0 1 2 3 4 5 6 7 8 9 10 11 12 13

$-1i$
$-2i$
$-3i$
$-4i$
$-5i$
$-6i$
$-7i$
$-8i$
$-9i$
$-10i$

KOMPLEKSNI BROJEVI

by DARIO

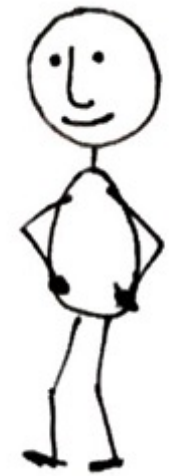
$$\frac{1}{2\pi i}\oint_C f(z)\,dz = \sum \mathrm{Res}$$

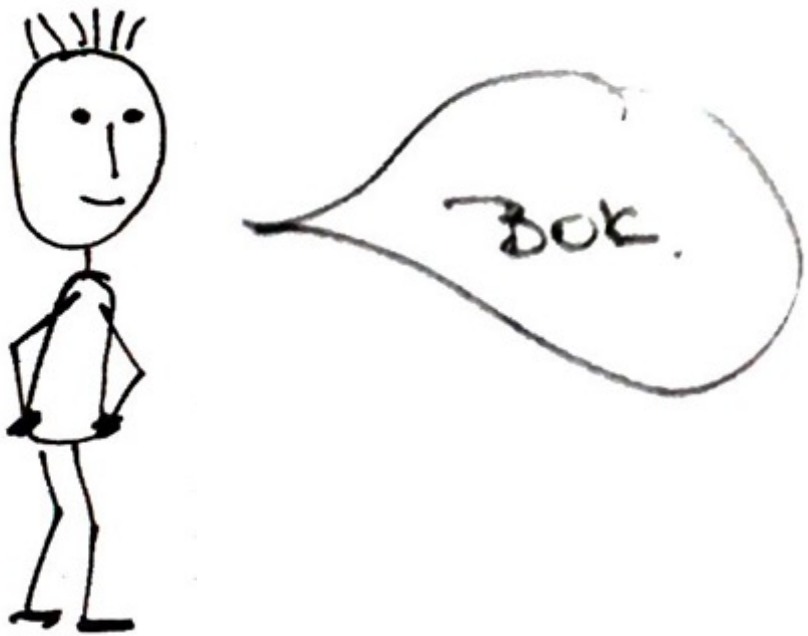
$\sqrt{-1} = i$, $i^2 = -1$, ma nije nema šanse

