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Islam and Western contribution and achievements in the field of mathematics: A Comparative Study.

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ABSTRACT

Mathematics is known as queen of sciences by the West today, this slogan does not signify that this field has occupied an elevated position in Western scholarship. Other culture and past civilization have had a vibrant contribution to this field, Islam being at the fore front. This study as a result seeks to assess Islamic contribution to this field in the past and its influence on modern mathematics; showing similarities and differences. The study uses a descriptive analytical synthetic approach in the form of textual commentary. The study realizes the great contribution of Islam in the field of mathematics, which actually influenced modern mathematics to a greater extent, which influence is still vividly reflected on modern mathematical contribution, even though, in most cases not revealed. The Quran and Sunnah were the main drives which acted as an eye opener to Muslim contribution to this field, besides their benefit from other civilization especially the Indian civilization. The study realized that Muslim contribution to this field today is almost non-existent; making people sideline its contribution. Muslim institutions of learning need to reveal and emphasize this contribution to the young generation in order to revive in them the love of mathematics such that they will be able to contribute positively like their predecessors did.

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INTRODUCTION

It is un- believable that the most back-word are the teachers of the most advanced. Such a statement may be fitting when some ones looks at historical facts relating to scientific advancement. Facts must be said however irritating they may sound to the ears of those who deny their truthfulness. Indeed Muslims contributed enormously to the field of science in various ways, though, this is what is to be heard from contemporary Muslims which echoes their consolation, thus rendering themselves to weakening the more. The denial of some Western scientists and academicians in acknowledging Muslim's scientific contribution is unfortunate and unfair, because, there are documented historical evidences to support this claim. Even today, the traces of this contribution can be spotted. Muslim's contribution covered a wide range of fields ranging from al-Chemy to mathematics, one of the fields that mostly attracted Muslim's attention, though not an end to itself, but rather a means by which to accomplish so much else. The Islamic heritage in mathematics inherited a huge body of learning from earlier civilizations, which were rendered into Arabic during the ninth and tenth centuries, either directly from Greek or through the medium of Syriac. Hill (1990) avows that the Hellenistic sources were rendered into Arabic in the ninth and tenth centuries, either directly from the Greek or through the medium of Syriac, included most of the major works of Greek mathematics. Thus, the Elements and Data of Euclid, the Conics, the section of a ratio and the Determinate Solution of Appollonius of Perga were translated. Hills went ahead to elaborate that, of particular importance for Islamic Mathematics specifically mechanics, Archimedes, whose writings such as the Spheres, the Cylinder, and The Measurement of the Circle, The Equilibrium of Planes, and Floating Bodies were translated into Arabic. Another crucial factor according to Hill (1990) in the development of Islamic mathematics was assisted by the transmission of Indian mathematics into Islam. However, Hill (1990) clarifies that, the period of translation and initiation in the ninth century was succeeded by a time of creativity during which the translated material was progressively annotated, discussed and corrected. In fact Hill (1990) stressed that, Arabic writers were not afraid of disputing and in some cases correcting their results. This responds to the claims that, Muslims were mere regurgitations of knowledge from earlier

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civilization. It is undisputable that besides the Quran and Sunnah they utilized knowledge from other civilization, but it was assimilated with a critical mind. Mathematics is a vast subject with a lot of contributions from Muslims, which later influenced mathematics in the West and Indian Sub-continent. However, it important to make it clear at this moment that Muslim mathematics was an important tool in implementing and fulfilling their religious obligation; a major motivating factor in the development of mathematics. It is important to note that there was and still there is a close relationship between mathematics and religion in Islamic civilization, because it acted as a queen of all science, traditionally mathematics is present in every branch of knowledge compared to others. Thus, Muslims made an important contribution to mathematics, which was studied in close relation to religion, unlike modern mathematics, which is only interested in some aspects of mathematics whereby they only attach to it a utilitarian value. Therefore, the current study will deliberate on the position of mathematics in the Quran and God's visible activity in it, which acted as a major driving force in its development and in attracting the attention of Muslim scientists, a necessary tool, without which implementing some Islamic teachings would be impossible. This will calumniate into Muslim contributions in this field, by quoting selected cases, which will show the influence of Muslim mathematics to modern Western mathematics.

