HERON

Little is known of the life of Greek mathematician, physicist and inventor **Heron of Alexandria** (c. 10 – c. 75 A.D.), sometimes called Hero, except through his extant work and references to him by others. He probably was Egyptian with a Greek education. Some historians dismiss Heron as little more than a very talented artisan who merely repeated ideas known to others before his time. In his *A History of Greek Mathematics,* Sir Thomas Heath writes:

"Heron was an almost encyclopedic writer on mathematical and physical subjects.

…. Heron makes little or no claim to originality; he often quotes authorities, but, in accordance with Greek practice, he more frequently omits to do so; only when he has made what is in his opinion any slight improvement on the methods of his predecessors does he trouble to mention the fact, a habit which clearly indicates that except in these cases, he is simply giving the best traditional methods in the form which seemed to him easiest of comprehension and application."

Modern scholars have mostly discredited this view. Heron was an extremely ingenious mathematician, a mechanical genius and a scientific engineer. It is true he was very much interested in applying mathematics, not sharing the Greek interest in speculative mathematics. There is evidence that Heron taught at the great Museum in Alexandria. Some of his works are textbooks and handbooks for mathematics, mechanics, physics, and pneumatics. His mathematical works contain extensive lists of computational procedures, occasional proofs, and formulas for finding areas and volumes. Other books are extensive instructions for making and using surveying and architectural instruments.

In one work Heron provided detailed instructions for making moving toys, magical tricks, and mechanical inventions powered by water, steam, and descending weights. It is here that he made contributions to what must be called automation. His contrivances made use of feedback control devices. He invented what today would be called do-loops for iterative processes. It wouldn't be until the 1600s when another feedback machine was invented and by that time those of Heron's had been all but forgotten. A machine with no practical application that was nevertheless quite amazing was "Heron's Magic Horse." It was an automaton horse whose head stayed attached to its body after a knife had entered the neck at one side and passed completely through it. To add to the spectacle, the animal took a long drink immediately after the operation. Those interested in learning how this and other Heron's wonders worked should read *The Pneumatics of Hero of Alexandria* (1851), from the original Greek, translated and edited by Bennet Woodcroft, Professor of Machinery in University College, London.

In his *Catoptrica* (*theory of mirrors*), Heron was the first one to show that the law of reflection from a mirror could be explained if light rays took the shortest path from the source to destination via the surface of the mirror. This can be seen by looking through the mirror at the path of light before reflection. To view the image of an object in a mirror, you must sight along a line at the image location. As you sight at the image, light travels to your eye along a path shown in Figure 3.3. The ray of light traces a straight line from the apparent position of the object in the mirror to your eye. If the angle of incidence $\acute{\alpha}$ were not the same as the angle of reflection α, it would not be a straight line and would therefore be a longer path.

Normal

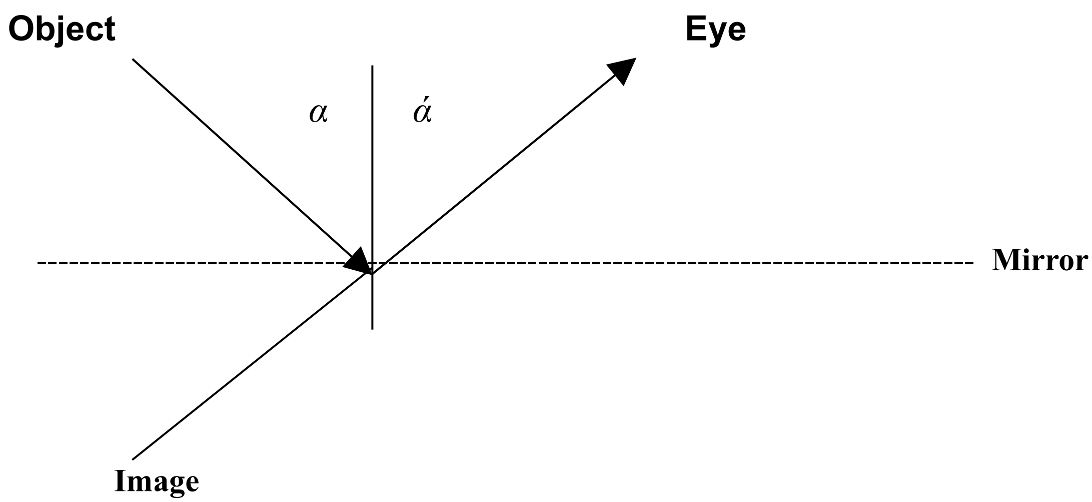

Figure 3.3

Heron wrote several treatises on mechanics. They provided means for lifting heavy objects and described simple mechanical machines. In Book I of his *Mechanica*, Heron explores the idea of motion, certain statics problems and the theory of the balance. In Book II he discusses the use of what he called the "five powers," that is the simple machines – the wheel-and-axle, lever, pulley, wedge and screw.

Heron's famous area formula appeared as Proposition I.8 of his *Metrica.* It states that if A is the area of a triangle with sides a, b, and c, and

$$s = (a + b + c)/2$$

then,

$$A = \sqrt{s(s - a)(s - b)(s - c)}$$

With this formula Heron calculated the area of a triangle in terms of the semiperimeter s of the triangle. Some may question why one should use this formula to find the area of a triangle when there is a far simpler formula for area of a triangle given in terms of the base b and height h of the triangle, namely:

$$A = (bh)/2$$

Ah, but remember that Heron was a practical mathematician. His formula could be used in measuring the area of a real triangular region where the boundaries were known but it was not possible to enter the region to determine its height. Heron's formula has many practical applications. Surveyors who know the lengths of a three-sided lot can easily compute the area, and lots with more than three sides can be computed by dividing them into triangular lots.

It is a shame that the Heron's work was forgotten for so long, essentially lost because those in authority did not view his work or the Alexandrian Library as treasures. The Library remained active from its founding around 300 BCE until the Christians forced its closing in A.D. 529 because they objected to its huge collection of pagan documents. Ultimately the Arabs burned it in A.D. 641, causing the loss of much of classical civilization. Fortunately the writings of Heron and others were preserved in the works of the Byzantines. During the Renaissance fragments of Heron's works were among the first Greek works to be translated.

Periods in which the free explorations of ideas have been encouraged are but a small fraction of recorded history. The development of ideas does not always march forward; it is often stagnant; often restricted; often overturned and made to move backwards. Heron lived near the end of an age of evolution of new ideas, thriving just prior to a time when such progress was shut down in a large portion of the so-called Western world. Both ecclesiastical and temporal authorities feared the consequences of the free flow of ideas and the development of new ones. Those who live in a time and place where such things are encouraged must always be vigilant lest these rights be taken away.

Quotation of the Day: "The mechanicians of Heron's school say that mechanics can be divided into a theoretical and manual part: the theoretical part is composed of geometry, arithmetic, astronomy and physics, the manual of work in metals, architecture, carpentering, and painting and anything involving skill with the hands.” – Pappus