

Argelia Vélez-Rodríguez (1936 – Present)

The first black woman to receive a doctorate in Mathematics in Cuba

“There are two major issues facing minorities in their educational development, [...] one is the socio-economic factor, and the other is the quality of preparation [they] receive.”



In Texas College, she got involved in education of the National Science Foundation, and later became involved in programs for black students and other minorities. She joined the Bishop College in Dallas, Texas and there became an appointed chair of the Department of Mathematical Science (1975-1978). Later, she became a manager of the Minority Institutions Science Program at the US Department of Education in Washington, D.C. A lot of her life's work was focused on teaching mathematics in a manner which would be beneficial to students who were part of a minority.

Argelia Vélez-Rodríguez is a Cuban mathematician. Argelia was born during a time of education reform. Her interest in Mathematics was noted by her teachers when she won a Mathematics competition at age 9. She proceeded to study Mathematics at the Marianao Institute (1952-1955), having her first son in 1955. After her degree, she joined the University of Havana (1955-1960) to complete her Ph.D. using differential equations to study astronomical orbits. At the time only about 10% of the population in Cuba was black, and she became the first Black woman to receive a doctorate in Mathematics.

Discrimination in the United States

Due to several political problems in Cuba, Argelia and her family emigrated to USA (1962), although her husband was only able to leave Cuba 3 years later. She mentions that whilst in Cuba she never felt discriminated for either her ethnicity, or for being woman. Despite encountering a better life in the US, she also encountered discrimination for being both black and a woman.

Argelia Velez-Rodriguez's daughter, Argelia Rodriguez., received her B.S. degree from Stanford University in 1980, and her M.B.A. degree from the Harvard Business School in 1984. She spent almost a quarter-century as the president and CEO of the District of Columbia College Access Program (DC-CAP), a start-up nonprofit which she brought to success by establishing a college-going culture and tripling the number of students who graduate.



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Argelia's
research paper



Improving STEM Education for Minority Students

Through her research, Argelia recognized that access to quality learning for underrepresented students in STEM fields was poor. She focused much of her life's work on developing, more effective teaching approaches to improve science and mathematics education at minority-serving institutions.

An extract from Argelia's 1986 paper entitled '[Technology Literacy and Ethnic Minority Students](#)'.

The following table shows the differences in standardized test scores among the various ethnic groups.

Race/Ethnic Group	SAT-V	SAT-M	TOTAL
American Indians	391	425	816
Asian/Pacific Americans	397	513	910
Blacks	332	362	694
Mexican Americans	373	415	788
Mainland Puerto Ricans	361	396	757
Whites	442	483	925

Source: The Admissions Testing Program of the College Board, Profiles, College-Bound Senior, 1981.

Argelia directed multiple national-scale programs focused on improving STEM education for minority students, including the Minority Science Improvement Program for both the National Science Foundation and the Department of Education. She also conducted studies on teacher shortages in various communities around the USA

These strategies include:

- Acquisition of new instructional equipment.
- Renovation of existing physical facilities or construction of new ones.
- Special early intervention programs.
- Tutorial sessions.
- Availability of career information.
- Emphasis on career and personal counseling.
- Student and faculty exchange programs.
- Development of innovative instructional methods using computers.
- Undergraduate research and independent study programs.
- Research opportunities and facilities for faculty.
- Part-time and full-time faculty study leaves.
- Improvement of mathematics for non-science majors.
- Strengthening pre-service and in-service training programs for science and mathematics teachers.
- Dissemination of science/technology-oriented information among members of the minority community.
- Continued support for successful minority programs already in place.

Another extract from Argelia's 1986 paper entitled '[Technology Literacy and Ethnic Minority Students](#)', showing her devised strategies for improving the effectiveness of science and technology education for minority students

Argelia earned her PhD in Mathematics with a dissertation entitled 'Determination of Orbits Using Talcott's Method', which focused on the use of advanced differential equations to predict paths of objects in space.

$$F = \frac{GMm}{r^2}$$

Where F is gravitational force, M is the mass of the central body, m is the mass of the orbiting object and r is the distance between them

Newton's law of gravitation (above) forms the basis of the differential equations used in orbital calculations. Argelia's research applied mathematical models derived from laws such as this to problems in orbit determination.



