Mathlore — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Mathlore.

Write in the book, circle your answers, and check the Answer Key at the back.

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1. Ancient Number Systems

Circle the correct answer

1. What is the simplest way humans first counted objects thousands of years ago?
(A) Tally marks — one scratch or notch for each object (B) Saying numbers out loud without any record (C) Writing numbers 1, 2, 3 on paper (D) Using a calculator made of stone

2. What does it mean for a number system to be 'positional'?
(A) Numbers can only be written in one correct position on the page (B) The value of a digit depends on its position — the 3 in 300 is worth more than the 3 in 30 (C) Numbers must be written from left to right (D) Each number has a fixed position in the counting sequence

3. What base does our modern number system use?
(A) Base 100 — because cents go up to 100 (B) Base 5 — because we have 5 fingers on one hand (C) Base 12 — because there are 12 months in a year (D) Base 10 (decimal) — we group by tens, hundreds, thousands

4. What number does the Roman numeral XIV represent?
(A) 14 (B) 19 (C) 11 (D) 16

5. Why are Roman numerals difficult to use for multiplication and division compared to our Hindu-Arabic system?
(A) Because the Romans didn't know how to multiply (B) Roman numerals aren't positional — there's no place value system, making column arithmetic impossible (C) Because Roman numerals only go up to 1000 (D) Because Roman numerals use letters instead of numbers

6. The Hindu-Arabic number system we use today was invented in which civilization?
(A) Ancient Rome — alongside Roman numerals (B) Ancient Greece — by Pythagoras and Euclid (C) Ancient China — along with paper and gunpowder (D) Ancient India — then transmitted to Europe through Arab mathematicians

Write the answer

7. If you were counting in base 5 (quinary), what would come after the number 4?
Answer: ________

8. The ancient Sumerians (and later Babylonians) used base 60 for their number system. Where do we still use base 60 today?
Answer: ________

9. In ancient Egypt, the hieroglyphic number for 100 was a coiled rope. If an Egyptian wrote three coiled ropes and five single strokes, what number did they mean?
Answer: ________

10. What is an 'abacus' and why was it important in ancient mathematics?
Answer: ________

Match each question to its answer

1. Which ancient civilization is credited with inventing the concept of zero as a number? →
2. The Chinese rod numeral system used horizontal and vertical rods to represent digits. What clever rule made their system positional? →
3. Write the number 2024 in Roman numerals. →
4. Why is having a symbol for zero so important for a positional number system? →
5. The Inca civilization in South America used 'quipus' for record-keeping. What were quipus? →

(A) Knotted strings where different types of knots at different positions represented numbers in base 10
(B) MMXXIV
(C) Ancient India — Brahmagupta (628 CE) was the first to treat zero as a number with rules for arithmetic
(D) Without zero, you can't distinguish between numbers like 52, 502, and 520 — zero holds the empty position
(E) They alternated between vertical rods (for ones, hundreds, ten-thousands) and horizontal rods (for tens, thousands), making each position visually distinct

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2. Babylonian and Egyptian Mathematics

Circle the correct answer

11. The ancient Egyptians built the Great Pyramid of Giza with remarkable precision. Its base is almost a perfect square. What mathematical concept was essential for making the corners exactly 90 degrees?
(A) Calculus — they needed to calculate the curve of the pyramid (B) Right angles — the Egyptians used rope stretchers to create precise right angles (C) Probability — they guessed where to place the stones (D) Negative numbers — they measured downward from the top

12. What is a 'unit fraction'?
(A) A fraction with 1 as the numerator, like 1/2, 1/3, 1/4, or 1/7 (B) Any fraction that equals exactly 1 (C) A fraction where the numerator and denominator are equal (D) A fraction used to measure one unit of length

13. Express 3/4 as a sum of Egyptian unit fractions.
(A) 3/4 (it's already a unit fraction) (B) 1/4 + 1/4 + 1/4 (C) 1/3 + 1/4 (D) 1/2 + 1/4

14. The Rhind Papyrus (about 1650 BCE) is one of the most important ancient Egyptian mathematical documents. What types of problems does it contain?
(A) Practical problems about dividing bread, calculating areas, and solving equations — with worked solutions (B) Instructions for building the pyramids (C) Prayers and religious texts with some numbers (D) Only theoretical proofs about perfect numbers

15. The Babylonians knew that $3^2 + 4^2 = 5^2$ ($9 + 16 = 25$) over 1,000 years before Pythagoras. The clay tablet 'Plimpton 322' lists many such triples. What are these number sets called?
(A) Perfect squares — because all three numbers are squared (B) Pythagorean triples — sets of three whole numbers where $a^2 + b^2 = c^2$ (C) Triangle numbers — because they relate to triangle shapes (D) Babylonian triples — because the Babylonians discovered them first

16. The Babylonians approximated $\sqrt{2}$ as 1.41421356..., accurate to 6 decimal places. They wrote this on a clay tablet called YBC 7289. Why did they need to know $\sqrt{2}$?
(A) To predict eclipses of the sun and moon (B) To calculate the diagonal of a square — if a square has side 1, its diagonal is exactly $\sqrt{2}$ (C) To calculate how much grain fit in a rectangular container (D) To measure the circumference of a circle

Write the answer

17. Ancient Egyptians calculated the area of a circle using a method equivalent to using $\pi \approx 3.16$. How did they describe this method?
Answer: ________

18. Babylonian math problems were written on clay tablets in cuneiform. One tablet asks: 'I found a stone but did not weigh it. I added one-seventh and one-eleventh of its weight, then added 1 mina, reaching 1 mina total.' This is essentially what type of math problem?

Answer: ________

19. The Egyptian 'seked' measured the slope of a pyramid face. A seked of 5 palms and 1 finger (per cubit of height) was used for the Great Pyramid. What modern mathematical concept is this similar to?

Answer: ________

20. The Babylonians could solve quadratic equations (like $x^2 + 6x = 16$) by 1800 BCE. They used a method similar to what we now call 'completing the square.' What did they NOT have that makes their achievement even more impressive?

Answer: ________

Match each question to its answer

1. Ancient Egyptians used a clever method for multiplication called 'duplation' (doubling). To multiply 13 × 12, they doubled 12 repeatedly: 1×12=12, 2×12=24, 4×12=48, 8×12=96. Then since 13 = 8+4+1, the answer is 96+48+12 = ? →
2. Why were the annual floods of the Nile River important for the development of Egyptian mathematics? →
3. The Babylonians used base 60 for mathematics but base 10 for everyday counting. In base 60, the number we write as 75 would be written as 1,15 (one sixty plus fifteen). How would you write 130 in Babylonian base 60? →
4. Egyptian tomb paintings show a measuring tool called a 'cubit rod.' A royal cubit was about 52.4 cm and was divided into 7 palms, each further divided into 4 fingers. How many fingers are in one cubit? →
5. Babylonian scribes spent years in school (called 'edubba' or 'tablet house') learning mathematics. Students practiced by copying math problems onto clay tablets. Why was clay an ideal medium for mathematical education? →

(A) 2,10 (two sixties plus ten = 120 + 10 = 130)
(B) Floods erased land boundaries, requiring mathematical surveying to re-measure and redistribute farmland each year
(C) 28 fingers
(D) Wet clay could be smoothed and rewritten, allowing students to practice repeatedly — mistakes could be erased
(E) 156

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3. Mayan and Aztec Mathematics

Circle the correct answer

21. The Maya used a base-20 (vigesimal) number system. Most cultures use base 10 because we have 10 fingers. Why do scholars believe the Maya chose base 20?
(A) They had 20 gods and wanted to honor each one (B) They counted using both fingers and toes, giving 20 digits total (C) Their calendar had exactly 20 months (D) They believed 20 was a sacred prime number

22. The Mayan number system used only three symbols: a dot (worth 1), a bar (worth 5), and a shell shape (worth 0). How would you write the number 13 in Mayan numerals?
(A) Thirteen dots in a row (B) Two bars and three dots (5 + 5 + 3 = 13) (C) Two bars and one dot (5 + 5 + 1 = 11) (D) One bar and three dots (5 + 3 = 8)

23. The Maya independently invented the concept of zero, represented by a shell glyph. This happened around 350 CE. Remarkably, zero was independently invented in only one other major civilization. Which one?
(A) Ancient Greece (where Aristotle used zero in philosophy) (B) India (where Brahmagupta formalized zero around 628 CE) (C) Egypt (where hieroglyphs included a zero symbol) (D) China (where the abacus replaced the need for zero)

24. In the Mayan positional number system, place values go upward vertically. The bottom position is 1s, the next up is 20s, and the next is 400s (20 × 20). What does a Mayan number with a dot in the 400s place, a shell (zero) in the 20s place, and two bars in the 1s place represent?
(A) 510 (1 × 500 + 10) (B) 210 (1 × 200 + 0 + 10) (C) 410 (1 × 400 + 0 × 20 + 10 × 1) (D) 4010 (adding the digits together differently)

25. The Mayan calendar used a special modification to their base-20 system. Instead of the third position being 400 (20 × 20), it was 360. Why did the Maya make this exception?
(A) To match the Babylonian base-60 system they borrowed (B) Because 360 degrees make a full circle (C) Because their religious ceremonies occurred every 360 days (D) To make the third position approximate one solar year (365 days ≈ 360)

26. The Mayan Tzolk'in calendar combined a cycle of 13 numbers with a cycle of 20 named days. How many unique date combinations existed before the pattern repeated?
(A) 260 (13 × 20, since 13 and 20 share no common factors) (B) 520 (13 × 20 × 2) (C) 33 (13 + 20) (D) 200 (the approximate number of working days)

Write the answer

27. The Maya also used a 365-day solar calendar called the Haab'. Together with the 260-day Tzolk'in, the two calendars created a combined cycle called the Calendar Round. How many years until the Calendar Round repeated?

Answer: ________

28. Mayan astronomers tracked Venus with extraordinary precision. They calculated the Venus cycle as 584 days. The actual synodic period of Venus is 583.92 days. What is their percentage error?

Answer: ________

29. The Mayan Long Count calendar measured dates from a mythological creation date (August 11, 3114 BCE). In 2012, the Long Count reached 13.0.0.0.0, completing a major cycle. Many people incorrectly believed this meant the end of the world. What did it actually represent mathematically?

Answer: ________

30. The Aztec number system was also vigesimal (base 20), but instead of dots and bars, they used a different notation. A dot represented 1, a flag represented 20, a feather represented 400, and an incense bag represented 8,000. How would an Aztec scribe write the number 9,245?

Answer: ________

Match each question to its answer

1. The Aztecs used a standardized measurement system for land based on body parts. Their basic unit was the 'cemmatl' (about 2.5 meters, the span of outstretched arms). A square plot measuring 20 cemmatl on each side was called a 'quahuitl' parcel. What area (in square cemmatl) was one quahuitl parcel? →
2. Aztec tribute records like the Codex Mendoza used pictographic numerals to track taxes from conquered cities. If a page shows 3 feather symbols next to a bundle of cacao beans, how many cacao beans were owed as tribute? →
3. Compare the Mayan and Aztec number systems. Both are base 20, but they represent numbers very differently. What is the key structural difference? →
4. The Aztec calendar stone (Sun Stone) is a massive carved disk weighing about 24 tons. At its center are symbols representing the five 'suns' or ages of the world. The current age, the Fifth Sun, began on the date 4-Movement. This intricate carving demonstrates that the Aztecs viewed mathematics and what other domain as deeply interconnected? →
5. A Mayan farmer needed to plant a field and wanted to calculate its area. The field was shaped like a rectangle measuring 15 by 8 cemmatl. First, convert 15 and 8 to Mayan numerals, then calculate the area. How would you write 120 (the area) in Mayan base-20? →

(A) 1,200 cacao beans (3 × 400 = 1,200)
(B) The Mayan system is positional (place value matters, like our system), while the Aztec system is additive (symbols are simply added together)
(C) Religion and cosmology — mathematics structured their understanding of the universe and creation
(D) A dot in the 20s place and a shell (zero) in the 1s place (1 × 20 + 0 × 1 = 120 — wait, that's 20). Actually: a bar-dot (6) in the 20s place and zero in the 1s place (6 × 20 = 120)
(E) 400 square cemmatl (20 × 20)

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4. Indian Mathematics: Zero and Algebra

Circle the correct answer

31. The Bakhshali manuscript (~300-400 CE) contains one of the earliest written uses of zero as a number (not just a placeholder). Before zero was treated as a number, why was it so difficult for ancient mathematicians to accept zero as a legitimate value?
(A) They hadn't invented the circular symbol yet and had no way to write it (B) Numbers were understood as counting quantities of things — the idea of a number representing 'nothing' seemed contradictory and philosophically problematic (C) The abacus already handled empty positions, so there was no practical need (D) Their rulers banned the concept because it was considered bad luck

32. Brahmagupta (628 CE) wrote the first rules for computing with zero. He stated that any number plus zero equals itself, and any number times zero equals zero. But one of his rules was later found to be incorrect. Which rule was it?
(A) He said any number minus zero equals the number itself (B) He said zero plus zero equals one (C) He said zero times zero equals one (D) He said zero divided by zero equals zero (modern math says it's undefined)

