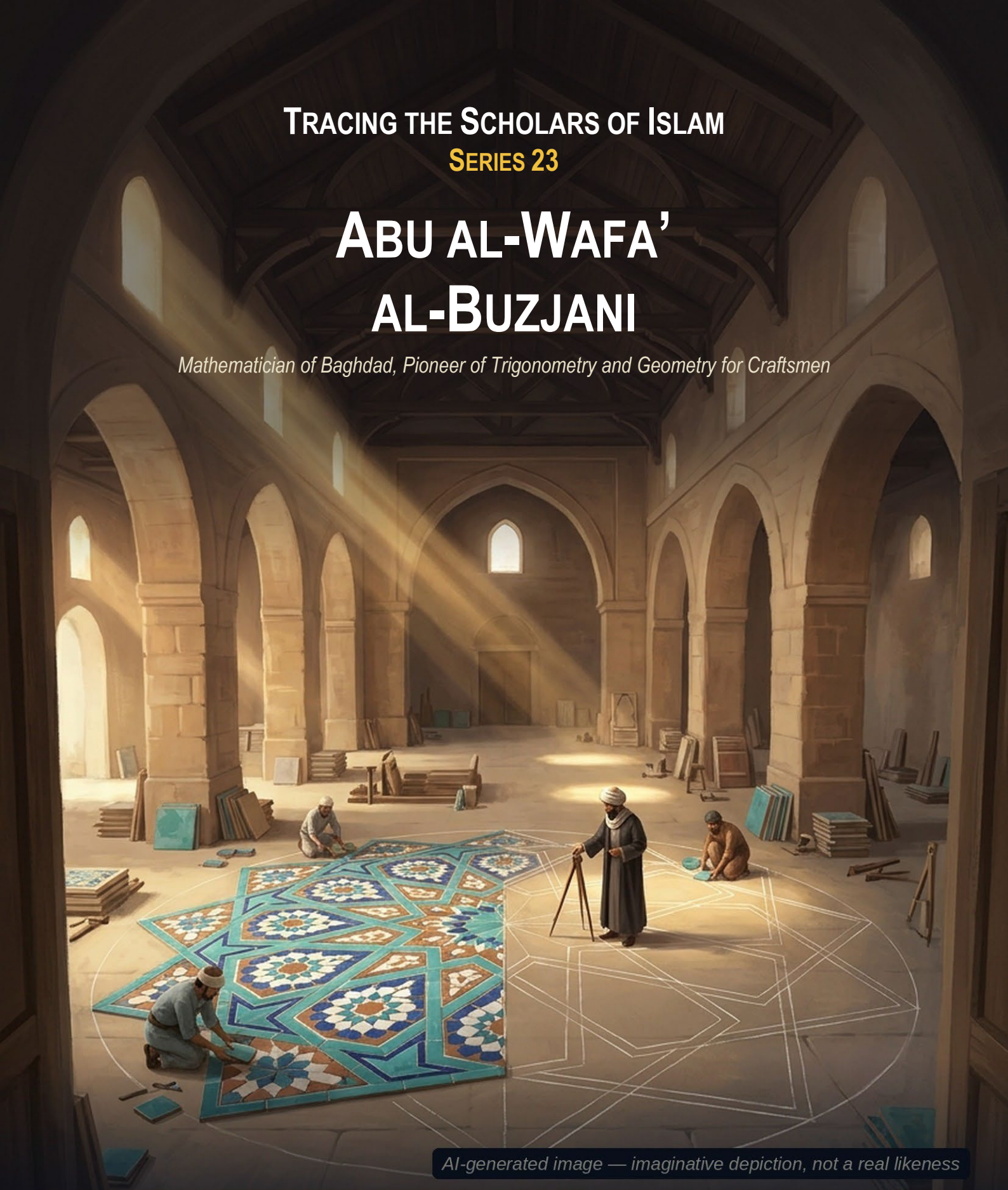
Tracing the Scholars of Islam

Series 23

Abu al-Wafa' al-Buzjani

Mathematician of Baghdad, Pioneer of Trigonometry and Geometry for Craftsmen



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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

TRACING THE SCHOLARS OF ISLAM

SERIES 23

ABU AL-WAFA' AL-BUZJANI

Mathematician of Baghdad, Pioneer of Trigonometry and Geometry for Craftsmen

إِنَّا كُلَّ شَيْءٍ خَلَقْنَٰهُ بِقَدَرٍ

"Indeed, all things We created with predestination."

SURAH AL-QAMAR 54:49

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ACKNOWLEDGEMENT

All praise is due to Allah, who created all things in precise measure. Blessings and peace be upon the Messenger of Allah ﷺ, and upon his family and his Companions.

This eBook is specially dedicated to my beloved wife,

ZAHARAH MOHD LATIF;

my dear children,

MUHAMMAD HAFIZ, NOOR HAZWANI, ABDUL HAKIM, NOOR HIDAYAH, NOR AQILA and **NOR ATIQAH**;

and my sons- and daughters-in-law,

FAZILAH, MALEK, HANIN, FAIRIZAL and **FIRWAN**.

This twenty-third book of Tracing the Scholars of Islam tells the story of a mathematician who wrote for astronomers, scribes and craftsmen. May his story show that advanced knowledge can be made simple and useful for everyone.

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ABOUT THE COVER OF THIS EBOOK

The cover of this eBook is an **image generated by artificial intelligence (AI)** — an ***imaginative depiction, not a real likeness*** of Abu al-Wafa'. This label is also printed on the cover. This time the picture is a **wide shot**, taken from the doorway of a great hall in Baghdad, with every figure small.

On the floor, **craftsmen** are laying a **geometric star pattern** in turquoise, cobalt, white and terracotta tiles. Half is already tiled; the other half is still **chalk lines** and **compass arcs** — a symbol of his book on ***geometry for craftsmen***.

Abu al-Wafa' stands in the middle of the pattern with a **wooden compass**, pointing out the lines to the craftsmen. **Sunlight** from high windows lights up knowledge turned into art.

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Colour guide: green box = verses of the Qur'an; gold box = Hadith; brown box = history note (reports from the books of history and biography); blue table = comparison. Underlined blue narrator names can be clicked to open the narrator's page on sunnah.com.

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ABU AL-WAFA' AL-BUZJANI

The twenty-third book of **Tracing the Scholars of Islam** tells the story of ***Abu al-Wafa' Muhammad ibn Muhammad ibn Yahya al-Buzjani***, a mathematician and astronomer in ***Baghdad*** in the 10th century CE. He advanced ***trigonometry***, including the ***tangent function***, and wrote a book of ***geometry for craftsmen*** — a foundation for the geometric patterns that adorn mosques.

He wrote for ***three groups***: astronomers, scribes and merchants, and craftsmen. Advanced knowledge was made ***simple and useful***.

This eBook explains the knowledge he left behind: ***sine tables***, ***the tangent and shadows***, ***spherical trigonometry*** that helps determine ***the qiblah and prayer times***, ***the eclipse in two cities***, ***arithmetic for merchants***, the ***geometric patterns*** of mosques, and on to modern technology such as ***GPS***.

Note: The translation of Qur'anic verses in this eBook is that of Sahih International. The grading of each Hadith is stated in the Hadith box. Information from books of history and modern research is **biographical narration (not Hadith)** *and is placed in the brown "History Note" boxes. A cover image that shows the scholar is an AI-generated image and is marked as such.*

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ALL THINGS ACCORDING TO MEASURE

SURAH AL-QAMAR 54:49

إِنَّا كُلَّ شَيْءٍ خَلَقْنَٰهُ بِقَدَرٍ ﴿٤٩﴾

Indeed, all things We created with predestination.

Translation: Sahih International — quran.com/54:49

Allah says: ***"Indeed, all things We created with predestination"***. Everything created has ***precise measure***. Tafsir Ibn Kathir 54:49.

SURAH AL-MULK 67:3

ٱلَّذِى خَلَقَ سَبْعَ سَمَٰوَٰتٍ طِبَاقًا ۖ مَّا تَرَىٰ فِى خَلْقِ ٱلرَّحْمَٰنِ مِن تَفَٰوُتٍ ۖ فَٱرْجِعِ ٱلْبَصَرَ هَلْ تَرَىٰ مِن فُطُورٍ ﴿٣﴾

[And] who created seven heavens in layers. You do not see in the creation of the Most Merciful any inconsistency. So return [your] vision [to the sky]; do you see any breaks.