Image source: [Zenith Telescope](#)

Zenith Telescope used for Talcott's Method of determining latitude.

Kathleen Ollerenshaw (1912 – 2014)

Deaf politician and mathematician

“Mathematics is the one school subject not dependent on hearing.”



“That this should have been afforded to someone who had, [...], been out of active mathematics research for over 40 years will, I hope, encourage others. The delight of discovery is not a privilege reserved solely for the young”

Recreational Mathematics:

Later in her career, she transitioned into amateur astronomy and solved recreational maths puzzles alongside her political work and education. In 1980, Ollerenshaw was the first person to create an algorithm for solving a Rubik's cube, and she also made notable breakthroughs with magic squares and many other puzzles. Throughout her life, she published at least 26 mathematical papers.



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short video

Dame Kathleen Ollerenshaw (1912-2014) was an English mathematician and politician. Becoming deaf from the age of 8, she very quickly learned to lip-read, later receiving a hearing aid at age 37. Despite growing up in a society not accessible to hearing impairment, Ollerenshaw did not let this set her back. She was appointed Dame Commander in 1970 for services to education, appointed Lord Mayor of Manchester in 1975, and was the founding president of the Institute of Mathematics in 1978. Ollerenshaw received her doctorate from the University of Oxford for her work on critical lattices, which describe how to most efficiently stack geometric objects. She completed her Ph.D. without submitting a thesis, writing 5 research papers on the subject in two years.

‘Subliminal Learning’ was a technique developed by Ollerenshaw in boarding school, in which she would trace important aspects of a problem, such as shapes or equations, with her finger on her wall before going to sleep. She would wake up with the facts or arguments she needed clearly imprinted in her mind.

Ollerenshaw was truly multi-talented; she even played on a women's ice-hockey team that represented England. She also learnt how to sail, climb, and ski! Moreover, after having received her hearing aids, she began to appreciate music and became involved in the creation of what is now known as the Royal Northern College of Music.

Kathleen Ollerenshaw (1912 – 2014)

Deaf politician and mathematician

Magic Squares

Kathleen had a strong interest in 'Magic Squares', which occupied her mathematical research for around 8 years. A square array of numbers is 'magic' when the sum of all the integers present in each row, column and main diagonal is the same.

A 3x3 square is the simplest example of a magic square. Apart from swapping rows or columns and rotations, there is only one possible combination of numbers that can make a 3x3 magic square. The number that each row, column and diagonal adds up to is referred to as the square's 'magic number', which is 15 for the 3x3 example.

2	7	6	→15
9	5	1	→15
4	3	8	→15
15	15	15	15

The only 3x3 magic square which is possible. Image source: [Magic Square](#)

7	12	1	14
2	13	8	11
16	3	10	5
9	6	15	4

A normal 4x4 Magic Square.

Image source: [Normal Magic Square 4x4](#)

A 'normal' magic square is a magic square in which all integers are values between 1 and n^2 (where n refers to the order of the square). For a 'normal' magic square, the magic number can be calculated using the following equation:

$$M = n \times (n^2 + 1) \div 2$$

Where M is the magic constant and n is the order of the square

Using this equation, we can see that M for normal magic squares of $n = 3$ is 15, and for magic squares of $n = 4$, $M = 34$

Kathleen worked on magic squares with extra requirements than just normal magic squares, called 'pandiagonal magic squares', and 'Most-Perfect magic squares'.

A pandiagonal magic square is a magic square with the additional property that the broken diagonals, shown below, also add up to the magic number

Image source: [pandiagonal magic square](#)

Pandiagonal magic squares remain pandiagonally magic even when rotated, reflected or when columns are moved to the opposite side of the square

A Most-Perfect magic square is a pandiagonal magic square with the following additional properties. For an order n Most-Perfect magic square, let $T = n^2 + 1$:

- Every 2x2 block of cells (including wrap-around blocks) sums to $2T$
- Any pair of integers separated by $\frac{n}{2}$ cells along a diagonal sum to T

4	5	16	9
14	11	2	7
1	8	13	12
15	10	3	6

An example of a Most-Perfect magic square.