33. Brahmagupta also developed rules for negative numbers, which he called 'debts' (and positive numbers were 'fortunes'). Using his rule that 'a debt subtracted from zero is a fortune,' what is 0 - (-5)?
(A) -5 (zero minus anything is negative) (B) 5 (subtracting a negative is the same as adding a positive) (C) -10 (double the negative) (D) 0 (anything involving zero stays zero)

34. Aryabhata (476 CE) wrote the Aryabhatiya, a mathematical treatise covering arithmetic, algebra, and trigonometry in just 121 verses of poetry. Why would a mathematician write formulas as poetry?
(A) Poetry was considered more prestigious than plain mathematics (B) He wanted to prove that math and art were the same thing (C) Written prose was forbidden by the ruling king of that era (D) Before printing, poetry with meter and rhyme was

easier to memorize and transmit accurately across generations through oral tradition

35. Aryabhata calculated π (pi) as approximately 3.1416, which is accurate to four decimal places. He described his method: 'Add four to one hundred, multiply by eight, and then add sixty-two thousand. The result is approximately the circumference of a circle of which the diameter is twenty thousand.' What value of π does his formula give?
(A) 3.1592 — the result if you multiply instead of add (B) 3.14 — a rough approximation missing the last two digits (C) 3.1416 — the formula gives (100 + 4) × 8 + 62,000 = 62,832, divided by 20,000 = 3.1416 (D) 3.1428 — close but not matching the exact formula

36. The decimal place value system (using digits 0-9 with positional notation) was invented in India and later transmitted to Europe through Arab scholars. Europeans called these 'Arabic numerals.' Why is the name 'Hindu-Arabic numerals' more historically accurate?
(A) The system was invented by Indian (Hindu) mathematicians and then transmitted westward by Arab scholars — both cultures deserve credit (B) The name was created by the United Nations to be diplomatically neutral (C) Hindus invented the numbers 1-5 and Arabs invented 6-9 and zero (D) Hindu refers to the religious context and Arabic to the mathematical context

Write the answer

37. Indian mathematicians developed a method called 'kuttaka' (the pulverizer) for solving problems like: 'Find a number that gives remainder 1 when divided by 5 and remainder 2 when divided by 7.' This is known today as solving a system of linear congruences. What is the smallest positive number that satisfies both conditions?
Answer: ________

38. Mahavira (9th century) posed this problem in his book Ganita Sara Sangraha: 'A peacock sitting on a pillar 9 units high pounces on a snake 27 units from the base. Both the peacock and snake travel equal distances. How far from the base of the pillar do they meet?
Answer: ________

39. The Kerala School of Mathematics (1300s-1600s CE) in southern India discovered infinite series for π, sine, and cosine — approximately 200 years before Newton and Leibniz in Europe. Madhava of Sangamagrama found that π/4 = 1 - 1/3 + 1/5 - 1/7 + 1/9 - ... What is the approximate value of π if you use just the first 4 terms of this series?
Answer: ________

40. Bhaskara II (12th century) wrote the Lilavati, a mathematics textbook framed as problems posed to his daughter Lilavati. One problem states: 'The square of one-eighth of a group of monkeys, diminished by three, is playing in a grove. One monkey is on the hill. How many monkeys are there total?' This translates to: $(n/8)^2 - 3 + 1 = n$. What is n?

Answer: ________

Match each question to its answer

1. Indian mathematicians used the word 'shunya' for zero. This word literally means 'void' or 'emptiness' and comes from Buddhist and Hindu philosophical concepts. How might this philosophical background have helped Indian mathematicians accept zero as a number when other cultures could not? →
2. Aryabhata developed a place-value system for very large numbers using Sanskrit syllables. He could express numbers up to 10^18 (a quintillion). Our modern system uses names like million, billion, trillion. Indian mathematics already had specific names for each power of 10 up to 10^17. What does this suggest about their mathematical ambitions? →
3. Brahmagupta gave a formula for the area of a cyclic quadrilateral (a four-sided figure inscribed in a circle) with sides a, b, c, d: Area = $\sqrt{(s-a)(s-b)(s-c)(s-d)}$, where $s = (a+b+c+d)/2$. If a cyclic quadrilateral has sides 3, 4, 5, and 6, what is s? →
4. The Indian numeral system spread along trade routes: India → Arab world → North Africa → Spain → all of Europe. This journey took roughly 500 years (600 CE to 1100 CE). The Italian mathematician Fibonacci helped popularize these numerals in Europe with his 1202 book Liber Abaci. What made adoption slow in Europe? →
5. Aryabhata (499 CE) stated that the Earth rotates on its axis, explaining the apparent motion of stars. He used this insight to calculate the length of a sidereal day (one complete rotation) as 23 hours, 56 minutes, and 4.1 seconds. The modern value is 23 hours, 56 minutes, and 4.091 seconds. How close was he? →

(A) Indian mathematicians were comfortable thinking about extremely large numbers and needed them for astronomical and cosmological calculations
(B) European merchants and scholars were deeply invested in Roman numerals and the abacus — switching systems meant retraining entire professions
(C) Indian philosophy already embraced the concept of emptiness/void as meaningful and real, making it natural to treat 'nothing' as a legitimate mathematical quantity
(D) 9 ($s = (3+4+5+6)/2 = 18/2 = 9$)
(E) Within 0.009 seconds — astonishingly accurate for the 5th century

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5. Islamic Geometric Art and Patterns

Circle the correct answer

41. Islamic geometric art is built on a prohibition against depicting living beings in religious spaces. Instead, artists created astonishingly complex patterns using only geometric shapes. What mathematical concept is most fundamental to creating these repeating patterns?
(A) Probability — patterns were generated randomly to avoid human figures (B) Statistics — artists measured audience preferences to choose designs (C) Calculus — artists needed to calculate curved surfaces (D) Symmetry — specifically translational, rotational, and reflective symmetry that allows a pattern to tile a surface infinitely

42. Mathematicians have classified exactly 17 distinct 'wallpaper groups' — the 17 possible ways a pattern can repeat to fill a flat surface. Remarkably, all 17 groups have been found in the tile work of the Alhambra palace in Granada, Spain. How many centuries before mathematicians classified these groups did Islamic artists use them all?
(A) About 1 century (the classification happened shortly after) (B) About 5-6 centuries (Alhambra was built in the 1300s; mathematical classification came in the late 1800s) (C) They were classified simultaneously by different communities (D) About 10 centuries (Islamic art predates the Alhambra by that much)

43. To construct Islamic geometric patterns, artists began with a circle divided into equal parts. An 8-pointed star pattern starts by dividing a circle into 8 equal parts. What is the angle between adjacent division points?
(A) 45° (360° ÷ 8 = 45°) (B) 40° (360° ÷ 9, wrong divisor) (C) 60° (360° ÷ 6, hexagonal division) (D) 36° (360° ÷ 10, decagonal division)

44. Islamic patterns typically use 3-fold, 4-fold, 6-fold, 8-fold, 10-fold, or 12-fold rotational symmetry. Notably, 5-fold and 7-fold symmetry are extremely rare. Why can't regular pentagons (5-fold) or heptagons (7-fold) tile a flat surface by themselves?
(A) Their interior angles (108° for pentagons, ~128.6° for heptagons) don't divide evenly into 360°, so they leave gaps or overlaps when placed together (B) These shapes are too complex for human eyes to perceive the symmetry (C) The tools available couldn't accurately construct 5-sided or 7-sided figures (D) Artists considered odd numbers unlucky and avoided them

45. Al-Khwarizmi (780-850 CE) wrote the foundational algebra text 'Al-Kitab al-Mukhtasar fi Hisab al-Jabr wal-Muqabala.' Two words from this title became part of modern mathematics. 'Al-jabr' (restoration) became 'algebra.' What did his name 'al-Khwarizmi' eventually become?
(A) Axiom — from his systematic approach to mathematical proofs (B) Logarithm — combining 'al-Khwarizmi' with Greek 'logos' (C) Algorithm — the word 'algorithm'

derives from the Latinized form of his name, 'Algoritmi'   (D) Arithmetic — from the Arabic root of his name

46. The Darb-i Imam shrine in Isfahan, Iran (1453 CE) contains tile patterns that exhibit a form of 5-fold symmetry — patterns that never exactly repeat. In 2007, physicists Peter Lu and Paul Steinhardt showed these patterns match what mathematical concept discovered in the West in the 1970s?
(A) Fractals — self-similar patterns at every scale, discovered by Mandelbrot in 1975   (B) Penrose tilings (aperiodic tilings) — non-repeating patterns with 5-fold symmetry, discovered by Roger Penrose in 1974   (C) Topology — the study of shapes that can be continuously deformed   (D) Chaos theory — patterns that appear random but follow deterministic rules

Write the answer

47. Islamic artists used a technique called 'girih' (knot) to create their patterns. The basic method involves drawing construction lines on a grid, then selectively erasing and connecting segments. To create a 6-pointed star from a regular hexagon, you connect every other vertex. What geometric name describes this 6-pointed star shape?
Answer: ________

48. The House of Wisdom (Bayt al-Hikma) in Baghdad (founded ~830 CE) was one of the greatest centers of learning in history. Scholars translated Greek, Indian, and Persian mathematical texts into Arabic, then extended them with new discoveries. Which of these was a direct result of the House of Wisdom's translation movement?
Answer: ________

49. Omar Khayyam (1048-1131 CE) classified and solved cubic equations (like $x^3 + ax = b$) using the intersections of conic sections (circles, parabolas, hyperbolas). He found that two overlapping conic sections can intersect at 0, 1, or 2 points. What does each intersection point represent?
Answer: ________

50. A common Islamic geometric pattern called an 'arabesques' uses interlacing lines that weave over and under each other. If a single interlacing line crosses over another line, then under the next, then over, then under — continuing this pattern — it creates a woven appearance. How many times does a line change from 'over' to 'under' (or vice versa) in one complete circuit of an octagonal interlace pattern with 8 crossings?
Answer: ________

Match each question to its answer

1. Al-Biruni (973-1048 CE) calculated the Earth's radius using a mountain and trigonometry. He climbed a mountain of known height h, measured the angle of depression θ to the horizon, and used the formula: $R = h \cdot \cos(\theta) / (1 - \cos(\theta))$. His result was about 6,340 km. The modern value is 6,371 km. What was his percentage error? →
2. Islamic geometric patterns follow strict construction rules using only a compass and straightedge — the same tools Euclid specified. Why did Islamic artisans restrict themselves to these two tools when they could have used rulers with measurements? →
3. Girih tiles are a set of 5 tile shapes used in Islamic architecture. They include a regular decagon, an elongated hexagon (bowtie), a rhombus, a pentagon, and a convex hexagon. All edges are the same length, and all angles are multiples of 36°. Why is 36° the key angle? →
4. Nasir al-Din al-Tusi (1201-1274 CE) wrote the first treatment of trigonometry as a discipline independent from astronomy. He established the law of sines: $a/\sin(A) = b/\sin(B) = c/\sin(C)$ for any triangle. In a triangle where angle A = 30° (sin 30° = 0.5), side a = 7 cm, and angle B = 45° (sin 45° ≈ 0.707), what is the length of side b? →
5. Islamic art often features tessellations — patterns where shapes fit together with no gaps and no overlaps. Which of the following combinations of regular polygons can meet at a single vertex to create a valid tessellation? →

(A) Compass and straightedge constructions are exact — they produce geometrically perfect relationships that rulers with numerical measurements can only approximate
(B) About 0.5% ($|6340-6371|/6371 \times 100 \approx 0.49\%$)
(C) About 9.9 cm ($7/0.5 = 14$, so $b = 14 \times 0.707 \approx 9.9$)
(D) Two regular octagons and one square (135° + 135° + 90° = 360°)
(E) Because 36° = 360° ÷ 10, and all girih patterns are based on 10-fold (decagonal) symmetry

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6. African Mathematics and Fractal Geometry

Circle the correct answer

51. Ron Eglash, a mathematician, discovered that many traditional African villages are built in fractal patterns — shapes that repeat at different scales. The Ba-ila settlement in Zambia has a large oval enclosure containing smaller oval enclosures, each containing even smaller oval structures. What mathematical property defines a fractal?
(A) Self-similarity — the same pattern or shape appears at multiple scales, from large to small (B) Periodicity — the pattern repeats at regular intervals like a wallpaper (C) Randomness — the shape has no predictable structure at any scale

(D) Symmetry — the shape looks the same when flipped or rotated

52. The Ishango bone, found near Lake Edward in the Democratic Republic of Congo, is approximately 20,000 years old. It contains groups of tally marks organized in patterns. One column shows: 11, 13, 17, 19. What is mathematically special about all four of these numbers?
(A) They increase by the same amount each time (B) They are all prime numbers (divisible only by 1 and themselves) (C) They are all odd numbers (true, but that's a less significant pattern) (D) They are all Fibonacci numbers