Translation: Sahih International — quran.com/67:3

There is no ***"inconsistency"*** in the creation of the Most Merciful. The geometric patterns of Islamic art — symmetry, balance and repetition — are a reflection on the ***order of creation***.

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DETERMINED WITH PRECISE DETERMINATION

SURAH AL-FURQAN 25:2

ٱلَّذِى لَهُۥ مُلْكُ ٱلسَّمَٰوَٰتِ وَٱلْأَرْضِ وَلَمْ يَتَّخِذْ وَلَدًا وَلَمْ يَكُن لَّهُۥ شَرِيكٌ فِى ٱلْمُلْكِ وَخَلَقَ كُلَّ شَىْءٍ فَقَدَّرَهُۥ تَقْدِيرًا ۝٢

He to whom belongs the dominion of the heavens and the earth and who has not taken a son and has not had a partner in dominion and has created each thing and determined it with [precise] determination.

Translation: Sahih International — quran.com/25:2

Allah ***"determined it with [precise] determination"***. The word ***qaddara*** (to set the measure) shows that the universe is built with fixed ***proportions and ratios***. Tafsir Ibn Kathir 25:2.

That is why nature can be ***measured***. Mathematicians such as Abu al-Wafa' did not invent those measures — they ***discovered*** the measures Allah had set, and wrote them down as numbers and tables.

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THE SUN AND MOON BY CALCULATION

SURAH AR-RAHMAN 55:5

ٱلشَّمۡسُ وَٱلۡقَمَرُ بِحُسۡبَانٍ ۝٥

The sun and the moon [move] by precise calculation.

Translation: Sahih International — quran.com/55:5

Allah says: ***"The sun and the moon [move] by precise calculation"***. Because their motion is ***constant***, people can ***calculate*** it. Tafsir Ibn Kathir 55:5.

SURAH YUNUS 10:5

هُوَ ٱلَّذِي جَعَلَ ٱلشَّمۡسَ ضِيَآءٗ وَٱلۡقَمَرَ نُورٗا وَقَدَّرَهُۥ مَنَازِلَ لِتَعۡلَمُواْ عَدَدَ ٱلسِّنِينَ وَٱلۡحِسَابَۚ مَا خَلَقَ ٱللَّهُ ذَٰلِكَ إِلَّا بِٱلۡحَقِّۚ يُفَصِّلُ ٱلۡأٓيَٰتِ لِقَوۡمٖ يَعۡلَمُونَ ۝٥

It is He who made the sun a shining light and the moon a derived light and determined for it phases - that you may know the number of years and account [of time]. Allah has not created this except in truth. He details the signs for a people who know.

Translation: Sahih International — quran.com/10:5

Allah set the courses of the sun and moon ***"that you may know the number of years and account [of time]"***. This verse makes ***calculation*** (hisab) part of the purpose of creating the sun and moon. Tafsir Ibn Kathir 10:5.

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THE SUN AND MOON FOR CALCULATION

SURAH AL-AN'AM 6:96

فَالِقُ ٱلۡإِصۡبَاحِ وَجَعَلَ ٱلَّيۡلَ سَكَنٗا وَٱلشَّمۡسَ وَٱلۡقَمَرَ حُسۡبَانٗاۚ ذَٰلِكَ تَقۡدِيرُ ٱلۡعَزِيزِ ٱلۡعَلِيمِ ٩٦

[He is] the cleaver of daybreak and has made the night for rest and the sun and moon for calculation. That is the determination of the Exalted in Might, the Knowing.

Translation: Sahih International — quran.com/6:96

Allah made ***"the sun and moon for calculation"***. The word ***husbana*** in this verse comes from the same root as ***hisab***. Tafsir Ibn Kathir 6:96.

Muslim astronomers such as Abu al-Wafa' needed ***trigonometry*** to calculate the positions of the sun and moon precisely — to determine ***prayer times***, ***the direction of the qiblah*** and ***the start of the Hijri months***.

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BACKGROUND: FROM BUZJAN TO BAGHDAD

Abu al-Wafa' was born in ***Buzjan***, a small town in ***Khurasan*** (now in eastern Iran, near the border with Afghanistan). Khurasan at that time produced many scholars and scientists.

> **HISTORY NOTE: BAGHDAD UNDER THE BUYIDS**
>
> In ***945 CE***, the ***Buyid*** family took control of Baghdad. Although the power of the Abbasid caliphs had weakened, the Buyid amirs patronised scholars, physicians and mathematicians.
>
> The amir ***'Adud al-Dawla*** built the 'Adudi Hospital, and his son ***Sharaf al-Dawla*** ordered the building of an ***observatory*** in his palace garden in Baghdad in ***988 CE***.

THE OBSERVATORY OF SHARAF AL-DAWLA

At that observatory, Abu al-Wafa' worked with ***Abu Sahl al-Quhi*** and other astronomers to observe ***the motion of the sun*** and the ***solstices***. A large ***wall quadrant*** is said to have been built for those observations.

Observatories like this were the ***science laboratories*** of their age — places where mathematics was tested against observation of the sky.

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CONTEMPORARIES

SCHOLAR	CONTRIBUTION
Abu Sahl al-Quhi	Geometry, centres of gravity and observation at the Baghdad observatory.
Ibn Sahl (Book 22)	The law of refraction and burning lenses (c. 984 CE).
Abu Nasr Mansur	Spherical trigonometry; teacher of al-Biruni.
Abu Mahmud al-Khujandi	Built a giant sextant at Rayy to observe the tilt of the earth's axis.
Al-Biruni	Partner in the eclipse observation of 997 CE; encyclopaedic scientist.

Abu al-Wafa' lived in ***the golden age of trigonometry***. Many scholars worked on the same problems, ***commenting on and improving*** each other's work.

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WHO WAS ABU AL-WAFA'?

Abu al-Wafa' was ***born on 10 June 940 CE*** in ***Buzjan***, Khurasan. At the age of ***20***, he moved to ***Baghdad***, where he lived until his death in ***997 or 998 CE***.

HISTORY NOTE: UNDER BUYID PATRONAGE

The Buyid rulers of Baghdad were great patrons of learning. Abu al-Wafa' observed at the ***Bab al-Tibn*** observatory, and later ***helped build a new observatory*** ordered by Amir ***Sharaf al-Dawla***, together with the instrument maker ***al-Kuhi***.

He wrote about ***22 books and treatises***, of which about eight survive — including commentaries on the works of Euclid, Diophantus and al-Khwarizmi (see Book 18).

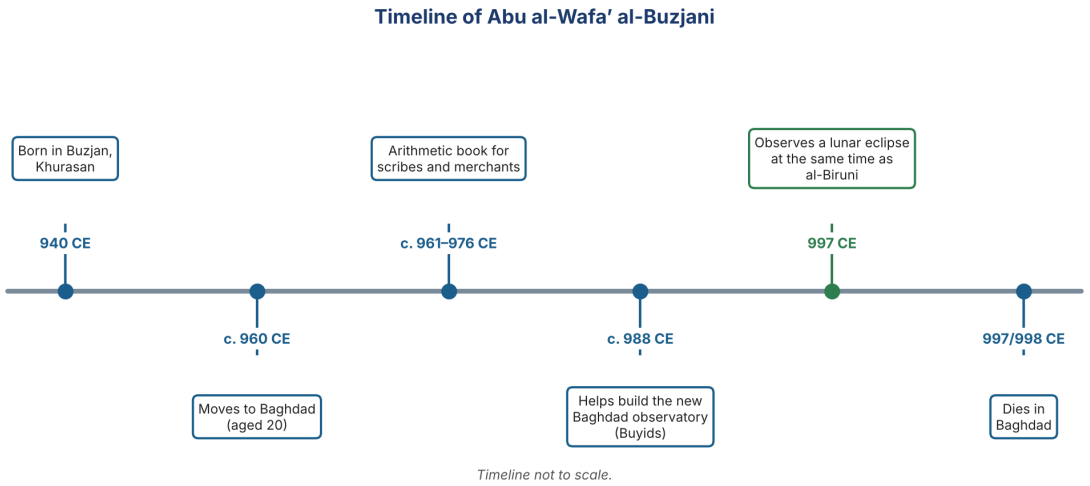


Figure 1: Timeline of Abu al-Wafa' al-Buzjani.

