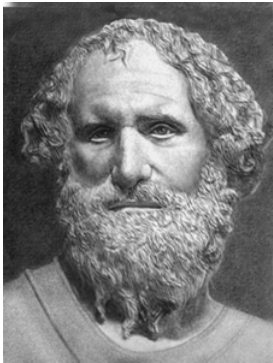




10.4 Archimedes

Archimedes was a Greek mathematician who specialized in geometry. He figured out the value of π and the volume of a sphere, and has been called “the father of integral calculus.” During his lifetime, he was famous for using compound pulleys and levers to invent war machines that successfully held off an attack on his city for three years. Today he is best known for Archimedes’ principle, which was the first explanation of how buoyancy works.

Archimedes’ screw



Archimedes was born in Syracuse, on Sicily (then an independent Greek city-state), in 287 B.C. His letters suggest that he studied in Alexandria, Egypt, as a young man. Historians believe it was there that he invented a device for raising water by means of a rotating screw or spirally bent tube within an inclined hollow

cylinder. The device known as Archimedes’ screw is still used in many parts of the world.

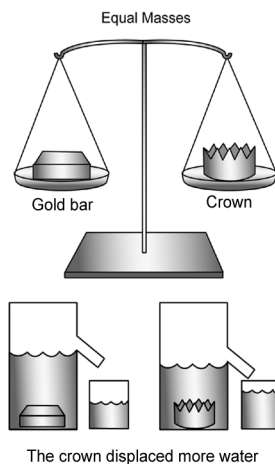
“Eureka!”

A famous Greek legend says that King Hieron II of Syracuse asked Archimedes to figure out if his new crown was pure gold or if the craftsman had mixed some less expensive silver into it. Archimedes had to determine the answer without destroying the crown. He thought about it for days and then, as he lowered himself into a bath, the method for figuring it out struck him. The legend says Archimedes ran through the streets, shouting “Eureka!”—meaning “I have found it.”

A massive problem

Archimedes realized that if he had equal masses of gold and silver, the denser gold would have a smaller volume. Therefore, the gold would displace less water than the silver when submerged.

Archimedes found the mass of the crown and then made a bar of pure gold with the same mass. He submerged the gold bar and measured the volume of water it



displaced. Next, he submerged the crown. He found the crown displaced more water than the gold bar had and, therefore, could not be pure gold. The gold had been mixed with a less dense material. Archimedes had confirmed the king’s doubts.

Why do things float?

Archimedes wrote a treatise titled *On Floating Bodies*, further exploring **density** and **buoyancy**. He explained that an object immersed in a fluid is pushed upward by a force equal to the weight of the fluid displaced by the object. Therefore, if an object weighs more than the fluid it displaces, it will sink. If it weighs less than the fluid it displaces, it will float. This statement is known as *Archimedes’ principle*. Although we commonly assume the fluid is water, the statement holds true for any fluid, whether liquid or gas. A helium balloon floats because the air it displaces weighs more than the balloon filled with lightweight gas.

Cylinders, circles, and exponents

Archimedes wrote several other treatises, including “On the Sphere and the Cylinder,” “On the Measurement of the Circle,” “On Spirals,” and “The Sand Reckoner.” In this last treatise, he devised a system of exponents that allowed him to represent large numbers on paper—up to 8×10^{63} in modern scientific notation. This was large enough, he said, to count the grains of sand that would be needed to fill the universe. This paper is even more remarkable for its astronomical calculations than for its new mathematics. Archimedes first had to figure out the size of the universe in order to estimate the amount of sand needed to fill it. He based his size calculations on the writings of three astronomers (one of them was his father). While his estimate is considered too small by today’s standard, it was much, much larger than anyone had previously suggested. Archimedes was the first to think on an “astronomical scale.”

Archimedes was killed by a Roman soldier during an invasion of Syracuse in 212 B.C.



Reading reflection

1. The boldface words in the article are defined in the glossary of your textbook. Look them up and then explain the meaning of each in your own words.
2. Imagine you are Archimedes and have to write your resume for a job. Describe yourself in a brief paragraph. Be sure to include in the paragraph your skills and the jobs you are capable of doing.
3. What was Archimedes' treatise "The Sand Reckoner" about?
4. Why does a balloon filled with helium float in air, but a balloon filled with air from your lungs sink?
5. **Research** one of Archimedes' inventions and create a poster that shows how the device worked.