# HISTORY AND DEVELOPMENT OF MATHEMATICS pdf

## 1: Ancient Mathematics - History of Mathematics

*The area of study known as the history of mathematics is primarily an investigation into the origin of discoveries in mathematics and, to a lesser extent, an investigation into the mathematical methods and notation of the past.*

Babylonian mathematics refers to any mathematics of the peoples of Mesopotamia modern Iraq from the days of the early Sumerians through the Hellenistic period almost to the dawn of Christianity. The first few hundred years of the second millennium BC Old Babylonian period , and the last few centuries of the first millennium BC Seleucid period. Later under the Arab Empire , Mesopotamia, especially Baghdad , once again became an important center of study for Islamic mathematics. In contrast to the sparsity of sources in Egyptian mathematics , our knowledge of Babylonian mathematics is derived from more than clay tablets unearthed since the s. Some of these appear to be graded homework. They developed a complex system of metrology from BC. From around BC onwards, the Sumerians wrote multiplication tables on clay tablets and dealt with geometrical exercises and division problems. The earliest traces of the Babylonian numerals also date back to this period. It is likely the sexagesimal system was chosen because 60 can be evenly divided by 2, 3, 4, 5, 6, 10, 12, 15, 20 and  The problem includes a diagram indicating the dimensions of the truncated pyramid. Egyptian mathematics refers to mathematics written in the Egyptian language. From the Hellenistic period , Greek replaced Egyptian as the written language of Egyptian scholars. Mathematical study in Egypt later continued under the Arab Empire as part of Islamic mathematics , when Arabic became the written language of Egyptian scholars. The most extensive Egyptian mathematical text is the Rhind papyrus sometimes also called the Ahmes Papyrus after its author , dated to c. In addition to giving area formulas and methods for multiplication, division and working with unit fractions, it also contains evidence of other mathematical knowledge, [27] including composite and prime numbers ; arithmetic , geometric and harmonic means ; and simplistic understandings of both the Sieve of Eratosthenes and perfect number theory namely, that of the number 6. One problem is considered to be of particular importance because it gives a method for finding the volume of a frustum truncated pyramid. Finally, the Berlin Papyrus c. Greek mathematics The Pythagorean theorem. The Pythagoreans are generally credited with the first proof of the theorem. Greek mathematics of the period following Alexander the Great is sometimes called Hellenistic mathematics. All surviving records of pre-Greek mathematics show the use of inductive reasoning, that is, repeated observations used to establish rules of thumb. Greek mathematicians, by contrast, used deductive reasoning. The Greeks used logic to derive conclusions from definitions and axioms, and used mathematical rigor to prove them. Although the extent of the influence is disputed, they were probably inspired by Egyptian and Babylonian mathematics. According to legend, Pythagoras traveled to Egypt to learn mathematics, geometry, and astronomy from Egyptian priests. Thales used geometry to solve problems such as calculating the height of pyramids and the distance of ships from the shore. As a result, he has been hailed as the first true mathematician and the first known individual to whom a mathematical discovery has been attributed. The Pythagoreans are credited with the first proof of the Pythagorean theorem , [38] though the statement of the theorem has a long history, and with the proof of the existence of irrational numbers. The diagram accompanies Book II, Proposition 5. Though he made no specific technical mathematical discoveries, Aristotle â€”c. Although most of the contents of the Elements were already known, Euclid arranged them into a single, coherent logical framework. Euclid also wrote extensively on other subjects, such as conic sections , optics , spherical geometry , and mechanics, but only half of his writings survive. Around the same time, Eratosthenes of Cyrene c. AD 90â€” , a landmark astronomical treatise whose trigonometric tables would be used by astronomers for the next thousand years. His main work was the Arithmetica, a collection of algebraic problems dealing with exact solutions to determinate and indeterminate equations. He is known for his hexagon theorem and centroid theorem , as well as the Pappus configuration and Pappus graph. His Collection is a major source of knowledge on Greek mathematics as most of it has survived. The first woman mathematician recorded by history was Hypatia of Alexandria AD â€" She succeeded her father as Librarian at the Great Library and wrote many works on applied mathematics. Because of a political dispute, the Christian community in Alexandria had her stripped publicly and executed. The closure of the neo-Platonic Academy of Athens by the emperor Justinian in AD is traditionally held as marking the end of the era of Greek mathematics, although the Greek tradition continued unbroken in the Byzantine empire with mathematicians such as Anthemius of Tralles and Isidore of Miletus , the architects of the Haghia Sophia.

## 2: The Development of Mathematics Â« Mathematical Science & Technologies

*the story of mathematics. This is not intended as a comprehensive and definitive guide to all of mathematics, but as an easy-to-use summary of the major mathematicians and the developments of mathematical thought over the centuries.*