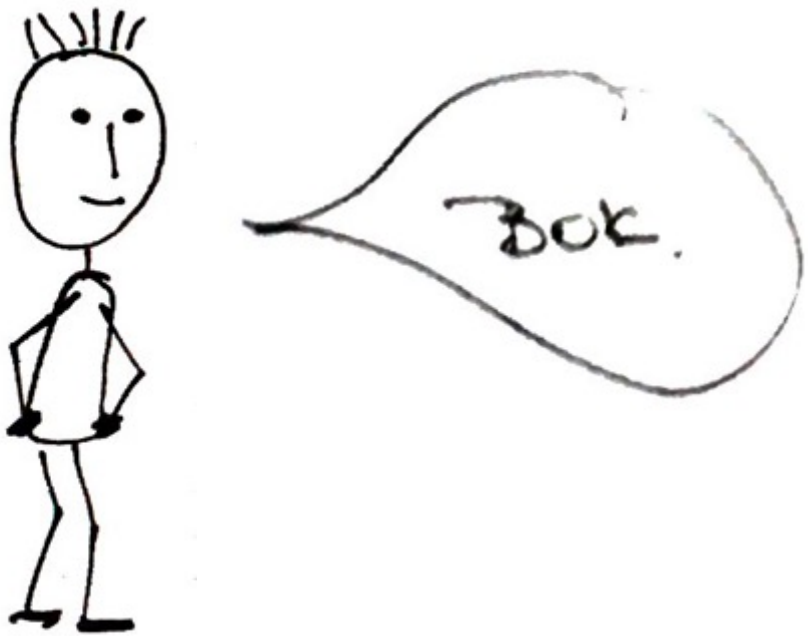
$$e^{\pi i} + 1 = 0$$

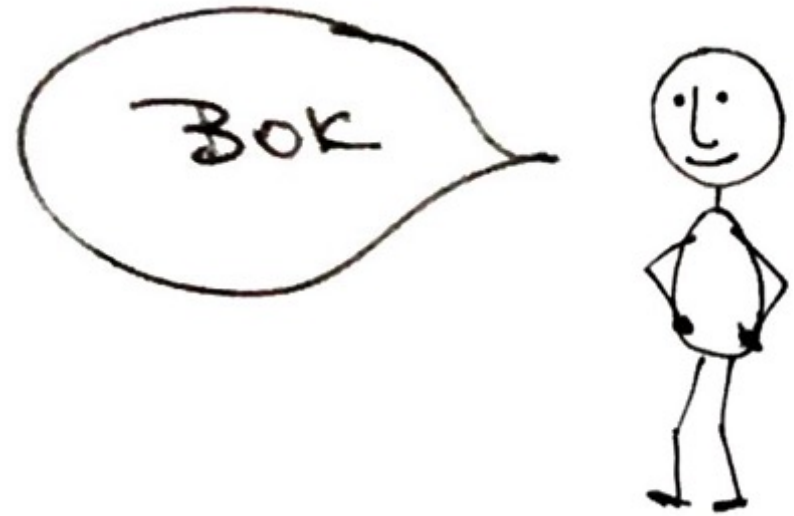
$$i\hbar \frac{\partial \psi}{\partial t} + \frac{\hbar^2}{2m}\Delta\psi - V\psi = 0$$

$$\delta(x-\xi) = \frac{1}{2\pi}\sum_{n=-\infty}^{+\infty} e^{in(x-\xi)}$$




BOK.

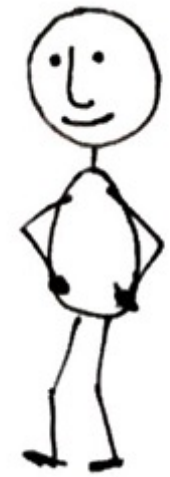

BOK.


