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$z = r \left(\cos\varphi + i \cdot \sin\varphi \right)$

$10^{10^{34}}$

π

$\varphi = \sqrt{5}$

Special exhibition

Attention, please:
Numbers!

The fascinating world between zero and infinity

1st February – 18th May '08

Contents

Preface

The HNF is proud to present the special exhibition »Attention, please: Numbers! The fascinating world between zero and infinity« to mark Germany's Year of Mathematics in 2008.

Divided into ten sections, the exhibition spans a wide range of topics, from the cultural history of numbers via instruments used to survey the world all the way to the history of games of chance. A Number Circus introduces an element of fun, while the theory of numbers supplies hard facts. Visitors will meet some of the great masters of mathematics, as well as the »number animals« created by illustrator Nadia Budde.

The exhibition focuses on historical and storytelling aspects alike. Its objective is either to arouse people's interest or revive an old passion. Numbers are a varied and vivid means of gaining access to the world of mathematics for everyone. And if, after viewing the exhibition, you are left with the feeling that you're better at maths than you thought, then the exhibition has achieved its goal!
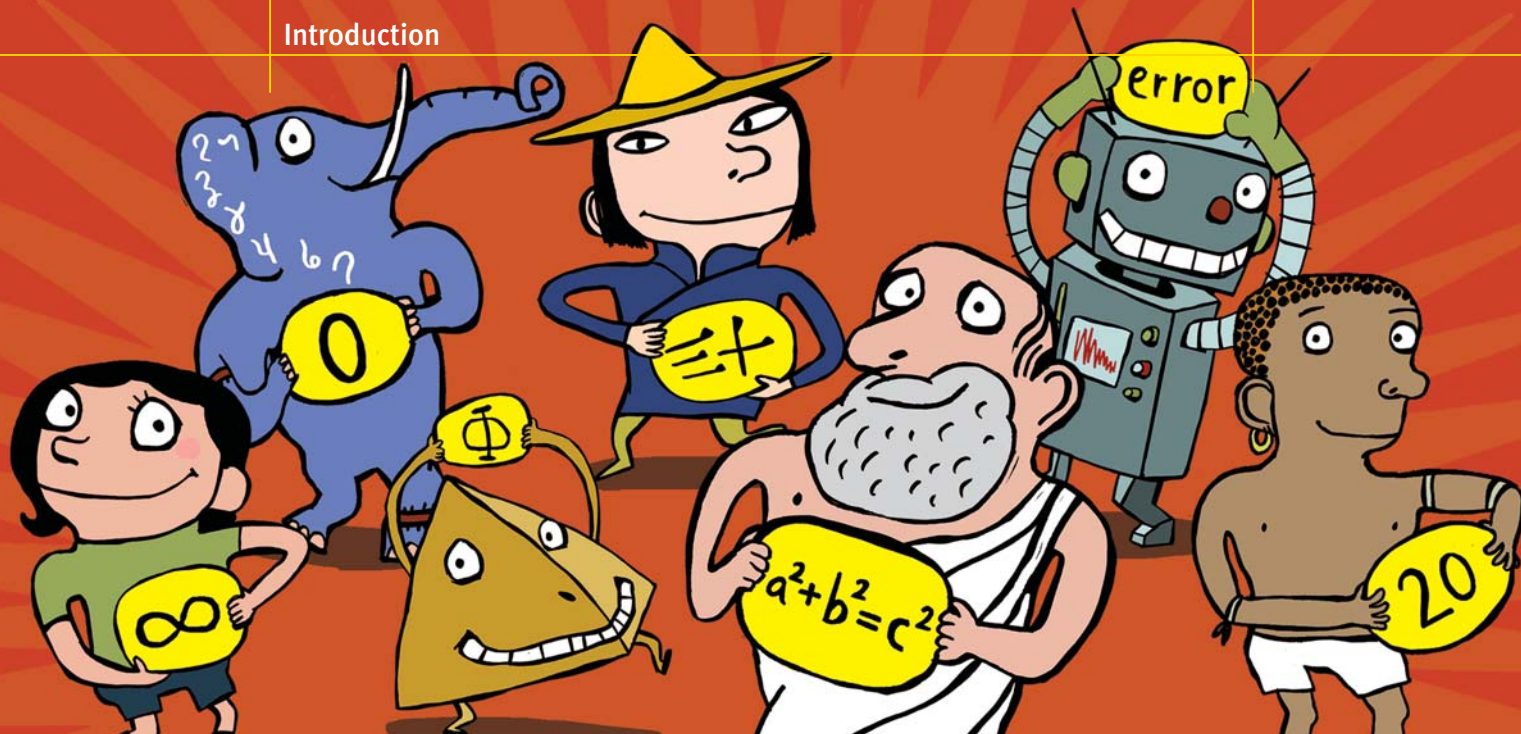
Norbert Ryska