A Brief History of Mathematics Education in America Jessica Furr Waggener Spring There is no shortage of analyses or critiques on the teaching of mathematics, especially since the s. Admittedly, the accuracy of such inferences are severely limited by the glaring absence of data from within the classroom. Formal education in colonial America was primarily limited to teaching literacy and training the elite college-bound in the classics. One common form of schooling in northeast and middle colonies was the town school, an English institution for training clerks. Thus, the curriculum originally included arithmetic until puritan influence replaced this "non-academic," "skill" subject with religion and a greater emphasis on reading. In cities with business interests, certain mechanical mathematics skills were still needed and taught in a few schools Willoughby, , p. This form of inclusion was quite distinct from the mathematics that migrated into the Latin Grammar Schools. College preparatory schools espoused the faculty psychology approach to education, believing that the mind trained on the most difficult subjects would be prepared for any task. Until this meant learning the ancient languages. In , Harvard hired its first professor of mathematics and soon after began requiring proficiency in arithmetic as a requisite for entrance to the college Willoughby, p. In response, arithmetic began to be taught in most secondary schools. The rise of universal, free, compulsory education together with new college entrance requirements and the continuing need for basic commercial computational skills meant a significant increase in the number of students who were being taught arithmetic and a similar increase in the few privileged boys learning algebra and geometry. Unfortunately, there was no previous generation of citizens trained in mathematics to be available to teach these students. The common school movement in general suffered a shortage of teachers, and while the new normal schools helped to train this new workhorse and introduced a pedagogical aspect to the profession, they did little to develop the kind of mathematical understanding that effective teaching requires. Arithmetic during this time was considered an extremely difficult subject; and boys, if they even attempted to learn it, did not begin until age twelve or thirteen. Girls were never taught the formal rules and, like most citizens, any practical knowledge of numbers they attained came from life experience alone. As the first "new math," this program of study was designed to lead even very young children five or six years old through the discovery of the concepts of numbers and operations. The process is the converse of the old rule method in which abstract characters and patterns were presented first and exercised until one was proficient enough to try a practical problem. What most students learned under such instruction was how to follow examples. Very rarely did they understand an operation. Only then are the abstract numbers and signs introduced to help the child develop a general principle. The primary emphasis is on understanding. Somewhere between the ideals of instruction and the actual classroom, however, something always seems to get lost. One explanation for pedagogical disparities in mathematics education lies in the attitudes of teachers toward their subject. When mathematics is seen exclusively as a tool or set of skills, it is most often taught by drill. But only when a teacher believes that the real value of mathematics is in the ongoing process of discovering new relationships will he naturally guide pupils to learn through analytical induction Grouws, , p. Thus its teaching was characterized by such extremes of drill and discipline that up to one-half of every school day could be spent on arithmetic, without much learning occurring. In fact, arithmetic was the primary cause for non-promotion in the late s Grouws, p. At the same time, the secondary school population was rapidly increasing Willoughby, p. Understandably, there was a growing public dissatisfaction with the formal methods and a revolt against the idea of mathematics as a subject worthy of study for its intellectual value Grouws, p. From the s to the s, American society predominantly viewed the role of mathematics as solely for social utility. In , a societal hope in progress through the scientific method was being applied to the classroom through a streamlining of the mathematics curriculum. Two surveys Stitt, and Wilson, by educators stand out for assessing what kinds of math were considered by the business community and the average citizen to be important in daily life. They found that only the smaller numbers and the most basic operations were used regularly and thus it was suggested that the more complex, perplexing, and tedious practices be eliminated from the curriculum Grouws, p. His suggestions to postpone much of mathematics education to later years, however, was incorporated into a post-WW1 anti-intellectual movement which went so far as to threaten the role of mathematics as a standard school subject Grouws, p. Another blow in this struggle came from E. Thorndike in the s. His research, though not extremely rigorous or conclusive, argued against theories of "transfer of learning. To a certain extent, this debunking of transfer theory was positive because it ended the reign of faculty psychology and the veneration of drill among educational theorists Willoughby, p. He joined with those who wanted much of the laborious, abstract, and unrealistic mathematics dropped from the curriculum, but instead of advocating understanding and structure, he championed a new rule and a simplified, problem-specific approach. This form of arithmetic without reasoning strengthened the anti-intellectual movement to teach only that mathematics that was immediately useful, if any at all p. At the turn of the century a new phenomenon appeared that, even today, continues to characterize educational reform - the committee of experts. Groups have been at times privately or publicly funded, professionally homogenous or diverse, and variously reported, researched, or recommended changes in organization, curriculum, and pedagogy. The abundance of commissions, boards, and studies would comprise a bibliography longer than this composition, but a few of the most influential reports from these groups will be presented here in their historical context. It is debatable to what extent any of these commissions affected life within the mathematics classroom, but some ideas of contemporary practices can be drawn from their criticisms and evaluations. The final report sided with the social utilitarians for leaving the most perplexing and exhausting topics out of arithmetic, and for including courses such as bookkeeping for high school students without college aspirations or trigonometry for boys in the natural and technological sciences. On the side of meaningful mathematics, the committee recommended a general trend toward the decompartmentalization of subjects in mathematics and proposed that secondary schools teach parallel courses in algebra and geometry designed for integrating the subjects. While the parallel courses were attempted, they generally failed either because the teachers were more interested in one subject than the other or because they were unable to draw connections between the two Willoughby, p. The official policy of this board was to never dictate public secondary school curriculums, but the influence of such an organization is inevitable. Their significant impact on education in the s will be discussed later. In , the International Commission on the Teaching of Mathematics produced among its reports a survey of American education which gives us a picture of the status of secondary mathematics at the time. Recall, first, that algebra was not even required by colleges until and geometry was not taught until  The study found that almost all secondary schools in the U. The culmination of the progressive era for mathematics education was presented in a report by a branch of the Mathematical Association of America. The Report of the National Committee on Mathematical Requirements was responsible for formulating a plan of curriculum for the newly redesigned school organization while incorporating the findings of educational research from psychology and various experimental school programs. The report included practical, cultural, and disciplinary justifications for the subject and outlined a variety of plans for junior and senior high curriculums which could be easily adapted to particular circumstances. Some topics in algebra and geometry were recommended to be introduced in junior high and it was suggested that all students complete the program through eighth grade, with only those who mastered continuing on. Most of the history discussed thus far took place among a limited circle of professionals and interested parties; but if there was ever a time when the issues of mathematics education really attained national prominence and captured the attention of the average citizen, it was during the "New Math" movement of the late s and s. The common misperception then, however, was that the reform of mathematics instruction was a new idea. Obviously, such discussions had already been occurring even in the s. Other factors in the continuum of ideas which have not yet been discussed are important to consider here before looking at the phenomenon of "new math. One characteristic of their research was the laboratory school. In the twentieth century, experimental school programs continued to abound, increasingly within the context of the university. These programs encompassed such a diversity of purposes and methods that it is difficult to even choose one which is representative. Most had only a regional influence, but the point here is that there was a great deal of research and effort aimed at reforming mathematics education long before "new math. This brought back the idea of mathematics as a subject useful for teaching reasoning skills adaptable to any task. This focus on insight was opposed to the behavioristic ideas of the previous century. Such intuitive ideas had been popular among mathematicians and educators since the s, but were overshadowed by the emergence of standardized intelligence and proficiency tests and the demands of utilitarian mathematics for the new secondary school population. After World War II, Gestalt psychology became one of the foundations of the mathematics reform movement. Several committees during the war expressed concern over the inadequate mathematics skills of incoming officers. The NCTM Commission on Post-War Plans reported in and a series of recommendations aimed at achieving "functional competence" in mathematics for all who were able Willoughby, p. What made the projects and committees of the s unique from their predecessors and those to follow was the increased involvement of mathematicians and their dominant influence over the ideas of educators. The twentieth century saw advances and discoveries in pure mathematics as significant as those in technology; and after the war, mathematicians became interested in education, especially with the hope that more mathematics could be taught before students began their undergraduate studies. At the same time, there was a general rising awareness that the job market was requiring increased technical competence. Research at the time showed that children were capable of learning quite advanced topics at much younger ages. What was not discussed at this time was whether or not such subjects as set theory, linear algebra, and formal deductive reasoning should be taught to most students Barlage. Reform programs were designed for very capable students as if a whole generation of mathematicians were being trained. The report of this group was the first national proposal for substantial reorganization of secondary mathematics curriculum to include what was termed as "modern mathematics. This report might not have received any attention, except that in October of the Soviet Union launched the first satellite in space, Sputnik 1. The impact of this event can not be overstated. Suddenly, every American was intensely concerned with the quality of mathematics and science education Barlage, p. Not only was it a matter of pride, but one of national security. The consequence of that concern was money. In the National Defense Education Act was passed and for the first time, funding was available for programs concerned with developing new programs for mathematics education. This was the most influential of all projects at the time p. Its primary accomplishment was the development a number of textbooks for all grade levels with emphasis on mathematical structure, the real number system, careful use of language and deductive proofs, discovery, experimentation, and scientific applications. These were meant as a model for commercial publishers who soon followed with appropriately revised textbooks Willoughby, p. The first phase of the reform movement as mentioned above was aimed at college bound students. The Cambridge Conference of marked a second phase in which the redesign of instruction for all grades and all levels of ability became important. The "Cooperative Research Act" of and the "Elementary and Secondary Education Act" of continued to provide funding for new program developments. This second round of programs, however, was still characterized by the same goals of the first ones -- more advanced, modern, and abstract mathematics at a younger age, and instruction through the discovery of structure versus memorization -- ideals that had originated among college mathematics professors for college-bound students. The devlopment of curriculum and tests were not guided by learning theories or educational research McIntosh, , p. Quite a lot of controversy surrounded "new math" from the beginning McIntosh, , p. Despite all the talk of radical reform, the changes amounted to shifts in emphasis. Categorically, they consisted of: From a historical perspective, it is easy to see that most of these changes are merely continuations of long-running themes in educational reform. So the only really "new" aspects of "new math" were the modern topics, a new demand for specialized mathematics teachers in the elementary schools, and a significant rise of in-service teacher training through conferences, workshops, and academic courses Barlage. In discussing the "new math" movement, it is easy to think that the curriculum and pedagogical changes were felt in every classroom in the nation. The greatest effects were felt in urban high schools of over students.