Source: [Most-Perfect Magic Squares](#)

Emmy Noether (1882 – 1935)

Jewish war-time mathematician

*"Fraulein Noether was the most significant mathematical genius thus far produced since the higher education of women began." -
Albert Einstein*



In a time when women were often excluded from academic circles, Noether pushed beyond these limitations and made significant contributions to mathematics and theoretical physics. Her most famous achievement, Noether's theorem, established a profound connection between symmetries in nature and the conservation laws of physics. Noether's story is a testament to the power of perseverance and the impact one person can have, regardless of the barriers they face.

'Noether's Theorem' - Every continuous symmetry in a physical system corresponds to a conserved quantity. For example, time symmetry leads to energy conservation, and spatial symmetry leads to momentum conservation. This theorem links the concepts of symmetry and conservation laws, making it fundamental in physics.

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1882 - Born in Erlangen, Germany.

1907 - Earned her doctorate in mathematics from the University of Erlangen.

1915 - Invited to the University of Göttingen by David Hilbert and Felix Klein.

1918 - Formulated Noether's theorem, linking symmetries to conservation laws.

1919 - Officially joined the faculty at the University of Göttingen.

1921-1928 - Made major contributions to abstract algebra, especially ring and ideal theory.

1932 - Received the Ackermann–Teubner Memorial Prize for her mathematical work.

1933 - Fled Nazi Germany and began teaching at Bryn Mawr College in the U.S.

1935 - Passed away on April 14, leaving a lasting impact on mathematics and physics.

Universities often did not allow women to hold official positions or receive salaries, regardless of their qualifications. Despite her groundbreaking contributions, Noether worked without pay for several years at the University of Göttingen, where she lectured under a male colleague's name until she was granted a formal position. She was dismissed by the Nazis in 1933 due to her Jewish heritage.

Noether's Theorem: every symmetry in nature corresponds to a conservation law

Noether's theorem states that every continuous symmetry corresponds to a conserved physical quantity. A symmetry is a transformation that leaves the laws of physics unchanged. Common examples include:

- **Time translation symmetry:** If the laws of physics don't change over time, energy is conserved
- **Spatial translation symmetry:** If the laws are the same everywhere in space, linear momentum is conserved
- **Rotational symmetry:** If the laws are the same in all directions, angular momentum is conserved

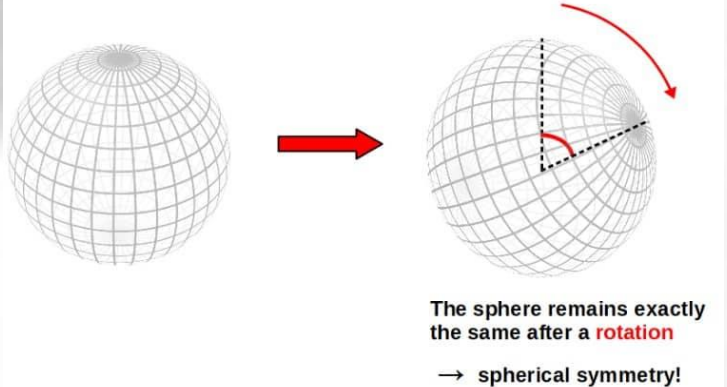


Image source: [Noether's Theorem: A Complete Guide With Examples – Profound Physics](#)

Noether's Theorem is fundamental to both classic and modern physics and forms the basis of knowledge for topics such as classical mechanics and quantum field theory.

NOETHERIAN RINGS

A ring is Noetherian if every ideal can be generated by finitely many elements. Below is a simple example:

In the ideal

$$(n) = \{nk : k \in \mathbb{Z}\}$$

For $n=3$:

$$(3) = \{3k : k \in \mathbb{Z}\}$$

So

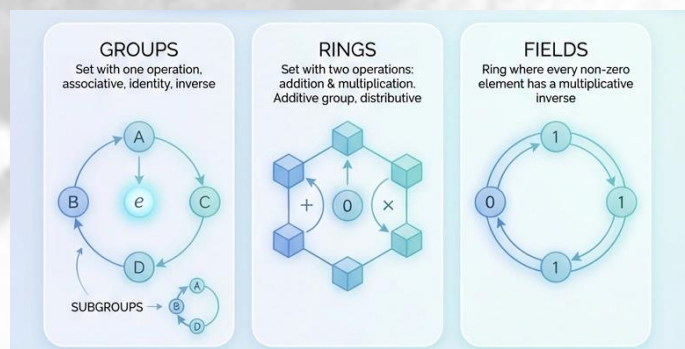
$$(3) = \{\dots, -6, -3, 0, 3, 6, 9, \dots\}$$