BOK

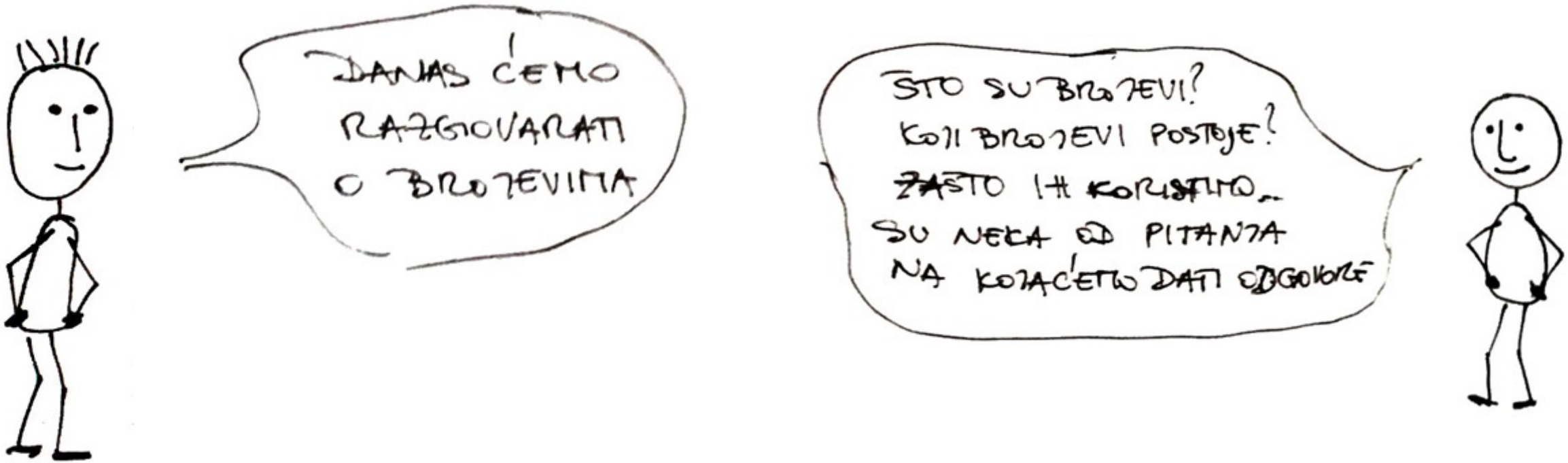
JA SAM PETAR.
DOLAZIM S LIJEVE
STRANE

JA SAM PETAR.
DOLAZIM S LIJEVE
STRANE

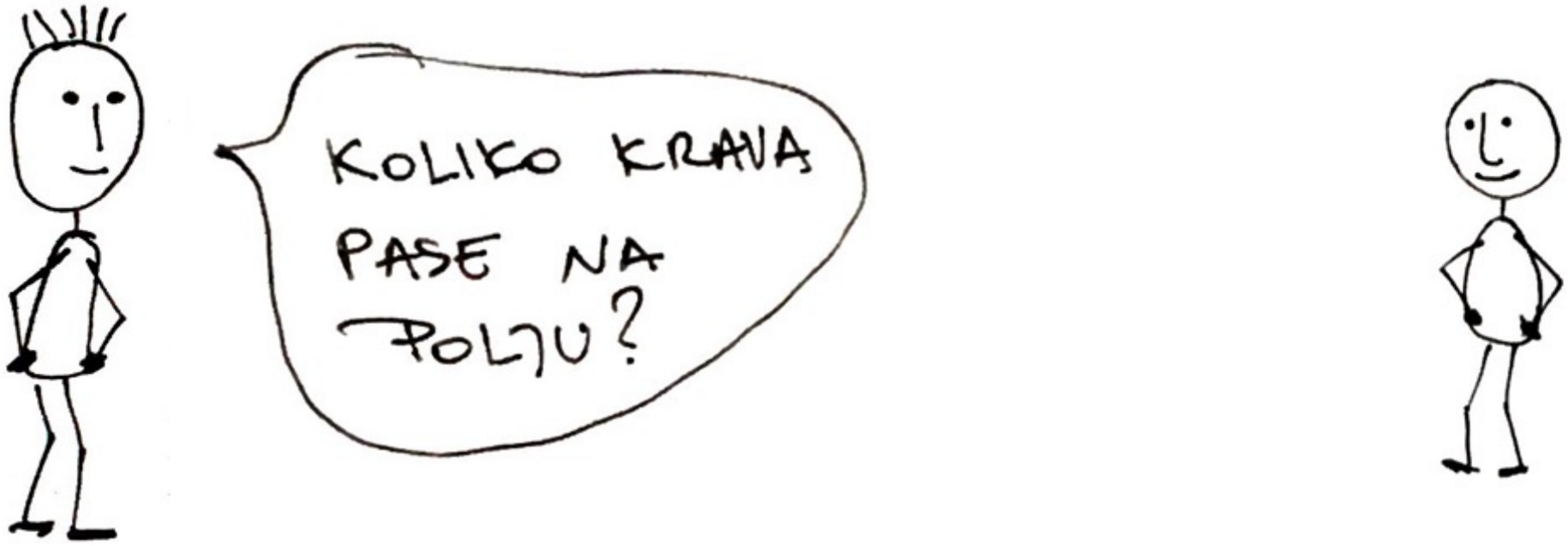
A JA SAM IVAN
I DOLAZIM S
DESNE STRANE

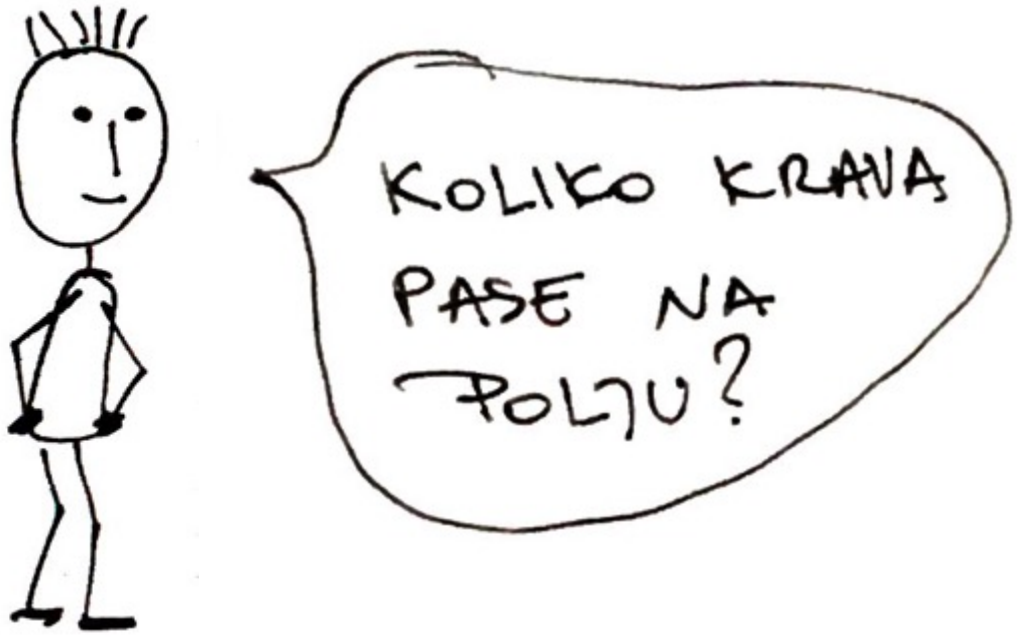