## 3: The Development of Algebra - 1 : www.enganchecubano.com

*The development of mathematics is intimately interwoven with the progress of civilization, influencing the course of history through its application to science and technology. But mathematics has changed.*

Because much of genetics is based on quantitative data, mathematical techniques are used extensively in genetics. The laws of probability are applicable to crossbreeding and are used to predict frequencies of specific genetic constitutions in offspring. Geneticists also use statistical methods to determineâ€¦ Ancient mathematical sources It is important to be aware of the character of the sources for the study of the history of mathematics. The history of Mesopotamian and Egyptian mathematics is based on the extant original documents written by scribes. Although in the case of Egypt these documents are few, they are all of a type and leave little doubt that Egyptian mathematics was, on the whole, elementary and profoundly practical in its orientation. For Mesopotamian mathematics, on the other hand, there are a large number of clay tablets, which reveal mathematical achievements of a much higher order than those of the Egyptians. The tablets indicate that the Mesopotamians had a great deal of remarkable mathematical knowledge, although they offer no evidence that this knowledge was organized into a deductive system. Future research may reveal more about the early development of mathematics in Mesopotamia or about its influence on Greek mathematics, but it seems likely that this picture of Mesopotamian mathematics will stand. This stands in complete contrast to the situation described above for Egyptian and Babylonian documents. Although, in general outline, the present account of Greek mathematics is secure, in such important matters as the origin of the axiomatic method , the pre-Euclidean theory of ratios, and the discovery of the conic sections , historians have given competing accounts based on fragmentary texts, quotations of early writings culled from nonmathematical sources, and a considerable amount of conjecture. Many important treatises from the early period of Islamic mathematics have not survived or have survived only in Latin translations, so that there are still many unanswered questions about the relationship between early Islamic mathematics and the mathematics of Greece and India. In addition, the amount of surviving material from later centuries is so large in comparison with that which has been studied that it is not yet possible to offer any sure judgment of what later Islamic mathematics did not contain, and therefore it is not yet possible to evaluate with any assurance what was original in European mathematics from the 11th to the 15th century. In modern times the invention of printing has largely solved the problem of obtaining secure texts and has allowed historians of mathematics to concentrate their editorial efforts on the correspondence or the unpublished works of mathematicians. However, the exponential growth of mathematics means that, for the period from the 19th century on, historians are able to treat only the major figures in any detail. In addition, there is, as the period gets nearer the present, the problem of perspective. Mathematics, like any other human activity, has its fashions, and the nearer one is to a given period, the more likely these fashions will look like the wave of the future. For this reason, the present article makes no attempt to assess the most recent developments in the subject. Berggren Mathematics in ancient Mesopotamia Until the s it was commonly supposed that mathematics had its birth among the ancient Greeks. What was known of earlier traditions, such as the Egyptian as represented by the Rhind papyrus edited for the first time only in , offered at best a meagre precedent. This impression gave way to a very different view as historians succeeded in deciphering and interpreting the technical materials from ancient Mesopotamia. Existing specimens of mathematics represent all the major erasâ€"the Sumerian kingdoms of the 3rd millennium bce, the Akkadian and Babylonian regimes 2nd millennium , and the empires of the Assyrians early 1st millennium , Persians 6th through 4th century bce , and Greeks 3rd century bce to 1st century ce. The level of competence was already high as early as the Old Babylonian dynasty , the time of the lawgiver-king Hammurabi c. The application of mathematics to astronomy, however, flourished during the Persian and Seleucid Greek periods. The numeral system and arithmetic operations Unlike the Egyptians, the mathematicians of the Old Babylonian period went far beyond the immediate challenges of their official accounting duties. For example, they introduced a versatile numeral system, which, like the modern system, exploited the notion of place value, and they developed computational methods that took advantage of this means of expressing numbers; they solved linear and quadratic problems by methods much like those now used in algebra ; their success with the study of what are now called Pythagorean number triples was a remarkable feat in number theory. The scribes who made such discoveries must have believed mathematics to be worthy of study in its own right, not just as a practical tool. The older Sumerian system of numerals followed an additive decimal base principle similar to that of the Egyptians. But the Old Babylonian system converted this into a place-value system with the base of 60 sexagesimal. The reasons for the choice of 60 are obscure, but one good mathematical reason might have been the existence of so many divisors 2, 3, 4, and 5, and some multiples of the base, which would have greatly facilitated the operation of division. For numbers from 1 to 59, the symbols for 1 and for 10 were combined in the simple additive manner e. But to express larger values, the Babylonians applied the concept of place value. For example, 60 was written as , 70 as , 80 as , and so on. In fact, could represent any power of  The context determined which power was intended. By the 3rd century bce, the Babylonians appear to have developed a placeholder symbol that functioned as a zero , but its precise meaning and use is still uncertain. Furthermore, they had no mark to separate numbers into integral and fractional parts as with the modern decimal point. The four arithmetic operations were performed in the same way as in the modern decimal system, except that carrying occurred whenever a sum reached 60 rather than  Multiplication was facilitated by means of tables; one typical tablet lists the multiples of a number by 1, 2, 3,â€¦, 19, 20, 30, 40, and  To multiply two numbers several places long, the scribe first broke the problem down into several multiplications, each by a one-place number, and then looked up the value of each product in the appropriate tables. He found the answer to the problem by adding up these intermediate results. These tables also assisted in division, for the values that head them were all reciprocals of regular numbers. Regular numbers are those whose prime factors divide the base; the reciprocals of such numbers thus have only a finite number of places by contrast, the reciprocals of nonregular numbers produce an infinitely repeating numeral. In base 10, for example, only numbers with factors of 2 and 5 e. In base 60, only numbers with factors of 2, 3, and 5 are regular; for example, 6 and 54 are regular, so that their reciprocals 10 and 1 6 40 are finite. To divide a number by any regular number, then, one can consult the table of multiples for its reciprocal. An interesting tablet in the collection of Yale University shows a square with its diagonals. The scribe thus appears to have known an equivalent of the familiar long method of finding square roots. They also show that the Babylonians were aware of the relation between the hypotenuse and the two legs of a right triangle now commonly known as the Pythagorean theorem more than a thousand years before the Greeks used it. A type of problem that occurs frequently in the Babylonian tablets seeks the base and height of a rectangle, where their product and sum have specified values. In the same way, if the product and difference were given, the sum could be found. This procedure is equivalent to a solution of the general quadratic in one unknown. In some places, however, the Babylonian scribes solved quadratic problems in terms of a single unknown, just as would now be done by means of the quadratic formula. Although these Babylonian quadratic procedures have often been described as the earliest appearance of algebra , there are important distinctions. The scribes lacked an algebraic symbolism; although they must certainly have understood that their solution procedures were general, they always presented them in terms of particular cases, rather than as the working through of general formulas and identities. They thus lacked the means for presenting general derivations and proofs of their solution procedures. Their use of sequential procedures rather than formulas, however, is less likely to detract from an evaluation of their effort now that algorithmic methods much like theirs have become commonplace through the development of computers. If one selects values at random for two of the terms, the third will usually be irrational , but it is possible to find cases in which all three terms are integers: Such solutions are sometimes called Pythagorean triples. A tablet in the Columbia University Collection presents a list of 15 such triples decimal equivalents are shown in parentheses at the right; the gaps in the expressions for h, b, and d separate the place values in the sexagesimal numerals: The entries in the column for h have to be computed from the values for b and d, for they do not appear on the tablet; but they must once have existed on a portion now missing. In the table the implied values p and q turn out to be regular numbers falling in the standard set of reciprocals, as mentioned earlier in connection with the multiplication tables. Scholars are still debating nuances of the construction and the intended use of this table, but no one questions the high level of expertise implied by it. Mathematical astronomy The sexagesimal method developed by the Babylonians has a far greater computational potential than what was actually needed for the older problem texts. With the development of mathematical astronomy in the Seleucid period, however, it became indispensable. Astronomers sought to predict future occurrences of important phenomena, such as lunar eclipses and critical points in planetary cycles conjunctions, oppositions, stationary points, and first and last visibility. The results were then organized into a table listing positions as far ahead as the scribe chose. Although the method is purely arithmetic, one can interpret it graphically: While observations extending over centuries are required for finding the necessary parameters e. Within a relatively short time perhaps a century or less , the elements of this system came into the hands of the Greeks. Although Hipparchus 2nd century bce favoured the geometric approach of his Greek predecessors, he took over parameters from the Mesopotamians and adopted their sexagesimal style of computation. Through the Greeks it passed to Arab scientists during the Middle Ages and thence to Europe, where it remained prominent in mathematical astronomy during the Renaissance and the early modern period. To this day it persists in the use of minutes and seconds to measure time and angles. Aspects of the Old Babylonian mathematics may have come to the Greeks even earlier, perhaps in the 5th century bce, the formative period of Greek geometry. There are a number of parallels that scholars have noted. Further, the Babylonian rule for estimating square roots was widely used in Greek geometric computations, and there may also have been some shared nuances of technical terminology. Although details of the timing and manner of such a transmission are obscure because of the absence of explicit documentation, it seems that Western mathematics, while stemming largely from the Greeks, is considerably indebted to the older Mesopotamians. Page 1 of 6.