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MAJOR WORKS

WORK	DESCRIPTION
al-Majisti	A book of astronomy and trigonometry; defines the tangent function and sine tables.
Arithmetic for scribes and officials	Written between 961–976 CE for taxes, weights and trade.
Geometry for craftsmen	Methods for drawing geometric figures with ruler and compass.
al-Zij al-Wadih	Astronomical tables; now lost.
Commentaries on Euclid, Diophantus and al-Khwarizmi	Explaining and improving the works of earlier mathematicians.

The name ***al-Buzjani*** refers to his birthplace. In Europe his name is spelled ***Abul Wafa***, and a ***crater on the Moon*** is now named after him.

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TRIGONOMETRY: THE LANGUAGE OF ANGLES

Trigonometry is the science of the relationship between ***angles and side lengths*** in triangles (Britannica: trigonometry). It lets us measure what ***cannot be reached*** — the height of a mountain, the distance of a star, or the width of a river.

In his book ***al-Majisti***, Abu al-Wafa' ***used the tangent function systematically*** and defined ***all six trigonometric functions*** — sine, cosine, tangent, cotangent, secant and cosecant — and the relationships between them.

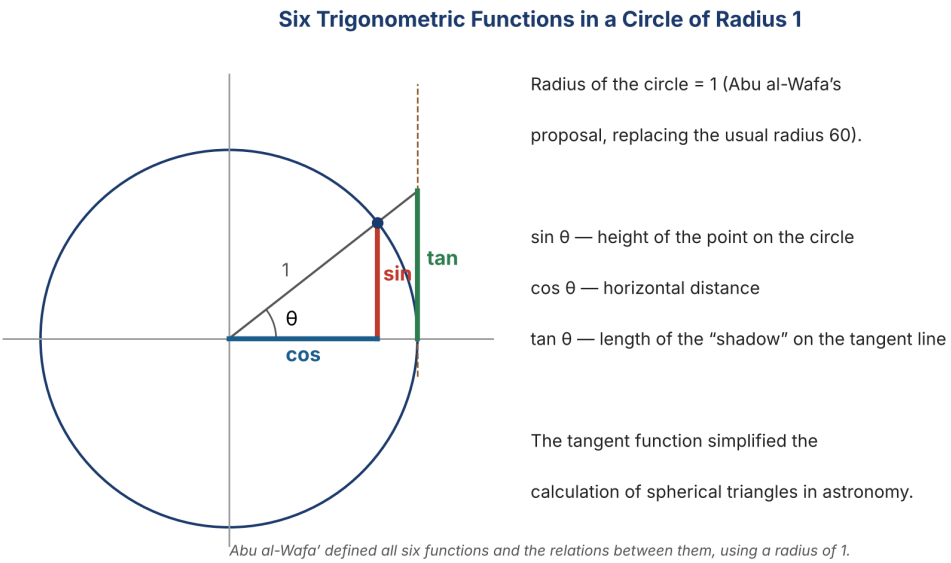


Figure 2: Trigonometric functions in a circle of radius 1.

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THE SIX TRIGONOMETRIC FUNCTIONS

FUNCTION	MEANING IN A RIGHT-ANGLED TRIANGLE
Sine (sin)	Opposite side ÷ hypotenuse
Cosine (cos)	Adjacent side ÷ hypotenuse
Tangent (tan)	Opposite side ÷ adjacent side
Cotangent (cot)	Adjacent side ÷ opposite side
Secant (sec)	Hypotenuse ÷ adjacent side
Cosecant (cosec)	Hypotenuse ÷ opposite side

The word ***sine*** itself comes from the Latin translation of the Arabic word ***jayb*** — evidence that trigonometry reached Europe ***through Arabic books***.

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A PRECISE TABLE OF SINES

Before calculators existed, astronomers relied on ***tables*** — lists of sine values for every angle. The closer the intervals and the more precise the values, the more accurate the astronomical calculations.

Abu al-Wafa' devised ***a new method of compiling sine tables*** at intervals of ***15 minutes of arc*** (a quarter of a degree), with greater accuracy than before, and used ***a radius of 1*** — a convention later followed by al-Biruni and still used today (MacTutor: Abu'l-Wafa).

SAMPLE SINE VALUES

ANGLE	SINE VALUE (RADIUS 1)
0°	0
30°	0.5
45°	c. 0.7071
60°	c. 0.8660
90°	1

LESSON

A precise table is built ***little by little***, value by value. Patience in small tasks produces ***great precision***.

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THE TANGENT AND SHADOWS

The ***tangent*** function grew out of the study of ***shadows***. Muslim astronomers used a ***gnomon*** (an upright rod) and measured the length of its shadow to find ***the altitude of the sun***. Shadow tables had been compiled earlier by ***Habash al-Hasib*** (9th century CE), and Abu al-Wafa' arranged them ***systematically*** as a trigonometric function.

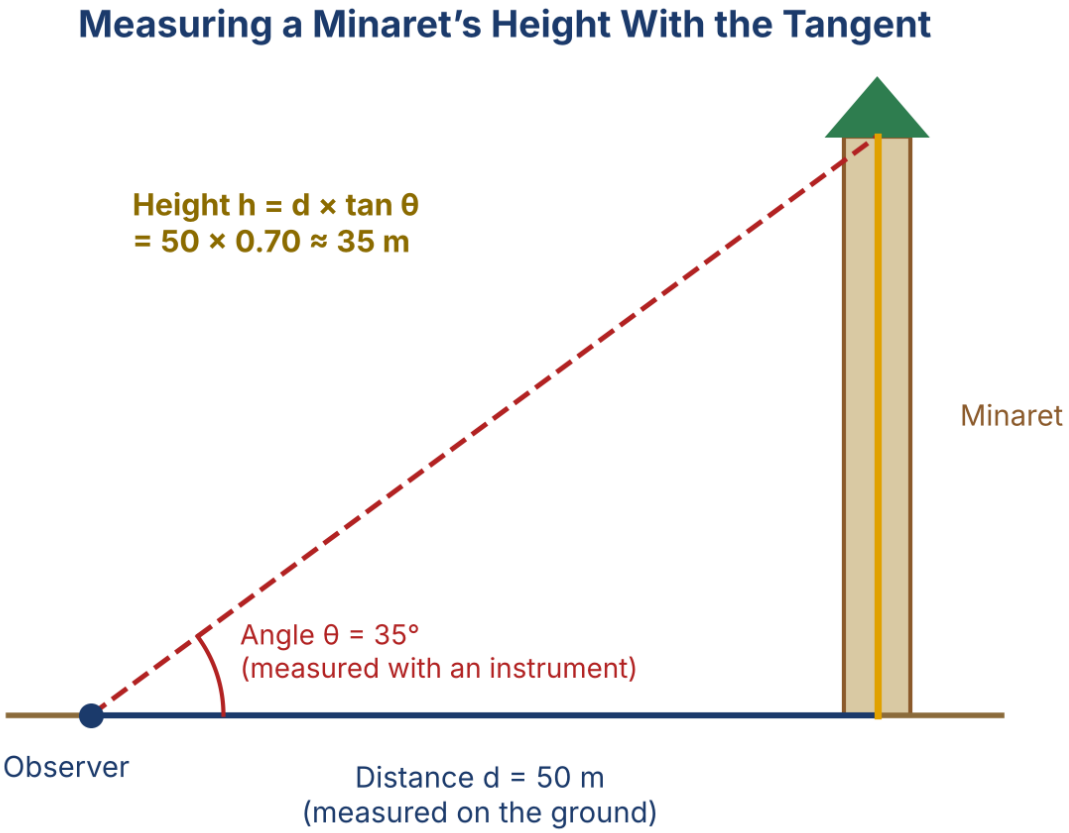


Figure 3: Measuring the height of a minaret with the tangent.

With the tangent, we can measure ***the height of a minaret*** without climbing it: measure the distance to its base and the angle to its top, then multiply the distance by the tangent of that angle.