Norbert Ryska
Managing Director

Wissenschaftsjahr 2008
Mathematik
Alles, was zählt

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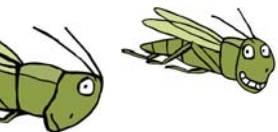**for further information**
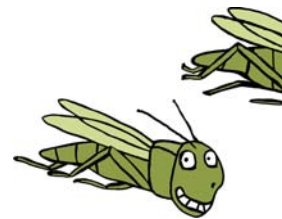
>> **Number is the essence of all things.** <<
Pythagoras

Attention, please:

Numbers!

Numbers, numerals and codes feature in almost every aspect of our daily lives. Life without them would be extremely hard to imagine, »incalculable« in fact. Accordingly, the world of numbers casts its spell on you as soon as you enter the exhibition: your ascent on the escalator to the first floor is accompanied by a countdown, and at the top you are greeted by the HDTV video »Numbers on the move«. Its 5,000 images per second will provide a vivid impression of the ubiquity of numbers in our daily lives. Just let yourself be swept along by this dynamic tide – we're counting on you!

Number Circus

Children and adults alike are introduced to the world of numbers in playful fashion: as well as meeting The Count from Sesame Street, they can expect to encounter a sheep counting machine and Goethe's witches' multiplication table. Here, visitors big and small alike can get to the bottom of the following questions:

····⟫ Can such a complex number as pi be determined simply by dropping jackstraws?

····⟫ What do numbers and music have in common?

····⟫ Why are measurements so important in our daily lives?

····⟫ Is a »Number Devil« a good teacher?

Toy calculators and a numbers drawer invite inspection by curious visitors, and those who want to try things out for themselves can tackle original numbers games.

Sheep counting machine by Patricia Waller, 2007

Fractions with wooden »apple calculators«

>> **The teacher's ABC was torture to me. Words aren't paramount. It's numbers that count!** << The Count

The cultural history
of numbers

Archaic clay slab, approx. 3,000 BC, specifying quantities for beer production

Set out with us on an exciting trip through the history of numbers – from the first tally marks on rock faces in the Stone Age to our modern daily lives, which would be almost impossible to imagine without numerals of some kind. Your journey will take you back in time to the civilisations on the Nile, Euphrates and Tigris rivers, whose early number systems marked the dawn of the age of arithmetic. New forms of government in Asia and Central America also required new types of resources to cope with the associated economic and military administration: it is ultimately bureaucrats who must be credited with inventing both writing with characters and calculating with numbers. This section of the exhibition gives you a fascinating insight into a wide range of number systems and numerals alike.

Warazans: right up to the 20th century, the inhabitants of Japan's Ryukyu islands used these knotted lengths of rice straw to perform calculations.

》》 Numbers are symbols of the transitory. 《《
Oswald Spengler, German philosopher

Masters of mathematics

Germany's old 10-DM banknote bore an image of mathematician Carl Friedrich Gauss and his heliotrope.

