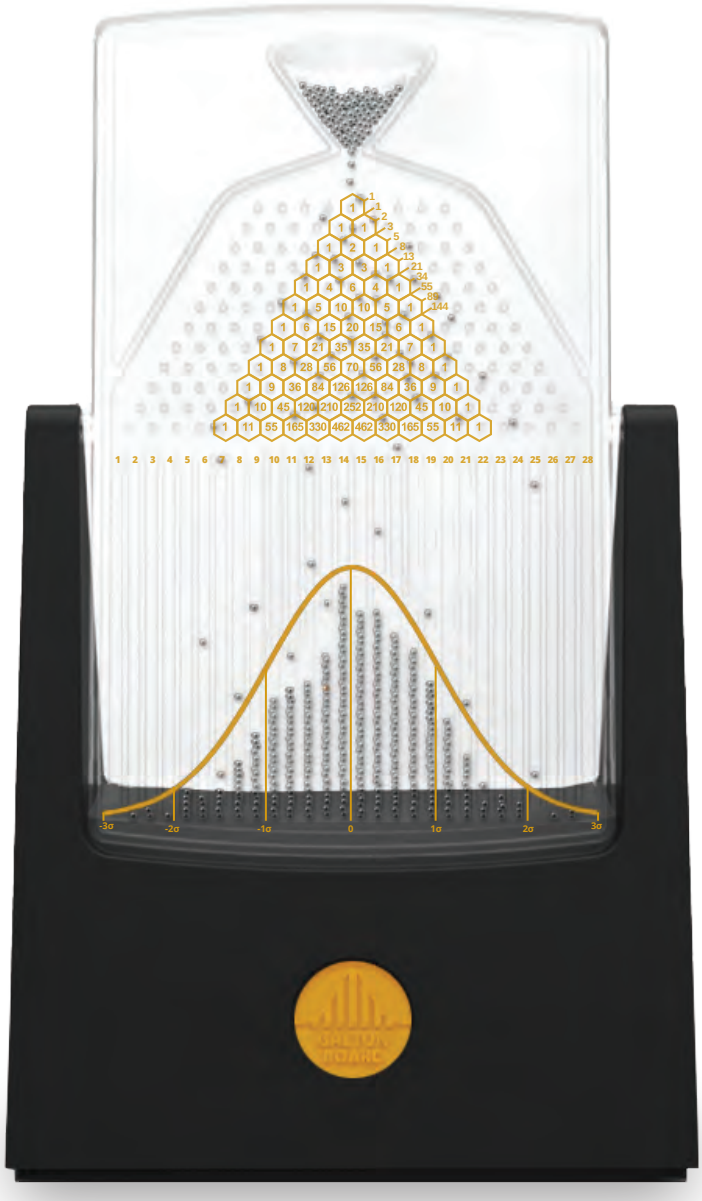
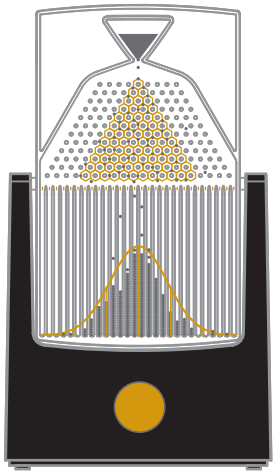
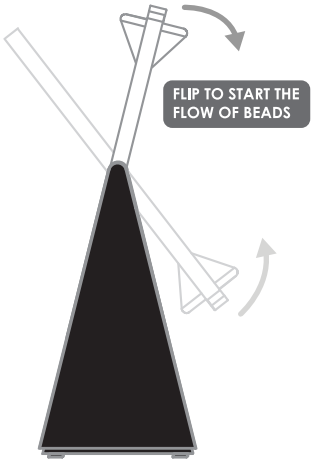
STEM.ORG AUTHENTICATED™ EDUCATIONAL PRODUCT

GALTON BOARD

Math in Motion







The Galton Board is math in motion, demonstrating centuries-old mathematical concepts in an innovative desktop device. It incorporates Sir Francis Galton's (1822-1911) illustration of the binomial distribution, which for a large number of beads approximates the normal distribution. Overlaid on the pegs is **Pascal's triangle** (Blaise Pascal, 1623-1662), which is a triangle of numbers that follows the rule of adding the two numbers above to get the number below. The number at each peg represents the number of different paths a bead could travel from the top peg to that peg. It also shows the **Fibonacci numbers** (Leonardo Fibonacci, 1175-1250), which are the sums of specific diagonals in Pascal's triangle.

When rotated on its axis, the 3,000 steel beads cascade through rows of symmetrically placed pegs in the desktop-sized Galton Board. When the device is level, each bead bounces off the pegs with equal probability of moving to the left or right. As the beads settle into the bins at the bottom of the board, they accumulate to approximate a bell-shaped histogram. Printed on the board is a **bell curve**, as well as the average and standard deviation lines. The bell curve, also known as the **Gaussian distribution** (Carl Friedrich Gauss, 1777-1855), is important in statistics and probability theory. It is used in the natural and social sciences to represent random variables, like the beads in the Galton Board.

"The Galton Board is a chilling reminder that out of wonderful, wild randomness, order and stability can emerge."