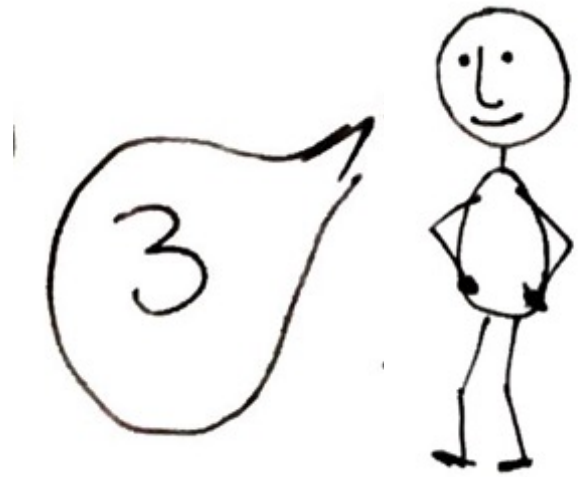

DANAS ĆEMO
RAZGOVARATI
O BROJEVIMA

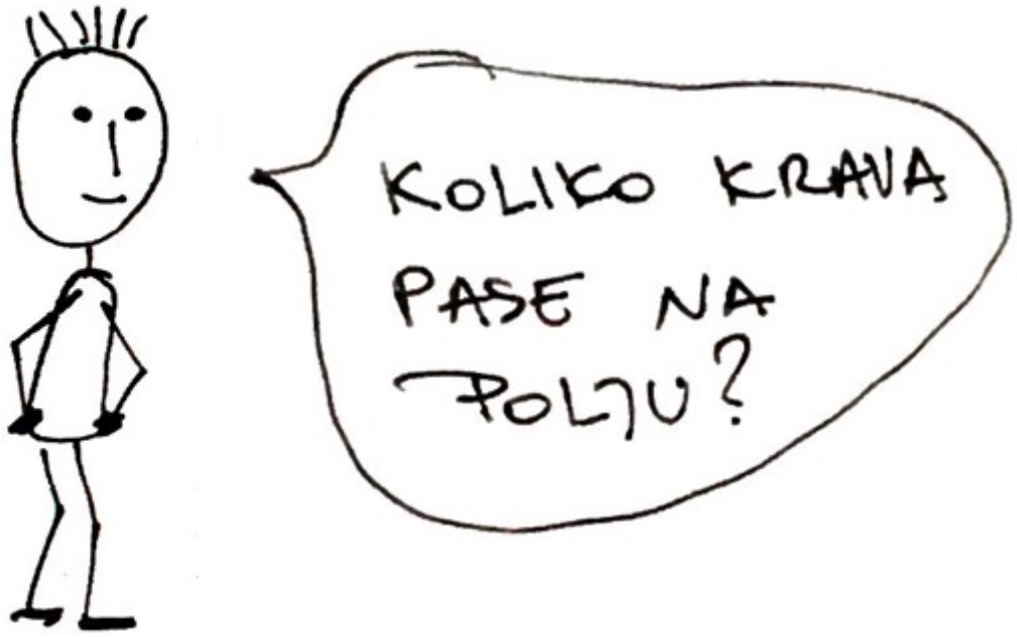

DANAS ĆEMO RAZGOVARATI O BROJEVIMA
ŠTO SU BROJEVI? KOLI BROJEVI POSTOJE? ZAŠTO IH KORISTIMO... SU NEKA OD PITANJA NA KOJA ĆETE DATI ODGOVORE