53. Another column on the Ishango bone shows: 3, 6, 4, 8, 10, 5, 5, 7. Some researchers notice a doubling pattern hidden in this sequence. Which pairs show doubling?
(A) 3→6 (×2), 4→8 (×2), and 5→10 (×2) — three pairs where the second number is double the first (B) The whole sequence doubles: 3, 6, 12, 24... (C) 6→12 and 8→16 (these numbers aren't on the bone) (D) 3→4→5 shows addition by 1, not doubling

54. Ethiopian multiplication (also called Russian peasant multiplication) is an ancient method that multiplies two numbers using only doubling, halving, and addition. To multiply 13 × 15: halve the left column (ignoring remainders) and double the right column, then add right-column values where the left column is odd. What is 13 × 15 using this method?
(A) 210 (added all rows including even ones), which is why this approach is recommended by experts (B) 195 (Left: 13, 6, 3, 1 | Right: 15, 30, 60, 120 | Odd rows: 13→15, 3→60, 1→120 | Sum: 15+60+120 = 195) (C) 180 (missed the first row where 13 is odd), which is the most common explanation for this phenomenon (D) 225 (15 × 15, wrong starting number), which is the most common explanation for this phenomenon

55. Ethiopian multiplication works because halving a number and checking if it's odd is the same as reading its binary representation. The number 13 in binary is 1101 (8+4+0+1). Why does crossing out even rows and adding the remaining doubled values produce the correct product?
(A) Even numbers always cancel out in multiplication, which is the most common explanation for this phenomenon (B) It's a coincidence that works for small numbers but fails for large ones, which is the most common explanation for this phenomenon (C) The crossing out removes errors introduced by the halving process, as this is what research and standard practice suggests (D) Each odd left-column value represents a '1' bit in the binary representation of the multiplier, and the corresponding right-column value is the multiplicand multiplied by that power of 2

56. The Yoruba people of Nigeria developed a complex number system based on 20 (vigesimal) with subtraction. For example, 45 is expressed as '5 from 50' (i.e., 50-5), and 35 is '5 from 2 twenties' (2×20-5=35). How would the Yoruba express 77?
(A) 7 from 4 twenties (4 × 20 - 7 = 73) (B) 17 from 5 twenties (5 × 20 - 17 = 83) (C) 3 from 80 (same answer but not using the vigesimal structure) (D) 3 from 4 twenties (4

× 20 - 3 = 80 - 3 = 77)

Write the answer

57. The Yoruba divination system called Ifá uses a binary code. The diviner casts a chain of 8 half-shells, each landing open (1) or closed (0), creating one of $2^8 = 256$ possible patterns. Each pattern is associated with specific verses and wisdom. How many possible outcomes does one cast of the Ifá chain produce?
Answer: ________

58. Fractal patterns appear in African textiles, hairstyles, architecture, and art. The Fulani wedding blankets feature patterns where a large diamond shape contains smaller diamond shapes, which contain even smaller ones. If the largest diamond has a side length of 24 cm and each nested diamond is exactly half the side length of its parent, what is the side length of the third-level (smallest) diamond?
Answer: ________

59. The ancient Egyptian method of multiplication (also used across Africa) works by doubling. To multiply 23 × 17, you build a doubling table starting with 1 × 17 = 17, then select rows that add up to 23. Which rows do you select?
Answer: ________

60. The Chokwe people of Angola and the Democratic Republic of Congo create elaborate geometric drawings in sand called 'sona' (singular: lusona). These drawings are made with a single continuous line that never lifts from the surface and never retraces itself. This is mathematically equivalent to which famous problem?
Answer: ________

Match each question to its answer

1. To determine if a Chokwe sona drawing can be completed in a single continuous line, the artist checks if the number of intersection points with an odd number of lines meeting at them is 0 or 2. This is exactly Euler's rule for Eulerian paths. If a sona design has all even-degree vertices, what can you conclude? →
2. The Akan people of Ghana use a system of gold weights for measuring gold dust in trade. The weights follow a mathematical progression. A set of Akan gold weights might include: 1, 2, 3, 6, 12, 24 units. What mathematical relationship connects 3, 6, 12, and 24? →
3. African fractal architecture serves social purposes. In many West African villages, the chief's compound is a large version of the family compound, which is a large version of the individual house. The decreasing size represents decreasing social authority. If the chief's compound covers 400 m², family compounds cover 100 m² each, and individual houses cover 25 m² each, what is the scaling factor between each

level? →

4. The Kuba people of the Democratic Republic of Congo are famous for their geometric textile designs. Kuba cloth features complex patterns created using four types of symmetry transformations. A Kuba artist creates a base motif and then applies these four operations to fill the cloth. What are the four fundamental symmetry operations? →

5. The ancient game of Mancala, originating in Africa and at least 7,000 years old, requires sophisticated mathematical strategy. In the 'count and capture' variant, a player distributes seeds one-by-one around the board. If you have a pit with 14 seeds and the board has 12 pits total, how many complete laps will the seeds make, and how many seeds remain after the last complete lap? →

(A) Each weight is double the previous one — a geometric sequence with common ratio 2

(B) The drawing can be completed as a closed loop (Eulerian circuit) — the artist can start and end at the same point

(C) Translation (slide), rotation (turn), reflection (mirror), and glide reflection (slide + mirror)

(D) 1/2 for linear dimensions (each level has 1/4 the area, so linear dimensions scale by √(1/4) = 1/2)

(E) 1 complete lap with 2 seeds remaining (14 ÷ 12 = 1 remainder 2)

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7. Asian Mathematics: Origami, Tangrams, and Beyond

Circle the correct answer

61. Japanese origami (paper folding) can solve geometric problems that are impossible with a compass and straightedge alone. One famous example: it's impossible to trisect (divide into 3 equal parts) an arbitrary angle using only compass and straightedge, but origami can do it. What mathematical advantage does paper folding have over compass and straightedge?

(A) Paper is more flexible than metal compasses, allowing more precise measurements (B) Origami uses three dimensions while compass and straightedge only work in two (C) Paper folding is faster, allowing more operations in less time (D) Origami folds can create cubic curves (third-degree equations), while compass and straightedge are limited to quadratic (second-degree) equations

62. A tangram is a Chinese puzzle consisting of 7 pieces (tans) cut from a square: 2 large right triangles, 1 medium right triangle, 2 small right triangles, 1 square, and 1 parallelogram. If the original square has side length 4, what is the area of one small right triangle?
(A) 8 square units (this is one large triangle's area) (B) 2 square units (the small triangle has legs of length 2, so area = ½ × 2 × 2 = 2) (C) 4 square units (this is the medium triangle's area) (D) 1 square unit (half the correct area)

63. The Chinese Remainder Theorem (CRT) was first described by Sun Tzu (the mathematician, not the military strategist) around 300 CE. The classic problem: 'A number has remainder 2 when divided by 3, remainder 3 when divided by 5, and remainder 2 when divided by 7. What is the number?' What is the smallest positive solution?
(A) 53 (53 ÷ 3 = 17 R 2, 53 ÷ 5 = 10 R 3, 53 ÷ 7 = 7 R 4, fails third) (B) 37 (37 ÷ 3 = 12 R 1, doesn't satisfy first condition) (C) 128 (128 ÷ 3 = 42 R 2, 128 ÷ 5 = 25 R 3, 128 ÷ 7 = 18 R 2 — valid but not smallest) (D) 23 (23 ÷ 3 = 7 R 2, 23 ÷ 5 = 4 R 3, 23 ÷ 7 = 3 R 2)

64. The Lo Shu magic square is one of the oldest mathematical objects in Chinese culture (dating to ~650 BCE). It's a 3×3 grid where every row, column, and diagonal sums to the same number. The numbers 1-9 are used exactly once. What is the magic constant (the common sum)?
(A) 18 (slightly too large for numbers 1-9) (B) 9 (the largest single number, not the row sum) (C) 15 (the sum of all numbers 1-9 is 45, divided equally among 3 rows gives 45÷3 = 15) (D) 12 (too small — even 7+8+9 > 12... wait, 7+8+9=24, so 12 is way too small)

65. Sangaku are Japanese geometric puzzles that were painted on wooden tablets and hung in Shinto shrines and Buddhist temples during the Edo period (1603-1867). This tradition arose because Japan was largely isolated from Western mathematics. A classic sangaku problem: three equal circles of radius r are packed inside a larger circle, each touching the other two and the outer circle. What is the radius R of the outer circle in terms of r?
(A) $R = r(1 + 2/\sqrt{3}) = r(1 + 2\sqrt{3}/3) \approx 2.155r$ (B) $R = 3r$ (simply three times the small radius) (C) $R = r\sqrt{3}$ (the ratio for a different packing arrangement) (D) $R = 2r$ (the circles don't all fit touching each other at this size)

66. The Japanese soroban (abacus) has one bead above the bar (worth 5) and four beads below (each worth 1) on each rod. Expert soroban users can perform calculations faster than electronic calculators. What is the maximum value that can be represented on a single rod?
(A) 5 (only using the top bead) (B) 10 (5 + 5, but there's only one 5-bead per rod) (C) 15 (adding all beads regardless of position) (D) 9 (one 5-bead + four 1-beads = 5 + 4 = 9)

Write the answer

67. The Nine Chapters on the Mathematical Art (Jiuzhang Suanshu, ~200 BCE - 200 CE) is one of China's most important mathematical texts. It contains a method for solving systems of linear equations that is essentially identical to what Europeans later called 'Gaussian elimination' (named after Gauss, 1800s). The Chinese method uses a counting rod arrangement that looks like what we now call a matrix. Solve this system from the Nine Chapters: $2x + y = 10$ and $x + 3y = 15$.
Answer: ________

68. Origami's mathematical power comes from the Huzita-Hatori axioms — 7 fundamental operations that define what paper folding can achieve. One axiom states: 'Given two points p1 and p2, fold p1 onto p2.' What geometric construction does this fold create?
Answer: ________

69. Seki Takakazu (1642-1708), often called 'Japan's Newton,' independently developed concepts equivalent to determinants, Bernoulli numbers, and calculus methods — all while Japan was isolated from the West. He calculated π to 10 decimal places using a method similar to but distinct from European approaches. What does Seki's independent discovery of the same mathematical concepts tell us?
Answer: ________

70. The Chinese 'Sunzi Suanjing' (3rd-5th century CE) contains this problem: 'A woman washing bowls in a river was asked how many she had. She said: if I count by 2s, 1 is left over; by 3s, 2 are left over; by 4s, 3 are left over; by 5s, 4 are left over; by 6s, 5 are left over; by 7s, nothing is left over.' Notice the pattern: the remainder is always one less than the divisor for 2-6. This means the number is 1 less than a multiple of LCM(2,3,4,5,6). What is LCM(2,3,4,5,6)?
Answer: ________

Match each question to its answer

1. The Kokichi Sugihara illusion uses mathematical principles to create 3D objects that look impossible from certain viewpoints. One famous example: a slope appears to go uphill, but a ball placed on it rolls 'uphill.' This exploits the difference between actual 3D geometry and its 2D projection. What mathematical concept makes this illusion work? →

2. The ancient Chinese text 'Zhou Bi Suan Jing' (c. 1046 BCE) contains one of the earliest proofs of the Pythagorean theorem using a visual 'rearrangement' argument. The proof shows a square of side (a+b) containing 4 right triangles and a smaller tilted square. The area of the large square equals the sum of the parts. Set up the equation that proves $a^2 + b^2 = c^2$. →

3. Korean mathematician Choi Seok-jeong (1646-1715) created orthogonal Latin squares — a mathematical structure later studied by Euler in 1782. A Latin square is an n×n grid where each symbol appears exactly once in each row and column. Two Latin squares are orthogonal if, when overlaid, every possible pair of symbols appears exactly once. How many unique pairs exist when overlaying two 3×3 Latin squares using symbols {A,B,C} and {1,2,3}? →
4. The Kaprekar constant (discovered by Indian mathematician D.R. Kaprekar) shows a surprising property of the number 6174. Take any 4-digit number with at least 2 different digits, arrange digits in descending then ascending order, subtract the smaller from the larger, and repeat. You always reach 6174 within 7 steps. Try starting with 3087: arrange descending (8730), ascending (0378), subtract. What do you get? →
5. The Zhu Shijie triangle (1303 CE, China) is identical to what Europeans call Pascal's Triangle (1653). Zhu's version, published in his book 'Precious Mirror of the Four Elements,' predates Pascal by 350 years. The triangle's nth row gives the coefficients of $(a+b)^n$. What are the coefficients of $(a+b)^4$? →

(A) 8352 (8730 - 0378 = 8352)
(B) $(a+b)^2 = 4(½ab) + c^2 \rightarrow a^2 + 2ab + b^2 = 2ab + c^2 \rightarrow a^2 + b^2 = c^2$
(C) 9 pairs (3×3 = 9 possible combinations: A1, A2, A3, B1, B2, B3, C1, C2, C3)
(D) Projection — a 3D shape can have infinitely many different 3D forms that produce the same 2D image from a specific viewpoint
(E) 1, 4, 6, 4, 1 (so $(a+b)^4 = a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$)