God the Supreme Mathematician:

Theologically speaking Allah is the supreme mathematician thus, now and then in the holy Quran covers aspects that are related to God's mathematical activities. Consequently, one of His attributes is the giver of shapes, or forms, or geometrical forms present in the natural world, God loves mathematical forms, which is exhibited in a number of ways. Allah says in the Quran; "*He is Allah, the Creator, The Originator, The Fashioner, to Him belongs the The Most Beautiful Names: whatever is in the heavens and on earth, doth declare His Praises and Glory: and he is the exalted in might, the Wise*"(Al-Quran 59:24). Thus, Allah is the sole giver of different kinds of forms, physical and non –physical and nothing comes before or after him. On this the Quran explicitly say: "*He is the First, the Last, the Evident and the Hidden, and he has full knowledge of all things (Al-Quran 57:3)".*

Besides Allah being the Giver of geometrical forms, he is also the Giver of proportions in relation to the creation of humans and other creatures as well. Allah says in the Quran: "*It is He who has created for you all things that are on earth; then he turned to the heaven and made them into seven firmaments and of all things he has perfect knowledge*"(*Al-Quran 2:59)* Allah again says: "*Who has created and further, given order and proportion" (Al-Quran 87:2).*

Another mathematical aspect is to be found in the Islamic principle of the Oneness of Allah on which the whole faith is built. This is mentioned in a number of verses, the chapter of *Ikhlas* being the most prominent, which the Prophet, God be pleased with him said that it constitutes a third of the whole Quran, simply because it is dealing with the unity of Allah, the fundamental principle of Islam as a religion. It says: "*Say: He is Allah, The One, Allah, the eternal, Absolute, He begetteth not, nor is He begotten, and there is none like unto Him*"(*Al-Quran 114: 1-4*)

Consequently, Nasr (1968) opined that number one signifies the singularity of God therefore it is not a number, but the generator of other numbers since one is present in each and every number, just like Allah's presence everywhere and in everything, hence, to know God we must know mathematics in order to understand *Tauhid*. Nasr (1968) continues to put in plain words that, Unity, the central idea of Islam is an obstruction from the human point of view; even-though in its self is concrete. Just as all figures are generated from the point, and all numbers from unity, so does all multiplicity came from the Creator, who is One. Thus, numbers and figures, as ontological aspects of unity and not merely as pure quantity, became vehicles for the expression of Unity in multiplicity.

In another Quranic verse Allah refers to Himself as a supreme accountant. The Quran says," *He will say: "What number of years did ye stay on earth*?" *They will say:"We stayed a day or part of a day; but ask those who keep account."*(*Al-Quran* 23:112-113) To elaborate on this more, Allah again says: "*That he may know that they have (truly) brought and delivered the messages of their Lord and He encompasses all that is with them, and takes account of every single thing"* (*Al-Quran 72:28).* Again Allah in another verse confirms his being the supreme accountant, he says: "*Then it will be us to call them to account*" *Al-Quran 88:36)*

The concept of balance is also evidence that God is a Supreme Mathematician which has a practical application in measuring weights. The Quran say: "*who has measured and granted guidance" (Al-Quran 87:3).* In another verse Allah deliberates on the concept of balance in clearer fashion. He says: "*Then, he whose balance (of good deeds) will be (found) heavy, will be in a life of good pleasure and satisfaction, But he whose balance (of good deeds) will be found light will have his home in a (bottomless) pit" (Al-Quran101:6-9)* To enlighten more on this, the Quran again says: "*Give full measure when you measure and weigh with a balance that is straight: that is better and fairer in the final determination"(Al-Quran*17:35)

The concept of limit is another clear evidence of Allah being the Supreme Mathematician. The Quran now and then worms against transgressing Allah's limits. The Quran says: "…*these are the limits ordained by Allah; so do not transgress them if any do transgress the limits ordained by Allah, such persons wrong (themselves as*