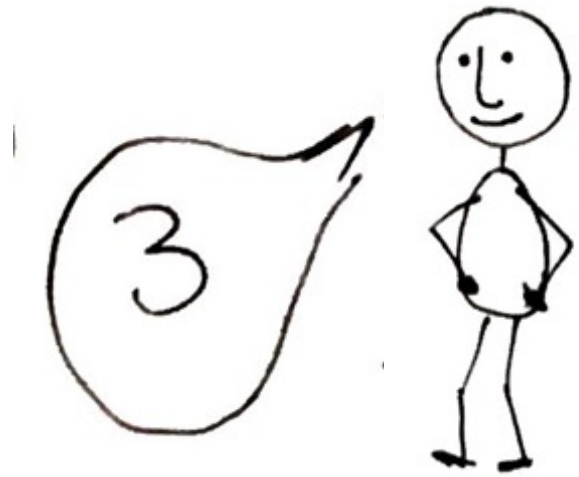
ZAŠTO TREBAMO BROJEVE?


KOLIKO KRAVA PASE NA POLJU?


KOLIKO KRAVA PASE NA POLJU?


3


KOLIKO KRAVA PASE NA POLJU?


3


1 2 3 4 5 6 ...

Brojevi su povezani s brojanjem

Brojevi su povezani s brojanjem

I II III

Brojevi su povezani s brojanjem

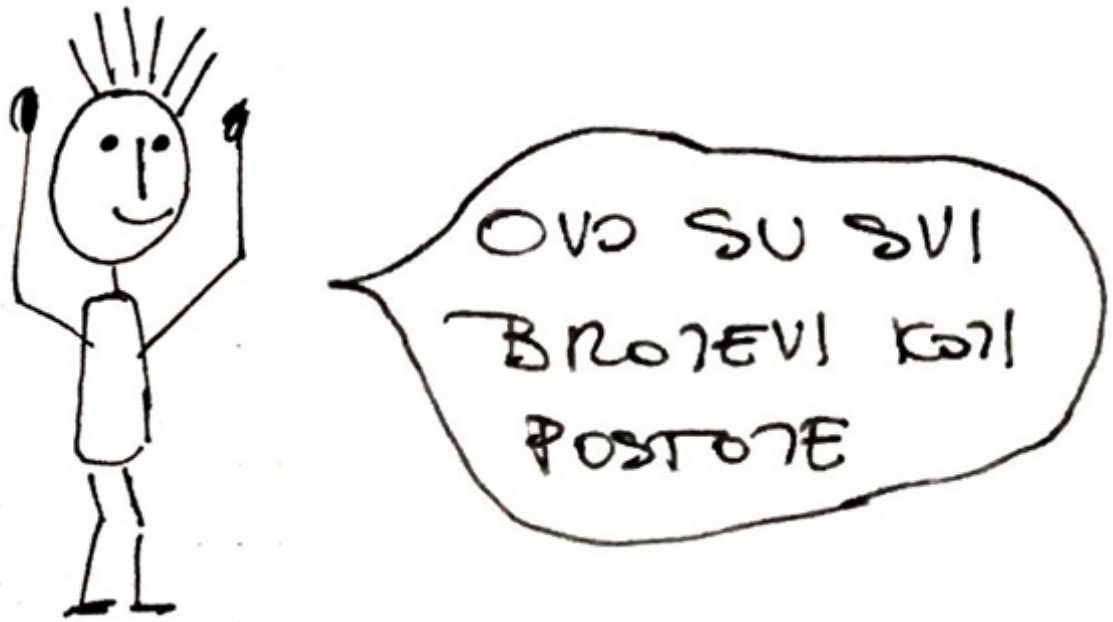
I II III

— = ≡

Brojevi su povezani s brojanjem

I II III

- = ≡ 1 2 3



$$\bullet \quad \bullet \quad \bullet \quad \bullet \quad \bullet \quad \bullet \quad \cdots$$