The history of mathematics was predominantly shaped by individuals. It was they who achieved massive scientific breakthroughs, solved thorny problems, developed new theories or recorded the status of science in writing. Ten great »masters of mathematics«, ranging from Pythagoras to Andrew Wiles, were selected for this exhibition from a conspicuously large group of famous mathematicians. The life history of each is on display,

alongside samples of their mathematical ability. These figures range from philosophical mathematicians of the ancient world via the spare-time numbers theoretician Pierre de Fermat and the mathematical all-rounder Leonhard Euler all the way to the enigmatic genius Srinivasa Ramanujan.

Czech stamp commemorating the proving of Fermat's Last Theorem by Andrew Wiles.

» **Do not worry about your difficulties in mathematics, I assure you that mine are greater.** «
Albert Einstein

Surveying the world

Mechanical model of
the planets designed
by James Ferguson, 1763
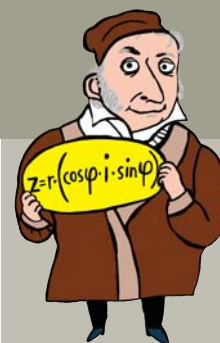
Every point on the earth's surface can be determined by its latitude and longitude – as Ptolemy knew as early as 2 AD. This knowledge formed the basis of what we now know as surveying, one of the very earliest applications for numbers and mathematics. Those wishing to navigate or determine their position on the high seas could use the stars at night, and the sun at noon.

Exhibits on show in this section include instruments historically used for positioning purposes, from the compass via the octant all the way to the theodolite used by land surveyors. Navigation always went hand in hand with time measurement.

Timekeepers from various ages are displayed alongside historical meteorological instruments.

> Measure everything that is measurable and render everything measurable that is not yet so. Archimedes

Numbers in nature

**The nautilus shell:
a logarithmic spiral**

**Rabbit reproduction
according to Fibonacci**

Both animate and inanimate nature comply with strict laws and regularities which can be portrayed in mathematical form. This is evident in the case of crystals, whose structure can be described precisely using the laws of physics and geometry. The diamond is perhaps the most beautiful example of all.

Various numerical proportions also occur in plant and animal life, the four-leaf clover and the millipede among them. The alignment of twigs to the light obeys the law of the golden angle, and the densest arrangement of petals or grains forms a Fibonacci number chain. Artist Patricia Waller has crocheted a pineapple with the numbers of the Fibonacci series on its surface. Equally, the golden section is not merely an artistic formula, but can be encountered in the plant world.
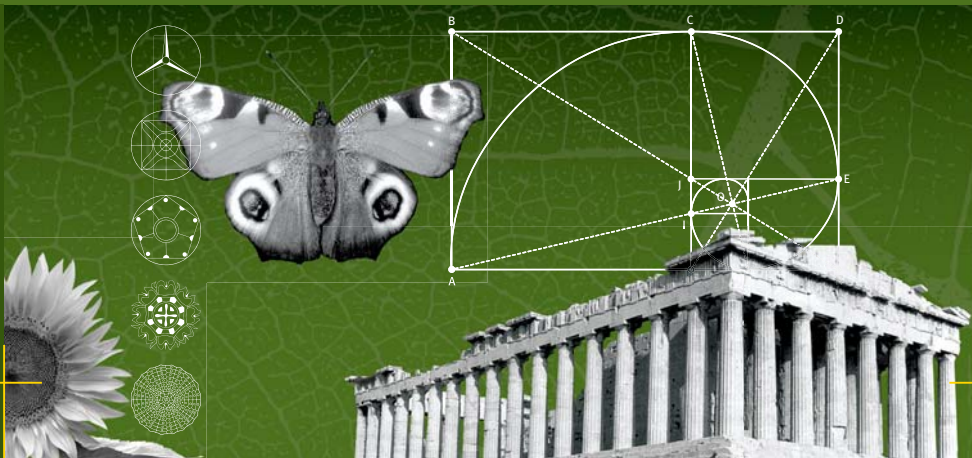

**Fibonacci pineapple by
Patricia Waller, 2007**

» **The book of nature is written
in the language of mathematics.** «
Galileo Galilei

The theory of numbers

Solving equations with the use of bicycle chains: mechanical number sieve by Derrick Lehmer.