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well as others (Al-Quran 2:229). Allah further says: "*…provided they feel that they can keep the limits ordained by Allah. Such are the limits ordained by Allah, which He makes plain to those who know" (Al-Quran 2:230).*

The Spiritual Aspect of Mathematics:

It consequently follows that; it is not by guess that mathematics became one of the major fields of study that attracted the attention of Muslim scientists. Allah's being the Supreme Mathematician was enough motivation to the pursuing of this field. The Quality of Supreme Mathematician is further evidenced in religious practices given by Allah to people to fulfill the main obligation of their creation. To this effect, there are canonical rituals to be performed to accomplish the responsibility of a vicegerent. These constitute what is today known as the *Sharia*.

Without mathematics some aspects of *Sharia* would be difficult to implement. Therefore worship is related to mathematics, this is found in various forms of worship like canonical prayers, which must be done five times a day, whose direction of the *Kiblat* required mathematics in its determination. Mathematics also plays a crucial role in determining the timing of various forms of worship, like when to begin fasting and when to end, when to pray, when to go for pilgrimage, hence without mathematics certain aspects of Islamic law would be impossible to implement. Another clear example is that of inheritance, where Allah himself put the divisions in ratios as Quran 4, states; "*Allah (thus) directs you as regards your children's (inheritance): - to the male, a portion equal to that of two females: - if only daughters, two or more, their share is two-thirds of the inheritance; - if only one, her share is a half. For parents, a sixth share of the inheritance to each, if the deceased left children; if no children, - and the parents are the (only) heirs, the mother has a third; - if the deceased left brothers (or sisters), the mother has a sixth. (The distribution in all cases is) after the payment of legacies and debts. Ye know not whether your parents or your children are nearest to you in benefit. These are settled portions ordained by Allah and Allah is All-Knowing, All-Wise (Al-Quran 4:10-12).* Thus the most famous Muslim mathematician Muhammad Musa al-Hawarizm (c.780-850) created algebra to serve this purpose.

The giving of Alms is another aspect which is mathematical, whose percentage of 2.5% requires mathematical calculations, besides that the pillars of Islam involve mathematics too, they are five, a figure Muslims mathematicians considered the principle of balance, well as number one which signifies unity or *Tauhid* represents stability. Consequently, mathematics became an important tool in the application of Islamic law, thus, having a theological importance, unlike the modern mathematicians who only look at it as a calculation devise.

Muslim Contribution to Mathematics; Selected Cases:

It is true that Arabs of the Jahiliya period knew basic mathematics, like simple counting. Muslims developed mathematics after learning Indian mathematical numerals including zero. Besides that, Muslims developed decimals based on the idea of ten (10) to the application of Zero, which were adopted by the West through Hindu-Arab numerical system.

Hill (1990) asserts that Muslims contribution to mathematics is enormous and it can be traced in various aspects of even today's modern mathematics. One of the apparent major contributions was the division of mathematics into four divisions, arithmetic, geometry, astronomy and music. An Arab philosopher, Al-Kindi(ca.800-870 CE) too subscribes to this division, but a century later, mathematics had expanded and more branches of mathematics were added to it. Al-Farabi(ca.870-950) added optics, science of weights, engineers' devices, astronomy, today considered part of physics, even music was considered part of mathematics till the twentieth century when it was made an independent branch of mathematics.

Hill (1990), goes on to give facts that Muslim mathematicians arithmetically had three separate systems of numeration and calculation from their predecessors and successive generations worked hard to produce a unified system that was superior to any of the earlier ones. There were no integrated arithmetical work in Arabic regarded as canonical by all practitioners; rather, it was up to the mathematician to choose those elements that suited his purpose and inclinations, besides these numbers and algebraic quantities were expressed in words.