$$1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6$$

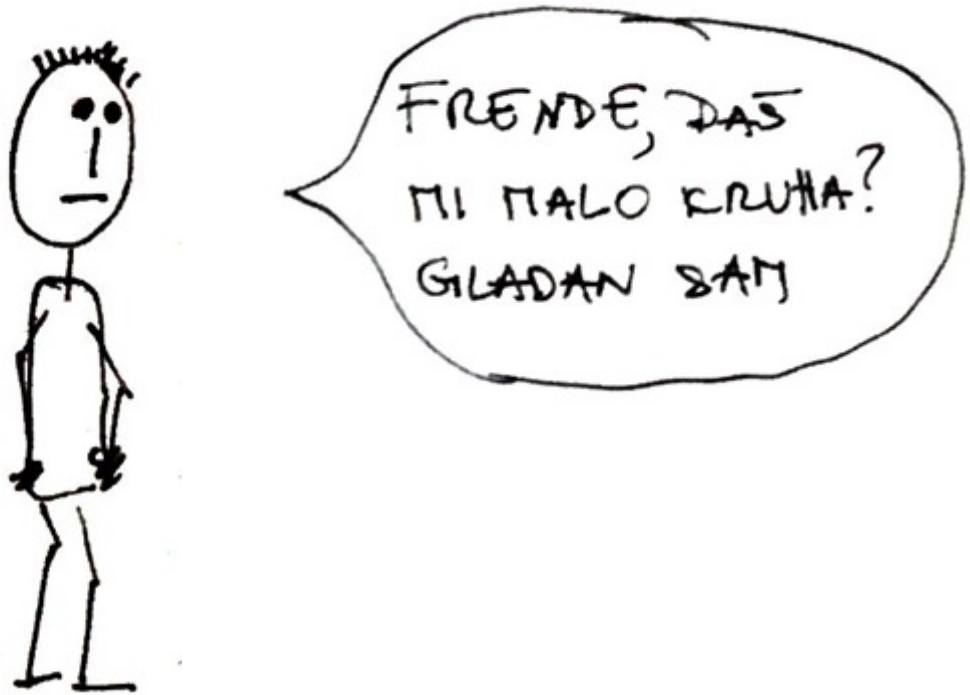
OVO SU SVI BROJEVI KOJI POSTOJE

DA, DA, SVE VISE OD TOGA BILO BI BESMISLENO

• • • • • • ...