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USES OF THE TANGENT TODAY

FIELD	USE
Engineering	Calculating the slope of roads, roofs and stairs.
Surveying	Measuring the height of buildings and hills from a distance.
Aviation	Calculating an aircraft's landing angle.
Islamic astronomy	Calculating shadow lengths for the times of Zuhr and 'Asr.

The shadows we see every day hold ***mathematical secrets***. Abu al-Wafa' turned those shadows into ***precise measuring tools***.

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SPHERICAL TRIGONOMETRY AND THE QIBLAH

SURAH AL-BAQARAH 2:144

قَدْ نَرَىٰ تَقَلُّبَ وَجْهِكَ فِي ٱلسَّمَآءِ ۖ فَلَنُوَلِّيَنَّكَ قِبْلَةً تَرْضَىٰهَا ۚ فَوَلِّ وَجْهَكَ
شَطْرَ ٱلْمَسْجِدِ ٱلْحَرَامِ ۚ وَحَيْثُ مَا كُنتُمْ فَوَلُّوا۟ وُجُوهَكُمْ شَطْرَهُۥ ۗ وَإِنَّ ٱلَّذِينَ
أُوتُوا۟ ٱلْكِتَٰبَ لَيَعْلَمُونَ أَنَّهُ ٱلْحَقُّ مِن رَّبِّهِمْ ۗ وَمَا ٱللَّهُ بِغَٰفِلٍ عَمَّا يَعْمَلُونَ ﴿١٤٤﴾

We have certainly seen the turning of your face, [O Muhammad], toward the heaven, and We will surely turn you to a qiblah with which you will be pleased. So turn your face toward al-Masjid al-Haram. And wherever you [believers] are, turn your faces toward it [in prayer]. Indeed, those who have been given the Scripture well know that it is the truth from their Lord. And Allah is not unaware of what they do.

Translation: Sahih International — quran.com/2:144

Allah commands: ***"wherever you [believers] are, turn your faces toward it"***. For Muslims living far from Makkah, determining the ***direction of the qiblah*** precisely requires knowledge. Tafsir Ibn Kathir 2:144.

The earth is a ***sphere***, so the shortest direction to Makkah follows ***a great-circle arc***, not a straight line on a flat map. This problem is solved with ***spherical trigonometry*** — a field advanced by Abu al-Wafa' and his colleagues (Britannica: spherical trigonometry).

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THE SPHERICAL LAW OF SINES

Abu al-Wafa' is associated with the ***law of sines for spherical triangles***: in a triangle on the surface of a sphere, the ratio of the sine of a side to the sine of the opposite angle is ***the same*** for all three sides. This law simplifies the calculation of the qiblah and the positions of stars.

THE QIBLAH IN MALAYSIA

For Peninsular Malaysia, the qiblah is about ***292°–293° from north*** (measured clockwise), that is, towards the north-west (Wikipedia: Qibla). This precision is ***a fruit of the knowledge*** inherited from Muslim astronomers.

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PRAYER TIMES AND ASTRONOMY

Prayer times are determined by ***the position of the sun***. The Messenger of Allah ﷺ explained the limits of the prayer times:

HADITH — SAHIH MUSLIM, NO. 612

حَدَّثَنَا أَبُو غَسَّانَ الْمِسْمَعِيُّ، وَمُحَمَّدُ بْنُ الْمُثَنَّى، قَالاَ حَدَّثَنَا مُعَاذٌ، - وَهُوَ ابْنُ هِشَامٍ - حَدَّثَنِي أَبِي، عَنْ قَتَادَةَ، عَنْ أَبِي أَيُّوبَ، عَنْ عَبْدِ اللَّهِ بْنِ عَمْرٍو، أَنَّ نَبِيَّ اللَّهِ صلى الله عليه وسلم قَالَ «إِذَا صَلَّيْتُمُ الْفَجْرَ فَإِنَّهُ وَقْتٌ إِلَى أَنْ يَطْلُعَ قَرْنُ الشَّمْسِ الأَوَّلُ ثُمَّ إِذَا صَلَّيْتُمُ الظُّهْرَ فَإِنَّهُ وَقْتٌ إِلَى أَنْ يَحْضُرَ الْعَصْرُ فَإِذَا صَلَّيْتُمُ الْعَصْرَ فَإِنَّهُ وَقْتٌ إِلَى أَنْ تَصْفَرَّ الشَّمْسُ فَإِذَا صَلَّيْتُمُ الْمَغْرِبَ فَإِنَّهُ وَقْتٌ إِلَى أَنْ يَسْقُطَ الشَّفَقُ فَإِذَا صَلَّيْتُمُ الْعِشَاءَ فَإِنَّهُ وَقْتٌ إِلَى نِصْفِ اللَّيْلِ».

TRANSLATION:

'Abdullah ibn 'Amr رضى الله عنهما reported that the Prophet of Allah ﷺ said: **"When you pray Fajr, its time lasts until the first edge of the sun rises. When you pray Zuhr, its time lasts until 'Asr comes. When you pray 'Asr, its time lasts until the sun turns yellow. When you pray Maghrib, its time lasts until the twilight disappears. When you pray 'Isha', its time lasts until half the night."**

CHAIN OF NARRATION: Narrated by Imam Muslim: from Abu Ghassan al-Misma'i and Muhammad ibn al-Muthanna, from Mu'adh (ibn Hisham), from his father (Hisham ad-Dastuwa'i), from Qatadah, from Abu Ayyub (al-Maraghi), from 'Abdullah ibn 'Amr رضى الله عنهما.

REFERENCE: Narrated by Imam Muslim in Sahih Muslim, Book of Mosques and Places of Prayer, Hadith No. 612.

GRADE: SAHIH — contained in Sahih Muslim, the second most authentic book of Hadith after Sahih al-Bukhari.

Source: https://sunnah.com/muslim:612a

LESSONS FROM THIS HADITH

Each prayer time is linked to ***a solar phenomenon***: sunrise, the sun passing its zenith, yellowing, sunset and the disappearance of the twilight glow. To calculate these times in advance for every city, astronomers need ***spherical trigonometry***.

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THE SHADOW OF 'ASR

According to the Shafi'i school, the time of 'Asr begins when ***the shadow of an object equals its length*** (plus its shadow when the sun passed its zenith). This calculation is ***a tangent problem*** — just like the shadow tables studied by Abu al-Wafa'.

Today prayer timetables in Malaysia are calculated with trigonometric formulas based on the ***latitude and longitude*** of each zone. Every time we look at a prayer timetable, we see ***the legacy of Islamic astronomy***.

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AN UNLETTERED NATION AND CALCULATION

The Messenger of Allah ﷺ said that his community at that time was ***unlettered*** — neither writing nor calculating:

HADITH — SAHIH AL-BUKHARI, NO. 1913

حَدَّثَنَا آدَمُ، حَدَّثَنَا شُعْبَةُ، حَدَّثَنَا الأَسْوَدُ بْنُ قَيْسٍ، حَدَّثَنَا سَعِيدُ بْنُ عَمْرٍو، أَنَّهُ سَمِعَ ابْنَ عُمَرَ ـ رضى الله عنهما ـ عَنِ النَّبِيِّ صلى الله عليه وسلم أَنَّهُ قَالَ «إِنَّا أُمَّةٌ أُمِّيَّةٌ، لاَ نَكْتُبُ وَلاَ نَحْسُبُ الشَّهْرُ هَكَذَا وَهَكَذَا». يَعْنِي مَرَّةً تِسْعَةً وَعِشْرِينَ، وَمَرَّةً ثَلاَثِينَ.

TRANSLATION:

Ibn 'Umar رضى الله عنهما narrated that the Prophet ﷺ said: **"We are an unlettered nation; we neither write nor calculate. The month is like this and like this"** — meaning sometimes twenty-nine days and sometimes thirty.

CHAIN OF NARRATION: Narrated by Imam al-Bukhari: from Adam ibn Abi Iyas, from Shu'bah, from al-Aswad ibn Qays, from Sa'id ibn 'Amr, from 'Abdullah ibn 'Umar رضى الله عنهما.

REFERENCE: Narrated by Imam al-Bukhari in Sahih al-Bukhari, Book of Fasting (Kitab as-Sawm), Hadith No. 1913; also narrated by Muslim (No. 1080).