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8. Master Ethnomathematician Capstone

Circle the correct answer

71. You've studied number systems from Babylonian (base-60), Mayan (base-20), Chinese (base-10), and Egyptian (base-10 additive). Which mathematical concept did the Babylonians and Mayans both independently develop that the Egyptians and early Romans did NOT use?
(A) Addition and subtraction operations (B) Positional notation with place value (C) The concept of fractions (D) Symbols for numbers greater than 100

72. The concept of zero was independently developed in at least three civilizations: Mayan (~350 CE), Indian (~628 CE formalized by Brahmagupta), and Babylonian (as placeholder). However, only one civilization developed zero as a TRUE number you could use in arithmetic (add, subtract, multiply). Which civilization was that?
(A) Indian mathematicians (B) Babylonian mathematicians (C) Chinese mathematicians (D) Mayan mathematicians

73. Compare these multiplication methods: Egyptian doubling (used in Africa for millennia), Russian peasant multiplication, and the lattice method (used in Islamic mathematics). What do the Egyptian and Russian methods have in common that the lattice method does NOT share?
(A) They both only work for numbers less than 1000 (B) They both require writing numbers in base-2 before calculating (C) They both give approximate answers rather than exact ones (D) They both use only doubling and addition, avoiding memorized multiplication tables

74. Islamic geometric art uses all 17 possible wallpaper symmetry groups, African Kente cloth uses all 7 possible frieze groups, and Japanese origami can solve cubic equations that compass-and-straightedge cannot. What do these three achievements have in common?
(A) Each culture learned these techniques from Greek mathematicians (B) Each culture used trial and error without understanding the underlying mathematics (C) Each culture independently reached the mathematical limits of what is possible in their domain (D) Each achievement was only recognized by Western mathematicians in the 21st century

75. A museum is creating a timeline of π (pi) approximations from different cultures. Place these in chronological order: (A) Zu Chongzhi's 355/113, (B) al-Kashi's 16-digit calculation, (C) Aryabhata's 3.1416, (D) Archimedes' upper bound of 22/7. Which is the correct order?
(A) D, C, A, B (B) A, D, C, B (C) C, D, A, B (D) D, A, C, B

76. You're designing a math game that teaches different cultural number systems. A player enters the number 47. Convert this to Mayan notation (base-20 with dots, bars, and levels). How many levels does it need, and what goes on each level?
(A) Two levels: bottom level shows 4 (four dots), top level shows 7 (one bar and two dots) (B) One level showing 47 (nine bars and two dots) (C) Two levels: bottom level shows 7 (one bar and two dots), top level shows 2 (two dots) (D) Three levels: bottom shows 7, middle shows 4, top shows 0

Write the answer

77. The Ishango bone (Africa, ~20,000 BCE) shows prime numbers. The Sieve of Eratosthenes (Greece, ~240 BCE) is a systematic method for finding primes. The Indian mathematician Brahmagupta (628 CE) used primes in his number theory work. What does this 20,000-year span suggest about prime numbers?
Answer: ________

78. A student claims: 'Real mathematics was only invented in ancient Greece. Other cultures just did practical calculations.' Using evidence from at least TWO non-Greek cultures, construct the strongest counter-argument.

Answer: ________

79. Both Ba-ila villages in Africa and Sierpinski triangles in Western mathematics show fractal self-similarity. The Ba-ila villages were built centuries before Benoit Mandelbrot coined the word 'fractal' in 1975. If you measure the fractal dimension of a Ba-ila village layout where each scale is 1/3 the size and there are 3 copies, what is the fractal dimension?

Answer: ________

80. The Chinese Remainder Theorem, the Indian kuttaka method, and the Euclidean algorithm all solve problems about remainders. A farmer has eggs that leave remainder 2 when counted by 3s, remainder 3 when counted by 5s, and remainder 2 when counted by 7s. Using the Chinese Remainder Theorem, what is the smallest positive number of eggs?

Answer: ________

Match each question to its answer

1. Compare tessellation traditions: Islamic artists used regular polygons to tile planes, Escher (influenced by the Alhambra) used transformed shapes, and African Kuba cloth artists used geometric motifs with all four symmetry operations. What mathematical constraint applies to ALL tessellations regardless of culture? →

2. You're creating an exhibit comparing how different cultures used mathematics for astronomy. Match each achievement to its culture: (1) Eclipse prediction tables in the Dresden Codex, (2) Calculating Earth's radius within 0.5% accuracy, (3) Measuring the sidereal day within 0.009 seconds of modern values. The cultures are: Mayan, Islamic (al-Biruni), and Indian (Aryabhata). →

3. The knowledge transfer route from India to Europe went: Indian mathematicians → Arab scholars (House of Wisdom, Baghdad) → Islamic Spain (al-Andalus) → medieval Europe. This journey took roughly 500 years (600s–1100s CE). If the Hindu-Arabic numeral system had reached Europe 300 years earlier, which European development might have happened sooner? →

4. Design a new number system inspired by what you've learned. Your system must be base-8 (octal), use positional notation (like Mayan and Babylonian), and include a symbol for zero (like Indian mathematics). How would you write the decimal number 100 in your base-8 system? →

5. Pascal's Triangle appears independently in Chinese mathematics (Jia Xian, 1050 CE), Persian mathematics (Omar Khayyam, 1100 CE), Indian mathematics (Pingala, ~200 BCE for binary coefficients), and European mathematics (Pascal, 1653 CE). What does row 6 of Pascal's Triangle look like? →

(A) 144 (1×64 + 4×8 + 4×1)
(B) The angles meeting at every vertex must sum to exactly 360°
(C) The Scientific Revolution and development of modern algebra
(D) 1, 6, 15, 20, 15, 6, 1
(E) 1-Mayan, 2-Islamic (al-Biruni), 3-Indian (Aryabhata)

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9. Elements & Principles Deep Dive

Circle the correct answer

81. What is the simplest way humans first counted objects thousands of years ago?
(A) Using a calculator made of stone (B) Writing numbers 1, 2, 3 on paper (C) Saying numbers out loud without any record (D) Tally marks — one scratch or notch for each object

82. Why are Roman numerals difficult to use for multiplication and division compared to our Hindu-Arabic system?
(A) Because Roman numerals only go up to 1000 (B) Because the Romans didn't know how to multiply (C) Because Roman numerals use letters instead of numbers (D) Roman numerals aren't positional — there's no place value system, making column arithmetic impossible

83. What is an 'abacus' and why was it important in ancient mathematics?
(A) A type of clay tablet for writing numbers, as this directly follows from the underlying principles (B) A musical instrument that counted rhythmic beats, and this has been consistently demonstrated in practice (C) A counting tool with beads on rods that represents place values — it enabled fast arithmetic before written calculation methods existed (D) An ancient telescope for studying stars, and this has been consistently demonstrated in practice

84. The ancient Yoruba people of Nigeria used a base-20 (vigesimal) system with subtraction. The number 35 was expressed as '5 from 2 twenties' (2×20 - 5). What would 45 be?
(A) 1 twenty and 25 (20 + 25 = 45), and this has been consistently demonstrated in practice (B) 5 from 2 and a half twenties, or 10 from 3 twenties (3×20 - 10 = 50 - 10 = ... actually it would be expressed as 5 from 50, meaning 50 - 5 = 45) (C) 4 twenties and 5 (4×20 + 5 = 85), which is the most common explanation for this phenomenon (D) 2 twenties and 5 (2×20 + 5 = 45), which is the most common explanation for this phenomenon

85. The ancient Egyptians built the Great Pyramid of Giza with remarkable precision. Its base is almost a perfect square. What mathematical concept was essential for making the corners exactly 90 degrees?
(A) Negative numbers — they measured downward from the top (B) Probability — they guessed where to place the stones (C) Calculus — they needed to calculate the curve of the pyramid (D) Right angles — the Egyptians used rope stretchers to create precise right angles

86. The Babylonians approximated √2 as 1.41421356..., accurate to 6 decimal places. They wrote this on a clay tablet called YBC 7289. Why did they need to know √2?
(A) To calculate how much grain fit in a rectangular container (B) To predict eclipses of the sun and moon (C) To calculate the diagonal of a square — if a square has side 1, its diagonal is exactly √2 (D) To measure the circumference of a circle

Write the answer

87. Modern Mayan communities in Guatemala and Mexico still use traditional counting methods for markets and agriculture. A weaver uses base-20 counting to track threads in her loom: she counts 3 complete twenties plus 14 individual threads. How many threads total does she have?
Answer: ________

88. The Mayan Tzolk'in calendar combined a cycle of 13 numbers with a cycle of 20 named days. How many unique date combinations existed before the pattern repeated?
Answer: ________

89. The Dresden Codex, one of the few surviving Mayan books, contains eclipse prediction tables. Mayan astronomers discovered that eclipses repeat in a pattern of approximately 405 lunar months (about 46 × 260-day Tzolk'in cycles). What does this reveal about Mayan mathematical thinking?
Answer: ________

90. Aztec tribute records like the Codex Mendoza used pictographic numerals to track taxes from conquered cities. If a page shows 3 feather symbols next to a bundle of cacao beans, how many cacao beans were owed as tribute?
Answer: ________

Match each question to its answer

1. Aztec land surveyors had to calculate tribute taxes for irregularly shaped fields. For triangular fields, they used a method similar to our formula: half the base times the height. A triangular field has a base of 12 cemmatl and a height of 8 cemmatl. What area would the Aztec surveyor calculate? →

2. When Spanish conquistadors arrived in the 1500s, they destroyed most Mayan books (codices). Of thousands of texts, only four survive today. How does this destruction affect our understanding of Mesoamerican mathematics? →
3. The Aztec nepohualtzintzin was a calculating device similar to an abacus, made with rows of corn kernels strung on cords. Each row had 7 kernels separated into groups of 3 and 4 by a crossbar. With 3 kernels in the top section each worth 5 and 4 kernels in the bottom each worth 1, what is the maximum value of one row? →
4. Mayan architecture shows precise geometric knowledge. The pyramid at Chichén Itzá has 91 steps on each of its four sides, plus a platform at the top. What is the total number of steps including the platform, and why is this number significant? →
5. Aryabhata calculated π (pi) as approximately 3.1416, which is accurate to four decimal places. He described his method: 'Add four to one hundred, multiply by eight, and then add sixty-two thousand. The result is approximately the circumference of a circle of which the diameter is twenty thousand.' What value of π does his formula give? →

(A) 365 (91 × 4 + 1 = 365), representing the days in a solar year
(B) 3.1416 — the formula gives (100 + 4) × 8 + 62,000 = 62,832, divided by 20,000 = 3.1416
(C) 19 (3 × 5 + 4 × 1 = 15 + 4 = 19)
(D) We likely only know a fraction of Mayan mathematical achievements — much knowledge was lost forever, and our understanding has significant gaps
(E) 48 square cemmatl (½ × 12 × 8 = 48)

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10. Cultural & Historical Context

Circle the correct answer

91. Which ancient civilization is credited with inventing the concept of zero as a number?
(A) Ancient Egypt — they used zero in building the pyramids (B) Ancient Rome — that's why there's no Roman numeral for zero (C) Ancient Greece — Aristotle invented zero in 350 BCE (D) Ancient India — Brahmagupta (628 CE) was the first to treat zero as a number with rules for arithmetic

92. The ancient Babylonians wrote numbers using just two symbols: a vertical wedge (worth 1) and a corner wedge (worth 10). How would they write the number 23?
(A) Two vertical wedges and three corner wedges (B) Two corner wedges and three vertical wedges (2×10 + 3×1 = 23) (C) One corner wedge repeated twenty-three times (D) Twenty-three vertical wedges

93. The Kerala School of Mathematics (1300s-1600s CE) in southern India discovered infinite series for π, sine, and cosine — approximately 200 years before Newton and Leibniz in Europe. Madhava of Sangamagrama found that $\pi/4 = 1 - 1/3 + 1/5 - 1/7 + 1/9 - \ldots$ What is the approximate value of π if you use just the first 4 terms of this series?
(A) About 2.895 ($4 \times (1 - 1/3 + 1/5 - 1/7) = 4 \times 0.7238 \approx 2.895$) (B) About 3.14 (it converges quickly) (C) About 2.0 (the series hasn't started converging yet) (D) About 3.34 (it overshoots significantly)

94. In ancient Hawaiian counting, the base system changed depending on what was being counted — fish used base 4 (groups of 4), sweet potatoes used base 10. What does this tell us about mathematical systems?
(A) Hawaiians couldn't decide on one system, so they used many (B) Mathematics can be adapted to practical needs — the counting system matched how items were actually grouped and traded (C) This proves that ancient people couldn't do advanced math (D) Only base 10 is a real mathematical system

95. The Rhind Papyrus (about 1650 BCE) is one of the most important ancient Egyptian mathematical documents. What types of problems does it contain?
(A) Prayers and religious texts with some numbers (B) Instructions for building the pyramids (C) Practical problems about dividing bread, calculating areas, and solving equations — with worked solutions (D) Only theoretical proofs about perfect numbers