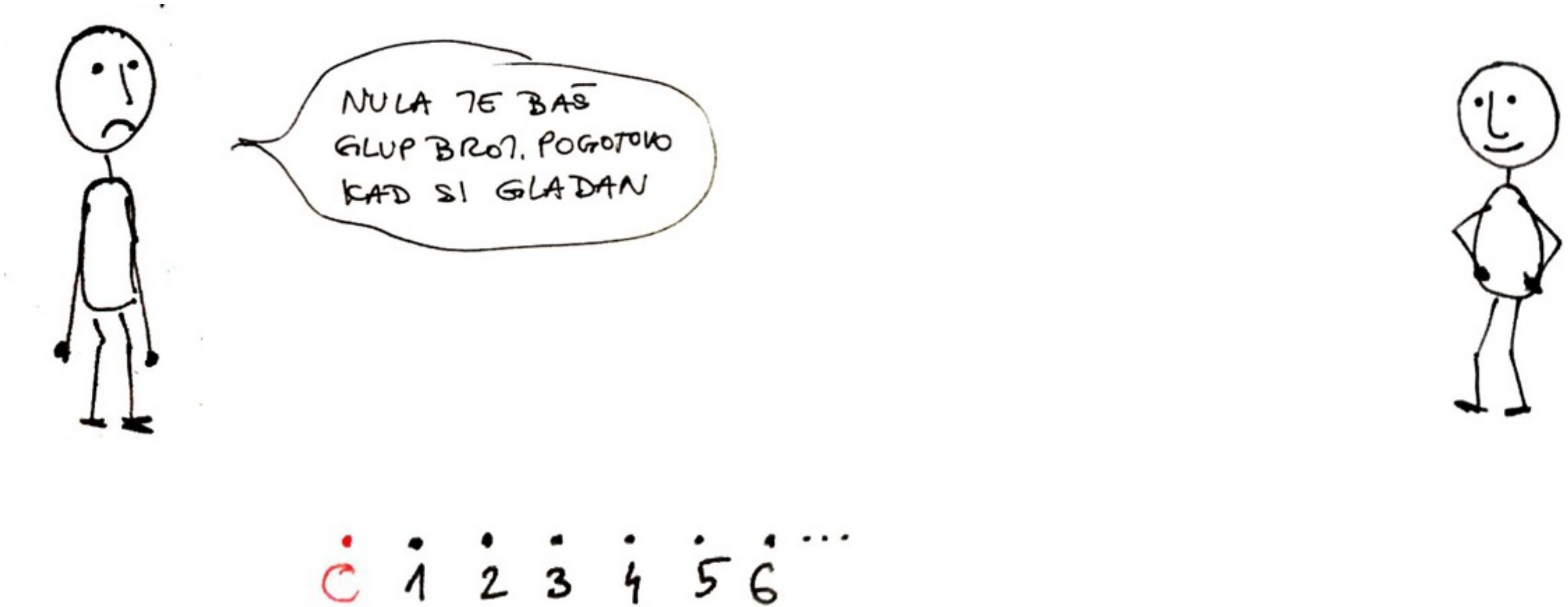
1 2 3 4 5 6

HM, HM, A JESU LI
TO ZBILJA SVI
BROJEVI?


FRENDE, DAŠ
MI MALO KRUHA?
GLADAN SAM

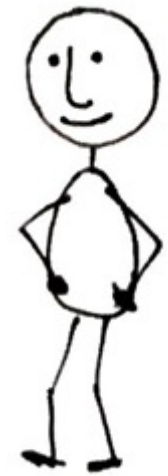

FRENDE, DAŠ MI MALO KRUHA? GLADAN SAM
IDE MI NA ŽIVCE, ALI NE SMIJEM REĆI DA MU NE DAM JER ĆE ME NAZVATI PAPCOM.