Even though this ideal contains infinitely many values, all of them come from multiplying 3 by some integer. Therefore, it can be described by just one number: 3. Noetherian rings allow ideals to contain infinitely many elements, as long as each ideal is generated by finitely many generators.

Therefore, every ideal can be simplified to finitely many generators, so the algebra remains manageable. Noetherian rings are fundamental in algebra, number theory and algebraic geometry, and continue to be used in modern mathematical research.

ABSTRACT ALGEBRA

Before the work of Emmy Noether 'algebra' largely consisted of solving polynomial equations or computing with specific algebraic objects. Noether shifted the entire perspective to abstract structures, such as rings, ideals and their mappings. Instead of focusing on what specific equations do, she focused on what structures make equations behave the way they do. Her work changed how mathematicians think about structure, symmetry and proof.



Diagrams showing some fundamental ideas within abstract algebra. Emmy Noether was a major contributor to the development of such techniques. Image source: [Abstract Algebra Diagram](#)

Nalini Joshi (1958 - Present)

A Burmese-Australian mathematician

"I struggle with maths everyday - the difference is that I enjoy the struggle. It's a myth that to be good at something, it must come easy."



Achievements:

2006: Fellow of the Australian Academy of Science - for contributions to mathematics and her leadership in the field.

2010: Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) - outstanding contributions to science and engineering.

2017: Mathematical Association of New South Wales (MANSW) Distinguished Service Award - Recognized for her service and contributions to the mathematical community.

2020: Order of Australia (AM) - Appointed a Member of the Order of Australia for significant service to mathematics education, research, and gender equity in STEM fields.

Nalini Joshi is a prominent Australian mathematician known for her work in nonlinear differential and difference equations, particularly in the field of integrable systems. Born in Burma (now Myanmar) and raised in Australia, Joshi became the first woman in Australia to be appointed as a Professor of Mathematics at the University of Sydney. She has held several leadership positions, including being the president of the Australian Mathematical Society and serving on various advisory panels for scientific organizations. Joshi is also an advocate for gender equity in science and mathematics, working to support and inspire women in STEM fields.

Joshi studied at the University of Sydney, where she earned a Bachelor of Science with Honours in Mathematics. Her exceptional performance and enthusiasm for the subject led her to continue her studies, where she completed a PhD in Mathematics. Her research focused on integrable systems and nonlinear differential equations, areas that captivated her due to their complexity and elegant solutions.

Nalini Joshi has been a dedicated advocate, promoting diversity in STEM, focusing on supporting women and under-represented groups in science and mathematics. As President of the Australian Mathematical Society, she led initiatives to enhance inclusivity and representation. Joshi has actively mentored young researchers, including guiding women through academic challenges and promoting their advancement in the field. Her involvement in programs like the Australian Mathematics Trust and the STEM Women organization highlights her commitment to inspiring and engaging students from diverse backgrounds. Through these efforts, Joshi has played a crucial role in fostering a more inclusive and supportive scientific community.



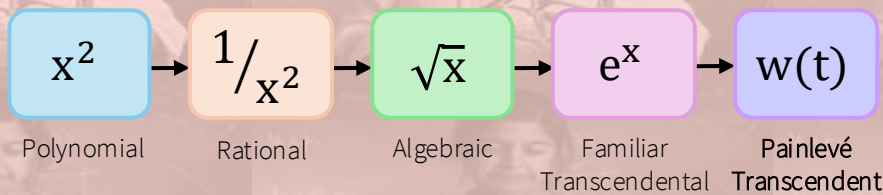
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Continuous and Discrete Painlevé Equations

Nalini Joshi has authored and coauthored [over 180 mathematical papers](#) focusing primarily on integrable systems. Much of Joshi's work has centred around Painlevé equations, their complicated behaviour and remarkable hidden structures.