GRADE: SAHIH — contained in Sahih al-Bukhari, the most authentic book of Hadith after the Qur'an by consensus of the Hadith scholars.

Source: https://sunnah.com/bukhari:1913

LESSONS FROM THIS HADITH

This Hadith explains that ***the start of the month*** is determined in a way that is easy for everyone — ***sighting the new moon*** — and that a Hijri month is either ***29 or 30 days***. It is ***not a prohibition*** on learning calculation, for the Qur'an itself mentions the purpose of "knowing the number of years and the account".

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SURAH AL-ISRA' 17:12

وَجَعَلْنَا ٱلَّيْلَ وَٱلنَّهَارَ ءَايَتَيْنِ ۖ فَمَحَوْنَآ ءَايَةَ ٱلَّيْلِ وَجَعَلْنَآ ءَايَةَ ٱلنَّهَارِ مُبْصِرَةً
لِّتَبْتَغُوا۟ فَضْلًا مِّن رَّبِّكُمْ وَلِتَعْلَمُوا۟ عَدَدَ ٱلسِّنِينَ وَٱلْحِسَابَ ۚ وَكُلَّ شَىْءٍ
فَصَّلْنَٰهُ تَفْصِيلًا ﴿١٢﴾

And We have made the night and day two signs, and We erased the sign of the night and made the sign of the day visible that you may seek bounty from your Lord and may know the number of years and the account [of time]. And everything We have set out in detail.

Translation: Sahih International — quran.com/17:12

Allah made the night and day two signs so that you ***"may know the number of years and the account [of time]"***. Tafsir Ibn Kathir 17:12.

A community that was once unlettered went on to produce ***some of the world's greatest mathematicians*** — al-Khwarizmi, Abu al-Wafa' and al-Biruni. Knowledge came ***with Islam***, not against it.

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AN ECLIPSE IN TWO CITIES

HISTORY NOTE: THE COLLABORATION OF ABU AL-WAFA' AND AL-BIRUNI

In ***997 CE***, Abu al-Wafa' in ***Baghdad*** and ***al-Biruni*** in ***Kath*** (Khwarazm) agreed to ***observe the same lunar eclipse*** at the same time.

By comparing the ***local times*** of the eclipse in the two cities, they calculated the ***difference in longitude*** between Baghdad and Kath — about ***one hour***, very close to the modern value.

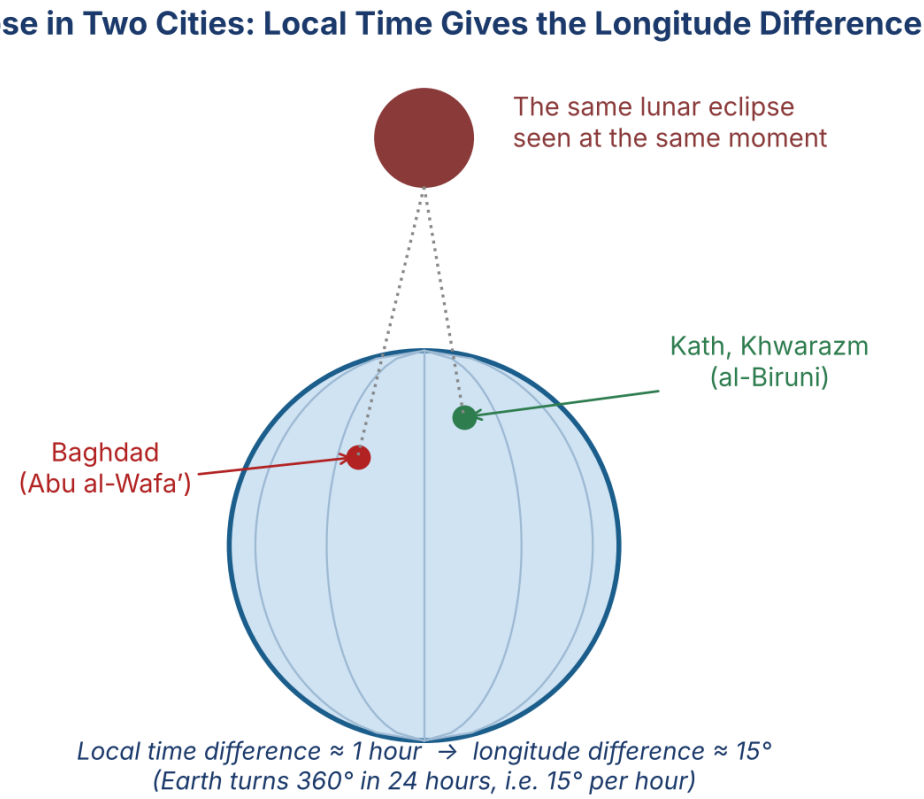


Figure 4: The same lunar eclipse gives the longitude difference between two cities.

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WHY DOES ONE HOUR EQUAL 15°?

The earth turns ***360° in 24 hours***, that is, ***15° each hour***. A lunar eclipse happens at ***the same instant*** all over the world, but ***local clocks*** differ. If the eclipse happens at 9 pm in one city and 10 pm in another, their longitudes differ by about 15°.

REFLECTION

Two distant scholars worked together for knowledge. ***Cooperation***, not competition, produced precision. This method was later used to ***draw world maps*** more accurately.

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ARITHMETIC FOR SCRIBES AND MERCHANTS

Abu al-Wafa' wrote an arithmetic book for ***scribes, tax officials and merchants***. It teaches ***fractions***, ***ratios***, ***land measurement***, ***weights*** and ***tax calculation***.

> **HISTORY NOTE: NEGATIVE NUMBERS**
>
> Abu al-Wafa's arithmetic book is said to be among the earliest Islamic texts to use ***negative numbers*** — to describe ***debt***, an amount less than zero.
>
> Interestingly, the book ***does not use Hindu–Arabic numerals***, but writes numbers out ***in words***, following the custom of the scribes of the time (MacTutor: Abu'l-Wafa).

LESSON

Good knowledge is written for ***the needs of its readers***. Abu al-Wafa' wrote for merchants in the language they used, so that matters of ***weights and measures*** would be fair.

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GEOMETRY FOR CRAFTSMEN

His book ***"On the Geometric Constructions Needed by Craftsmen"*** teaches how to draw geometric figures with ***a ruler and compass***, including with ***a compass of fixed opening***. These methods helped tile-makers and builders produce precise patterns.

A craftsman's careful work is ***ihsan***, as the Messenger of Allah ﷺ said:

HADITH — SAHIH MUSLIM, NO. 1955

حَدَّثَنَا أَبُو بَكْرِ بْنُ أَبِي شَيْبَةَ، حَدَّثَنَا إِسْمَاعِيلُ ابْنُ عُلَيَّةَ، عَنْ خَالِدٍ الْحَذَّاءِ، عَنْ أَبِي قِلاَبَةَ، عَنْ أَبِي الأَشْعَثِ، عَنْ شَدَّادِ بْنِ أَوْسٍ، قَالَ ثِنْتَانِ حَفِظْتُهُمَا عَنْ رَسُولِ اللَّهِ صلى الله عليه وسلم قَالَ «إِنَّ اللَّهَ كَتَبَ الإِحْسَانَ عَلَى كُلِّ شَىْءٍ فَإِذَا قَتَلْتُمْ فَأَحْسِنُوا الْقِتْلَةَ وَإِذَا ذَبَحْتُمْ فَأَحْسِنُوا الذِّبْحَ وَلْيُحِدَّ أَحَدُكُمْ شَفْرَتَهُ فَلْيُرِحْ ذَبِيحَتَهُ».

TRANSLATION:

Shaddad ibn Aws رضى الله عنه said: Two things I memorised from the Messenger of Allah ﷺ; he said: **"Indeed Allah has prescribed excellence (ihsan) in everything.** So when you kill (where it is permitted), kill well; and when you slaughter, slaughter well. Let each of you sharpen his blade and spare his animal suffering."

CHAIN OF NARRATION: Narrated by Imam Muslim: from Abu Bakr ibn Abi Shaybah, from Isma'il ibn 'Ulayyah, from Khalid al-Hadhdha', from Abu Qilabah, from Abu al-Ash'ath as-San'ani, from Shaddad ibn Aws رضى الله عنه.

