"All men by nature, desire to know."1 tllroughtout history the need to know has been a prime source of governing mens actions. This need has founded civilizations, it has started wars, and it has led man to his ultimate control of his environment 1 I shall examine the causes and developments of mathematics. Starting with early Egypt and Babylon, then on to classical Greece, and finally the 17th century through modern times; I will trace the need and development of mathematics.

"Priority in the development of mathematics belongs to Babylon, where ancient land numeration, algebra, and geometry methods existed at least from the Hammurabi dynasty, around 1700 B. C.. „2 although "Neither Egypt nor Rome advanced beyond the level of elementary practical arithmetic and mensuration."] These ancient civilizations developed mostly practical mathematics, but thier effect, even upon modern mathematics, is still enormous. I shall cover both the need and the methods used in this ancient mathematics.

"There is little doubt that mathematics arose from necessity. The annual flooding of the Nile valley, for example, forced the ancient Egyptions to develop some

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1 Aristotle

2 "Mathematics, History", <u>Encyclopedia Britannica,</u> volume 11,page 642

J Ibid

system of reastablishing land boundries.,,4 Increased barter increased the need for early practical arithmatic.[5] The need for a calender, if a basic one, led to development in mathematics; "'theastronomy of the old Babylonian period was just adequate for maintaining the calender, on which the irragation system supporting the civilization depended.,,6 Civilization and mathematics are inseperable i. ~. "Mathematics beyond primitive counting originated wi*n the evolution of advanced form ..:-soçiety. "[7] As Aris-t.Q)tleonce pointed out; a civilization is necessary "to; Sl'eperatea thinking class from the working class.

Early mathematios~consisted almost exclusively of trfual and error. Early Egyptian mathematics was geometry.8 The Egyptians also developed formulas for the areas and volumes of many shapes, but used trial and error rather than proofs, so they were not entirely correct in their formulas.[9] The Babyloneans were only more advanced than the Egyptians. "The Babylonians were interested in number relations beyond the merely practical mathematics.,,10 i. e. "An old Babylonian text (1700 B. C.) investigates

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4 "Mathematics", Encyclopedia Americana, volume 17, page 392

5 Ibid

6 Michal Moffatt, The ages of Mathematics vol. 1, Page 35

7 "Mathematics", Encyclopedia Americana, volume 17, Page 388

8 The word geometry is from a ~reek word meaning "measure of the land".

9 Michal Moffatt, The ages of Mathematics vol. 1, page 43

10 Ibid

triples of Pythagoran numbers; that is, numbers satisfying the relationship $a^2 + b^2$ ::c^2 .,,11 "The facility of numerical computation, as the result of the place value notation, is everywhere visible in Babylonian mathematics."1~ The Babylonians had a sort of combination between base 10 and base 60 with a zero.[13]

The acomplishments of ancient Greece dwarfed those of Egypt and Babylon, and rival the achievements of the 17th and 18th centuries! It was during this period that such great men as Pythagoras, Euclid, and Archimedes lived. "The Greeks insisted that mathematical facts must be established not by empirical procedures but by deductive reasoning.,,14 This led to a system of undefined terms, axioms, theorems et cetera.[15] Although most Greek mathematic; "Purely algebraic notation had been

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11 "Mathematics, History", Encyclopedia Britannica, volume 11, page 644

12 Ibid

13 Bases are a part of the place value notation, that is the position of each digit tells its magnit~de. For ~xample, t~e number ~94071 means 3 x 10 ".9 x 10 + 4 x 10 + 0 x 10 +7 x 10 + 1 x 1. If we were to write a number in another base besides base 10 ~t would be like: 13702 (base 8) equals 1 x 8_+ 3 x 8^3 + 7 x 8^2 + 0 x 8 + 2 ~ 1, of B3AI06 (base 12) = BO(11) x 12^5 + 3 x 124 + A (10) x 123 + 1 x 122+ x 12 + 6 x 1. All bases need the number of different charactors equal to the number of the base (zero is one of the digits). ~ithout zero a place value system cannot exist, the number 57,302, for example, would have to be written 5732, which could mean 500,732 or 5,732,000Qr just 5732 or any number of other things.