Painlevé Equations: six families of nonlinear differential equations whose generic solutions (Painlevé transcendents) cannot be written using polynomials or familiar [transcendental functions](#).

Function class hierarchy:



The first and second Painlevé Equations:

Continuous:

Discrete:

$$P_I: w'' = 6w^2 + t \quad \leftrightarrow \quad dP_I: w_n(w_{n+1} + w_n + w_{n-1}) = an + b + cw_n$$

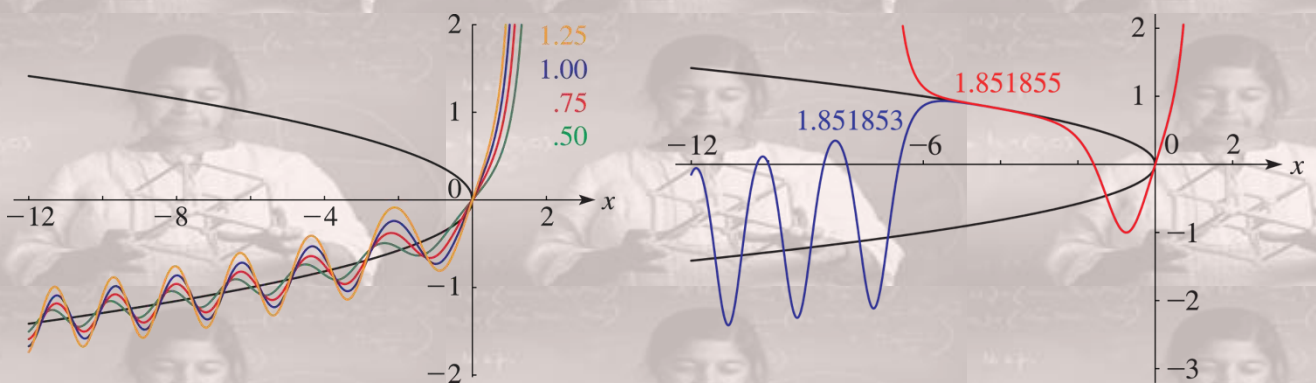
$$P_{II}: w'' = 2w^3 + tw + a \quad \leftrightarrow \quad dP_I: w_{n+1} + w_{n-1} + \frac{(an+b)w_n + c}{1-w_n^2}$$

Where a, b and c are constants.

Parallels between corresponding Painlevé equations:

Continuous P	Discrete dP
Function $w(t)$	Sequence w_n
Derivatives describe change	Shifts $n \pm 1$ describe change
Need $w(t_0)$ and $w'(t_0)$	Need two starting values, e.g. w_0, w_1
Produces a continuous curve	Produces a sequence of points

Joshi's work notably includes developed geometric and asymptotic methods for discrete Painlevé equations and explores their relationship with their continuous counterparts.



Plots of solutions $w_k(x)$ of P_I with $w_k(0) = 0$ and $w'_k(0) = k$ for various values of k – in colour – and the parabola $6w^2 + x = 0$ – in black. Source: [Digital Library of Mathematical Functions](#).

Sofia Kovalevskaya (1850 - 1891)

First female mathematics professor making large contributions to mechanics

“It is impossible to be a mathematician without being a poet in soul.”



Kovalevskaya was the first female mathematics professor in the world, teaching in Stockholm. Her paper entitled, *‘The Theory of Partial Differential Equations’* was published in Crelle’s journal whilst she was still an unknown researcher. She demonstrated a high aptitude for mathematical excellence from a young age, teaching herself trigonometry to work her way through a physics textbook. This was noticed by the author, who was her sole supporter in ensuring she pursued an education in St. Petersburg.

At the time, the closest university allowing women was in Switzerland and women were unable to travel without a male escort. This pushed Sofia into her ‘marriage of convenience’ with her husband, Vladimir Kovalevsky, who was a Russian nihilist supporting the emancipation of women. This meant Kovalevskaya could now travel freely to pursue an education. However, her fight to learn more did not end here as many of the best institutions (the ones Kovalevskaya aimed to learn at) still did not allow female students. Her intelligence and drive caught the attention of Karl Weierstrass, one of the most renowned German mathematicians in 1869 who agreed to privately tutor her upon her acceptance as the first female student at Heidelberg University.