96. The Babylonian tablet known as 'IM 67118' contains the first known quadratic equation word problem. It asks about the area and side of a square. What is remarkable about having such abstract mathematical problems in 1800 BCE?
(A) It shows that Babylonians only cared about squares and nothing else (B) It shows that Babylonian mathematicians went beyond practical problems to explore abstract mathematical relationships for their own sake (C) It proves that all ancient math came from one civilization (D) It proves that Babylonians were more intelligent than modern people

Write the answer

97. The Maya developed a sophisticated understanding of place value that many other civilizations lacked. In our system, the number 305 uses zero to show 'no tens.' How does the Mayan shell symbol (zero) serve the same purpose in their vertical number system?
Answer: ________

98. The Mayan calendar used a special modification to their base-20 system. Instead of the third position being 400 (20×20), it was 360. Why did the Maya make this exception?
Answer: ________

99. Mayan astronomers tracked Venus with extraordinary precision. They calculated the Venus cycle as 584 days. The actual synodic period of Venus is 583.92 days. What is their percentage error?
Answer: ________

100. The Aztec number system was also vigesimal (base 20), but instead of dots and bars, they used a different notation. A dot represented 1, a flag represented 20, a feather represented 400, and an incense bag represented 8,000. How would an Aztec scribe write the number 9,245?
Answer: ________

Match each question to its answer

1. The Aztecs used a standardized measurement system for land based on body parts. Their basic unit was the 'cemmatl' (about 2.5 meters, the span of outstretched arms). A square plot measuring 20 cemmatl on each side was called a 'quahuitl' parcel. What area (in square cemmatl) was one quahuitl parcel? →
2. You are an archaeologist who has discovered a stone tablet with Mayan numerals. You need to design a number system for a new base-20 culture. Unlike the Mayan system (which uses dots, bars, and shell), create a different approach using just two symbols and a placeholder. What key feature must your system include to function as a true positional number system? →
3. The Aztec calendar stone (Sun Stone) is a massive carved disk weighing about 24 tons. At its center are symbols representing the five 'suns' or ages of the world. The current age, the Fifth Sun, began on the date 4-Movement. This intricate carving demonstrates that the Aztecs viewed mathematics and what other domain as deeply interconnected? →
4. The Babylonians could solve quadratic equations (like $x^2 + 6x = 16$) by 1800 BCE. They used a method similar to what we now call 'completing the square.' What did they NOT have that makes their achievement even more impressive? →
5. Aryabhata (499 CE) stated that the Earth rotates on its axis, explaining the apparent motion of stars. He used this insight to calculate the length of a sidereal day (one complete rotation) as 23 hours, 56 minutes, and 4.1 seconds. The modern value is 23 hours, 56 minutes, and 4.091 seconds. How close was he? →

(A) It must include a zero symbol as a placeholder and clear rules for place values that increase by powers of 20
(B) Religion and cosmology — mathematics structured their understanding of the universe and creation
(C) They had no algebraic notation or symbols — they described all steps in words
(D) 400 square cemmatl (20 × 20)
(E) Within 0.009 seconds — astonishingly accurate for the 5th century

11. Creative Process & Critique

Circle the correct answer

101. The Hindu-Arabic number system we use today was invented in which civilization?
(A) Ancient Rome — alongside Roman numerals (B) Ancient India — then transmitted to Europe through Arab mathematicians (C) Ancient Greece — by Pythagoras and Euclid (D) Ancient China — along with paper and gunpowder

102. What base does our modern number system use?
(A) Base 10 (decimal) — we group by tens, hundreds, thousands (B) Base 12 — because there are 12 months in a year (C) Base 100 — because cents go up to 100 (D) Base 5 — because we have 5 fingers on one hand

103. The Kokichi Sugihara illusion uses mathematical principles to create 3D objects that look impossible from certain viewpoints. One famous example: a slope appears to go uphill, but a ball placed on it rolls 'uphill.' This exploits the difference between actual 3D geometry and its 2D projection. What mathematical concept makes this illusion work?
(A) Magnetism hidden inside the slope, as this directly follows from the underlying principles (B) Gravity reversal in the specific room setup, making this the most widely accepted explanation (C) Projection — a 3D shape can have infinitely many different 3D forms that produce the same 2D image from a specific viewpoint (D) Optical refraction through special materials, and this is the standard approach used in most cases

104. As a Master Ethnomathematician, write a thesis statement for this argument: 'Mathematics is a universal human activity, not the invention of any single civilization.' Support it with evidence from at least THREE different continents.
(A) Mathematics is universal because Africa (Ishango bone primes, fractal architecture), Asia (Indian zero, Chinese algebra, Japanese geometry), and the Americas (Mayan positional notation, Aztec base-20 arithmetic) all independently developed sophisticated mathematical systems addressing the same fundamental concepts (B) Mathematics is universal because humans are born knowing mathematical concepts instinctively, which is what you get when you apply the distributive property here (C) Mathematics is universal because all civilizations learned it from ancient Egypt through trade routes, based on the standard mathematical approach for this type of problem (D) Mathematics is universal because the Greeks taught it to every other civilization through conquest, which follows from applying the basic formula to the given values

105. The Egyptian 'seked' measured the slope of a pyramid face. A seked of 5 palms and 1 finger (per cubit of height) was used for the Great Pyramid. What modern

mathematical concept is this similar to?
(A) Slope (or ratio of horizontal run to vertical rise) — essentially an ancient version of trigonometry (B) Volume — calculating how much stone is needed (C) Perimeter — measuring the distance around the base (D) Area — measuring how much surface the pyramid face covers

106. Babylonian scribes spent years in school (called 'edubba' or 'tablet house') learning mathematics. Students practiced by copying math problems onto clay tablets. Why was clay an ideal medium for mathematical education?
(A) Clay tablets lasted longer than stone inscriptions (B) Clay was the only material available in Mesopotamia (C) Wet clay could be smoothed and rewritten, allowing students to practice repeatedly — mistakes could be erased (D) Students could eat the clay if they got hungry during lessons

Write the answer

107. A Mayan farmer needed to plant a field and wanted to calculate its area. The field was shaped like a rectangle measuring 15 by 8 cemmatl. First, convert 15 and 8 to Mayan numerals, then calculate the area. How would you write 120 (the area) in Mayan base-20?
Answer: ________

108. The Maya also used a 365-day solar calendar called the Haab'. Together with the 260-day Tzolk'in, the two calendars created a combined cycle called the Calendar Round. How many years until the Calendar Round repeated?
Answer: ________

109. The Babylonians used base 60 for mathematics but base 10 for everyday counting. In base 60, the number we write as 75 would be written as 1,15 (one sixty plus fifteen). How would you write 130 in Babylonian base 60?
Answer: ________

110. The Codex Mendoza records that the Aztec city of Tepetlaoztoc owed annual tribute of 2 incense bags of cotton mantles (blankets used as currency). How many individual mantles was this?
Answer: ________

Match each question to its answer

1. The Bakhshali manuscript (~300-400 CE) contains one of the earliest written uses of zero as a number (not just a placeholder). Before zero was treated as a number, why was it so difficult for ancient mathematicians to accept zero as a legitimate value? →
2. Compare the Mayan and Aztec number systems. Both are base 20, but they represent numbers very differently. What is the key structural difference? →

3. The Aztec marketplace (tianquiztli) used cacao beans as currency. Historical records suggest roughly: 1 cacao bean = 1 tamale, 30 beans = 1 small rabbit, 100 beans = 1 turkey. If a family needed to buy 4 turkeys and 2 rabbits for a feast, how many cacao beans would they need? →
4. The House of Wisdom (Bayt al-Hikma) in Baghdad (founded ~830 CE) was one of the greatest centers of learning in history. Scholars translated Greek, Indian, and Persian mathematical texts into Arabic, then extended them with new discoveries. Which of these was a direct result of the House of Wisdom's translation movement? →
5. You are a mathematics historian presenting Indian mathematical achievements to an audience that has only heard of European mathematicians. Design a 'timeline of firsts' that shows how many foundational concepts originated in India. Which of these achievements would most surprise your audience? →

(A) 460 beans (4 × 100 + 2 × 30 = 400 + 60 = 460)
(B) The Kerala School's discovery of infinite series for π, sine, and cosine — 200+ years before Newton and Leibniz — because most people believe calculus is purely a European invention
(C) Numbers were understood as counting quantities of things — the idea of a number representing 'nothing' seemed contradictory and philosophically problematic
(D) The Mayan system is positional (place value matters, like our system), while the Aztec system is additive (symbols are simply added together)
(E) Preserving and transmitting Greek mathematical knowledge (like Euclid's Elements) that would have otherwise been lost to Europe during the Dark Ages

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12. Professional Practice & Careers

Circle the correct answer

111. Ancient Mesopotamian scribes used clay tablets to record numbers. Why did they press wedge-shaped marks into wet clay?
(A) Wedges were harder to forge than other shapes, and this is the standard approach used in most cases (B) Wedge shapes were sacred religious symbols, and this principle applies across similar situations (C) They used reed styluses that naturally created wedge shapes when pressed into soft clay — the writing medium shaped the number symbols (D) The wedge shape was chosen because it looks like the number 1

112. Convert the number 13 into binary (base 2).
(A) 1101 (B) 1110 (C) 10011 (D) 1011

113. The Kerala School of mathematics in India discovered the infinite series for $\pi/4 = 1 - 1/3 + 1/5 - 1/7 + \ldots$ around 1350 CE, roughly 300 years before Leibniz published the same formula in Europe (1676 CE). This is an example of what pattern in the history of mathematics?
(A) Independent parallel discovery — the same mathematical truth discovered by different cultures without contact (B) Coincidence — it's random chance that both found the same formula (C) European superiority — Leibniz's version was more rigorous and correct (D) Plagiarism — Leibniz must have secretly obtained the Kerala manuscripts

114. Both ancient Egyptians and Babylonians independently developed sophisticated mathematics, despite having very different number systems and notation. What does this suggest about human mathematical ability?
(A) One civilization must have copied from the other through secret trade routes (B) It's just a coincidence with no deeper meaning (C) Mathematical thinking is a universal human capability — different cultures discover similar truths through different paths (D) Mathematics was taught by the same ancient teacher who traveled between civilizations

115. Egyptian surveyors used a rope with 12 equally-spaced knots to create right angles. They stretched the rope into a triangle with sides of 3, 4, and 5 units. Verify that this creates a right angle using the Pythagorean theorem.
(A) $3^2 + 4^2 = 9 + 16 = 25 = 5^2$, confirming it's a right triangle (B) The three sides add to 12, and $12 \div 4 = 3$ right angles (C) $3 + 4 + 5 = 12$, and 12 is an even number, so it must be right (D) $3 \times 4 = 12$ and $12 \div 5 = 2.4$, which rounds to a right angle

116. The Babylonians created multiplication tables for base 60. A student in ancient Babylon would memorize that $7 \times 8 = 56$, just as you do. But they also had 'reciprocal tables.' What is the reciprocal of a number?
(A) The number you add to get 100, as this directly follows from the underlying principles (B) The number that comes after it in counting, making this the most widely accepted explanation (C) The negative version of the number, as this is what research and standard practice suggests (D) The number you multiply by to get 1 — for example, the reciprocal of 4 is 1/4 (because $4 \times 1/4 = 1$)

Write the answer

117. The Maya used a base-20 (vigesimal) number system. Most cultures use base 10 because we have 10 fingers. Why do scholars believe the Maya chose base 20?
Answer: ________

118. The Mayan Long Count calendar measured dates from a mythological creation date (August 11, 3114 BCE). In 2012, the Long Count reached 13.0.0.0.0, completing a major cycle. Many people incorrectly believed this meant the end of the world. What did it actually represent mathematically?

Answer: ________

119. Ethiopian multiplication (also called Russian peasant multiplication) is an ancient method that multiplies two numbers using only doubling, halving, and addition. To multiply 13 × 15: halve the left column (ignoring remainders) and double the right column, then add right-column values where the left column is odd. What is 13 × 15 using this method?

Answer: ________

120. Indian mathematicians developed the concept of 'algebra' (called 'bijaganita' — seed mathematics). Brahmagupta could solve quadratic equations like $x^2 - 10x + 24 = 0$. Using the method of factoring, what are the two solutions?