# HISTORY AND DEVELOPMENT OF MATHEMATICS pdf

## 4: History overview

*A Brief History of Mathematics development of mathematics. Solving polynomial equations (roots of equations) A few important problems in the.*

Springer-Verlag, Berlin-New York, Famous problems of mathematics; a history of constructions with straight edge and compasses. Van Nostrand Reinhold, New York, History of analytic geometry. Scripta Mathematica, New York, Bretschneider, Carl Anton, Die Geometrie und die Geometer vor Euklides: Coolidge, Julian Lowell A history of geometrical methods. Clarendon Press, Oxford, Dover, New York, A history of the conic sections and quadric surfaces. History of algebraic geometry: Hidetoshi , and D. Euclidean and non-Euclidean geometries: The method of analysis: Hobson, Ernest William Chelsea, New York, A mathematical history of division in extreme and mean ratio. Wilfrid Laurier University Press, Waterloo, Felix Klein and Sophus Lie: Translated from Feliks Klein i Sofus Li. The ancient tradition of geometric problems. Space through the ages; The evolution of geometrical ideas from Pythagoras to Hilbert and Einstein. Academic Press, London-New York, Elements of geometry, geometrical analysis and plane trigonometry. Loomis, Elisha Scott Edwards Brothers, Ann Arbor, Il passato ed il presente delle pricipali teorie geometriche. The beginnings of plane and spherical trigonometry. Current Life, Science and Technology: Series "Mathematics and Cybernetics" 82, 5. A long way from Euclid. Boris Abramovich A history of non-Euclidean geometry: Translated from Istoriia neevklidovoi geometrii by Abe Shenitzer. Springer-Verlag, New York, William Whitehead Famous geometrical theorems and problems, with their history. Stackel, Paul, , editor. Die theorie der parallellinien von Euklid bis auf Gauss; eine urkundensammlung zur vorgeschichte der nichteuklidischen geometrie. A history of the teaching of elementary geometry, with reference to present-day problems. Columbia University, New York, La geometrie grecque, comment son histoire nous est parvenue et ce que nous en savons. An introduction to the ancient and modern geometry of conics. Deighton Bell, Cambridge, Yates, Robert Carl Franklin Press, Baton Rouge, Geometry and algebra in ancient civilizations.

## 5: History of statistics - Wikipedia

*An Episodic History of Mathematics An important development of twenty-ï¬•rst century life is that mathe- history of mathematics, for a course of mathematics.*