Visitors will become better acquainted with our present-day number system as well as with other aspects of the world of numbers. Although some number types have been known about for centuries, it was only at the end of the 19th century that people succeeded in establishing an inherently coherent number system, encompassing natural numbers, integers, rational numbers, real and complex numbers alike. The world of numbers contains many special numbers. Zero, for example, only reached Europe in the Middle Ages, after travelling from India via Arabia and North Africa. Pi is probably is the best known number of all, while the prime numbers still hold many secrets. And infinity is also the subject of great speculation and debate.
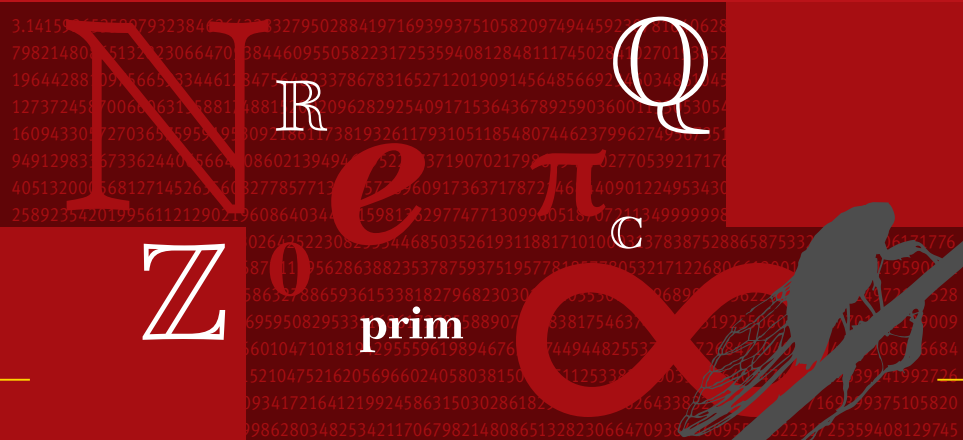
Visitors can use an interactive number telescope to survey the exhibition area in a playful and hands-on approach to the world of numbers and their significance.

Number design by the legendary designer Anton Stankowski

» **God created the integers; everything else was the work of man.** «
Leopold Kronecker, mathematician

Lucky numbers

Roman legionnaire's die, approx. 300 AD

Lottery, dice, roulette or poker – these games can turn on a single number. It is the elements of luck and chance that make them so irresistible to many. Even the ancient Greeks and Romans were slaves to games of chance, and dice have been found dating back to before their time. So this section of the exhibition features a number of ancient and modern exhibits – from the dice machine all the way to the lottery machine – arranged around a roulette wheel. You will find out which lottery tip holds out the greatest promise of success and why the trajectory of a roulette ball simply cannot be predicted. Or perhaps it can after all? If you like, you can have a go at opening a safe or try out a harmless version of Russian roulette. Slot machines and random generators are testimony to the difficulty of generating truly random numbers; the calculus of probability and combinatorics sadly prove that the player always ends up empty-handed.
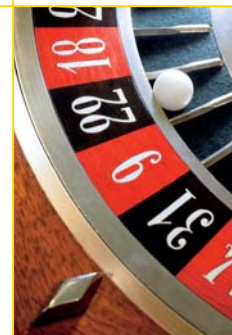
Rien ne va plus.