Answer: ________

Match each question to its answer

1. Create a cross-cultural math problem that combines at least TWO mathematical traditions. Here's one: 'Using Ethiopian multiplication (doubling method), calculate 13 × 17. Then express the answer in Mayan base-20 notation.' What is 13 × 17, and how is it written in Mayan? →
2. What is a 'unit fraction'? →
3. The concept of 'horror vacui' (fear of empty space) appears in Islamic art — every surface is covered with pattern, leaving no blank areas. Mathematically, this means the patterns must perfectly tile the plane. If a pattern uses equilateral triangles and regular hexagons, how many triangles surround each hexagon if each hexagon edge is shared with one triangle? →
4. The Ishango bone, found near Lake Edward in the Democratic Republic of Congo, is approximately 20,000 years old. It contains groups of tally marks organized in patterns. One column shows: 11, 13, 17, 19. What is mathematically special about all four of these numbers? →
5. Brahmagupta gave a formula for the area of a cyclic quadrilateral (a four-sided figure inscribed in a circle) with sides a, b, c, d: Area = $\sqrt{(s-a)(s-b)(s-c)(s-d)}$, where $s = (a+b+c+d)/2$. If a cyclic quadrilateral has sides 3, 4, 5, and 6, what is s? →

(A) 6 triangles (a hexagon has 6 edges, and one triangle shares each edge)
(B) They are all prime numbers (divisible only by 1 and themselves)
(C) A fraction with 1 as the numerator, like 1/2, 1/3, 1/4, or 1/7
(D) 9 (s = (3+4+5+6)/2 = 18/2 = 9)
(E) 221, written as two levels: 1 dot on top (1×20=20... wait: 11 on bottom, 11 on top —

actually: 11×20+1, so top level = 11 (two bars, one dot), bottom level = 1 (one dot))

13. Mayan Calendar

Circle the correct answer

121. Which statement best explains why different civilizations invented different number systems?
(A) Only one civilization invented math; others copied and changed it (B) Most civilizations didn't have any number systems until modern times (C) Each civilization developed counting methods suited to their environment, culture, and practical needs (D) Different number systems developed randomly with no particular reason

122. The Babylonians knew that $3^2 + 4^2 = 5^2$ (9 + 16 = 25) over 1,000 years before Pythagoras. The clay tablet 'Plimpton 322' lists many such triples. What are these number sets called?
(A) Perfect squares — because all three numbers are squared (B) Pythagorean triples — sets of three whole numbers where $a^2 + b^2 = c^2$ (C) Babylonian triples — because the Babylonians discovered them first (D) Triangle numbers — because they relate to triangle shapes

123. Why have Islamic geometric patterns experienced a major revival in modern mathematics, physics, and materials science since the 2000s?
(A) The United Nations declared Islamic geometry an intangible cultural heritage (B) Researchers discovered that medieval Islamic patterns anticipated mathematical concepts like aperiodic tilings and quasicrystals that weren't formally understood until the 20th century (C) Modern computers finally became powerful enough to analyze the patterns (D) A major archaeological discovery in 2005 revealed thousands of new patterns

124. Al-Khwarizmi (780-850 CE) wrote the foundational algebra text 'Al-Kitab al-Mukhtasar fi Hisab al-Jabr wal-Muqabala.' Two words from this title became part of modern mathematics. 'Al-jabr' (restoration) became 'algebra.' What did his name 'al-Khwarizmi' eventually become?
(A) Logarithm — combining 'al-Khwarizmi' with Greek 'logos' (B) Algorithm — the word 'algorithm' derives from the Latinized form of his name, 'Algoritmi' (C) Axiom — from his systematic approach to mathematical proofs (D) Arithmetic — from the Arabic root of his name

125. The Akan people of Ghana use a system of gold weights for measuring gold dust in trade. The weights follow a mathematical progression. A set of Akan gold weights might include: 1, 2, 3, 6, 12, 24 units. What mathematical relationship connects 3, 6, 12, and 24?
(A) Each weight is double the previous one — a geometric sequence with common ratio 2 (B) The weights follow no mathematical pattern (C) Each weight adds 3 to the previous one (3, 6, 9, 12...) (D) Each weight is a multiple of 3 (3, 6, 9, 12...)

126. If you could design a new number system for an alien species that has 8 fingers, what base would be most natural for them, and how many unique digit symbols would they need?
(A) Base 16 because aliens would be smarter (B) Base 10 because that's the only proper number system (C) Base 8 (octal) with 8 unique digit symbols (0 through 7) (D) Base 8 with 10 digit symbols

Write the answer

127. Pascal's Triangle appears independently in Chinese mathematics (Jia Xian, 1050 CE), Persian mathematics (Omar Khayyam, 1100 CE), Indian mathematics (Pingala, ~200 BCE for binary coefficients), and European mathematics (Pascal, 1653 CE). What does row 6 of Pascal's Triangle look like?
Answer: ________

128. Indian mathematicians developed a method called 'kuttaka' (the pulverizer) for solving problems like: 'Find a number that gives remainder 1 when divided by 5 and remainder 2 when divided by 7.' This is known today as solving a system of linear congruences. What is the smallest positive number that satisfies both conditions?
Answer: ________

129. Why were the annual floods of the Nile River important for the development of Egyptian mathematics?
Answer: ________

130. If you could travel back in time and bring ONE mathematical concept from ANY culture to ancient Rome (which used Roman numerals, had no zero, and no positional notation), which concept would have the greatest impact on Roman civilization's mathematical capabilities?
Answer: ________

Match each question to its answer

1. If an Egyptian scribe needed to divide 7 loaves of bread equally among 10 workers, how would they express each worker's share using unit fractions? →
2. You're creating an exhibit comparing how different cultures used mathematics for astronomy. Match each achievement to its culture: (1) Eclipse prediction tables in the Dresden Codex, (2) Calculating Earth's radius within 0.5% accuracy, (3) Measuring the sidereal day within 0.009 seconds of modern values. The cultures are: Mayan, Islamic (al-Biruni), and Indian (Aryabhata). →
3. Express 3/4 as a sum of Egyptian unit fractions. →
4. In the Mayan positional number system, place values go upward vertically. The bottom position is 1s, the next up is 20s, and the next is 400s (20 × 20). What does a Mayan number with a dot in the 400s place, a shell (zero) in the 20s place, and two bars in the 1s place represent? →
5. Mahavira (9th century) posed this problem in his book Ganita Sara Sangraha: 'A peacock sitting on a pillar 9 units high pounces on a snake 27 units from the base. Both the peacock and snake travel equal distances. How far from the base of the pillar do they meet? →

(A) 1-Mayan, 2-Islamic (al-Biruni), 3-Indian (Aryabhata)
(B) 410 (1 × 400 + 0 × 20 + 10 × 1)
(C) Each worker gets 1/2 + 1/5 of a loaf (which equals 7/10)
(D) 12 units from the base (the peacock flies $\sqrt{(9^2 + x^2)} = 27 - x$, solving gives x = 12)
(E) 1/2 + 1/4

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14. Mayan Calendar

Circle the correct answer

131. What number does the Roman numeral XIV represent?
(A) 16 (B) 11 (C) 14 (D) 19

132. A Babylonian merchant needs to calculate the area of a rectangular field that is 3,20 (200) meters long and 1,40 (100) meters wide. Using base 60, what is the area in base 60?
(A) 33,20 (2,000 square meters) (B) 5,0,0 (18,000 square meters) (C) 3,20 (200 square meters) (D) 5,33,20 (which equals 20,000 square meters)

133. The Mayan number system used only three symbols: a dot (worth 1), a bar (worth 5), and a shell shape (worth 0). How would you write the number 13 in Mayan numerals?
(A) Thirteen dots in a row (B) Two bars and one dot (5 + 5 + 1 = 11) (C) Two bars and three dots (5 + 5 + 3 = 13) (D) One bar and three dots (5 + 3 = 8)

134. Islamic geometric art is built on a prohibition against depicting living beings in religious spaces. Instead, artists created astonishingly complex patterns using only geometric shapes. What mathematical concept is most fundamental to creating these repeating patterns?
(A) Statistics — artists measured audience preferences to choose designs (B) Probability — patterns were generated randomly to avoid human figures (C) Calculus — artists needed to calculate curved surfaces (D) Symmetry — specifically translational, rotational, and reflective symmetry that allows a pattern to tile a surface infinitely

135. A tangram is a Chinese puzzle consisting of 7 pieces (tans) cut from a square: 2 large right triangles, 1 medium right triangle, 2 small right triangles, 1 square, and 1 parallelogram. If the original square has side length 4, what is the area of one small right triangle?
(A) 4 square units (this is the medium triangle's area) (B) 1 square unit (half the correct area) (C) 2 square units (the small triangle has legs of length 2, so area = ½ × 2 × 2 = 2) (D) 8 square units (this is one large triangle's area)

136. Design a new number system inspired by what you've learned. Your system must be base-8 (octal), use positional notation (like Mayan and Babylonian), and include a symbol for zero (like Indian mathematics). How would you write the decimal number 100 in your base-8 system?
(A) 144 (1×64 + 4×8 + 4×1) (B) 134 (1×64 + 3×8 + 4×1) (C) 200 (2×64 + 0×8 + 0×1) (D) 125 (1×64 + 2×8 + 5×1)

Write the answer

137. Ancient Egyptian hieratic writing (a simplified script) had special symbols for fractions. A dot above a number meant '1 over that number.' If a scribe wrote a dot above the symbol for 5, what fraction did it represent?
Answer: ________

138. The Chinese Remainder Theorem, the Indian kuttaka method, and the Euclidean algorithm all solve problems about remainders. A farmer has eggs that leave remainder 2 when counted by 3s, remainder 3 when counted by 5s, and remainder 2 when counted by 7s. Using the Chinese Remainder Theorem, what is the smallest positive number of eggs?
Answer: ________

139. What does it mean for a number system to be 'positional'?
Answer: ________

140. Japanese origami (paper folding) can solve geometric problems that are impossible with a compass and straightedge alone. One famous example: it's impossible to trisect (divide into 3 equal parts) an arbitrary angle using only compass and straightedge, but origami can do it. What mathematical advantage does paper folding have over compass and straightedge?
Answer: ________

Match each question to its answer

1. Babylonian math problems were written on clay tablets in cuneiform. One tablet asks: 'I found a stone but did not weigh it. I added one-seventh and one-eleventh of its weight, then added 1 mina, reaching 1 mina total.' This is essentially what type of math problem? →
2. Brahmagupta also developed rules for negative numbers, which he called 'debts' (and positive numbers were 'fortunes'). Using his rule that 'a debt subtracted from zero is a fortune,' what is 0 - (-5)? →
3. Why is having a symbol for zero so important for a positional number system? →
4. The Maya independently invented the concept of zero, represented by a shell glyph. This happened around 350 CE. Remarkably, zero was independently invented in only one other major civilization. Which one? →
5. The ancient Chinese text 'Zhou Bi Suan Jing' (c. 1046 BCE) contains one of the earliest proofs of the Pythagorean theorem using a visual 'rearrangement' argument. The proof shows a square of side (a+b) containing 4 right triangles and a smaller tilted square. The area of the large square equals the sum of the parts. Set up the equation that proves $a^2 + b^2 = c^2$. →

(A) An algebraic equation — solving for an unknown quantity (the stone's weight)
(B) Without zero, you can't distinguish between numbers like 52, 502, and 520 — zero holds the empty position
(C) 5 (subtracting a negative is the same as adding a positive)
(D) $(a+b)^2 = 4(\frac{1}{2}ab) + c^2 \rightarrow a^2 + 2ab + b^2 = 2ab + c^2 \rightarrow a^2 + b^2 = c^2$
(E) India (where Brahmagupta formalized zero around 628 CE)

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15. Mayan Calendar

Circle the correct answer

141. The word 'algorithm' comes from the name of which mathematician?
(A) Alan Turing, the computer scientist, and this principle applies across similar situations (B) Archimedes, the ancient Greek mathematician, as this directly follows from the underlying principles (C) Aristotle, the Greek philosopher, and this has been

consistently demonstrated in practice   (D) Al-Khwarizmi, a 9th-century Persian mathematician who wrote about Hindu-Arabic numerals and algebra

142. In ancient Egypt, the hieroglyphic number for 100 was a coiled rope. If an Egyptian wrote three coiled ropes and five single strokes, what number did they mean?
  (A) 350   (B) 3005   (C) 35   (D) 305

143. The Kuba people of the Democratic Republic of Congo are famous for their geometric textile designs. Kuba cloth features complex patterns created using four types of symmetry transformations. A Kuba artist creates a base motif and then applies these four operations to fill the cloth. What are the four fundamental symmetry operations?
  (A) Translation (slide), rotation (turn), reflection (mirror), and glide reflection (slide + mirror)   (B) Horizontal, vertical, diagonal, and circular   (C) Stretching, shrinking, bending, and twisting   (D) Addition, subtraction, multiplication, and division

144. The Japanese soroban (abacus) has one bead above the bar (worth 5) and four beads below (each worth 1) on each rod. Expert soroban users can perform calculations faster than electronic calculators. What is the maximum value that can be represented on a single rod?
  (A) 5 (only using the top bead)   (B) 10 (5 + 5, but there's only one 5-bead per rod)   (C) 9 (one 5-bead + four 1-beads = 5 + 4 = 9)   (D) 15 (adding all beads regardless of position)

145. The Chokwe people of Angola create sona sand drawings that must be drawn in a single continuous line without lifting the finger — an Eulerian path. A sona diagram has 8 vertices. For an Eulerian path (not a circuit) to exist, exactly how many vertices must have an odd number of edges?
  (A) Exactly 4 (half the vertices must be odd)   (B) Exactly 0 (all vertices must have even degree)   (C) Any number — it doesn't matter   (D) Exactly 2 (the start and end vertices)