Such concepts would have been part of everyday life in hunter-gatherer societies. The idea of the "number" concept evolving gradually over time is supported by the existence of languages which preserve the distinction between "one", "two", and "many", but not of numbers larger than two. For example, paleontologists have discovered in a cave in South Africa , ochre rocks about 70, years old, adorned with scratched geometric patterns. Moreover, hunters and herders employed the concepts of one, two, and many, as well as the idea of none or zero, when considering herds of animals. One common interpretation is that the bone is the earliest known demonstration [8] of sequences of prime numbers and of Ancient Egyptian multiplication. The Ishango bone consists of a series of tally marks carved in three columns running the length of the bone. Common interpretations are that the Ishango bone shows either the earliest known demonstration of sequences of prime numbers [7] or a six-month lunar calendar. The First 50, Years, Peter Rudman argues that the development of the concept of prime numbers could only have come about after the concept of division, which he dates to after 10, BC, with prime numbers probably not being understood until about BC. He also writes that "no attempt has been made to explain why a tally of something should exhibit multiples of two, prime numbers between 10 and 20, and some numbers that are almost multiples of  Iraqi mathematics Mesoptamian mathematics, or Babylonian mathematics, refers to any mathematics of the people of Mesopotamia modern Iraq , from the days of the early Sumerians , through the Babylonian period, until the beginning of the Parthian period. It is named Babylonian mathematics due to the central role of Babylon as a place of study, which ceased to exist during the Hellenistic period. From this point, Babylonian mathematics merged with Greek and Egyptian mathematics to give rise to Hellenistic mathematics. In contrast to the sparsity of sources in Egyptian mathematics , our knowledge of Babylonian mathematics is derived from more than clay tablets unearthed since the s. Written in Cuneiform script , tablets were inscribed whilst the clay was moist, and baked hard in an oven or by the heat of the sun. Some of these appear to be graded homework. They developed a complex system of metrology from BC. From around BC onwards, the Sumerians wrote multiplication tables on clay tablets and dealt with geometrical exercises and division problems. The earliest traces of the Babylonian numerals also date back to this period. Plimpton Babylonian clay tablet YBC with annotations. The diagonal displays an approximation of the square root of 2 in four sexagesimal figures, which is about six decimal figures. The Babylonian mathematical tablet Plimpton , dated to BC. The Old Babylonian period is the period to which most of the clay tablets on Babylonian mathematics belong, which is why the mathematics of Mesopotamia is commonly known as Babylonian mathematics. Some clay tablets contain mathematical lists and tables, others contain problems and worked solutions. The majority of recovered clay tablets date from to BC, and cover topics which include fractions, algebra, quadratic and cubic equations, and the calculation of Pythagorean triples see Plimpton  Babylonian mathematics were written using a sexagesimal base numeral system. From this we derive the modern day usage of 60 seconds in a minute, 60 minutes in an hour, and 60 x 6 degrees in a circle. Babylonian advances in mathematics were facilitated by the fact that 60 has many divisors. Also, unlike the Egyptians, Greeks, and Romans, the Babylonians had a true place-value system, where digits written in the left column represented larger values, much as in the decimal system. They lacked, however, an equivalent of the decimal point, and so the place value of a symbol often had to be inferred from the context. They are particularly known for pioneering mathematical astronomy. In the Hellenistic world, Babylonian astronomy and mathematics exerted a great influence on the mathematicians of Alexandria , in Ptolemaic Egypt and Roman Egypt. This is particularly apparent in the astronomical and mathematical works of Hipparchus , Ptolemy , Hero of Alexandria , and Diophantus. Ancient Egyptian mathematics c. Egyptian mathematics Egyptian mathematics refers to mathematics written in the Egyptian language. From the Hellenistic period , Greek replaced Egyptian as the written language of Egyptian scholars, and from this point Egyptian mathematics merged with Greek and Babylonian mathematics to give rise to Hellenistic mathematics. Mathematical study in Egypt later continued under the Arab Empire as part of Islamic mathematics , when Arabic became the written language of Egyptian scholars. Early Dynastic Period to Old Kingdom c. These labels appear to have been used as tags for grave goods and some are inscribed with numbers. The problem includes a diagram indicating the dimensions of the truncated pyramid. The earliest true Egyptian mathematical documents date to the Middle Kingdom period, specifically the 12th dynasty c. The Rhind Mathematical Papyrus which dates to the Second Intermediate Period ca BC is said to be based on an older mathematical text from the 12th dynasty. Like many ancient mathematical texts, it consists of what are today called "word problems" or "story problems", which were apparently intended as entertainment. One problem is considered to be of particular importance because it gives a method for finding the volume of a frustum: A truncated pyramid of 6 for the vertical height by 4 on the base by 2 on the top. You are to square this 4, result  You are to double 4, result 8. You are to square 2, result 4. You are to add the 16, the 8, and the 4, result  You are to take one third of 6, result 2. You are to take 28 twice, result  See, it is  You will find it right. In addition to giving area formulas and methods for multiplication, division and working with unit fractions, it also contains evidence of other mathematical knowledge see [3] , including composite and prime numbers ; arithmetic , geometric and harmonic means ; and simplistic understandings of both the Sieve of Eratosthenes and perfect number theory namely, that of the number 6 [4]. It also shows how to solve first order linear equations [5] as well as arithmetic and geometric series [6]. Also, three geometric elements contained in the Rhind papyrus suggest the simplest of underpinnings to analytical geometry: Finally, the Berlin papyrus c. Indian mathematics Harappan mathematics c. This civilisation developed a system of uniform weights and measures that used the decimal system, a surprisingly advanced brick technology which utilised ratios , streets laid out in perfect right angles , and a number of geometrical shapes and designs, including cuboids , barrels , cones , cylinders , and drawings of concentric and intersecting circles and triangles. Mathematical instruments included an accurate decimal ruler with small and precise subdivisions, a shell instrument that served as a compass to measure angles on plane surfaces or in horizon in multiples of 40â€" degrees, a shell instrument used to measure 8â€"12 whole sections of the horizon and sky, and an instrument for measuring the positions of stars for navigational purposes. The Indus script has not yet been deciphered; hence very little is known about the written forms of Harappan mathematics. The religious texts of the Vedic Period provide evidence for the use of large numbers. His notation was similar to modern mathematical notation, and used metarules, transformations.

# HISTORY AND DEVELOPMENT OF MATHEMATICS pdf

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*Even when mathematics history is taught as a senior seminar or capstone course, the common mathematical background of the students may include a relatively small number of mathematics courses or fields.*