>> **Alea iacta est – The die is cast.** <<
Cäsar

The ethnology of numbers

Numerals are among the oldest examples of human writing, but they are not based on the same system everywhere. In Germany, every child starts off with a base of ten, the origins of which can be traced back to the number of fingers on our hands – but quite different methods of counting have been used in different ages and by different peoples. Many cultures are familiar with the dozen, while others use both fingers and toes to make a base of 20. Some native tribes can only count up to two or three, but are still able to determine bigger numbers – in order to get some idea of the sums involved – by means of equivalents such as pebbles or sticks.

The exhibition presents a range of number systems, as well as a collection of so-called »number gestures«. Books on mathematics in various indigenous languages show the universal propagation of the European »Indo-Arabic« numbers as a consequence of Colonialism.

Uwok von Mumyerunde demonstrates the counting system from 1 to 25.

Tally stick as a defaulter record from the 19th century, Lower Saxony

> **In Samoa, when elementary schools were first established, the natives developed an absolute craze for arithmetical calculations.**
> Robert Briffault, French man of letters, historian and social anthropologist

Numbers in everyday life

Film scene from the digital composition »Watch Berlin«

Our daily life is dominated by numbers. The clock determines our diurnal rhythm, digital signposts inform us of the current motorway speed limit, massive display boards give us data on airport departure times, flight numbers and expected delays. This fact is the subject of a multimedia presentation which attempts to portray the number chaos on a typical day in Berlin. The interactive installation »bit-mirror« from Cologne's Academy of

Media Arts, on the other hand, transforms people into numbers, while the baffling Benford's Law continues to generate astonishment. It states that the digits in a list of numbers of any size, whether car registration plates or stock market figures, do not occur with equal frequency. The number 1 leads the way (30.1 %), followed at some distance by the number 2 (17.6 %), with number 9 bringing up the rear (4.6 %). Prepare to be fascinated!

Signs show the size of water pipes and position of hydrants.

Brillenbär
5
nur noch
10000

Sumatra Nashorn
nur noch 280-320
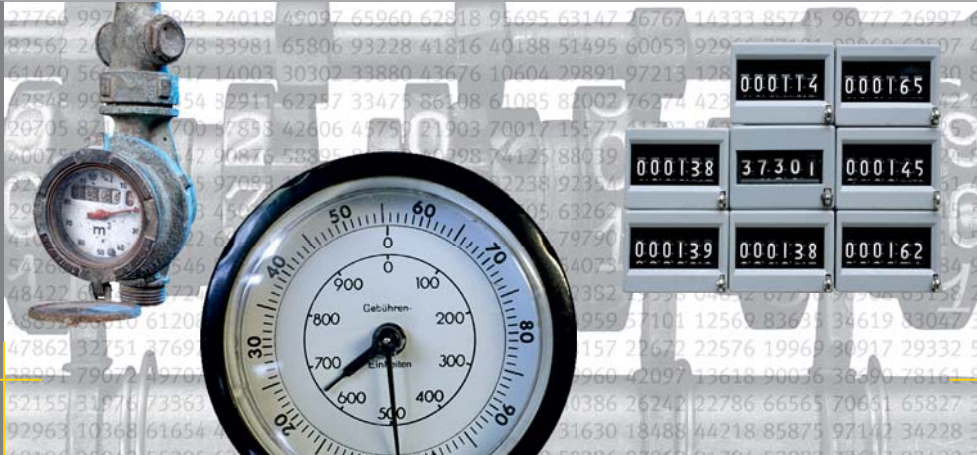
Animals and numbers

The chimpanzee Ayumu has the numerical sequence off pat.

»Hans«, the clever horse from Elberfeld, was able to calculate at great speed and communicate his results by beating his hoof or shaking his head. But he proved to be a master of perception rather than addition and subtraction: he was able to detect the smallest change in the questioner's facial expression or body language, thus revealing the correct result.

However, certain animals – including dolphins, apes and the common raven – really develop a feeling for numerical proportions and a talent for identifying »greater or fewer«. The charming illustrations by Nadia Budde supply further proof that there is a connection between animals and numbers, even if these animals cannot really perform calculations properly. In addition, the familiar face of Avatar Max from the permanent exhibition will be showing off his new skills in arithmetic, playing number games and even providing visitors with lottery numbers on request.