DING

VSAUCE

Visit galtonboard.com/video to watch Michael's video

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19200 Von Karman Ave Suite 150 Irvine, CA 92612 USA
888-368-3452 • 949-596-8489 • #4P-GB-1-JUN-2019
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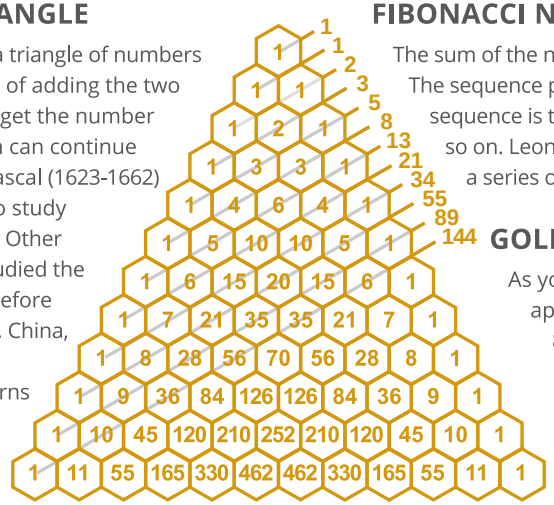
PASCAL'S TRIANGLE

Pascal's triangle is a triangle of numbers that follow the rule of adding the two numbers above to get the number below. This pattern can continue endlessly. Blaise Pascal (1623-1662) used the triangle to study probability theory. Other mathematicians studied the triangle centuries before him in India, Persia, China, Germany and Italy. The triangle's patterns translate to mathematical properties of the binomial coefficients.



FIBONACCI NUMBERS

The sum of the numbers on the diagonal shown on Pascal's triangle match the Fibonacci numbers. The sequence progresses in this order: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89 and so on. Each number in the sequence is the sum of the previous two numbers. For example: 2+3=5; 3+5=8; 5+8=13; 8+13=21 and so on. Leonardo Fibonacci popularized these numbers in his book *Liber Abaci* (1202). A Fibonacci spiral is a series of one-quarter circles drawn inside a pattern of squares with Fibonacci numbers for dimensions.

GOLDEN RATIO

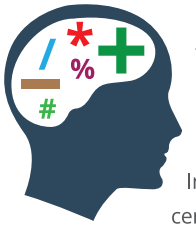
As you progress through the Fibonacci numbers, the ratios of consecutive Fibonacci numbers approach the Golden Ratio of 1.61803398...., but never equals it. For example: 55/34=1.618; 89/55=1.618 and 144/89=1.618. Euclid (325 BC- 270 BC) and other well-known mathematicians studied the properties of the Golden Ratio, including its appearance in dimensions of a regular pentagon and a golden rectangle. Artists and architects, including Dali, have proportioned their works to approximate the Golden Ratio, which can also be seen in many patterns in nature, including the spiral arrangement of leaves.

Sir Francis Galton

"Order in Apparent Chaos: I know of scarcely anything so apt to impress the imagination as the wonderful form of cosmic order expressed by the 'Law of Frequency of Error.' The law would have been personified by the Greeks and deified, if they had known of it. It reigns with serenity and in complete self-effacement amidst the wildest confusion. The huger the mob, and the greater the apparent anarchy, the more perfect is its sway. It is the supreme law of Unreason. Whenever a large sample of chaotic elements are taken in hand and marshalled in the order of their magnitude, an unsuspected and most beautiful form of regularity proves to have been latent all along."

-Sir Francis Galton, *Natural Inheritance, 1889*

SET YOUR MATH BRAIN IN MOTION!



The Galton Board, with the superimposed Pascal's triangle, Fibonacci numbers, bell curve with standard deviation lines, and numbered bins, incorporates together many mathematical, statistical, and probability concepts. *Can you spot them all?*

In the Galton Board you may see: the Gaussian curve of the normal distribution, or bell-shaped curve; the central limit theorem (the de Moivre-Laplace theorem); the binomial distribution (Bernoulli distribution); regression to the mean; probabilities such as coin flipping and stock market returns; the law of frequency of errors; and what Sir Francis Galton referred to as the "law of unreason."

Within Pascal's triangle, mathematical properties and patterns are evident. Those include: prime numbers; powers of two; Magic 11's; Hockey Stick Pattern; triangular numbers; square numbers; binary numbers; Fibonacci's sequence; Catalan numbers; binomial expansion; fractals; Golden Ratio; and Sierpinkski's Triangle.

STEM.ORG AUTHENTICATED™ EDUCATIONAL PRODUCT

INCLUDES	One Galton Board device X1 product and color my vary One Instruction Booklet X1
PACKAGE DIMENSIONS	9.5 x 5.0 x 3.6 inches (241.3 x 127 x 91.4 mm) 17.6 oz (500 g)
UNIT DIMENSIONS	7.25 x 4.5 x 2.56 inches (184.15 x 114.3 x 65.0 mm) 6.1 oz (173 g)
MANUFACTURER & DISTRIBUTOR	Four Pines Publishing, Inc. Irvine, California, | 1-888-368-3452 | FourPines.com All rights reserved. US Patent No. D784,449. Made in China. | Jun, 2019

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WARNING:
Chocking Hazard - small parts.
Not for children under 3 years.
Use with adult supervision only.