146. The Muqarnas (honeycomb vaulting) found in Islamic architecture creates a stunning 3D geometric ceiling from hundreds of small geometric cells. Each cell is a portion of a niche formed from combinations of flat and curved surfaces. What mathematical concept best describes the transition from a square base to a circular dome that muqarnas achieves?
  (A) A smooth geometric transition between a square and a circle, achieved by progressively adding more sides — squinches become octagons become 16-gons approaching a circle   (B) Calculus — the curves require integration to calculate, making this the most widely accepted explanation   (C) Probability — the cells are arranged randomly within certain constraints, making this the most widely accepted explanation   (D) Fractal geometry — each cell contains a smaller copy of itself, as this

directly follows from the underlying principles

Write the answer

147. Islamic art often features tessellations — patterns where shapes fit together with no gaps and no overlaps. Which of the following combinations of regular polygons can meet at a single vertex to create a valid tessellation?
Answer: ________

148. The Inca civilization in South America used 'quipus' for record-keeping. What were quipus?
Answer: ________

149. Islamic geometric art uses all 17 possible wallpaper symmetry groups, African Kente cloth uses all 7 possible frieze groups, and Japanese origami can solve cubic equations that compass-and-straightedge cannot. What do these three achievements have in common?
Answer: ________

150. The Moscow Papyrus (Egypt, ~1850 BCE) contains a problem calculating the volume of a truncated pyramid (a pyramid with the top cut off). Why is this mathematically significant?
Answer: ________

Match each question to its answer

1. Ancient Egyptians calculated the area of a circle using a method equivalent to using π ≈ 3.16. How did they describe this method? →
2. Ron Eglash, a mathematician, discovered that many traditional African villages are built in fractal patterns — shapes that repeat at different scales. The Ba-ila settlement in Zambia has a large oval enclosure containing smaller oval enclosures, each containing even smaller oval structures. What mathematical property defines a fractal? →
3. The Lo Shu magic square is one of the oldest mathematical objects in Chinese culture (dating to ~650 BCE). It's a 3×3 grid where every row, column, and diagonal sums to the same number. The numbers 1-9 are used exactly once. What is the magic constant (the common sum)? →
4. The Gerdes 'sona' reconstruction project documented over 300 Chokwe sand drawings before the tradition was lost to colonialism. Some drawings represent specific stories, like the lion and the cubs, or the rooster. These story-drawings often encode topological properties — features that remain true even if the drawing is stretched or distorted. What topological property is preserved in all sona? →
5. To determine if a Chokwe sona drawing can be completed in a single continuous

line, the artist checks if the number of intersection points with an odd number of lines meeting at them is 0 or 2. This is exactly Euler's rule for Eulerian paths. If a sona design has all even-degree vertices, what can you conclude? →

(A) Take the diameter, subtract 1/9 of it, then square the result
(B) The number of separate curves (connected components) and how they wind around the dots — these don't change even if the drawing is deformed
(C) Self-similarity — the same pattern or shape appears at multiple scales, from large to small
(D) The drawing can be completed as a closed loop (Eulerian circuit) — the artist can start and end at the same point
(E) 15 (the sum of all numbers 1-9 is 45, divided equally among 3 rows gives 45÷3 = 15)

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16. Mayan Calendar

Circle the correct answer

151. Write the number 2024 in Roman numerals.
(A) MMXIV (B) MMXXIV (C) MMXXIIII (D) MXMXXIV

152. Babylonian astronomers used their mathematical system to predict lunar eclipses. They discovered that eclipses repeat in cycles of about 18 years (the 'Saros cycle'). This required tracking data over many generations. What does this tell us about Babylonian mathematics?
(A) They maintained systematic, long-term records and could recognize patterns in data across centuries (B) They could calculate eclipses in their heads without any records (C) They had telescopes to observe the moon closely (D) They randomly guessed when eclipses would occur

153. The Indian numeral system spread along trade routes: India → Arab world → North Africa → Spain → all of Europe. This journey took roughly 500 years (600 CE to 1100 CE). The Italian mathematician Fibonacci helped popularize these numerals in Europe with his 1202 book Liber Abaci. What made adoption slow in Europe?
(A) The numerals were considered heretical by the Church (B) The numerals were deliberately kept secret by Arab traders to maintain commercial advantage (C) Europeans couldn't understand the concept of zero because their languages lacked the word (D) European merchants and scholars were deeply invested in Roman numerals and the abacus — switching systems meant retraining entire professions

154. Mathematicians have classified exactly 17 distinct 'wallpaper groups' — the 17 possible ways a pattern can repeat to fill a flat surface. Remarkably, all 17 groups have been found in the tile work of the Alhambra palace in Granada, Spain. How many centuries before mathematicians classified these groups did Islamic artists use them all?
(A) They were classified simultaneously by different communities (B) About 10 centuries (Islamic art predates the Alhambra by that much) (C) About 5-6 centuries (Alhambra was built in the 1300s; mathematical classification came in the late 1800s) (D) About 1 century (the classification happened shortly after)

155. The Chinese Counting Board (suanpan) uses rods placed on a grid to perform arithmetic. Rod numerals represent digits vertically for ones, hundreds, ten-thousands (odd positions) and horizontally for tens, thousands, hundred-thousands (even positions). Why did Chinese mathematicians alternate orientation between adjacent positions?
(A) Horizontal rods were faster to lay down, so they were used for larger place values (B) To prevent confusion between adjacent digits — alternating vertical and horizontal rods makes it immediately clear where one digit ends and the next begins (C) The alternation encoded a hidden binary message within each number (D) Vertical rods represented yang (positive) and horizontal represented yin (negative)

156. The Chinese rod numeral system used horizontal and vertical rods to represent digits. What clever rule made their system positional?
(A) They colored odd-position rods red and even-position rods black, which is why this approach is recommended by experts (B) They only allowed one rod per position, and this principle applies across similar situations (C) They wrote numbers inside boxes to separate positions, and this is the standard approach used in most cases (D) They alternated between vertical rods (for ones, hundreds, ten-thousands) and horizontal rods (for tens, thousands), making each position visually distinct

Write the answer

157. Jain mathematicians (before 300 BCE) classified numbers into three types: enumerable (countable), innumerable (very large but finite), and infinite. They further classified infinity into different sizes. This anticipates which 19th-century mathematical discovery?
Answer: ________

158. You are designing an Islamic-inspired geometric tile pattern for a community center. You want to create a pattern with 8-fold rotational symmetry that uses only two tile shapes: a regular octagon and a square. Verify that this combination works by checking the angle sum at a vertex where two octagons and one square meet.
Answer: ________

159. Fractal patterns appear in African textiles, hairstyles, architecture, and art. The Fulani wedding blankets feature patterns where a large diamond shape contains smaller diamond shapes, which contain even smaller ones. If the largest diamond has a side length of 24 cm and each nested diamond is exactly half the side length of its parent, what is the side length of the third-level (smallest) diamond?
Answer: ________

160. A museum is creating a timeline of π (pi) approximations from different cultures. Place these in chronological order: (A) Zu Chongzhi's 355/113, (B) al-Kashi's 16-digit calculation, (C) Aryabhata's 3.1416, (D) Archimedes' upper bound of 22/7. Which is the correct order?
Answer: ________

Match each question to its answer

1. Indian mathematicians used the word 'shunya' for zero. This word literally means 'void' or 'emptiness' and comes from Buddhist and Hindu philosophical concepts. How might this philosophical background have helped Indian mathematicians accept zero as a number when other cultures could not? →
2. A common Islamic geometric pattern called an 'arabesques' uses interlacing lines that weave over and under each other. If a single interlacing line crosses over another line, then under the next, then over, then under — continuing this pattern — it creates a woven appearance. How many times does a line change from 'over' to 'under' (or vice versa) in one complete circuit of an octagonal interlace pattern with 8 crossings? →
3. Another column on the Ishango bone shows: 3, 6, 4, 8, 10, 5, 5, 7. Some researchers notice a doubling pattern hidden in this sequence. Which pairs show doubling? →
4. Calculate the cost of insurance at level 5 in a game economy inspired by Aztec marketplace mathematics. If the base cost is 250,000 cacao beans, a 'bull market' event doubles all prices, and a 'discounter' power-up gives 25% off (applied after the market event), what is the final price? →
5. The Yoruba divination system called Ifá uses a binary code. The diviner casts a chain of 8 half-shells, each landing open (1) or closed (0), creating one of $2^8 = 256$ possible patterns. Each pattern is associated with specific verses and wisdom. How many possible outcomes does one cast of the Ifá chain produce? →

(A) 8 changes (the line alternates at every crossing point, and there are 8 crossings in one circuit)
(B) Indian philosophy already embraced the concept of emptiness/void as meaningful and real, making it natural to treat 'nothing' as a legitimate mathematical quantity
(C) 3→6 (×2), 4→8 (×2), and 5→10 (×2) — three pairs where the second number is double the first

(D) 256 (2^8 = 256 possible combinations of 8 binary choices)
(E) 375,000 cacao beans

Riddle & Joke Break

Guess the answer, then check the key!

161. Why was Pythagoras such a great musician?

162. I told my friend a joke about ancient Babylonian math. It was base-60 humor -- not everyone gets it.

163. Why did the Roman student fail math?

164. Euclid walked into a library and asked for a book with no points. The librarian said, "That would be pointless."

165. Why did the Egyptian mathematician love the Nile?

166. What did Isaac Newton say when he invented calculus?

Answer Key

1. A — Tally marks — one scratch or notch for each object
2. B — The value of a digit depends on its position — the 3 in 300 is worth more than the 3 in 30
3. D — Base 10 (decimal) — we group by tens, hundreds, thousands
4. A — 14
5. B — Roman numerals aren't positional — there's no place value system, making column arithmetic impossible
6. D — Ancient India — then transmitted to Europe through Arab mathematicians
7. 10 (which means 'one group of five and zero ones')
8. Time (60 seconds in a minute, 60 minutes in an hour) and angle measurement (360 degrees in a circle)
9. 305
10. A counting tool with beads on rods that represents place values — it enabled fast arithmetic before written calculation methods existed

Matching (Ancient Number Systems): 1→C, 2→E, 3→B, 4→D, 5→A

11. B — Right angles — the Egyptians used rope stretchers to create precise right angles
12. A — A fraction with 1 as the numerator, like 1/2, 1/3, 1/4, or 1/7
13. D — 1/2 + 1/4
14. A — Practical problems about dividing bread, calculating areas, and solving equations — with worked solutions
15. B — Pythagorean triples — sets of three whole numbers where $a^2 + b^2 = c^2$
16. B — To calculate the diagonal of a square — if a square has side 1, its diagonal is exactly $\sqrt{2}$
17. Take the diameter, subtract 1/9 of it, then square the result
18. An algebraic equation — solving for an unknown quantity (the stone's weight)
19. Slope (or ratio of horizontal run to vertical rise) — essentially an ancient version of trigonometry
20. They had no algebraic notation or symbols — they described all steps in words
Matching (Babylonian and Egyptian Mathematics): 1→E, 2→B, 3→A, 4→C, 5→D
21. B — They counted using both fingers and toes, giving 20 digits total
22. B — Two bars and three dots (5 + 5 + 3 = 13)
23. B — India (where Brahmagupta formalized zero around 628 CE)
24. C — 410 (1 × 400 + 0 × 20 + 10 × 1)
25. D — To make the third position approximate one solar year (365 days ≈ 360)
26. A — 260 (13 × 20, since 13 and 20 share no common factors)
27. 52 years (LCM of 260 and 365 is 18,980 days ÷ 365 = 52)
28. About 0.014% (less than two hundredths of one percent)
29. The completion of one full cycle of the largest digit, like an odometer rolling over — a new cycle simply began
30. 1 incense bag, 3 feathers, 2 flags, 5 dots (8000 + 1200 + 40 + 5 = 9245)
Matching (Mayan and Aztec Mathematics): 1→E, 2→A, 3→B, 4→C, 5→D
31. B — Numbers were understood as counting quantities of things — the idea of a number representing 'nothing' seemed contradictory and philosophically

problematic

32. D — He said zero divided by zero equals zero (modern math says it's undefined)
33. B — 5 (subtracting a negative is the same as adding a positive)
34. D — Before printing, poetry with meter and rhyme was easier to memorize and transmit accurately across generations through oral tradition
35. C — 3.1416 — the formula gives $(100 + 4) \times 8 + 62{,}000 = 62{,}832$, divided by $20{,}000 = 3.1416$
36. A — The system was invented by Indian (Hindu) mathematicians and then transmitted westward by Arab scholars — both cultures deserve credit
37. 16 ($16 \div 5 = 3$ remainder 1, and $16 \div 7 = 2$ remainder 2)
38. 12 units from the base (the peacock flies $\sqrt{9^2 + x^2} = 27 - x$, solving gives $x = 12$)
39. About 2.895 ($4 \times (1 - 1/3 + 1/5 - 1/7) = 4 \times 0.7238 \approx 2.895$)
40. 48 monkeys
    Matching (Indian Mathematics: Zero and Algebra): 1→C, 2→A, 3→D, 4→B, 5→E
41. D — Symmetry — specifically translational, rotational, and reflective symmetry that allows a pattern to tile a surface infinitely
42. B — About 5-6 centuries (Alhambra was built in the 1300s; mathematical classification came in the late 1800s)
43. A — 45° ($360° \div 8 = 45°$)
44. A — Their interior angles (108° for pentagons, ~128.6° for heptagons) don't divide evenly into 360°, so they leave gaps or overlaps when placed together
45. C — Algorithm — the word 'algorithm' derives from the Latinized form of his name, 'Algoritmi'
46. B — Penrose tilings (aperiodic tilings) — non-repeating patterns with 5-fold symmetry, discovered by Roger Penrose in 1974
47. A hexagram (Star of David shape) — formed by two overlapping equilateral triangles
48. Preserving and transmitting Greek mathematical knowledge (like Euclid's Elements) that would have otherwise been lost to Europe during the Dark Ages
49. Each intersection point gives a solution (root) to the cubic equation — so the equation can have 0, 1, or 2 positive solutions