14 "Mathematics", Encyclopedia Americana, volume 17, Page 393

15 Michal Moffatt, The ages of Mathematics vol. 1, page 67

used by Aristotle in his investigation of formal logic .1116 and liThe concept of area gave rise to a near rigorous theory of integration[17] even in ancient times. illS

liThe first great thinker in Greek history was Thales of Miletus.1I19 Thales as a youth went to Egypt to learn the methods from the priests. He was soon surpassing thier methods, which they established by trial and error and held in mystic regard. After he had learned all their knowledge, he willt)back to Greece and set up a school. In his school he set upas eries of pr,i-P,:- cisit ions (axioms) and derivedt hings with dedue tive me.thod s.~ Thales lived from 567 B. C. to 497 B. C. \.._21/He was one of the seven Wise men of Greece, the on lyon who d;dn't beeom~, one due to politics.[22]

The next major Greek mat~ematician was Pythagoras. Pythagoras was a student of Thales, and like Thales he went to Egypt. Pythagoras formed a school in Croton and let everyone, even women, learn thereV for free!23 He soon furthered the work on a deductive system started by Tales, building theorems upon theorems.

Pythagoras made five propositions which he 'proved; from

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lIP IIMathematics, Historyll, Encyclopedia Britannica, VOLUME 11, page 647

17 Integration is a function of calculus.

18 IIMathematics, History", Encyclopedia Britannica, volume 11, page 647

19 Michal Moffatt, The ages of Mathematics vol 1, page 73

20 Leon Perry, The Mathmen, page 17

21 Ibid

22 Michal Moffatt, The ages of Mathematics vol 1, page 82

~3 -?

known 'facts'.

1) The sum of the angles of a triangle equals two right angles (180°).

2) The sum of the exterior angles of a triangle equals four right angles (360°).

3) The sum of the interior a~g~Jf a polygon equals 2n-4 right angles, where n=the~umber of sides.

4) The sum of the exterior angles of any polygon equals four right angles (360°), regardless of the number of sides.

5) Three reqular polygons - a triangle, a square, ana a hexagon - fill the sRace about a point on a plane.

There is some question about the validity of these proofs, however. Not all of the 'facts' he assumed to prove them are valed. Non - Euclidean geometry, which is consistant and actually bette~. describes Einstienian space~s based on the assumption that his 'facts' are false(..---/Thisdiscussion .is essentially the same)c'\) as that of the parellel postulate[25] which I shall discuss much later in thes paper.

Any discussion of Pythagoras must include his remarkable theories of numbers.

> (ypythagOras believed that all things - physical and mental, all nature and all ideas - are built on a pattern of integers. Fractions he did not consider numbers. They were only rotios, relations between numbers. Having discovered the figurate numbers,

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24 George Gamow, One, Two, Three, Infinity, page 103

25 Pythagoras's proposition number one and Euclids' parellel postulate can each be proven from the other .

> Pythagoeas thought that he proved that geometry itself was formaed on some sort of number pattern. And it followed 'logically', he asserted, that all material things in nature were formed in a si~~ler manner and that -numbers rule the universe.~j

Pythagoras discovered prime and composite numbers. Another type of number that he discovered are 'perfect' numbers. Perfect numbers are numbers that equal the sum of their factors. Six, for example, equals one plus two plusthree. Pythagoras discovered the perfect numbers 6 and 28, his students discovered 496 and 8128. It was another 1500 years before the next perfect number, 3,550,336, was discovared. Today 17 are known, the highest of which is over 1300 digits long!27 'Friendly' numbers are also an invention of Pythagoras. They are numbers which are the sums of each others factors i. e. 284 = 1. 2 + 4 + 5 + 10 + 11 +20 + 22 + 44 + 55 + 110 (the factors of 220), 220 = 1 + 2 + 4 + 71 + 142 (the factors of 284). The above numbers are the only friendly numbers that Pythagoras discovered! It was 2000 years before another pair was discoveree! Leonard Euler alone found 60 pairs and today over 400 pairs ore known.
4 Still another group of numbers are male and female numbers~ One is the ancestor of numbers, not a number. Even numbers are female. Odd numbers are male. Five is the marriage number

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26 Leon Perry, <u>The Mathmen,</u> page 32

87 Ibid

because it is the sum of the first male number and the first female number (2 + 3~. Figurate numbers are devided into triangular numbers, square numbers, pentoginal numbers et cetera. They corespond to patterns of dots in triangles, squares, pentagDns et cetera. Triangular numbers are obtained by ading 2 then 3 then 4 et cetera to the number 1 i. e. 1 + 2 = 3, 3 + 3 = 6, 6 + 4 = 10, 10 +5 = 15 et cetera. This corresponds to triangles of 2 on a side, 3 on a side, 4 on a side et cetera. Square numbers correspond to squares of 2 wide, 3 wide, 4 wide et cetera; which can be obtained by adding 3 then 6 then 7 et cetera to the number 1. The other are similar. Pythagorean triples are what Pythagoras is most famous for. They are integers which fulfill the condition $a^2 + b^2 = c^2$, and a, b, and c will be the lengths of the sides of a right triangle. Pythagoras developed a formula to figure out such numbers:

n^2 + (~(n2 _ 1))2 = (~(n2 + 1))2

where n is an odd integer.