REFERENCE: Narrated by Imam Muslim in Sahih Muslim, Book of Hunting and Slaughter, Hadith No. 1955.

GRADE: SAHIH — contained in Sahih Muslim, the second most authentic book of Hadith after Sahih al-Bukhari.

Source: https://sunnah.com/muslim:1955a

LESSONS FROM THIS HADITH

Ihsan means doing something ***in the best possible way*** — whether worship, trade or handiwork. A precise geometric pattern on a mosque wall is ***ihsan in the form of art***.

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THE EIGHT-POINTED STAR AND MOSQUE PATTERNS

One of the best-known patterns in Islamic art is the ***eight-pointed star*** (*khatam*). It is built only from ***a circle and two squares*** — exactly the ruler-and-compass method taught by Abu al-Wafa'.

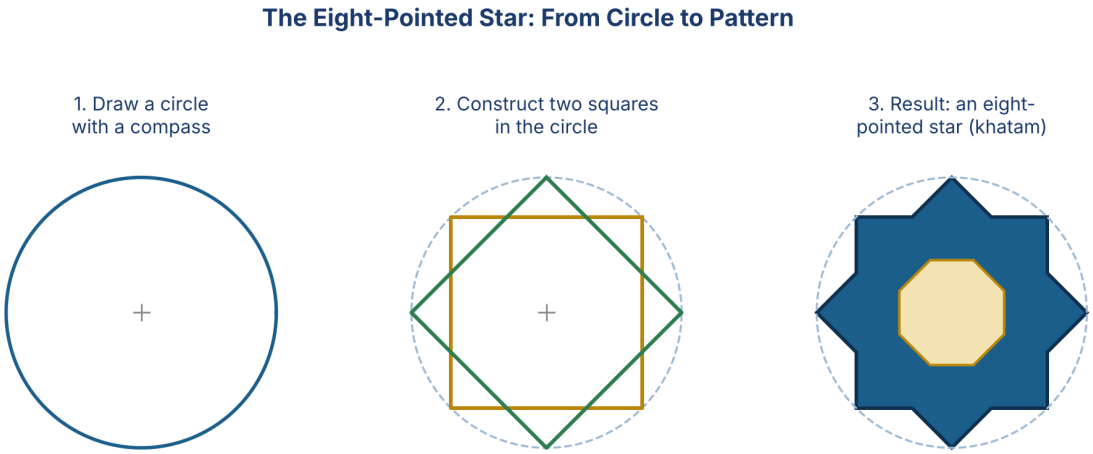


Figure 5: Building an eight-pointed star from a circle and two squares.

Patterns like this adorn mosques and madrasas from ***Andalusia to Southeast Asia*** (The Met: Geometric Patterns in Islamic Art).

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WHY GEOMETRIC PATTERNS?

Islamic art in mosques avoids images of living beings, so craftsmen turned to ***geometry, calligraphy and plant motifs***. Patterns that ***repeat without end*** remind us of ***the vastness of Allah's creation***.

LESSON

Mathematics and art ***are not separate***. A single circle drawn with a compass can be the beginning of ***a beautiful mihrab***.

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THE HONOUR OF HANDIWORK

SURAH SABA' 34:10–11

وَلَقَدْ ءَاتَيْنَا دَاوُۥدَ مِنَّا فَضْلًا ۖ يَٰجِبَالُ أَوِّبِى مَعَهُۥ وَٱلطَّيْرَ ۖ وَأَلَنَّا لَهُ ٱلْحَدِيدَ

﴿١٠﴾

And We certainly gave David from Us bounty. [We said], "O mountains, repeat [Our] praises with him, and the birds [as well]." And We made pliable for him iron.

أَنِ ٱعْمَلْ سَٰبِغَٰتٍ وَقَدِّرْ فِى ٱلسَّرْدِ ۖ وَٱعْمَلُوا۟ صَٰلِحًا ۖ إِنِّى بِمَا تَعْمَلُونَ بَصِيرٌ

﴿١١﴾

[Commanding him], "Make full coats of mail and calculate [precisely] the links, and work [all of you] righteousness. Indeed I, of what you do, am Seeing."

Translation: Sahih International — quran.com/34:10-11

Allah made iron pliable for Prophet Dawud عَلَيْهِ السَّلَامُ and commanded: ***"calculate [precisely] the links"***.

The exegetes explain that this verse teaches ***precise measurement*** in handiwork. Tafsir Ibn Kathir 34:11.

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The Messenger of Allah ﷺ also honoured handiwork:

HADITH — SAHIH AL-BUKHARI, NO. 2072

حَدَّثَنَا إِبْرَاهِيمُ بْنُ مُوسَى، أَخْبَرَنَا عِيسَى، عَنْ ثَوْرٍ، عَنْ خَالِدِ بْنِ مَعْدَانَ، عَنِ الْمِقْدَامِ ـ رضى الله عنه ـ عَنْ رَسُولِ اللَّهِ صلى الله عليه وسلم قَالَ « مَا أَكَلَ أَحَدٌ طَعَامًا قَطُّ خَيْرًا مِنْ أَنْ يَأْكُلَ مِنْ عَمَلِ يَدِهِ، وَإِنَّ نَبِيَّ اللَّهِ دَاوُدَ ـ عَلَيْهِ السَّلاَمُ ـ كَانَ يَأْكُلُ مِنْ عَمَلِ يَدِهِ ».

TRANSLATION:

Al-Miqdam رضى الله عنه narrated that the Messenger of Allah ﷺ said: **"No one has ever eaten food better than what he eats from the work of his own hands. And the Prophet of Allah David عَلَيْهِ السَّلَامُ used to eat from the work of his own hands."**

CHAIN OF NARRATION: Narrated by Imam al-Bukhari: from Ibrahim ibn Musa, from 'Isa ibn Yunus, from Thawr ibn Yazid, from Khalid ibn Ma'dan, from al-Miqdam ibn Ma'dikarib رضى الله عنه.

REFERENCE: Narrated by Imam al-Bukhari in Sahih al-Bukhari, Book of Sales (Kitab al-Buyu'), chapter on a man's earning and the work of his hands, Hadith No. 2072.

GRADE: SAHIH — contained in Sahih al-Bukhari, the most authentic book of Hadith after the Qur'an by consensus of the Hadith scholars.

Source: https://sunnah.com/bukhari:2072

LESSONS FROM THIS HADITH

Abu al-Wafa' ***respected craftsmen*** so much that he wrote a book especially for them. Islam honours ***lawful handiwork***, and advanced knowledge should ***help*** those who work with their hands.

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THE PUZZLE OF CUTTING SQUARES

Abu al-Wafa' is famous for ***geometric dissection problems***: how to cut ***several small squares*** and rearrange them into ***one large square*** without wasting any piece.

This problem mattered greatly to ***tile-makers***: they needed to cut tiles precisely so that small pieces could form a larger pattern (MacTutor: Abu'l-Wafa).

> **HISTORY NOTE: DISCUSSIONS BETWEEN MATHEMATICIANS AND CRAFTSMEN**
>
> Abu al-Wafa' relates that he attended ***meetings*** between geometers and craftsmen. Some of the craftsmen's methods were ***beautiful but inexact***, while some of the geometers' methods were ***exact but hard*** to carry out on site.
>
> He sought methods that were ***exact and simple*** — combining manual skill with mathematical truth.

LESSON

Good scholarship ***listens*** to the experience of those who work in the field. Scholars and craftsmen ***need each other***.

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COMMENTING ON EUCLID, DIOPHANTUS AND AL-KHWARIZMI

HISTORY NOTE: A CHAIN OF KNOWLEDGE

Abu al-Wafa' wrote commentaries on the ***Elements*** of ***Euclid*** (geometry), the ***Arithmetica*** of ***Diophantus*** (equations), and the ***al-Jabr*** of ***al-Khwarizmi*** (see Book 18).

He is also said to have translated or commented on Diophantus in Arabic, making it accessible to later Muslim mathematicians.

COMMENTING, NOT COPYING

In the Islamic scholarly tradition, a ***sharh*** (commentary) is not mere copying. The commentator ***explains, corrects and adds*** — just as Hadith scholars wrote commentaries on the books of Hadith.

