

DENSITY & Archimedes

Archimedes was born in 287 BC and was educated in the Greek city of Alexandria, Egypt. Even as a student, he had quite a reputation as a brilliant and creative thinker in mathematics and science. He was also a very vain person who had difficulty getting along with others.

"I'm Archimedes...I'm very intelligent...I'm the best at solving difficult and technical problems...but don't bother me with trivia because...I'm Archimedes the brilliant thinker..."

You get the idea. Archimedes was a genius but a little hard to like!

When Archimedes graduated from the university, he needed a job. He asked his cousin, King Hieron II of Syracuse on the island of Sicily, for a job. The King agreed to hire Archimedes as a technical advisor, someone he could call on to solve important and difficult problems. Actually the King didn't think he would need Archimedes' services very much. In return for his services, the King provided Archimedes with a little house, a servant, and a modest salary. Archimedes was very happy because he could devote a lot of time to his own private thoughts and investigations.



One day an ambassador from a foreign land visited the King. As the man was called forward to approach the throne, he began laughing and pointing at the King. Appalled, the King demanded to know what the visitor found so amusing. The man replied, "With all due respect, your majesty, that is the **UGLIEST** crown that I have ever seen!"

Embarrassed by the ambassador's laughter, the King called for his goldsmith and gave the man four one kilogram bars of pure gold and instructed him to produce a beautiful new crown.

A week later the goldsmith presented the new crown to the King. The King was delighted! The crown was a beautiful work of art. It had pointed spikes above the rim and carved lions above both ears. The King was very proud of his new crown.

AND THEN THE RUMORS STARTED...

"Psst! Have you heard? The goldsmith bought a new mansion with 20 rooms and servants for each of the rooms."



"WOW, how nice for the goldsmith."

"How did he pay for it?"

"WITH PURE GOLD"

"Psst! Have you heard? The goldsmith bought a new chariot complete with a matched set of beautiful prancing gray horses!"

"WOW, how nice for the goldsmith."

"How did he pay for it?"

"WITH PURE GOLD"

"Psst! Have you heard? The goldsmith had a large party in his new house with 200 guests and food and music that lasted for days!"

"WOW, how nice for the goldsmith."

"How did he pay for it?"

"WITH PURE GOLD"

King **"BRING ME THE GOLDSMITH!!!"** roared the King.

King When the goldsmith arrived, the King accused him of stealing a portion of the gold that was supposed to be used for the crown. The goldsmith did not appear worried.

Goldsmith The goldsmith said, "Do you remember, sire, that you gave me four one kilogram bars of gold? If you weigh the crown, you will find that it weighs four kilograms. I have stolen nothing, your majesty."

Narrator The King had the crown weighed, and sure enough it weighed four kilograms. Puzzled, he sent the goldsmith away.

Narrator A few days later, a goldsmith from another city informed the King that there was a way to fake pure gold. One-kilogram bar of silver could be substituted for one of the gold bars. If the one silver bar and three gold bars were melted and formed into a crown, the color, feel, and weight would be the same as if four gold bars had been used.

THERE WAS ONE DIFFERENCE...

The element silver is not as tightly packed, as dense, as gold. Therefore, one kilogram bar of silver occupies more volume (takes up more space) than a one kilogram bar of gold. The crown would still weigh four kilograms, but because it contained silver, it would occupy more space than the four bars of gold. A crown made partially from silver would have a larger volume than the four bars of gold.

VOLUME...VOLUME...VOLUME...

King "That's it!" cried the King. "All I have to do is compare the volume of the crown to the volume of the four bars of gold and I'll know whether the goldsmith cheated me. But how can I measure the volume of the crown? Easy...I'll get Archimedes to do it."



Narrator
The King called for Archimedes. Archimedes was NOT a happy man! How dare the King interrupt his important thoughts about important ideas!

Archimedes
"This better be important," said Archimedes to the King, "I've been working on some important theories in the field of mathematics."

King
"Yes, yes," said the King. "I've got a problem here that requires your immediate attention." The King told Archimedes the story about the new crown and the suddenly prosperous goldsmith.
Archimedes
"Archimedes, I'd like you to determine the volume of the crown."

"The volume of your crown?" said Archimedes with disbelief. "You interrupted my important work to give me a job any imbecile can do!"