Geometry, like in the case of other branches of mathematics was introduced to the Arabs through the translation of Greek works especially that of Euclid's Elements and the Indian Siddhantas. Arabic scholars also made notable contribution to theoretical geometry. The most remarkable works of theory according to Hill (1990) are those of Jawhari (ninth century), of Abhari and Nyrizis (tenth century), of Ibn al-Hytham(c.956-c.1040) and Umar Khayyam (c.1048-1131) and Nasr al-Din al-Tus (c. 1201-1274). Hill (1990) went on to declare that, these works were translated into Latin and Hebrew and their influence is evident in Western treatises of late medieval and Renaissance times. Trigonometry is another area that occupied an important place in Muslim mathematics and it was this branch that Muslims made the greatest original contribution. It also constituted an important link with astronomy through the establishment of calendars and gnomics –the theory and practice of sundials, whose construction was wide spread throughout the Islamic world. According to Hill,

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the basis of Islamic trigonometry was in three works: the Indian Siddhanta, the Almagest of Ptolemy and the Spherics of Menelaus.

Hill (1990) concludes that the mathematicians of the Islamic world adopted these new trigonometric functions, studied their characteristics and found solutions for every problem in plane and spherical triangles. Muhammad b. Musa al-Khuwarazmi wrote a work on astronomy based upon Indian and Greek sources, which contained the first Arabic tables of sines and tangents.

Like any other branches of Islamic science, mathematics too benefited from other civilizations whose ideas were accessed through translations. On this, Hill (1990) elucidates that; the Caliph Harun al-Rashid (786-809) enlarged translation activity and put it on a more formal basis. Large collections of Greek manuscripts were in the booty of Amorium and Ankara. Other Greek books on the physical sciences were acquired by diplomatic requests to the Byzantine emperor.

The library, *Khizanat al-Hikma* (The Treasury of Knowledge), became a reference tool for astronomers and physicians, due to its size, Harun appointed al-Fadl son of Nawbakht as a librarian who at the same time acted as a translator of Persian works. Hill again clarifies that; Harun son of Ma'mun went far beyond his father in providing support for the translators of scientific work, which at that time were predominantly Greek in origin.

According to Thanvi (2003) Musa's three sons, known as the brothers were known for their engineering devises, while al-Batani(858 –929) is famous in the field of astronomy another branch of knowledge known as trigonometry as a result of practical consideration in astronomy. It deals with the use of angles, tangents; to mention but a few, although in al-Farabi's classification did not appear yet as an independent branch. Trigonometry included arithmetic, geometry algebra related to calculation of the unknown, applied to practical problems.

Thanvi further explains that Ikhwan al-Swaffah (The Brothers (Brethren) of Purity)(10th century CE) had an idea on music and theory of numbers. To them, numbers are not only quantities, but poses personalities and symbols as well, as result therefore *Ikhwan al-Swaffah* became famous in the philosophy of number personality, geometrical figures, etc, thus were known as philosophers of mathematics.

It is again elaborated by Thanvi that after the translation movement, the Muslims became more interested in mathematics. Al-Khawarizmi created a new branch of algebra, though as part of arithmetic other than an independent branch of mathematics. Al-Farabi too, contributed in systematizing mathematics into different branches, he applied science into mathematics, science of weights and engineering devise like water clocks, astronomical devise to measure time, which is today part of physics, though retained by Kutub Din Shirazi (1236 – 1311 ad) as part of mathematics.

Al-Khawarizmi is credited with the first treatise on Algebra;he solved the first and second degree of algebraic equations, known as quadratic equations, alongside introducing the geometrical method of solving these equations. In addition to that, al-Khawarizmi also recognized that quadratic equations have two roots. His method was continued by Thabit bin Qura(c. 826 - 901), who translated Ptolemy's work and developed and he was also the first to use Algebra in geometry. Thanvi(2003) continues to elucidate that, by the 11th century Muslims hand founded, developed and perfected geometrical Algebra and could solve equations of the third and fourth degree known as polynomials.

Thanvi (2003) further ungues that Al-Khawarizimi and his colleagues the Banu Musa (Abūjaʿfar, Muḥammad ibn Mūsā ibn Shākir (803 –873), Abū al-Qāsim, Aḥmad ibn Mūsā ibn Shākir (d. 9th century) and Al-Ḥasan ibn Mūsā ibn Shākir (d. 9th century), were scholars at the House of Wisdom in Baghdad. Their task involved the translation of Greek scientific manuscripts and they also studied, and wrote on, algebra, geometry and astronomy. Certainly, al-Khawarizimi worked under the patronage of al-Mamun (786 –833)and he dedicated two of his texts to the caliph. These were his treatise on algebra and his treatise on astronomy. The algebra treatise *Hisab al-jbrw'al-muqabala* was the most famous and most important of all of al-Khawarizimi's works. It is the title of this text where the term algebra is derived.