LESSON

Knowledge grows as ***a chain***: Greeks → al-Khwarizmi → Abu al-Wafa' → al-Biruni → Europe. Every generation ***stands on the shoulders*** of the one before.

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CONVEYING KNOWLEDGE

Abu al-Wafa' wrote for ordinary people — scribes, merchants and craftsmen — not only for mathematicians. This spirit is in harmony with the saying of the Messenger of Allah ﷺ:

HADITH — SAHIH AL-BUKHARI, NO. 3461

حَدَّثَنَا أَبُو عَاصِمٍ الضَّحَّاكُ بْنُ مَخْلَدٍ، أَخْبَرَنَا الأَوْزَاعِيُّ، حَدَّثَنَا حَسَّانُ بْنُ عَطِيَّةَ، عَنْ أَبِي كَبْشَةَ، عَنْ عَبْدِ اللَّهِ بْنِ عَمْرٍو، أَنَّ النَّبِيَّ صلى الله عليه وسلم قَالَ «بَلِّغُوا عَنِّي وَلَوْ آيَةً، وَحَدِّثُوا عَنْ بَنِي إِسْرَائِيلَ وَلاَ حَرَجَ، وَمَنْ كَذَبَ عَلَيَّ مُتَعَمِّدًا فَلْيَتَبَوَّأْ مَقْعَدَهُ مِنَ النَّارِ».

TRANSLATION:

'Abdullah ibn 'Amr رضى الله عنهما reported that the Prophet ﷺ said: **"Convey from me, even if it is a single verse. And narrate from the Children of Israel, there is no harm (in it). And whoever lies about me deliberately, let him take his seat in the Fire."**

CHAIN OF NARRATION: Narrated by Imam al-Bukhari: from Abu 'Asim ad-Dahhak ibn Makhlad, from al-Awza'i, from Hassan ibn 'Atiyyah, from Abu Kabshah as-Saluli, from 'Abdullah ibn 'Amr رضى الله عنهما.

REFERENCE: Narrated by Imam al-Bukhari in Sahih al-Bukhari, Book of the Prophets, Hadith No. 3461.

GRADE: SAHIH — contained in Sahih al-Bukhari, the most authentic book of Hadith after the Qur'an by consensus of the Hadith scholars.

Source: https://sunnah.com/bukhari:3461

LESSONS FROM THIS HADITH

Conveying knowledge does not require waiting until one is an expert in everything — ***even a single verse***. At the same time, we must be ***honest*** and never attribute anything to the Messenger of Allah ﷺ without authentic proof.

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PRECISION AND PERSEVERANCE

Compiling highly accurate sine tables required ***years of perseverance***. The Messenger of Allah ﷺ taught this attitude:

HADITH — SAHIH AL-BUKHARI, NO. 6464

حَدَّثَنَا عَبْدُ الْعَزِيزِ بْنُ عَبْدِ اللَّهِ، حَدَّثَنَا سُلَيْمَانُ، عَنْ مُوسَى بْنِ عُقْبَةَ، عَنْ أَبِي سَلَمَةَ بْنِ عَبْدِ الرَّحْمَنِ، عَنْ عَائِشَةَ، أَنَّ رَسُولَ اللَّهِ صلى الله عليه وسلم قَالَ « سَدِّدُوا وَقَارِبُوا، وَاعْلَمُوا أَنْ لَنْ يُدْخِلَ أَحَدَكُمْ عَمَلُهُ الْجَنَّةَ، وَأَنَّ أَحَبَّ الأَعْمَالِ أَدْوَمُهَا إِلَى اللَّهِ، وَإِنْ قَلَّ

«

TRANSLATION:

'A'ishah رضى الله عنها narrated that the Messenger of Allah ﷺ said: **"Aim for what is right and come as close as you can (to perfection), and know that no one's deeds alone will admit him to Paradise. And the deeds most beloved to Allah are those done consistently, even if they are few."**

CHAIN OF NARRATION: Narrated by Imam al-Bukhari: from 'Abd al-'Aziz ibn 'Abdullah al-Uwaysi, from Sulayman ibn Bilal, from Musa ibn 'Uqbah, from Abu Salamah ibn 'Abd ar-Rahman, from 'A'ishah رضى الله عنها.

REFERENCE: Narrated by Imam al-Bukhari in Sahih al-Bukhari, Book of Softening the Heart (Kitab ar-Riqaq), Hadith No. 6464.

GRADE: SAHIH — contained in Sahih al-Bukhari, the most authentic book of Hadith after the Qur'an by consensus of the Hadith scholars.

Source: https://sunnah.com/bukhari:6464

LESSONS FROM THIS HADITH

"Strive to do what is right and come close" — this is the spirit of a mathematician: aiming to be as precise as possible, and keep drawing nearer to the truth. Deeds done ***consistently***, even if small, are most beloved to Allah.

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LEGACY: FROM SINE TABLES TO GPS

The trigonometric functions arranged by Abu al-Wafa' are now used in almost every modern technology.

TECHNOLOGY	USE OF TRIGONOMETRY
GPS and smartphones	Calculating position from the distances to several satellites.
Shipping and aviation	Calculating the shortest route over the spherical earth.
Engineering and architecture	Calculating forces, angles and slopes of structures.
Computer graphics and games	Rotating and moving objects on screen.
Sound and signals	Sound, radio and electrical waves are described with sine functions.

The ***GPS*** system uses signals from at least ***four satellites*** to determine our position on earth (GPS.gov). These calculations depend on geometry and spherical trigonometry.

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THE ABU AL-WAFA' CRATER ON THE MOON

As an honour, a ***crater on the Moon*** is named ***Abul Wáfa*** after him (Wikipedia: Abul Wáfa crater)). The astronomer who once calculated the motion of the Moon now has his name on the Moon's own surface.

A greater honour is that his knowledge ***continues to benefit*** — every time an engineer calculates, every time prayer times are computed, and every time a craftsman draws a pattern with a compass.

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ESTABLISHED REPORTS AND POPULAR STORIES

The table below separates what is established from what needs checking about Abu al-Wafa'.

STORIES AND THEIR STATUS

POPULAR STATEMENT	STATUS
Abu al-Wafa' used the tangent function in al-Majisti.	Established. Shadow (tangent) tables were compiled earlier by Habash al-Hasib; Abu al-Wafa' arranged them systematically.
He observed the eclipse of 997 CE with al-Biruni to calculate the difference in longitude.	Established.
He created all Islamic geometric patterns.	Exaggerated. He wrote geometric methods for craftsmen; the patterns developed through many craftsmen and generations.
He was the first to discover the law of sines for spherical triangles.	Disputed. Abu Nasr Mansur and al-Khujandi are also credited with it.
Sahih al-Bukhari 1913 forbids Muslims to learn calculation.	Incorrect. The Hadith explains an easy way to fix the start of the month; it does not forbid learning.
Hadith: "Allah loves that when one of you does a work, he does it with excellence (itqan)."	Its grading is disputed (narrated by al-Bayhaqi and al-Tabarani); it is not in Sahih al-Bukhari or Muslim. Its meaning is supported by the Hadith of ihsan (Sahih Muslim 1955).

REFLECTION — IHSAN WITH AUTHENTIC EVIDENCE

The "itqan" Hadith is very popular in the workplace, but its grading is disputed. We can hold to ***the same meaning*** through an authentic Hadith: ***"Indeed Allah has prescribed ihsan in all things."***

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LESSONS AND CONCLUSION

LESSONS FROM THIS EBOOK

First: All creation has precise measure (54:49; 25:2).

Second: There is no inconsistency in Allah's creation (67:3).

Third: The sun and moon move by calculation so that we can reckon time (55:5; 10:5).

Fourth: Turn your face to the qiblah wherever you are — with precise knowledge (2:144).

Fifth: Guard the prayer times set by the course of the sun (Sahih Muslim 612).

Sixth: Do everything with ihsan (Sahih Muslim 1955).

Seventh: Honour lawful handiwork (Sahih al-Bukhari 2072; 34:11).

Eighth: Convey knowledge, even a little, with honesty (Sahih al-Bukhari 3461).

Ninth: Strive with precision and consistency (Sahih al-Bukhari 6464).