"One day Pythagoras discovered wha-, was to him an incredeble fact: there were numbers which were neither integers nor fractions!"28 He was making an icosolese right triangle and fo~nd the hypotenuse to have a length of J2: which he found no integer nor fraction for. He, however, could not prove it was irrational. It was Hippasus, one of Pythagorases students, who proved «to be irrational. Later Theodorus proved ~ V5, Vb et cetera to be irrationa1.

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28 Leon Perry, <u>The Mathmen,</u> page 40

liThe famous Greek philosopher Plato made no great contribution to mathematics himself. But he created a school in which he trained and directed the works of so many famous mathematicians that he is numbered among the creaters of this science."[29] In his school, Academy, he had four 'roads' for the students to follow: astronomy, geometry, arithmatic[30], and music. The only very significant thing he did was to show the uniqueness of the Platonic figures; that is to prove that the tetrahedron (4 sides), the hexahedron (6 sides), the 6ctahedron (8 sides), the dodecahedron (12 sides), and the icosahedron (20 sides) are the only possible regular polyhedrons (shapes).

The next figure to enter the scene of Greek mathematics was Eudoxus. He was originally a student of Plato. He did a large amount of work on the theory of proportions (fractions).3ID His theory of concentric circles, which was an elaborate explanation as to the movement of planets with the earth in the center, lasted many thousand years. Another work of his was the development of a geometric system of irrational numbers.[32] He also did work which would become the predecesor to modern integral calculusl[33]

> IIHe (Aristotle) had no special field. His knowledge was universal, and he wrote about everything.

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29 IIMathematics, Historyll, <u>Encyclopedia Britannica,</u> volume 11, page 645

30 Arithmatic actually meant advanced number theory.

31 Leon Perry, <u>The Mathmefl,</u> page 42

32 "Mathematics, Historyll, <u>Encyclopedia Britannica,</u> vol ume 11, page 64!iY';U

33 Michal Moffatt, <u>Thw ages of Mathematics vol 1,</u> page 80

> He wrote on logic, physics, metaphysics, astronomy, meteorology, botany, zoology, embryology, medicin~, ethics, psychology, politics, economics, and literature. His treaties were used as textbooks in his school. But they were more than that. For they formed an encyclopedia of everything known in his time. This encyclopedia had no peer of rival for 2000 years until the French Encyclopedia in A. D. 1751 - 1765."34

Aristotle who lived from 384 to 322 B. C. , set up a school, Lyceum, which rivaled the great Academy!34 IIAristotle has long been celebrated for gibing us the key to the mastery of reasoning. Organon, his great book on logic, is that key.1I35 He didn1t write on Mathematics because he thought it was complete, but he was still a~~;/ great mathematician.

> /~s yet, as a mathematician, Euclids' fame is not tcIue to his own research. Few of the theorems in his textbooks are of his own. What Euclid did, and what made him great, was to take all the knowledge accumulated in mathematics to his time and codify it into a single work. In doing so, he evolved, as a starting point, a series of axioms and postulates that' werea dmirable for their brevity and elegance.IB6y

> "Euclids Elements in 300 B. C. superseded all preceding Greek writingson mathematics.IB7

> IIWe know his (Euclid) Elements, whose influence has not been equaled in the history of science. For twentY,.!l centuries, the great mathematicians of Greece, Egypt, Persia, Arabia, and India got their first stimulus from) it. Each pupil copied the manuscripts in order to have one of his own.
> The first printed edition ofEuclida ppeared just ten years before Columbus found the New World. One by one, there followed more than 1000 other editions-in more copies, in more languages, t~an any other book with the exception of the Bible/yJ8

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34 Leon Perry, The Mathmen, page 51

35 Ibid

36 Isaac Asimov, Asimov on Numbers, page 134

37 IIMathematics". Encyclopedia Americana, volume 17, page 395

38 Leon Perry, The Mathmen, page 53

Very little is known about the background of Euclid. It is, however , known that he taught in an Egyptian university called Museum. The library of Alexandria, which served Museum, is said to have had 600,000 papyrus rolls!