Narrator
Archimedes asked for a ruler and mumbled to himself about length, depth, width, and multiplication. He twisted the ruler this way and that way, jotted down numbers, and mumbled some more. After a long time, the King asked for an answer.

Archimedes
Archimedes cleared his throat and said, "Your majesty, I have concluded that the volume of the crown cannot be determined because the crown has an irregular shape. I cannot determine its length, width, and height."

Narrator
The King was furious! He demanded that Archimedes tell him the volume of the crown. Archimedes again patiently explained why this was not possible.

King
Finally the King shouted, "Archimedes, I **DEMAND** that you determine the volume of the crown and deliver the answer into my hands **tomorrow morning at sunrise or I WILL CUT OFF YOUR HEAD!** That's all I have to say!"

Narrator
Archimedes was terrified! He ran back to his little house clutching the crown and a ruler. He tried again and again to measure the crown's volume. He tried until the moon and the stars came out and into the early morning.

Archimedes
"Oh my goodness, I'm doomed! What can I do to save my life?" moaned Archimedes. "I know, I'll beg for the King's mercy. I'll beg him to spare my life. But look at me. I've been up all night trying to find the volume of the crown and I'm a mess. I need to look clean and neat when I beg for my life. I need a bath."

Archimedes
In a panic, Archimedes ran and fetched his servant. "Quick," he told her, "fill my bathtub with water for my bath. I must look my best when I go to see the King."

Narrator
The poor girl was VERY ANGRY because she had been awakened so early in the morning.

Servant Girl
"Oh yes, great and wonderful, Archimedes," muttered the servant girl, "I'll fill your bathtub for you. I'll fill it right to the VERY TOP so that when you get in, you'll clean up the mess!"



Narrator

Archimedes

Archimedes took one look at the filled-to-the-top-tub and moaned, "What have I done to deserve this treatment? First the King with his crown and now the servant has filled the tub to the top. Oh well, she'll clean up the mess."

Narrator

Archimedes stripped off his clothes and put one foot into the tub. Just as he thought, some water spilled onto the floor. Archimedes stared at the spilled water. The glimmer of an idea began to form. He wondered how much water had spilled onto the floor. His foot took up some space in the tub. Water overflowed the tub. How much water? Could the amount of water that overflowed be equal to the amount of the space his foot occupied?

Narrator

He put his other foot into the tub. More water overflowed. How much? The amount of water was equal to the amount of space his foot occupied! THE VOLUME OF HIS FOOT!

HE FOUND IT! A METHOD TO DETERMINE THE VOLUME OF THE CROWN!

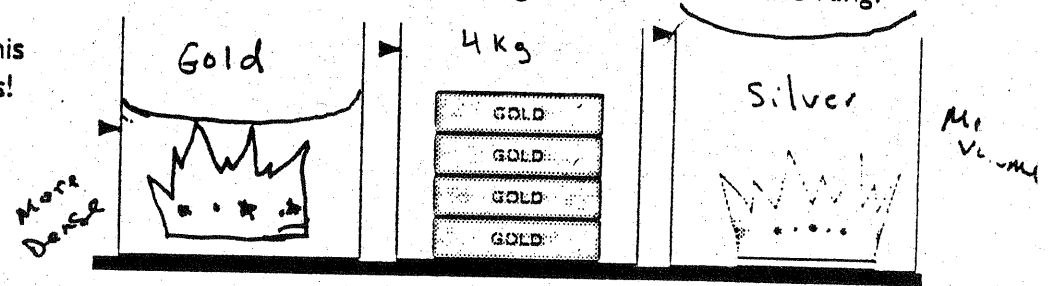
Narrator

Archimedes was SO excited that he jumped out of his bathtub and ran down the street yelling, "EUREKA! EUREKA!" (In Greek, that means I found it!)

Narrator

So, Archimedes told the King how to determine the volume of the crown. The King must now determine if the goldsmith cheated him. Explain how you know if the goldsmith cheated the King.

By the way, Archimedes kept his head, but the goldsmith lost his!



Comprehension Questions

Describe his procedure!

1. How do you think Archimedes measured the volume of the crown? _____

2. Which metal is more dense, gold or silver? _____

3. Based on the results of Archimedes' investigation, explain how you know that the goldsmith cheated the King.