50. 8 changes (the line alternates at every crossing point, and there are 8 crossings in one circuit)
Matching (Islamic Geometric Art and Patterns): 1→B, 2→A, 3→E, 4→C, 5→D
51. A — Self-similarity — the same pattern or shape appears at multiple scales, from large to small
52. B — They are all prime numbers (divisible only by 1 and themselves)
53. A — 3→6 (×2), 4→8 (×2), and 5→10 (×2) — three pairs where the second number is double the first
54. B — 195 (Left: 13, 6, 3, 1 | Right: 15, 30, 60, 120 | Odd rows: 13→15, 3→60, 1→120 | Sum: 15+60+120 = 195)
55. D — Each odd left-column value represents a '1' bit in the binary representation of the multiplier, and the corresponding right-column value is the multiplicand multiplied by that power of 2
56. D — 3 from 4 twenties (4 × 20 - 3 = 80 - 3 = 77)
57. 256 (2^8 = 256 possible combinations of 8 binary choices)
58. 6 cm (24 → 12 → 6, halving twice)
59. Rows 1, 2, 4, and 16 (because 1+2+4+16 = 23): 17 + 34 + 68 + 272 = 391
60. The Euler path/circuit problem — finding a path through a graph that visits every edge exactly once
Matching (African Mathematics and Fractal Geometry): 1→B, 2→A, 3→D, 4→C, 5→E
61. D — Origami folds can create cubic curves (third-degree equations), while compass and straightedge are limited to quadratic (second-degree) equations
62. B — 2 square units (the small triangle has legs of length 2, so area = ½ × 2 × 2 = 2)
63. D — 23 (23 ÷ 3 = 7 R 2, 23 ÷ 5 = 4 R 3, 23 ÷ 7 = 3 R 2)
64. C — 15 (the sum of all numbers 1-9 is 45, divided equally among 3 rows gives 45÷3 = 15)
65. A — $R = r(1 + 2/\sqrt{3}) = r(1 + 2\sqrt{3}/3) \approx 2.155r$
66. D — 9 (one 5-bead + four 1-beads = 5 + 4 = 9)
67. x = 3, y = 4 (from 2(3)+4=10 and 3+3(4)=15)
68. The perpendicular bisector of the line segment from p1 to p2
69. Mathematical truths are universal — different cultures can independently

discover the same results, suggesting these concepts exist objectively rather than being cultural inventions

70. 60 (LCM of 2,3,4,5,6 = 60)
    Matching (Asian Mathematics: Origami, Tangrams, and Beyond): 1→D, 2→B, 3→C, 4→A, 5→E
71. B — Positional notation with place value
72. A — Indian mathematicians
73. D — They both use only doubling and addition, avoiding memorized multiplication tables
74. C — Each culture independently reached the mathematical limits of what is possible in their domain
75. A — D, C, A, B
76. C — Two levels: bottom level shows 7 (one bar and two dots), top level shows 2 (two dots)
77. Humans have recognized primes as special numbers across vastly different cultures and time periods
78. Indian mathematicians developed zero and negative numbers as abstract concepts, and Islamic mathematicians proved geometric theorems about all 17 symmetry groups — both are pure mathematics, not just practical calculation
79. Approximately 1.0 (log 3 / log 3 = 1)
80. 23
    Matching (Master Ethnomathematician Capstone): 1→B, 2→E, 3→C, 4→A, 5→D
81. D — Tally marks — one scratch or notch for each object
82. D — Roman numerals aren't positional — there's no place value system, making column arithmetic impossible
83. C — A counting tool with beads on rods that represents place values — it enabled fast arithmetic before written calculation methods existed
84. B — 5 from 2 and a half twenties, or 10 from 3 twenties (3×20 - 10 = 50 - 10 = ... actually it would be expressed as 5 from 50, meaning 50 - 5 = 45)
85. D — Right angles — the Egyptians used rope stretchers to create precise right angles
86. C — To calculate the diagonal of a square — if a square has side 1, its diagonal is

exactly √2

87. 74 threads (3 × 20 + 14 = 74)
88. 260 (13 × 20, since 13 and 20 share no common factors)
89. They identified patterns by finding relationships between different cycles — connecting lunar, solar, and calendar mathematics
90. 1,200 cacao beans (3 × 400 = 1,200)
    Matching (Elements & Principles Deep Dive): 1→E, 2→D, 3→C, 4→A, 5→B
91. D — Ancient India — Brahmagupta (628 CE) was the first to treat zero as a number with rules for arithmetic
92. B — Two corner wedges and three vertical wedges (2×10 + 3×1 = 23)
93. A — About 2.895 (4 × (1 - 1/3 + 1/5 - 1/7) = 4 × 0.7238 ≈ 2.895)
94. B — Mathematics can be adapted to practical needs — the counting system matched how items were actually grouped and traded
95. C — Practical problems about dividing bread, calculating areas, and solving equations — with worked solutions
96. B — It shows that Babylonian mathematicians went beyond practical problems to explore abstract mathematical relationships for their own sake
97. It holds a position to show that a particular place value level is empty, preventing confusion between different numbers
98. To make the third position approximate one solar year (365 days ≈ 360)
99. About 0.014% (less than two hundredths of one percent)
100. 1 incense bag, 3 feathers, 2 flags, 5 dots (8000 + 1200 + 40 + 5 = 9245)
    Matching (Cultural & Historical Context): 1→D, 2→A, 3→B, 4→C, 5→E
101. B — Ancient India — then transmitted to Europe through Arab mathematicians
102. A — Base 10 (decimal) — we group by tens, hundreds, thousands
103. C — Projection — a 3D shape can have infinitely many different 3D forms that produce the same 2D image from a specific viewpoint
104. A — Mathematics is universal because Africa (Ishango bone primes, fractal architecture), Asia (Indian zero, Chinese algebra, Japanese geometry), and the Americas (Mayan positional notation, Aztec base-20 arithmetic) all independently developed sophisticated mathematical systems addressing the same fundamental concepts

105. A — Slope (or ratio of horizontal run to vertical rise) — essentially an ancient version of trigonometry
106. C — Wet clay could be smoothed and rewritten, allowing students to practice repeatedly — mistakes could be erased
107. A dot in the 20s place and a shell (zero) in the 1s place ($1 \times 20 + 0 \times 1 = 120$ — wait, that's 20). Actually: a bar-dot (6) in the 20s place and zero in the 1s place ($6 \times 20 = 120$)
108. 52 years (LCM of 260 and 365 is 18,980 days ÷ 365 = 52)
109. 2,10 (two sixties plus ten = 120 + 10 = 130)
110. 16,000 mantles ($2 \times 8{,}000 = 16{,}000$)
Matching (Creative Process & Critique): 1→C, 2→D, 3→A, 4→E, 5→B
111. C — They used reed styluses that naturally created wedge shapes when pressed into soft clay — the writing medium shaped the number symbols
112. A — 1101
113. A — Independent parallel discovery — the same mathematical truth discovered by different cultures without contact
114. C — Mathematical thinking is a universal human capability — different cultures discover similar truths through different paths
115. A — $3^2 + 4^2 = 9 + 16 = 25 = 5^2$, confirming it's a right triangle
116. D — The number you multiply by to get 1 — for example, the reciprocal of 4 is 1/4 (because $4 \times 1/4 = 1$)
117. They counted using both fingers and toes, giving 20 digits total
118. The completion of one full cycle of the largest digit, like an odometer rolling over — a new cycle simply began
119. 195 (Left: 13, 6, 3, 1 | Right: 15, 30, 60, 120 | Odd rows: 13→15, 3→60, 1→120 | Sum: 15+60+120 = 195)
120. $x = 4$ and $x = 6$ (since $(x-4)(x-6) = x^2 - 10x + 24$)
Matching (Professional Practice & Careers): 1→E, 2→C, 3→A, 4→B, 5→D
121. C — Each civilization developed counting methods suited to their environment, culture, and practical needs
122. B — Pythagorean triples — sets of three whole numbers where $a^2 + b^2 = c^2$
123. B — Researchers discovered that medieval Islamic patterns anticipated

mathematical concepts like aperiodic tilings and quasicrystals that weren't formally understood until the 20th century

124. B — Algorithm — the word 'algorithm' derives from the Latinized form of his name, 'Algoritmi'
125. A — Each weight is double the previous one — a geometric sequence with common ratio 2
126. C — Base 8 (octal) with 8 unique digit symbols (0 through 7)
127. 1, 6, 15, 20, 15, 6, 1
128. 16 (16 ÷ 5 = 3 remainder 1, and 16 ÷ 7 = 2 remainder 2)
129. Floods erased land boundaries, requiring mathematical surveying to re-measure and redistribute farmland each year
130. The Indian concept of zero and the positional decimal system
Matching (Mayan Calendar): 1→C, 2→A, 3→E, 4→B, 5→D
131. C — 14
132. D — 5,33,20 (which equals 20,000 square meters)
133. C — Two bars and three dots (5 + 5 + 3 = 13)
134. D — Symmetry — specifically translational, rotational, and reflective symmetry that allows a pattern to tile a surface infinitely
135. C — 2 square units (the small triangle has legs of length 2, so area = ½ × 2 × 2 = 2)
136. A — 144 (1×64 + 4×8 + 4×1)
137. 1/5 (one-fifth)
138. 23
139. The value of a digit depends on its position — the 3 in 300 is worth more than the 3 in 30
140. Origami folds can create cubic curves (third-degree equations), while compass and straightedge are limited to quadratic (second-degree) equations
Matching (Mayan Calendar): 1→A, 2→C, 3→B, 4→E, 5→D
141. D — Al-Khwarizmi, a 9th-century Persian mathematician who wrote about Hindu-Arabic numerals and algebra
142. D — 305
143. A — Translation (slide), rotation (turn), reflection (mirror), and glide reflection

(slide + mirror)

144. C — 9 (one 5-bead + four 1-beads = 5 + 4 = 9)
145. D — Exactly 2 (the start and end vertices)
146. A — A smooth geometric transition between a square and a circle, achieved by progressively adding more sides — squinches become octagons become 16-gons approaching a circle
147. Two regular octagons and one square (135° + 135° + 90° = 360°)
148. Knotted strings where different types of knots at different positions represented numbers in base 10
149. Each culture independently reached the mathematical limits of what is possible in their domain
150. The correct formula $V = (h/3)(a^2 + ab + b^2)$ requires sophisticated mathematical reasoning beyond simple measurement
    Matching (Mayan Calendar): 1→A, 2→C, 3→E, 4→B, 5→D
151. B — MMXXIV
152. A — They maintained systematic, long-term records and could recognize patterns in data across centuries
153. D — European merchants and scholars were deeply invested in Roman numerals and the abacus — switching systems meant retraining entire professions
154. C — About 5-6 centuries (Alhambra was built in the 1300s; mathematical classification came in the late 1800s)
155. B — To prevent confusion between adjacent digits — alternating vertical and horizontal rods makes it immediately clear where one digit ends and the next begins
156. D — They alternated between vertical rods (for ones, hundreds, ten-thousands) and horizontal rods (for tens, thousands), making each position visually distinct
157. Georg Cantor's discovery that there are different sizes of infinity (e.g., integers vs. real numbers)
158. 135° + 135° + 90° = 360° — it works perfectly, confirming the pattern tiles the plane without gaps
159. 6 cm (24 → 12 → 6, halving twice)
160. D, C, A, B

Matching (Mayan Calendar): 1→B, 2→A, 3→C, 4→E, 5→D

161. He really knew how to work the angles!
162. I told my friend a joke about ancient Babylonian math. It was base-60 humor -- not everyone gets it.
163. Because they kept telling her "I" is always 1, "V" is always 5, and she could never subtract properly!
164. Euclid walked into a library and asked for a book with no points. The librarian said, "That would be pointless."
165. Because it had so many natural divisions!
166. "I'm on a whole new curve!"