~Archimedes, the son of an astronomer, was the greatest scientist and mathematician of ancient times, and hes equal did not arise until Isaac Newton, two thousand years later."[39] Archimedes went to Museum. Despite his many inventions, he was more interested in pure mathematics. A remarkable feat of his was solving problems of differential calculus. He invented the water screw, pulleys, and levers and formulated the laws of boyancy. He also worked on r~g decimals and invented basic limits. Some of his major works are: The sand reckoner, which demonstrates that any number can be mathematically expressed; The cattle problem, a challenge to a rival, Apollonius, it has 8 variables with 8 equations with an answer billions of trillions of digits long; The law of the lever, concerning the behavior of levers; On floating bod~es, set down laws of boyancy. He once said "give my another earth to stand on and I shall lift this one" in reference to the powers of levers and pulleys. He also designed remarkable weapons including catapult to hurl ~ ton and 10 pound stones, cranes which could lift and throw ships, and lenses to ignite ships miles away!

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39 Isaac Asimov, Asimov on Numbers, page 173

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Starting in the 17th century a new wave of mathematical thought -? developed. Algebra was f~lY_ developed('nd, ~ew fields invented. k<~Lc" Some of the greatest men~e~ lived within 200 years of each other during this period. Also new light fell upon previous questions, which were unanswered.

One of the largest unsolved problems was Eucl1ds parellel postulate. It was unproved by the other axioms up to the 17th century. In 1733 Girolamo Saccheri unsuccesfully tried to prove it by 'reductio ad absurdum' or indirectly. "The 6).ssian Nikolai Ivanovich in 1829 and the hungarian Johann Bolyai in 1832, unknown to each other independently discovered a non - Euclidean geometry.,,39 They followed similar lines as Saccheri but asserted that no controdiction could be found.

> "It was during the 17th century that John Napier revealed his invention of logarythems. That Galileo Galilei founded the mathematics of dynamics. That Johannes Kepler induced his laws of planetary motion. That Gerald Desargues and Blaise Pascal formulated projective geometry. That Pierre de Fermat laid the foundations of modern number theory. And that Pascal, Fermat, and Christiaan Huygens made distinguished contributions to the theory of probibility.,,40

> "The development of analysis in the 17th century by the mathematicians Pierre de Fermat, Rene Descartes, and Isaac Newton soon left behind clawsical methods and problems, and an enormous wealth of new descoveries revealed an interaction between theoretical mathematics and all branches of physics and astronomy."41

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39 "Mathematics", Encyclopedia Americana, volume 17, page 396

40 Ibid

41 "Mathematics, History", Encyclopedia Britannica, volume-II, page 648

42 Ibid

The 19th century had an enormous quanity of new methods which were contridictions of old beliefs.

> ''')Ih843, after years of cogitation, the Irish mathematician William Bowan Hamilton was led to invent his quarternion algebra in which the commutative law of multiplication does not hold.G42

> ,'yIn1844 the german mathematician Hermann Gunther ~Grassman published the first edition of his remarkable Ausdehnungslehre, in which he developed classes of algebras of much greater generalarity than Hamiltons quarternion algebra. By weakoning or deleting various of the laws of common algebra, or by replacing some of the laws by others that are also consistant with the remaining ones, an eno.rmous variety of algebraic structures can be created.~43

Don't use quotation marks when you indent & single space - they mean the same

Hamilton and Grassman opened the world to abstract algebra. A mathematician can use any set of consistant axioms he choses.

"There has never been a man like Newton, and there never will be one like him. Not Einstein, not Archimedes, not Galileo, not Plank, not anybody else measured up to near his stature.,,44 Newton in addition to formulating the laws of gravity invented defferential and integral calculus. He developed systems to solve many problems which could not be solved until he solved them. Newton developed an excellent system of limits.

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42 "Mathematics", <u>Encyclopedia Americana,</u> volume 17 page 400

43 Ibid

44 Petr Beckmann, <u>A History of ?f,</u> page 137

This paper just sort of dies here.
How about a conclusion telling of the
tremendous men you have covered. Make a statement
Make the reader feel this paper was worth reading!
Most importantly - Conclude. It's as if you

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