Eureka! Archimedes of Syracuse
Greek Mathematician, Physicist, Engineer, Astronomer, Inventor
287 B.C.E. – 212 B.C.E.

Archimedes of Syracuse is considered one of the three greatest mathematicians in history along with Isaac Newton and Carl Gauss. His main work in mathematics was in geometry. He also did important work in physics, engineering, astronomy, and invention.

Archimedes was born in Syracuse, Sicily (then part of Greece) in 287 B.C.E. (or B. C.) and died at the hands of a Roman soldier in 212 B.C.E. His father, Phidias, was an astronomer. Archimedes traveled to Alexandria, Egypt to study at the school that had been established by the Greek mathematician Euclid. At the time, Alexandria was the 'intellectual center' of the world. After completing his studies, Archimedes returned to Syracuse, where he spent the rest of his life. It is not known if he married or had children.

Archimedes made many contributions in the areas of mathematics, physics and engineering. He improved the Greek counting system and devised an early form of differential calculus two thousand years before anyone else. However, most people remember him for running down the street naked, shouting "Eureka".

The Principle of Buoyancy. The most famous story about Archimedes relates how he uncovered an attempt to cheat King Hieron. The king ordered a golden crown and gave the goldsmith the exact amount of gold needed. The goldsmith made him a crown of the correct weight, but the king suspected that the goldsmith had cheated him by keeping some of the gold and replacing it with less-valuable silver. He asked Archimedes to find out if this is what happened. Archimedes was thinking about it while taking a bath. He noticed that the amount of water overflowing the tub was proportional to the amount of his body that was being immersed. In a flash of inspiration, he realized how to solve the problem of the crown. He was so thrilled that he forgot to get dressed, and ran naked through the streets shouting, "Eureka!" (Greek for "I have found it!").

How did Archimedes solve the crown problem? There are several possibilities. According to Archimedes' principle of buoyancy, a body immersed in water or any other fluid is buoyed up by a force equal to the weight of fluid that is displaced by the body. Using this method, he could calculate the density of pure gold and the density of the crown. If the crown was less dense than gold, he would know that it was not pure gold. Another possible method would be to place the crown on one side of a pair of scales, with an equal weight of gold on the other side. If the scales were then placed into water, they would still be balanced if the crown was pure gold. If it contained silver, it would be more buoyant underwater, and the scales would no longer balance.

Although Archimedes’ studies in density and buoyancy are important enough on their own, he made many other contributions. He did important work with leverage and pulleys and applied his theoretical knowledge to engineering problems, including military machines used to defend his city Syracuse when it was attacked by the Romans. Among the military machines he designed were catapults with improved range and accuracy (thanks to his knowledge of leverage), a machine that could lift other ships out of the water and sink them, and what is
sometimes called the “Archimedes death ray,” which was an array of mirrors that could focus sunlight on enemy ships, setting them on fire. Some of these inventions have been tested by modern scientists, and it is possible that they worked.

**The Archimedes screw** is a pump he invented. It consists of a revolving screw-shaped blade inside a cylinder. Turned by hand, it could be used to pump water into irrigation canals. The Archimedes screw is still in use today to pump liquids and granulated solids such as grain or sand.

Another invention was a miniature planetarium, with spheres whose motion imitated that of the planets.

Archimedes made important contributions to mathematics. He devised a way to accurately calculate the volumes of solids, such as the volume of a sphere. He also made an accurate calculation of the value of Pi. He was the first to invent a form of integral calculus. It was perhaps a primitive form of it, but it was 2000 years before Newton and Leibniz improved upon it. He also devised the idea of powers of ten, which made it much easier to count large numbers by referring to the number of 0’s in a number – prior to that, letters of the Greek alphabet had been used for large numbers, making mathematics unwieldy.

**Archimedes at war.** After King Hieron died, the Romans attacked Syracuse by land and sea. Archimedes’ improved catapults repelled the Romans on land. Some ancient writers also described a sort of death-ray invented by Archimedes that could set Roman ships on fire by using mirrors to focus sunlight on them (this has not been conclusively proven). The Claw of Archimedes was a crane-like arm with a grappling hook claw that sank ships by lifting them out of the water (it is also unproven if this worked). At any rate, despite Archimedes’ inventions, Syracuse eventually surrendered to the Romans.

The Roman leader General Marcellus considered Archimedes valuable and gave orders that he not be harmed. There are conflicting stories about how Archimedes died. According to one, Archimedes tried to surrender to a Roman soldier. Archimedes was carrying mathematical equipment. The soldier thought they were valuable items, and killed him for them. According to another story, Archimedes was studying a mathematical problem when a soldier came to take him to the general. Archimedes refused to go until he had finished what he was working on. This angered the soldier, who killed him.

This great scientist and mathematician Archimedes died, but his contributions to science put the world on the path to scientific development and human progress.
ANSWER THE QUESTIONS ABOUT ARCHIMEDES

1. When was Archimedes born?
   a. 287 B.C.E.
   b. 212 B.C.E.
   c. 287 A.D.
   d. No one knows

2. Where did Archimedes spend most of his life?
   a. Alexandria
   b. Syracuse
   c. Rome
   d. Mesopotamia

3. Which king did Archimedes serve?
   a. Marcellus
   b. Caesar
   c. Hieron
   d. All of the above

4. What areas did Archimedes work in?
   a. Physics and engineering
   b. Geometry and mathematics
   c. Astronomy and invention
   d. All of the above

5. What was Archimedes’ “death ray”?
   a. The first science fiction novel
   b. A device that focused sunlight to burn ships
   c. The first x-ray machine
   d. A crane-like arm with a claw

6. What is Archimedes’ screw?
   a. A toy
   b. A mountain road
   c. A pump
   d. A pitching style in baseball
Use complete sentences to answer the questions below.

1. Describe an experience or situation in your life that is somehow similar to Archimedes concentrating so hard on his scientific problem that he forgot his clothes.

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2. From the way it is used in the article what do you think is the meaning of buoyancy?

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3. Based on this article, what kind of person do you think Archimedes was? Why?

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4. Imagine you are trying to convince someone that Archimedes was a very important scientist and mathematician. Describe how you would convince them.

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5. What do you understand differently after reading about Archimedes? How will you use this information in the future?

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Writing about Archimedes

Archimedes loved engaging in thought problems and doing pure research about mathematics and physics. He may even have died because he refused to leave a mathematical problem until he had solved it. Nevertheless, he also used his theoretical knowledge to design many inventions that helped people, including the Archimedes screw pump. What do you think is more important, pure research or applied science? Why?

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Answers to ARCHIMEDES

Multiple-choice questions
1. a
2. b
3. c
4. d
5. b
6. c

Short-answer questions
1. Answers will vary. Accept logical, realistic answers.
2. buoyancy = the upward force that a fluid exerts on an object
3. Answers will vary. Accept logical, realistic answers.
4. Answers will vary. Accept logical, realistic answers.
5. Answers will vary. Accept logical, realistic answers.