The HNF Avatar Max has learnt to do sums especially for the exhibition.

>> Leave the thinking to the horses;
they have much bigger heads than you. <<
Old saying
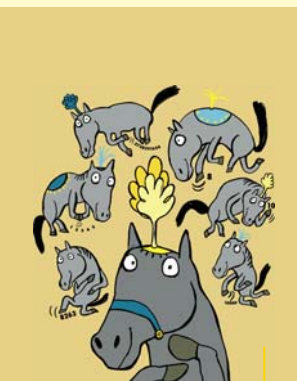
	Thurs	14th	February	3 - 4 pm	9 - 12 years
F	Tues	18th	March	10 - 11 am	9 - 12 years
F	Fri	28th	March	10 - 11 am	9 - 12 years
	Tues	22nd	April	3 - 4 pm	9 - 12 years
	Thurs	15th	May	3 - 4 pm	9 - 12 years

Everything is number

This saying is attributed to the famous Greek mathematician Pythagoras. This guided tour will show you whether there is any truth in it. Explore the fascinating world between zero and infinity, meet The Count from Sesame Street, find out how people performed calculations in the past and discover whether animals can do sums. You will see just how varied and exciting the world of numbers is.

The above tours may only be booked by individuals.

Cost: 3 euros. Group bookings should be arranged with the visitor service: Tues to Fri 35 euros, Sat/Sun 45 euros per group, plus reduced admission rate.

To make a binding booking, phone +49 (0)5251-3066-61.

Attention, please: Numbers!

Guided tours through the special exhibition »Attention, please: Numbers!« can be booked via the visitor service, tel. +49 (0)5251-3066-60 (Mon to Fri 8 am - 5 pm), fax +49 (0)5251-3066-69 or email service@hnf.de.

Length: approx. 45 minutes
Languages: German, English, French
Cost: Tues to Fri 30 euros, Sat/Sun 40 euros per group plus admission rate; max. 25 participants. Free public guided tours at weekends at 4 pm.

Admission to the special exhibition:
Adults: 4 euros, concessions: 2 euros, family ticket: 8 euros
Combined ticket with permanent exhibition:
Adults: 7 euros, concessions: 3.50 euros, family ticket: 12 euros
Groups from schools and training colleges, universities and universities of applied sciences, as well as groups of young people performing basic military or community service will be admitted free of charge by prior arrangement.

Obsessed with numbers

Discover in the HNF museum shop how exciting the world of numbers is! The selection of articles on sale to accompany the special exhibition bears testimony to the fact that numbers can be so much more than logical and uninspiring. The range of goods spans everything from zero to infinity and promises much more than just good entertainment for young and old alike! It includes various puzzles and games of skill, as well as books and music which deal with the topic of numbers. Best of all, the museum shop is selling many articles bearing the figures created by well-known illustrator Nadia Budde. If you are unable to visit the shop in person, you can view the special articles online at www.shopimmuseum.de.

Your shop team will be delighted to welcome you!

Shop articles available to mark the Year of Mathematics

HNF articles on the Year of Mathematics
These are some of the articles on sale in the museum shop:
ZahlenZauber
Magic or mathematics? Guess the thoughts of your fellow players. Card game, 3.95 euros
Faszination Mathematik
Recordings of the 2003 series of lectures. 10 DVDs, 39.95 euros
BlitzRechner
This trick will enable you to perform calculations in a jiffy. Dice game, 4.95 euros
Countdown 2008
Opening event of the special exhibition »Attention, please: Numbers!« on 31st January 2008. DVD, as of February 2008.

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Openening times

Tues to Fri: 9 a.m. to 6 p.m.

Sat/Sun: 10 a.m. to 6 p.m.

Closed Monday

Special arrangements on public holidays

Free guided tours are available on Satur-

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