Another interesting episode is reported by Thanvi(2003)on Resen's comment on al-Khawarizmi's work. He commented that al-Khwarizimi intended to teach what was easiest and most useful arithmetic, such as men constantly require in cases of inheritance, legacies, partitions, and trade, and in all their dealings with one another, or where the measuring of lands, the diggings of canals, geometrical computations and other objects of various sorts and kinds are concerned.

According to Thanvi (2003), algebra was practical and intended to solve real life problems that were part of everyday life in the Islamic empire at that time; consequently, al-Khawarizimi observed that, when I consider what people generally want in calculating, I found that it is always a number. I also observed that every number is composed of units, and that any number may be divided into units. Moreover, I found that every number which may be expressed from one to ten surpasses the preceding by one unit: afterwards the ten is doubled or tripled in the same manner as the units were: thus arise twenty, thirty, etc. until a hundred: then the hundred is doubled and tripled in the same manner as the units and the tens, up to a thousand and so forth to the utmost limit of numeration.

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In addition to that al-Khwarizimi introduced the solutions of equations which are linear composed of units and squares. He continued to study algebra in *Hisab al-jabrw'al-muqabala* he examines the laws of arithmetic for his algebraic objects. It is interesting to note that al-Khwarizimi used only words to describe his expression no symbols were used. Al-Khwarizimi Algebra consists of applications and the work example. He went further to look for rules for finding the area of figures such as the circle and also finding the volume of solids such as sphere, cone and pyramid (Thanvi 2003).

Al-Karaki of the 11th century, give details (Thanvi,2003),that he is considered to be one of the greatest Muslim mathematicians. He composed one arithmetic book and another on Algebra, in which he developed an appropriate method of finding square- roots, a theory of indices, a theory of Mathematical induction and a theory of intermediate quadratic equations. Muslims excelled in geometry as well, which started with the transition of Euclid and conic section of Apolonios, which were preserved and new discoveries were made in this domain.

Al-Biruni(973-1048)a contemporary of Ibn Sina(c. 980 1037), used to correspond on a number of interesting scientific ideas, which included physics and astronomy, which became known to other parts of the world, during the tenth century, a century that witnessed a fast dissemination of scientific information. Al-Birun elaborates Thanvi (2003) could carry out complicated arithmetical and geometrical series and he could make mathematical games. He was also good in astronomy, especially in trigonometric measurement of heights of mountains.

Another great contribution in the field of mathematics as noted by Encyclopedia Britannica (1994) was that of Ibn al-Haitham(c. 965 – c. 1040)in the field of optics. A science of vision, concerned with how light affect image of things of human sight. He also found out that light travels in straight line; he also studied mathematical properties of light when it travels through the media of various materials. He utilized science of trigonometry in developing optics, thus applying the science of mathematics in optics.

Further still, Thanvi scrutinizes that Ibn al-Hytham wrote a book on geometrical optics, dealing with problems that would be difficult solving even now. He solved problems involving the pure geometry of conic sections, including the areas and the volumes of plane and solid figures formed from them, and also investigated the optical properties of mirrors made from conic section, he as well used the ancient technique of analysis to reduce the solution of problems to constructions involving conic section.

Ibn al-Hytham was also an outstanding figure of a Muslim mathematician. His writings are too extensive; he wrote around 92 works of which remarkably over 55 have survived. His major topics were optics, including a theory of light and a theory of vision, astronomy and mathematics including geometry and number theory. *Kitab al-Manazir*, seven-volume work optics is considered by many to be his most important contribution. This work begins with an introduction in which Ibn al-Hytham declared that he would begin with the inquiry into the principles and premises; hence, his methods involved criticizing premises and exercising caution in drawing conclusions.