Version for printing Mathematics starts with counting. It is not reasonable, however, to suggest that early counting was mathematics. Only when some record of the counting was kept and, therefore, some representation of numbers occurred can mathematics be said to have started. In Babylonia mathematics developed from BC. Earlier a place value notation number system had evolved over a lengthy period with a number base of  It allowed arbitrarily large numbers and fractions to be represented and so proved to be the foundation of more high powered mathematical development. Systems of linear equations were studied in the context of solving number problems. Quadratic equations were also studied and these examples led to a type of numerical algebra. The Babylonian basis of mathematics was inherited by the Greeks and independent development by the Greeks began from around BC. A more precise formulation of concepts led to the realisation that the rational numbers did not suffice to measure all lengths. A geometric formulation of irrational numbers arose. Studies of area led to a form of integration. The theory of conic sections shows a high point in pure mathematical study by Apollonius. Further mathematical discoveries were driven by the astronomy, for example the study of trigonometry. After this time progress continued in Islamic countries. Mathematics flourished in particular in Iran, Syria and India. This work did not match the progress made by the Greeks but in addition to the Islamic progress, it did preserve Greek mathematics. From about the 11th Century Adelard of Bath, then later Fibonacci , brought this Islamic mathematics and its knowledge of Greek mathematics back into Europe. Major progress in mathematics in Europe began again at the beginning of the 16th Century with Pacioli , then Cardan , Tartaglia and Ferrari with the algebraic solution of cubic and quartic equations. Copernicus and Galileo revolutionised the applications of mathematics to the study of the universe. The 17th Century saw Napier , Briggs and others greatly extend the power of mathematics as a calculatory science with his discovery of logarithms. Cavalieri made progress towards the calculus with his infinitesimal methods and Descartes added the power of algebraic methods to geometry. Progress towards the calculus continued with Fermat , who, together with Pascal , began the mathematical study of probability. However the calculus was to be the topic of most significance to evolve in the 17th Century. Newton , building on the work of many earlier mathematicians such as his teacher Barrow , developed the calculus into a tool to push forward the study of nature. His work contained a wealth of new discoveries showing the interaction between mathematics, physics and astronomy. However we must also mention Leibniz , whose much more rigorous approach to the calculus although still unsatisfactory was to set the scene for the mathematical work of the 18th Century rather than that of Newton. The most important mathematician of the 18th Century was Euler who, in addition to work in a wide range of mathematical areas, was to invent two new branches, namely the calculus of variations and differential geometry. Euler was also important in pushing forward with research in number theory begun so effectively by Fermat. Toward the end of the 18th Century, Lagrange was to begin a rigorous theory of functions and of mechanics. The 19th Century saw rapid progress. Non-euclidean geometry developed by Lobachevsky and Bolyai led to characterisation of geometry by Riemann. Gauss , thought by some to be the greatest mathematician of all time, studied quadratic reciprocity and integer congruences. His work in differential geometry was to revolutionise the topic. He also contributed in a major way to astronomy and magnetism. The 19th Century saw the work of Galois on equations and his insight into the path that mathematics would follow in studying fundamental operations. Cauchy , building on the work of Lagrange on functions, began rigorous analysis and began the study of the theory of functions of a complex variable. This work would continue through Weierstrass and Riemann. Algebraic geometry was carried forward by Cayley whose work on matrices and linear algebra complemented that by Hamilton and Grassmann. The end of the 19th Century saw Cantor invent set theory almost single handedly while his analysis of the concept of number added to the major work of Dedekind and Weierstrass on irrational numbers Analysis was driven by the requirements of mathematical physics and astronomy. Maxwell was to revolutionise the application of analysis to mathematical physics. Statistical mechanics was developed by Maxwell , Boltzmann and Gibbs. It led to ergodic theory. The study of integral equations was driven by the study of electrostatics and potential theory. Notation and communication There are many major mathematical discoveries but only those which can be understood by others lead to progress. However, the easy use and understanding of mathematical concepts depends on their notation. For example, work with numbers is clearly hindered by poor notation. Try multiplying two numbers together in Roman numerals. Addition of course is a different matter and in this case Roman numerals come into their own, merchants who did most of their arithmetic adding figures were reluctant to give up using Roman numerals. What are other examples of notational problems. The best known is probably the notation for the calculus used by Leibniz and Newton. Let us think for a moment how dependent we all are on mathematical notation and convention. We are, often without realising it, using a convention that letters near the end of the alphabet represent unknowns while those near the beginning represent known quantities. It was not always like this: Harriot used a as his unknown as did others at this time. The convention we use letters near the end of the alphabet representing unknowns was introduced by Descartes in  Also ax is used to denote the product of a and x, the most efficient notation of all since nothing has to be written! It is quite hard to understand the brilliance of major mathematical discoveries. On the one hand they often appear as isolated flashes of brilliance although in fact they are the culmination of work by many, often less able, mathematicians over a long period. For example the controversy over whether Newton or Leibniz discovered the calculus first can easily be answered. Neither did since Newton certainly learnt the calculus from his teacher Barrow. Now we are in danger of reducing major mathematical discoveries as no more than the luck of who was working on a topic at "the right time". This too would be completely unfair although it does go some why to explain why two or more people often discovered something independently around the same time. There is still the flash of genius in the discoveries, often coming from a deeper understanding or seeing the importance of certain ideas more clearly. How we view history We view the history of mathematics from our own position of understanding and sophistication. There can be no other way but nevertheless we have to try to appreciate the difference between our viewpoint and that of mathematicians centuries ago. Often the way mathematics is taught today makes it harder to understand the difficulties of the past. In fact there is no real reason why negative numbers should be introduced at all. Nobody owned -2 books. We can think of 2 as being some abstract property which every set of 2 objects possesses. This in itself is a deep idea. Adding 2 apples to 3 apples is one matter. Negative numbers do not have this type of concrete representation on which to build the abstraction. It is not surprising that their introduction came only after a long struggle. An understanding of these difficulties would benefit any teacher trying to teach primary school children. Even the integers, which we take as the most basic concept, have a sophistication which can only be properly understood by examining the historical setting. A challenge If you think that mathematical discovery is easy then here is a challenge to make you think. Napier , Briggs and others introduced the world to logarithms nearly years ago. These were used for years as the main tool in arithmetical calculations. An amazing amount of effort was saved using logarithms, how could the heavy calculations necessary in the sciences ever have taken place without logs. Then the world changed. The pocket calculator appeared. The logarithm remains an important mathematical function but its use in calculating has gone for ever. Here is the challenge. What will replace the calculator? You might say that this is an unfair question. However let me remind you that Napier invented the basic concepts of a mechanical computer at the same time as logs. The basic ideas that will lead to the replacement of the pocket calculator are almost certainly around us. I have an answer to my own question but it would spoil the point of my challenge to say what it is. Think about it and realise how difficult it was to invent non-euclidean geometries, groups, general relativity, set theory, General bibliography of about items Article by:

## 7: List of Important Mathematicians - The Story of Mathematics

*Preface This book has its origin in notes which I compiled for a course on the history of mathematics at King's College London, taught for many years before we parted company.*

Historically, it was regarded as the science of quantity, whether of magnitudes as in geometry or of numbers as in arithmetic or of the generalization of these two fields as in algebra. Some have seen it in terms as simple as a search for patterns. During the 19th Century, however, mathematics broadened to encompass mathematical or symbolic logic, and thus came to be regarded increasingly as the science of relations or of drawing necessary conclusions although some see even this as too restrictive. The discipline of mathematics now covers - in addition to the more or less standard fields of number theory, algebra, geometry, analysis calculus , mathematical logic and set theory, and more applied mathematics such as probability theory and statistics - a bewildering array of specialized areas and fields of study, including group theory, order theory, knot theory, sheaf theory, topology, differential geometry, fractal geometry, graph theory, functional analysis, complex analysis, singularity theory, catastrophe theory, chaos theory, measure theory, model theory, category theory, control theory, game theory, complexity theory and many more. The history of mathematics is nearly as old as humanity itself. Since antiquity, mathematics has been fundamental to advances in science, engineering, and philosophy. It has evolved from simple counting, measurement and calculation, and the systematic study of the shapes and motions of physical objects, through the application of abstraction, imagination and logic, to the broad, complex and often abstract discipline we know today. From the notched bones of early man to the mathematical advances brought about by settled agriculture in Mesopotamia and Egypt and the revolutionary developments of ancient Greece and its Hellenistic empire, the story of mathematics is a long and impressive one. The East carried on the baton, particularly China , India and the medieval Islamic empire , before the focus of mathematical innovation moved back to Europe in the late Middle Ages and Renaissance. Then, a whole new series of revolutionary developments occurred in 17th Century and 18th Century Europe, setting the stage for the increasing complexity and abstraction of 19th Century mathematics, and finally the audacious and sometimes devastating discoveries of the 20th Century. Follow the story as it unfolds in this series of linked sections, like the chapters of a book. Read the human stories behind the innovations, and how they made - and sometimes destroyed - the men and women who devoted their lives to This is not intended as a comprehensive and definitive guide to all of mathematics, but as an easy-to-use summary of the major mathematicians and the developments of mathematical thought over the centuries. It is not intended for mathematicians, but for the interested laity like myself. My intention is to introduce some of the major thinkers and some of the most important advances in mathematics, without getting too technical or getting bogged down in too much detail, either biographical or computational. Explanations of any mathematical concepts and theorems will be generally simplified, the emphasis being on clarity and perspective rather than exhaustive detail. It is beyond the scope is this study to discuss every single mathematician who has made significant contributions to the subject, just as it is impossible to describe all aspects of a discipline as huge in its scope as mathematics. The choice of what to include and exclude is my own personal one, so please forgive me if your favourite mathematician is not included or not dealt with in any detail. The main Story of Mathematics is supplemented by a List of Important Mathematicians and their achievements, and by an alphabetical Glossary of Mathematical Terms. You can also make use of the search facility at the top of each page to search for individual mathematicians, theorems, developments, periods in history, etc. Some of the many resources available for further study of both included and excluded elements are listed in the Sources section.

