observe properties of materials and make predictions and classify materials. Students understand that water is a form of matter and has certain properties; that things sink and float in water based upon their density (mass) and displacement of water (the space of water the object takes up when placed in water); that buoyancy plays a role in whether an object will sink or float, based upon water pressure (water pushes up, opposing the pull of gravity); and that other characteristics can affect whether an object sinks or floats (the shape of the object, the material it is made from, how its weight is distributed, and whether it is wet or dry).

Mathematics: Students compare attributes or effects, diagram and use graphs, tables and representations appropriately.
Skills to be Developed

(Science process skills to be assessed using the Science Exemplars Rubric under the criteria: Scientific Procedures and Reasoning Strategies, and Scientific Communication Using Data)

Scientific Method: Observing, predicting/hypothesizing, conducting investigations, manipulating tools, recording observations, diagramming and labeling, drawing conclusions and explaining concepts.

Other Science Standards and Concepts Addressed

Scientific Method: Students describe, predict, investigate and explain phenomena.

Scientific Theory: Students look for evidence that explains why things happen and modify explanations when new observations are made.

Physical Science – Properties of Matter: Students describe and sort objects and materials according to observations of similarities and differences of physical properties.

Communication: Students use verbal and nonverbal skills to express themselves effectively.

Suggested Materials

- Cartesian divers (These can be made using glass eyedroppers with rubber tops or with plastic eyedroppers that are cut 1/2 inch under the bulb part. A metal nut should then be placed around the bottom part to provide extra weight.)
- Plastic bottles of different sizes filled with water and with caps on
- Cups of water for measuring water into the Cartesian divers
- Other optional materials such as food coloring, Alka-Seltzer tablets, soda pump lid
- Paper towels for spill cleanup

Possible Solutions

Students will have varied explanations and diagrams about the Cartesian divers. An accurate response will explain how water going into the diver as the bottle is squeezed gives the diver more weight or mass and thus makes it sink. When the bottle is let go, the extra water comes out, it again becomes lighter, and the diver returns to the surface. Students may also include appropriate vocabulary in their explanations. Diagrams must be labeled clearly to show what happens each step of the way and to demonstrate the students' understanding of how the Cartesian divers work.
Task-Specific Assessment Notes

Novice
This student includes a labeled diagram of the bottle and the Cartesian diver. The Cartesian diver is shown with water inside, indicating that the student understands the diver needs to have some extra water in it for weight. There is no indication from the diagram that the student was successful in getting the diver to sink and float. The diagram and labels do not show what the Cartesian diver does or indicate what makes it go up or down. There is no explanation included.

Apprentice
The student includes a labeled diagram of the bottle and the Cartesian diver. The Cartesian diver is shown with water inside of it, indicating that the student understands the diver needs to have some extra water in it for weight. However, each of the drawings of the diver show the same amount of water. The diagram only indicates arrows going up and an explanation about squeezing the bottle. It appears that the student was able to get the Cartesian diver to work successfully and go both up and down. The diagram and labels partially indicate what the Cartesian divers do and that the bottle needs to be squeezed for them to move. However, the diagram does not adequately show how the divers work. The explanation explains how squeezing the bottle makes the Cartesian diver sink and how letting go makes it rise. There is no explanation of how or why this happens.

Practitioner
The student includes a labeled diagram of the bottle and the Cartesian diver. The Cartesian diver is shown with water inside of it, indicating that the student understands the diver needs some extra water in it for weight. The diagram indicates that the student was able to get the Cartesian diver to work successfully. The diagram and labels indicate what the Cartesian divers do when the bottle is squeezed and how the divers work. There is an explanation that includes the idea that when the bottle is squeezed the diver fills with more water and is heavier; then when the bottle is let go there is more air in the diver and it returns to the surface. The student does not include what happened to the water when the diver begins to return to the surface, but s/he has the general concept of how Cartesian divers work.

Expert
The student includes a clearly labeled diagram of the bottle and the Cartesian diver. The Cartesian diver is shown with water inside of it, indicating that the student understands that the diver needs to have some extra water in it for weight. The diagram indicates that the student was able to get the Cartesian diver to work successfully. The diagram and labels clearly indicate what the Cartesian divers do when the bottle is squeezed and how the divers work. There is a detailed explanation that includes the idea that when the bottle is squeezed the diver fills with more water and is heavier; when the bottle is let go the water comes back out of the diver and it returns to the surface. The student also includes in his/her explanation some ideas about the role water pressure plays in what happens. This student tried food coloring in the diver and made some observations about what happened.
The student’s solution includes a labeled drawing. The diver on the way down shows water, thus added weight.

It does not appear from the diagram that the student got the diver to float again.

No explanation is provided.
Apprentice

When you let go they go up.

When you squeeze the bottle the C.D's go down.

The student’s solution includes a labeled drawing.

The diagram and explanation do not adequately show how and why the divers work.

Water is shown in the diver but does not change amount at all in each position.

The diagram only shows arrows going up, but the explanation includes a description of squeezing the bottle to make it go down and letting go to make it go up.

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I think that when you squeeze the bottle, the half-full Cartesian diver fills with more water and is heavy enough to go down to the bottom. Then it fills back up with same amount of air and goes to the top.

The student includes a labeled drawing that shows different amounts of water in the diver.

The explanation makes a connection between more and/or less air or water in the diver and squeezing the bottle.

The student did not fully explain where the water goes on the way back up, but s/he does demonstrate conceptual understanding.
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A detailed, labeled drawing shows clearly how the squeezing of the bottle affects the amount of water in the diver and the resulting action.

The student extends thinking by including the idea of using water color to assist observations as pressure changed.