The Birth of Calculus

The literal meaning of calculus originated from Latin, which means “a small stone used for counting.” There are two major interrelated topics in calculus known as differential and integral calculus. The differential calculus deals with motion and change, while integral calculus finds quantities such as area under a curve and so on. Various areas of studies have been taking advantage of calculus such as engineering, economics, business, statistics, computer science and etc. Calculus is profoundly intertwined with architecture, aviation and other technologies that are useful for our daily lives. For this reason, calculus stays to be one of the most fundamental math fields that sustains the balance of our lives.

Several Greek mathematicians contributed to the development of Calculus. For instance, in 225 BC, Archimedes constructed an infinite sequence of triangles, with an area A, to estimate the area of a parabola. Archimedes used the process of exhaustion to find the estimate area of a circle. These two attempts made Archimedes to take the credit for the infinite series sum. Between the 16th and 17th century, philosophers had the curiosity to apply the knowledge of math to discern the universe better. Galileo Galilee was one of the natural philosophers that had undertaken several experiments to observe mathematical analysis and motion in general. Johannes Kepler then came with an idea of measuring the area of a circle with indefinitely increasing isosceles triangles. Kepler also studied about the correlation and the movement of planets around the sun, as well as their speeds in completing a cycle. He explained that the distance between the sun and the planets, in the Copernican system, is highly dependent on the five regular solids that are uniquely circumscribed as shown in Fig 1.
The other mathematician who has contributed to the development of algebra and applied math to optics and navigation was Thomas Harriot (1560-1621). Harriot built the fundamental ingenious application that deals with the functional relations before the advent of calculus. In the later years, Rene Descartes studied comets and light, and correlated algebra and geometry. The above mathematicians’ works led to the birth of ideas and studies of velocities and infinite divisibility of space and time. Bonaventura Cavalieri (1598-1647) coined the principle of cutting a planar region into infinite sets of line segments by setting up an integral of $x^n$ from 0 equating it with $a^{(n+1)}/(n+1)$. Consequently, the idea of Cavalieri led Roverval to a more detailed method in finding the area between a curve and a line by setting up infinite numbers of narrow rectangular strips with an approximated integral value of $x^m$ from 0 to 1.

Graphing and finding areas for solid objects led Pierre de Fermat to use geometric partition of interval to explore the max and min by looking into place where the tangent of the graph was parallel to the x-axis. Fermat’s geometric partition includes the intervals from $[0, X_n)$.
or \([X_0,\infty)\). Ferment used the limit to compute the area for functions like \(y=x^k\). Presented for a given \(N\), the partition point is solved as shown below.

\[
x_0, \frac{m}{n}x_0, \left(\frac{m}{n}\right)^2x_0, \ldots, \left(\frac{m}{n}\right) > 1
\]

\[
R_1 = \left(\frac{m}{n}x_0 - x_0\right)y = x_0 \left(\frac{m}{n} - 1\right) \frac{1}{x_0^k} = \left(\frac{m}{n} - 1\right) \frac{1}{x_0^{k-1}}
\]

\[
R_2 = \left(\left(\frac{m}{n}\right)^2 x_0 - \left(\frac{m}{n}\right)x_0\right)y = \left(\frac{m}{n} - 1\right) \frac{m}{n}x_0 \frac{1}{\left(\frac{m}{n}x_0\right)^k}
\]

\[
= \left(\frac{m}{n} - 1\right) \left(\frac{n}{m}\right)^{k-1} \frac{1}{x_0^{k-1}}
\]

\[
= \left(\frac{n}{m}\right)^{k-1} R_1.
\]

Similarly

\[
R_3 = \left(\frac{n}{m}\right)^{2(k-1)} R_1.
\]