## 8: The Story of Mathematics - A History of Mathematical Thought from Ancient Times to the Modern Day

*Mathematics, the science of structure, order, and relation that has evolved from elemental practices of counting, measuring, and describing the shapes of objects. It deals with logical reasoning and quantitative calculation, and its development has involved an increasing degree of idealization and abstraction of its subject matter.*

See the bibliography below. Numerical notation, arithmetical computations, counting rods Traditional decimal notation -- one symbol for each of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, , , and  Goes back to origins of Chinese writing. Calculations performed using small bamboo counting rods. The positions of the rods gave a decimal place-value system, also written for long-term records. Arranged left to right like Arabic numerals. Back to B. The digits added merged left to right with carries where needed. Long multiplication similar to ours with advantages due to physical rods. Long division analogous to current algorithms, but closer to "galley method. Describes one of the theories of the heavens. Early Han dynasty B. Book burning of B. States and uses the Pythagorean theorem for surveying, astronomy, etc. Proof of the Pythagorean theorem. Calculations including with common fractions. Collects mathematics to beginning of Han dynasty. Longest surviving and most influential Chinese math book. Ch 1, Field measurement: Ch 2,3,6 on proportions, Cereals, Proportional distribution, Fair taxes. Ch 4, What width?: Describes usual algorithms for square and cube roots but takes advantage of computations with counting rods Ch 5, Construction consultations: Gives elimination algorithm for solving systems of three or more simultaneous linear equations. Involves use of negative numbers red reds for pos numbers, black for neg numbers. Rules for signed numbers. Ch 9, Right triangles: Wrote his mathematical manual. Includes "Chinese remainder problem" or "problem of the Master Sun": Take , 63, 30, add to get , subtract to get  Commentary on the Nine Chapters Approximates pi by approximating circles polygons, doubling the number of sides to get better approximations. From 96 and sided polygons, he approximates pi as 3. Originally appendix to commentary on Ch 9 of the Nine Chapters. Includes nine surveying problems involving indirect observations. Includes formula for summing an arithmetic sequence. Also an undetermined system of two linear equations in three unknowns, the "hundred fowls problem" Zu Chongzhi Astronomer, mathematician, engineer. Collected together earlier astronomical writings. Made own astronomical observations. Determined pi to 7 digits: Liu Zhuo Astronomer Introduced quadratic interpolation second order difference method. Wrote Xugu suanjing Continuation of Ancient Mathematics of 22 problems. Solved cubic equations by generalization of algorithm for cube root. Translations of Indian mathematical works. Hindu decimal numerals also introduced, but not adopted. Yi Xing tangent table. Streamlined extraction of square and cube roots, extended method to higher-degree roots using binomial coefficients. Solution of some higher-degree up to 10th equations. Systematic treatment of indeterminate simultaneous linear congruences Chinese remainder theorem. Euclidean algorithm for GCD. Li Yeh Ceyuan haijing Sea Mirror of Circle Measurements , 12 chapters, problems on right triangles and circles inscribed within or circumscribed about them. Yigu yanduan New Steps in Computation , geometric problems solved by algebra. Magic squares of order up through  Shou shi li Works and Days Calendar. Solves some higher degree polynomial equations in several unknowns. Rest of outline yet to write. Chronology of Mathematicians and Mathematical Works Early traditional texts These developed in a gradual accumulation of material over centuries. The dates given are roughly when they reached their final form. Suan shu shu A Book on Arithmetic c. A book of bamboo strips found in near Jiangling in Hubei province. Jiuzhang suanshu Nine Chapters of the Mathematical Art c. Zhu Shijie Hanqing, Songting fl. A collection of books in five submissions edited by Xu Guanqi and Li Tianjing with support of many others. It included several works on mathematics: Edited by Ruan Yuan.

## 9: History of Mathematics: History of Geometry

*A brief outline of the history of Chinese mathematics Primary sources are Mikami's The Development of Mathematics in China and Japan and Li Yan and Du Shiran's Chinese Mathematics, a Concise History.*