Tenth: Cooperation produces precision — like the eclipse observed in two cities.

Eleventh: Make advanced knowledge simple and useful — for scholars, merchants and craftsmen.

CONCLUSION

Abu al-Wafa' died in Baghdad around 998 CE. His tangent function is used every day by engineers, and geometric patterns continue to adorn mosques. The next book of **Tracing the Scholars of Islam**, in sha Allah, will tell the story of ***Ibn al-Haytham***, the father of modern optics. Wallahu a'lam.

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GLOSSARY AND REFLECTION QUESTIONS

GLOSSARY

TERM	MEANING
Trigonometry	The science of the relationship between the angles and sides of triangles.
Sine (jayb)	The ratio of the opposite side to the hypotenuse.
Tangent	The ratio of the opposite side to the adjacent side; arose from the study of shadows.
Spherical trigonometry	Trigonometry of triangles on the surface of a sphere such as the earth.
Longitude	East–west position on the earth, measured in degrees.
Gnomon	An upright rod whose shadow is used to measure the sun's position.
Khatam	The eight-pointed star of Islamic geometric art.
Ihsan	Doing something in the best possible way.

REFLECTION QUESTIONS

1. How do verses 55:5 and 10:5 encourage Muslims to study calculation?

2. Why is spherical trigonometry needed to determine the direction of the qiblah?

3. How did Abu al-Wafa' and al-Biruni calculate the longitude difference between two cities?

4. What can we learn from Abu al-Wafa's effort to write books for merchants and craftsmen?

5. How can we practise ihsan in our daily work?

SUGGESTED ACTIVITIES

Activity 1: Plant an upright stick in the sun. Measure the length of its shadow in the morning, at midday and in the afternoon. Compare with the prayer timetable.

Activity 2: Use a compass and ruler to draw an eight-pointed star as in Figure 5. Colour it and arrange several stars to form a pattern.

Activity 3: Measure the distance to a tree and estimate the angle to its top. Use a calculator to work out its height with the tangent function.

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SURAH AL-BAQARAH 2:261

مَّثَلُ ٱلَّذِينَ يُنفِقُونَ أَمۡوَٰلَهُمۡ فِي سَبِيلِ ٱللَّهِ كَمَثَلِ حَبَّةٍ أَنۢبَتَتۡ سَبۡعَ سَنَابِلَ فِي كُلِّ سُنۢبُلَةٖ مِّاْئَةُ حَبَّةٖۗ وَٱللَّهُ يُضَٰعِفُ لِمَن يَشَآءُۚ وَٱللَّهُ وَٰسِعٌ عَلِيمٌ ٢٦١

The example of those who spend their wealth in the way of Allah is like a seed [of grain] which grows seven spikes; in each spike is a hundred grains. And Allah multiplies [His reward] for whom He wills. And Allah is all-Encompassing and Knowing.

Translation: Sahih International — quran.com/2:261

SURAH SABA' 34:39

قُلۡ إِنَّ رَبِّي يَبۡسُطُ ٱلرِّزۡقَ لِمَن يَشَآءُ مِنۡ عِبَادِهِۦ وَيَقۡدِرُ لَهُۥۚ وَمَآ أَنفَقۡتُم مِّن شَيۡءٖ فَهُوَ يُخۡلِفُهُۥۖ وَهُوَ خَيۡرُ ٱلرَّٰزِقِينَ ٣٩

Say, "Indeed, my Lord extends provision for whom He wills of His servants and restricts [it] for him. But whatever thing you spend [in His cause] - He will compensate it; and He is the best of providers."

Translation: Sahih International — quran.com/34:39

HADITH — SAHIH MUSLIM, NO. 2588

حَدَّثَنَا يَحْيَى بْنُ أَيُّوبَ، وَقُتَيْبَةُ، وَابْنُ، حُجْرٍ قَالُوا حَدَّثَنَا إِسْمَاعِيلُ، - وَهُوَ ابْنُ جَعْفَرٍ - عَنِ الْعَلاَءِ، عَنْ أَبِيهِ، عَنْ أَبِي هُرَيْرَةَ، عَنْ رَسُولِ اللَّهِ صلى الله عليه وسلم قَالَ « مَا نَقَصَتْ صَدَقَةٌ مِنْ مَالٍ وَمَا زَادَ اللَّهُ عَبْدًا بِعَفْوٍ إِلاَّ عِزًّا وَمَا تَوَاضَعَ أَحَدٌ لِلَّهِ إِلاَّ رَفَعَهُ اللَّهُ ».

TRANSLATION:

Abu Hurayrah رضى الله عنه narrated that the Messenger of Allah ﷺ said: "Charity does not decrease wealth.

Allah does not increase a servant who forgives except in honour. And no one humbles himself for the sake of Allah except that Allah raises him in rank."

CHAIN OF NARRATION: Narrated by Imam Muslim: from Yahya bin Ayyub, Qutaibah bin Sa'id and 'Ali bin Hujr, from Isma'il bin Ja'far, from al-'Ala' bin 'Abd al-Rahman, from his father 'Abd al-Rahman bin Ya'qub, from Abu Hurayrah رضي الله عنه .

REFERENCE: Narrated by Imam Muslim in Sahih Muslim, Book of Virtue, Good Manners and Joining the Ties of Kinship (Kitab al-Birr wa al-Silah wa al-Adab), chapter on the encouragement of forgiveness and humility, Hadith No. 2588.

GRADE: SAHIH — contained in Sahih Muslim.

Source: https://sunnah.com/muslim:2588

HADITH — SAHIH MUSLIM, NO. 1631

حَدَّثَنَا يَحْيَى بْنُ أَيُّوبَ، وَقُتَيْبَةُ - يَعْنِي ابْنَ سَعِيدٍ - وَابْنُ حُجْرٍ قَالُوا حَدَّثَنَا إِسْمَاعِيلُ، - هُوَ ابْنُ جَعْفَرٍ - عَنِ الْعَلاَءِ، عَنْ أَبِيهِ، عَنْ أَبِي هُرَيْرَةَ، أَنَّ رَسُولَ اللَّهِ صلى الله عليه وسلم قَالَ « إِذَا مَاتَ الإِنْسَانُ انْقَطَعَ عَنْهُ عَمَلُهُ إِلاَّ مِنْ ثَلاَثَةٍ إِلاَّ مِنْ صَدَقَةٍ جَارِيَةٍ أَوْ عِلْمٍ يُنْتَفَعُ بِهِ أَوْ وَلَدٍ صَالِحٍ يَدْعُو لَهُ ».

TRANSLATION:

Abu Hurayrah رضي الله عنه narrated that the Messenger of Allah ﷺ said: "When a person dies, his deeds come to an end except for three: an ongoing charity, knowledge that is benefited from, or a righteous child who prays for him."

CHAIN OF NARRATION: Narrated by Imam Muslim: from Yahya bin Ayyub, Qutaibah bin Sa'id and 'Ali bin Hujr, from Isma'il bin Ja'far, from al-'Ala' bin 'Abd al-Rahman, from his father 'Abd al-Rahman bin Ya'qub, from Abu Hurayrah رضي الله عنه .

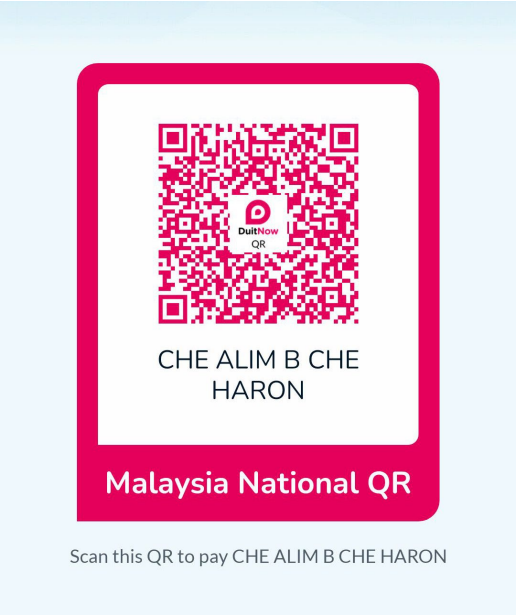
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GRADE: SAHIH — contained in Sahih Muslim.

Source: https://sunnah.com/muslim:1631

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