Now sum the rectangles

\[
R = R_1 + R_2 + \cdots
\]

\[
= R_1 \left[1 + \left(\frac{n}{m}\right)^{k-1} + \left(\frac{n}{m}\right)^{2(k-1)} + \cdots\right]
\]

\[
= R_1 \frac{1}{1 - \left(\frac{n}{m}\right)^{k-1}}
\]

\[
= \frac{1}{1 - \left(\frac{n}{m}\right)^{k-1}} \left(\frac{m}{n} - 1\right) \frac{1}{x_0^{k-1}}
\]

\[
= \frac{1}{\frac{n}{m} + \left(\frac{n}{m}\right)^2 + \cdots + \left(\frac{n}{m}\right)^{k-1}} \frac{1}{x_0^{k-1}}.
\]

Now let \(n/m \rightarrow 1\). This gives the equivalent of

\[
\int_{x_0}^{\infty} \frac{1}{x_0^k} dx = \frac{1}{(k-1)x_0^{k-1}}.
\]

Isaac Newton’s teacher in the mathematical subjects was Isaac Barrow (1630 –1677). Barrow’s work revolved around determining the areas and tangents of curves. His work led to the discovery of infinitesimal calculus. Barrow is believed to have played an early role for the
discovery of fundamental theorem of calculus, as well as his tremendous contribution to
differential calculus.

Evangelista Torricelli was in the field of astronomy and a committed Copernican at his youger years. Torricelli then worked on the treatise of motion with variable speed. Consequently, the idea of estimation led to the development of calculus by Newton, who was influenced by Descartes, DeBeaune and Leibniz. In 1666, Newton wrote a tract on fluxions with horizontal and vertical velocities or derivatives, briefly discussing anti-differentiation. Newton also calculated the series expansion for sine, cosine and exponential functions, although they are now called Taylor or Maclaurin series.

Although it has been disputed who should take the credit for the invention of calculus, among numerous mathematicians mentioned above, Isaac Newton and the self-taught German mathematician Gottfried Leibniz contributed to the rising of calculus, independently working to find general methods to find areas and volumes in the 17th century. Newton is known for the discovery of the inverse relationship of integral and derivative functions – which are equivalent to the area under the curve, and the slope of the curve. This correlation enabled crucial scientific dilemmas to be solved, such as calculating the slope of the tangent line, determining the velocity and acceleration of an object, finding the absolute and relative extreme of objects in a projectile motion, finding volume and surface area of solids and so forth. Newton applied calculus in geometry and the physical world, to describe the orbit of the planets around the sun. Due to this, Newton has been deemed as the creator of calculus.

In the other hand, Leibniz invented the notations that we still use for taking derivative and integral. Leibniz was a philosopher, which allowed him to manipulate mathematical arguments into notations and formulas that made calculus to be used efficiently. Leibniz studied
the correlation of sequences and sums, and tied it with the infinitesimal geometry that is based on the features of calculus. The other crucial thread that Leibniz contributed for mathematics was his notion on a harmonic triangle that starts with a number in each row which represents the reciprocal of the row number. And the value of each fraction is calculated by looking at the sum of two numbers just below it.

![Harmonic Triangle](image)

*Figure 2: Leibniz's symmetrical Harmonic Triangle*

All the problems and curiosities that were in the minds of philosophers and philosophers led for the birth of calculus that we use with great reverence today. After all, along with the existence of human beings on this planet, came problems to be solved—mathematical and others. Mathematics was first practiced to alleviate the burden of people from counting to value certain things. With the birth of math, people’s life has gotten simplified in a tremendous fold. For this reason, I strongly believe with S.Gudder’s saying “the essence of math is not to make simple things complicated, but to make complicated things simple.” One of the versatile branches of mathematics that has benefited several fields of studies is calculus, a field that was developed from algebra and geometry. Calculus allows complicated problems that are
consistently changing, focusing on infinitesimal moments, that can’t be solved using algebra or other field of mathematics. This is the beauty of calculus!
Work Cited

   <http://chemistry.mtu.edu/~pcharles/SCI HISTORY/GalileoGalilei.html>

   <http://www.wlym.com/archive/oakland/docs/TheRealCalculus.pdf>

Figure 1 source: http://galileo.rice.edu/sci/kepler.html

Figure 2 source: http://en.wikipedia.org/wiki/Leibniz_harmonic_triangle