Ibn al-Hytham makes it clear too that his investigation of light was to be based on experimental evidence rather than on obstruct theory. He noted that light is the same irrespective of the source. He gave the correction explanation of vision, showing that light is reflected from an object into the eye. His two of optics discusses visual perception while book one examines conditions necessary for good vision and how errors are caused. From a mathematical point of view book one discusses the theory of reflection, which includes experimental proof of the specula reflection of accidental as well as essential light, a complete formulation of the laws of reflection and a description of the construction and use a copper instrument for measuring reflections from plane, spherical, cylindrical and conical mirrors, whether convex or concave.

One of the mathematical problems ibn al-Hytham faced was the problem of squaring the circle. He wrote the work on the area of lunes, crescents formed from two intersecting circles, and then wrote the first two treatises on squaring the circle using lunes. His main purpose in analysis and synthesis was to study the methods mathematicians use to solve problems. The ancient Greeks used analysis to solve geometric problems, which ibn al-Hytham looked at as a more general mathematical method, which can be applied to other problems such as those in algebra. Thus, ibn al-Hytham realized that analysis was not an algorithm, which could automatically be applied using given rules, but he was of the opinion that the method requires intuition (Thanvi 2003).

Osman Bakar (1991) observes that Umar Khayyam (c.1048 –1131) made significant scientific contribution particularly to the field of geometry in his work entitled "*fi sharh ma ashakala min musadaratkitabUqlidus*" *(Concerning the Difficulties of Euclid's Elements)*In this treatise Khayyam criticized Euclid's theory of parallel lines and theory of ratios. Khayyam goes on in his treatise to r-examine the fifth postulate of Euclid concerning the parallel line theorem and tries to justify it by proposing and proving al-together eight theorems the most prominent of all being the theory of rations and proposition, on this he a significant contribution where he developed a new and more generalized concept of number by expanding the definitions provided by Eudoxos through the use of continuous fractions as a means of expressing ratios.

Thanvi (2003) agrees with Osman Baker (1991) and gives details that Khayyamwas an outstanding mathematician and astronomer in spite of the difficulties he faced during his time. He did write several works

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including problems of Arithmetic, a book on music and one of Algebra before the age of twenty-five years. After moving to Samarkand in Uzbekistan, he was supported by a prominent jurist thus, he wrote his most famous algebra work, which he termed as Treatise on Demonstration of Problems of Algebra. He also led the work of astronomical tables compilation as he contributed to calendar reform as well. Another great contribution of Khayyam was the measurement of the length of the year as 365.24219858156 days, which is outstandingly accurate. Besides that, Khayyam solved cubic equations for which he found positive root by considering the intersection of a rectangular hyperbola and a circle. Then an appropriate numerical solution was then found by interpolation in trigonometric tables. More remarkable still was when he stated that the solution of the cubic requires the use of conic sections and it could not be solved by ruler or compass methods.

One will realize that in the field of arithmetic Muslims used three different systems of numeration and calculations inherited from their predecessors, and successive generations of scholars tried their level best to produce a unified system, which was superior to any of the earlier ones. On the other hand, geometry encroaches on various sciences and technologies. Trigonometry is essential for astronomy, which is virtually an extension of geometry and geometrical proofs were applied to optics and algebra. Geometry was also applied to geodetic measurement and to land surveying, especially for fiscal purposes and for various transaction by landlords.

Trigonometry occupied an important place in Muslim mathematics and it was the branch to which Muslims made the greatest original contributions. It also constituted an important link with astronomy through the establishment of calendars and gnomics, the theory and practice of sundials- the construction of which was wide spread throughout the Islamic world.

The major distinguishing features between modern mathematics and Muslim mathematics is that modern mathematics is only interested in quantities of number which are used as a calculation devise, well as to Muslim mathematicians numbers poses quantities as well as qualities, for example number one (1) signifies the Oneness of Allah and all numbers are generated from one, this has an implication that Allah is present in each and every thing.