“Many who have had an opportunity of knowing any more about mathematics [...] consider it an arid science. In reality, however, it is a science which requires a great amount of imagination.”

In 1883, Kovalevskaya’s husband, after having separated with his wife, committed suicide after a stream of financial difficulty. This left Sofia with a young child and in a state of grief. This only pushed her further into her work, and she was given the position as Privat docent. However, to prove her competency as a female mathematician, she had to work for a year as an unpaid lecturer providing lessons in partial differential equations. In 1884, she was then awarded the official position of Professor. This did not go unnoticed, with a well-known mathematician stating in the local papers that, *‘a female professor is a pernicious and unpleasant phenomenon - even, one might say, a monstrosity.’* This blatant criticism of her skill did not stop her from pursuing her career further.



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At the height of her career in 1891, Sofia was diagnosed with pneumonia and she died soon after. Her tutor described Kovalevskaya as showing *‘how through deeds that women have been alienated from the highest strivings of mankind because of prejudice.’*

Partial Differential Equations (PDEs) and the Cauchy-Kovalevskaya Theorem

Sofia Kovalevskaya's 1875 paper on partial differential equations developed Cauchy's earlier ideas into a more general theorem and formed a central part of her doctoral work. [The Cauchy-Kovalevskaya theorem](#) states that if a PDE, its initial data and the initial surface are analytic, and the surface is non-characteristic, then there exists a unique local analytic solution.

Kovalevskaya proved a fundamental result on when solutions to partial differential equations exist and are unique.

For a Cauchy problem of the form:

$$\begin{aligned}u_t &= F(x, t, u, u_x, u_{xx}, \dots), \\u(x, 0) &= \phi(x)\end{aligned}$$

If the equation, the initial data and the initial surface are analytic (i.e., can be represented by a convergent Taylor series), and the surface is non-characteristic, there will exist a unique, local analytic solution.

The Taylor series expansion:

$$u(x, t) = u(x, 0) + t u_t(x, 0) + \frac{t^2}{2!} u_{tt}(x, 0) + \frac{t^3}{3!} u_{ttt}(x, 0) + \dots$$

Initial data gives the first term, $u(x, 0)$. The PDE can then be used repeatedly to determine the successive time derivatives - $u_t(x, 0)$, $u_{tt}(x, 0)$, $u_{ttt}(x, 0)$, etc. - and, therefore, the coefficients of the Taylor series.

Kovalevskaya's key achievement was not simply writing down this formal series, but proving that, under the theorem's assumptions, the series converges; It represents a genuine analytic solution to the PDE near the initial surface.

Kovalevskaya's result was the first existence theorem for PDEs. Modern mathematicians have extended it to broader settings, such as microlocal analysis and the theory of D-modules, while the original result remains a standard foundation in graduate PDE courses.

Further Contributions

The Kovalevskaya Top

Kovalevskaya discovered the third classical integrable case of a heavy rigid body rotating about a fixed point, following earlier cases studied by Euler and Lagrange.

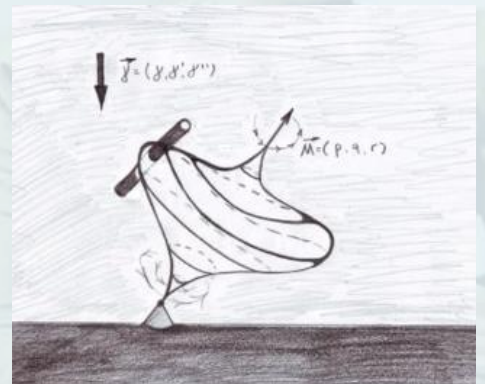
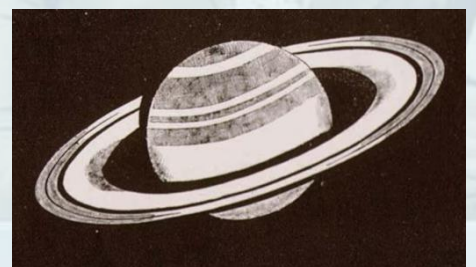