Phenomenology â€¦ in a nutshell The development of mathematics is intimately interwoven with the progress of civilization, influencing the course of history through its application to science and technology. But mathematics has changed. Even the mathematics of the s can seem quite strange now, so greatly has mathematics evolved in the past years and so thoroughly has it been reworked in the post-modern approach. Despite its arcane appearance from the outside looking in, the present, abstract and highly specialized state of mathematics is the natural evolution of the subject, and there is much ahead that is exciting. Here, then, is the story of mathematics, in a nutshellâ€¦ The Development of Mathematics, in a Nutshell Though mathematical knowledge is ancient, stretching back to the Stone Age , the evolution of mathematics to its current modern state has seen fundamental changes in concepts, organization, scope, outlook, and practice. Without understanding the evolution of mathematical thought, it is difficult to appreciate modern mathematics in its contemporary, highly specialized state. Seven Periods of Mathematical Practice Roughly speaking, I would identify seven periods in the evolution of mathematics, each with distinct characteristics. Proto-Mathematics from the mists of ancient time, through the archeological evidence of c. Proto-Mathematics The essence of mathematics, call it proto-mathematics, exists in empirical observations and interactions with the environment. Even the earliest man had need of basic mathematical understanding: Archaeological evidence for basic mathematical understanding e. This meant greater food with less work per capita, the impetus for greater specialization crafts , the growth of communities, the development of classes and heirarchies warrior, farmer , the growth of administration, and greater leisure. Writing allowed man to transmit his knowledge, to teach, and learn, and preserve what he had learned from generation to generation. Ancient Mathematics From empirical mathematics arose, through abstraction, the sciences of arithmetic number and geometry figure. These were developed into an extremely sophisticated science by the Babylonians and the Egyptians, and reached spectacular heights during their respective civilizations, applied to astronomy, the regulation of time, administration, planning and logistics, land surveying, calculation of areas and volumes, construction, and the engineering of incredible monuments. Each may have been viewed abstractly, and reasoning given, but the formal structure as a whole was absent. The knowledge and facility of Babylonian and Egyptian mathematics was quite sophisticated: Early Classical Mathematics The Greeks introduced to mathematics a fundamental abstraction: The view of mathematics was of a formal structure as a whole, held together by the laws of thought, with results organized into a linear body of work, each proved in terms of statements already accepted or proved, with the full understanding of the need for first principles, or axioms. The science of Geometry flourished under the Greeks, including applications to mechanics, machines, astronomy, and engineering, both Greek and Roman. Many challenging problems in curvilinear and solid geometry were obtained through methods of the Calculus: The Encountering of Paradox In the development of arithmetic and the number concept, the Greeks discovered early on the inadequacy of the common notion of number rational number to describe lengths. Indeed, a simple length, the diagonal of a square, eluded their common notion of number. This was the beginning of the discovery of paradoxes in the theory of mathematics. The fact that the diagonal and side of a square are logically incommensurable is not a problem of reality; it is a problem with the logical theory that had been developed: And here is this theory: And this theory blends arithmetic with geometry, number with measure. But the theory now, irrefutably, has a problem. These lengths are incommensurable. There is no rational number that can measure that length, no matter how small the scale of measurement is! This blew a fuse in the ancient Greek world and led to all kinds of intellectual searching to try to find the flaw, the problem. The key point to keep in mind, is that the problem is with construction of the mathematical theory. It is NOT an issue with the world, or with progress, or with science, or with engineering. In the real world, diagonals can be measured, no problem. In fact, all lengths can be measured up to the precision of the measuring instrument being used. Which means that all measurements are rational, and there is no practical difficulty. Given the complexities of the concept of number, trouble in attempting to expand it to cover all measurement existence of irrationals, etc. Numbers were regarded as useful, but with suspicion and not always reliable. This way of thinking led to geometry being supreme to the Greeks. But now a separation had clearly occurred between concrete and abstract mathematics, between practical science and engineering, and theoretical mathematics. The Resolution of the Paradox of Number The remedy for the problem of numbers is its expansion to include all Cauchy sequences of rational numbers, since these would be convergent so long as the point of their convergence existed. In this way can be filled in , for all primes , and, in principle, all numbers that can be approximated to indefinite precision i. This new and much larger domain of numbers is no longer a countable infinity but an uncountable infinity of numbers, as shown by Cantor. Late Classical Mathematics Algebra, the science of equations, was already well developed in Babylonian and Egyptian times. But it flourished during the Islamic era under Arabic and Central Asian mathematicians, as well as under the Indian mathematicians. Here it was that the modern notions of solution of algebraic expressions was developed into an algorithmic process by the Arabic and Central Asian mathematicians, and applied to astronomy, optics, engineering, and commerce. Mercantile Mathematics A flourishing trade and financial system had emerged during the thousand or so years of Islamic rule, first under the Baghdad and Damascus caliphs, then under the over-lordship of the Mongols, and finally under the courts of the Seljuk Turks. Computation, calculation, and other such practical mathematical matters, including negative numbers, were developed and flourishing in Arabia, Central Asia, India, and China. With the quickening of learning again in Europe during the Renaissance and the rise of the merchant states of Italy after the crusades, the mercantile mathematics of the Middle East and East arrived to Europe to revive arithmetic knowledge and the practical arts of computation. Under the resurgent interest in mathematics introduced in the mercantile period, further developments arose in arithmetic and algebra: Third and fourth degree polynomials were solved by radicals. The challenge was for higher degree polynomials. The Rise of the Notion of Functions It is at this point that the next major innovation is made in mathematics, one that unites arithmetic, geometry, algebra, and analysis. That notion is the notion of continuous function, its use in modeling physical and geometric situations, and its manipulations and analysis using algebra and arithmetic. This approach has been enormously fruitful, expanding the range of mathematics to all of science. The notion of function was developed out of the empirical observations and modeling, using functions, by Galileo, and its applications to the problems of geometry, analytic geometry, by Descartes and Fermat. The notions were deepened through the development of the analytic functions of trigonometry, logarithms, and exponential functions expanding the stable of functions away from the algebraic polynomials, radicals, and rational functions of classical algebra. These developments led to the watershed results of the calculus, namely the unification of the differential calculus problem of tangents , and the integral calculus problem of areas , and their applications in optimization, physics, and all manner of areas now rendered possible. The Pre-Modern Period Pre-modern mathematics is the relaxing of the synthetic classical geometry with the enhancement of the analytic geometrical methods and the rise of a symbolical algebra. Also, there was classical number theory without modern algebra, classical geometric analysis without limits or the infinitesimal calculus, classical complex numbers, classical probability theory. Though the Calculus was there, it was still viewed as a geometrical subject, with the attendant support of numerical computation and methods for derivation of otherwise geometrical phenomena. Euler was a transitional figure over the dividing line with modern mathematics during the first part of the s Euler. Modern Period The modern period of mathematics was characterized by the comprehensive and systematic synthesis of mathematical knowledge. It is remarkable for its uncovering of deep structural phenomena, and the generalization, unification, and synthesis of all of mathematics. Modern mathematics can be said to have been born in the s, and characterized by grappling with the challenges from the Classical period, as well with addditional disturbances that had been found and continued to be found with the theory of mathematics as then understood: What resulted was a rich development and re-working of mathematics: So modern mathematics is modern algebra, Galois theory of algebraic equations, modern number theory, analysis, set theory, complex variables, and Fourier analysis, etc.: Modern mathematics can be said to have been from the mid s to the early middle s, with mathematicians such as Cauchy, Weierstrass, Riemann, Dedekind, Bolzano, Cantor, and Hilbert, all establishing the language and patterns of thinking characteristic of modern mathematics. Though Laplace, Poisson, Gauss, Fourier, and Lagrange contributed to the establishment of many modern areas of investigation, in the late s and through the s, and uncovered important parts of the structures of modern mathematics, the form of their work and the style of their exposition would now appear archaic, being, as it usually was, in the style of pre-modern mathematics. Modern mathematics, though more unified, abstract, and diverse than the pre-modern mathematics, is still not the mathematics of today. Though the deeper structures of mathematical fields were being uncovered, they were not yet reflected in a standardized approach to its various areas. This is the legacy that has characterized the post-modern period. Post-Modern Period Contemporary mathematics is truly vast. The last time when it is said that one man could understand all of mathematics was perhaps in the s. That time has now long since gone and is not likely to return. The mathematics being practised today looks surprisingly different from the mathematics of even the early part of the s. Early in the post-modern period, the presentation of mathematics was thoroughly re-worked to reflect the deeper structures that have been discovered to permeate mathematics. Post-modern mathematics is thus characterized by the analytic and set theoretic language of mathematical practice and also by the modern algebraic. Consider topology, modern geometry very different than classical geometry , and all manner of modern abstractions, most of which are axiomatized, and the proceedings within which are axiomatic. Yes, there is an unabashed presentation of mathematics in terms of abstract definitions, axiomatized mathematical structures, and the investigation of the resulting objects, systems and their properties. But the state of modern abstract mathematics is a continuum along the natural evolution of the subject and body of knowledge. The opportunity for fruitful application to technology is enormous, and provided that the greater risk of misunderstanding in education can be addressed, there is much ahead that is exciting. Its Content, Methods and Meaning. Dover edition, ; mit press:

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