Muslim contribution to mathematics is worth mentioning, to which is clearly seen up to today in arithmetic according to Khaleel (2000) witting style of digits from right to left, which is originally Arabic. An illustrative example is the numeral for five thousands in English language which should be written as 0005, not as 5000 according to English's left-to right reading style. Irfan further asserts that, Muslim civilization also made a great contribution to fractions and the principles of errors, which is used to solve Algebra problems arithmetically. Besides that, Muslim scientists held this discipline in the highest esteem, due to their realization that its various branches formed the basis of the majority of sciences.

Another Muslim mathematician was Abu Kamil (c. 850 – c. 930) who certainly builds on the foundations of al-Khwarizimi and al-Karaji (953 - 1029) as an important links in his development of algebra. His book on algebra is divided into three parts: On the solution of quadratic equations, on applications of algebra to the regular pentagon and decagon and on Diophantine equations and problems of recreational mathematics. The content of the work is an application of algebra to geometrical problems; thus, it is a combination of the geometric methods developed by the Greeks together with the practical method developed by al-Khwarizimi. An important step in Abu Kamil's algebra is his ability to work with higher power of the unknown, which were not written in symbols but were written in words.

Kamil's book on surveying and geometry presents a number of rules for a given numerical solution of a geometric problem. Each rule is illustrated with a worked numerical example. Mainly the rules are for calculating the area, perimeter, and diagonals etc. of figures such as squares, rectangles, and various types of triangles. Abu Kamil also gave rules to calculate the volume and surface area of various solids such as rectangular parallelepipeds, right circular prisms, square pyramids and circular cones. The book of rare things in the art of calculation is concerned with solutions to intermediate equations.

Abu'l –Wafa(10 June 940 – 15 July 998)is another prominent Muslim mathematician. Like many scientists of that period, he translated and wrote commentaries on works of Euclid, Diophantus and al-Khwrizimi. He wrote a book entitled *Kitab fi ma yahtajilayh al-kuttabwa'l-ummal min 'ilm al-hisab* (Book on what is necessary from the science of arithmetic for scribes and businessmen). According to him, this book comprises all that an experienced or novice subordinate or chief in arithmetic needs to know, the art of civil servants, the employment of land taxes and all kinds of business needed in administration, proportions, multiplication, division, measurements, land taxes, distribution, exchange and all other practices used by various categories of men for doing business and which are useful to them in their daily life.

It is interesting that during this time they were two types of arithmetic books written; those using Indian symbols and those of finger -reckoning type to which Abul Wafa belonged and he wrote a book using the same system which he divided in seven chapters. Chapter one was about ratio, chapter two about multiplication and division; arithmetical operations with integers and fraction, chapter three measurements; areas of figures, volume of solids and finding distances, chapter four on taxes; different; kinds of taxes and tax calculation, chapter five on exchange and shares; types of crops and problems relating to their value and exchange, chapter

six miscellaneous topics; units of money, payment of soldiers, the granting and withholding of permits for ships on the river, merchant on the road and chapter seven further business topics.

Abu Wafa was the first to talk about negative numbers; he gave a general rule and a special case where subtraction of 5 from 3 gives a debt. He also wrote a book on geometric construction necessary for a craftsman, in which he talks about designing and testing instruments, the construction of right angles, approximate angle trisection, construction of parabolas, regular polygons, and methods of inscribing them, inscribing of various polygons in given polygons, the division of figures such as plane and the division of spherical surfaces into regular spherical polygons. Another interesting aspect is that Abu Wafa who tried to solve his problem with ruler and compass constructions, he is also well known for the first use of the tan function and compiling table of sines and tangents at 15' intervals, as he devised new methods of calculating sine tables, his trigonometric tables are accurate 8 decimal places.

Conclusion:

The major distinguishing features between modern mathematics and Muslim mathematics is that modern mathematics is only interested in quantities of number which are used as a calculation devise, well as to Muslim mathematicians numbers poses quantities as well as qualities, for example number one (1) signifies the Oneness of Allah and all numbers are generated from one, this has an implication that Allah is present in each and every thing. Thus, mathematics is a necessary tool in the implementation of religious obligations without which these obligations will not be fulfilled, something that will indicate a failure on the side of a servant to his Lord.

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