Image source: [ResearchGate](#)

Shape of Saturn's Rings

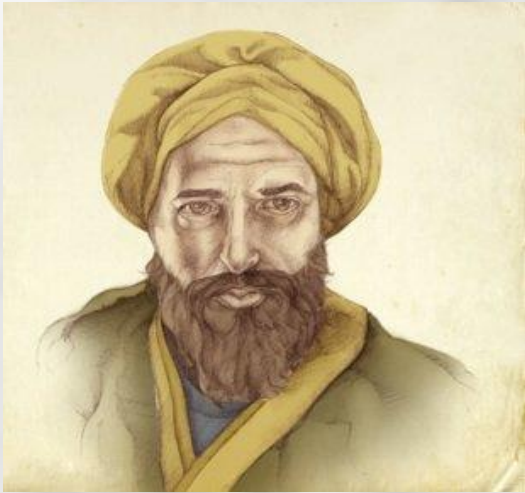
In her second doctoral paper, Kovalevskaya investigated the equilibrium shape of Saturn's rings, modelled as a fluid body. She argued that a stable cross-section of the ring could not be circular but instead oval.



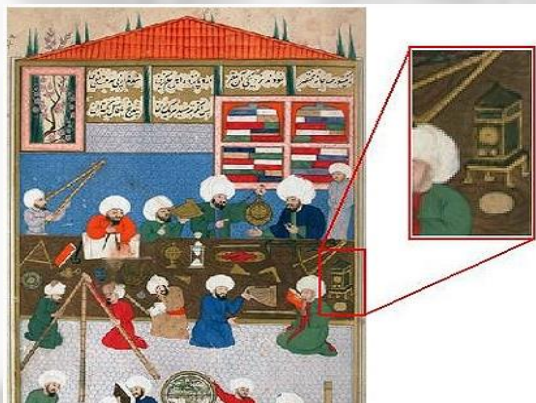
Taqi ad-Din Muhammad Ibn Ma'ruf Ash-Shami Al-Asadi (1526 – 1585)

Arab Muslim polymath

“The most important astronomer of Ottoman Turkey.”
– Encyclopaedia of Islam



“One of the greatest scientists of all time”
– Donald Routledge Hill



Taqi ad-Din was a versatile scholar in the Ottoman Empire, writing over 90 books on various subjects such as astronomy, clocks, engineering, mathematics, mechanics, optics, and natural philosophy. In 1574, the Ottoman Sultan Murad III invited him to establish an observatory in Istanbul, where he used instruments like an armillary sphere and mechanical clocks to observe the Great Comet of 1577. He also used European celestial and terrestrial globes received through gift exchanges. One of his major achievements from the observatory was a work titled *"The tree of ultimate knowledge in the Kingdom of the Revolving Spheres: The astronomical tables of the King of Kings (Murad III)"*. This book, based on observations in Egypt and Istanbul, built upon Ulugh Beg's 15th-century work, the *Zij-i Sultani*. It contains calculations, discussions on astronomical clocks, celestial circles, and details about three eclipses observed in Cairo and Istanbul.

Keeping the time

Taqi al-Din was tasked with creating a clock for accurate call to prayer timing, leading to his first book on building mechanical clocks in 1563, titled *"al-Kawakib al-Durriya fi Bengamat al-Dawriyya"*. He believed this would offer a precise understanding of celestial motions. He learned from European clockmakers and studied clocks in Semiz Ali Pasha's treasury, where he examined three types of clocks: those powered by weights, springs, and lever escapements. As Chief Astronomer, he designed a mechanical astronomical clock with three dials, enhancing observations at the Constantinople observatory.

Polymath - an individual whose knowledge spans many different subjects, used to describe the great thinkers of ancient times.



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a short turbine
animation

In 1551, Taqi al-Din created an early version of the steam turbine: a self-rotating spit. He also described four water-raising devices, including animal-powered pumps and paddle wheel-driven pumps. His innovative concepts predated many modern engines and laid the groundwork for steam engine development.

Taqi ad-Din Muhammad Ibn Ma'ruf Ash-Shami Al-Asadi (1526 – 1585)

Arab Muslim polymath

Time, Motion and the Stars

Working in the sixteenth-century Ottoman world, Taqi ad-Din pursued a clear goal in each of his disciplines: to make observation more reliable through precise measurement.

TIME: FALLING-WEIGHT CLOCK

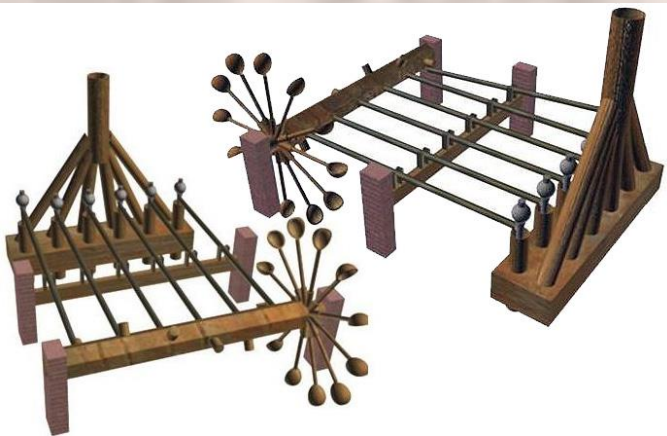
A clock designed by Taq ad-Din driven by falling weights; large gears and smaller pinions transmitted motion, while the escapement released the crown wheel one tooth at a time.

Taq ad-Din's 1559 treatise was the first known Islamic-world work on automatic mechanical clocks. A later observatory clock displayed hours, minutes and even seconds, although no measured daily error survives.

Precision context: early mechanical clocks often erred by about 15 min/day; Huygens's pendulum clock of 1656 later reached roughly 15 s/day.



Physical
Replica of
Taq al-Din's
Clock,
Image
Sourced
from:
[Istanbul
Museum.](#)



Virtual Replica of the Water Pump, Image Sourced from:
[Muslim Heritage.](#)

MOTION: SIX-CYLINDER WATER PUMP

Taqi ad-Din described a river-driven pump whose six-cam shaft converted rotation into the rise and fall of six pistons. Described circa 1550-52, its in-line cylinders and phased cams anticipated the continuous-delivery principle of modern multi-cylinder pumps and compressors.

Cam spacing = $360^\circ \div 6 = 60^\circ$

Six cams share one 360° revolution, so each begins 60° after the previous cam.

STARS: ISTANBUL OBSERVATORY

At the Istanbul Observatory, Taqi ad-Din measured celestial positions and recast astronomical fractions in decimal form. His *Jaridat al-durar* (1581–82) contains the first recorded decimal trigonometric tables.

Base 60 → base 10:

Sexagesimal writes angles in degrees, minutes and seconds: $1^\circ = 60'$ and $1' = 60''$. Decimal notation instead expresses fractional values as tenths, hundredths and thousandths.

The first documented decimal used in astronomy, by Taq ad-Din:

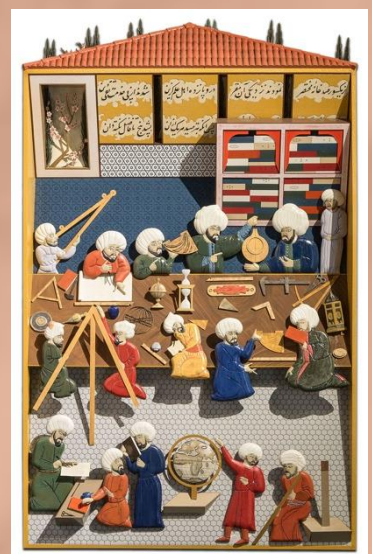
$532.876 = 5 \text{ hundreds} + 3 \text{ tens} + 2 \text{ ones} + 8 \text{ tenths} + 7 \text{ hundredths} + 6 \text{ thousandths}$

He expressed these place values in words, without a decimal point.

Applied to astronomy:

$23^\circ 28' 40'' = 23 + (28 \div 60) + (40 \div 3600) = 23.4778^\circ$

This was Taqi ad-Din's ecliptic value, expressed in modern decimal notation.



Istanbul Observatory
Diorama, Image Sourced
from: [Istanbul Museum.](#)