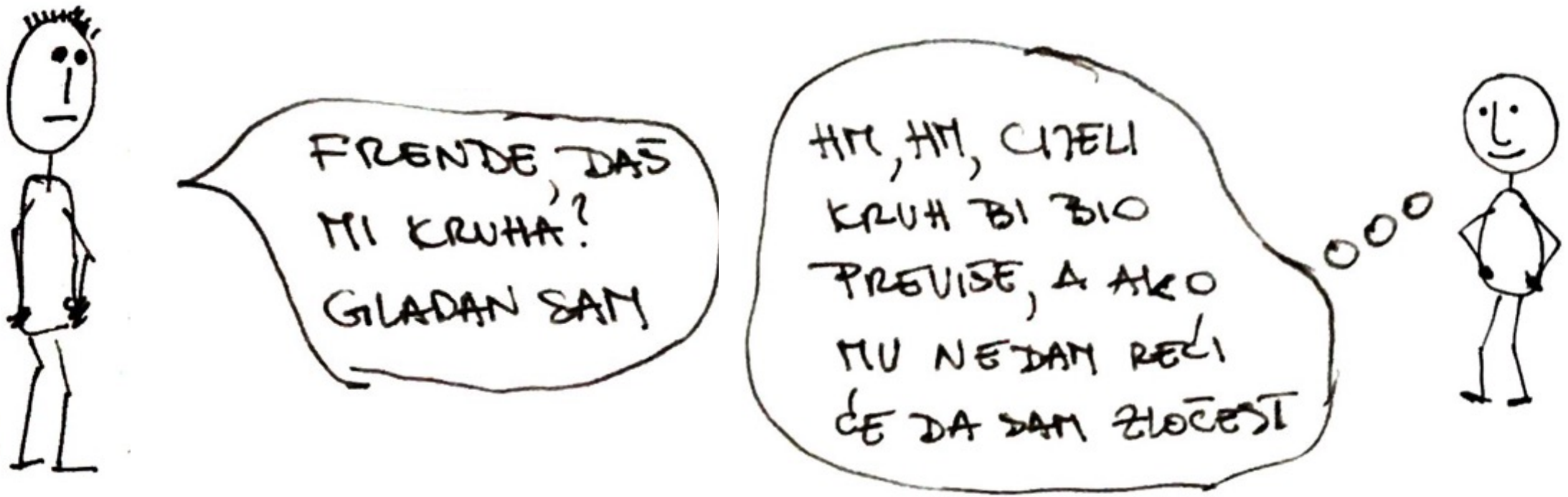

FRENDE, DAŠ MI MALO KRUHA? GLADAN SAM
MOŽE FRENDE, EVO TI NULA KRUHA

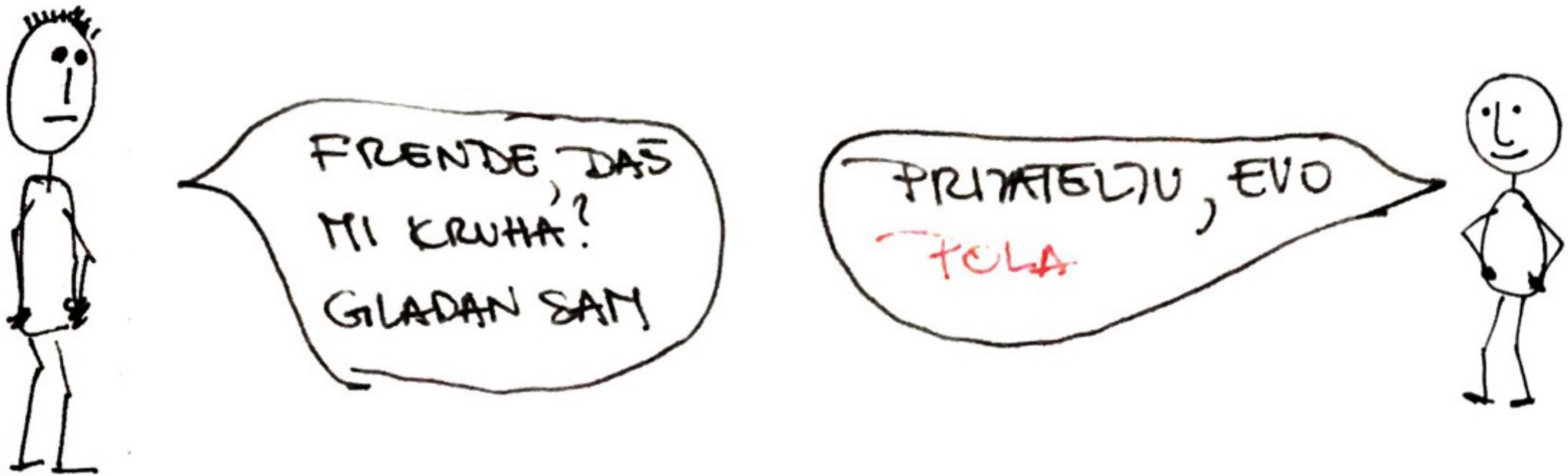

NULA JE BAŠ GLUP BROJ. POGOTOVO KAD SI GLADAN
0 1 2 3 4 5 6 ...

DOBRO, A JESU LI
SADA TO SVI
BROJEVI KOJE
TREBAMO?


FRENDE, DAŠ MI KRUHA?
GLADAN SAM

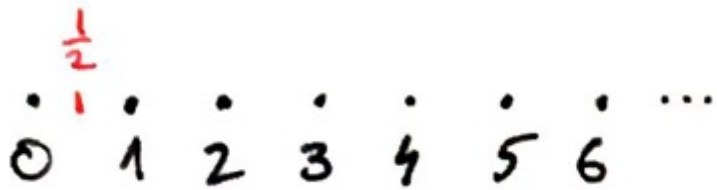



FRENDE, DAŠ MI KRUHA?
GLADAN SAM
HM, HM, CIJELI KRUH BI BIO PREVIŠE, A AKO MU NE DAM REĆI ĆE DA SAM ZLOČEST


FRENDE, DAŠ MI KRUHA?
GLADAN SAM
PRIJATELJU, EVO TOLA

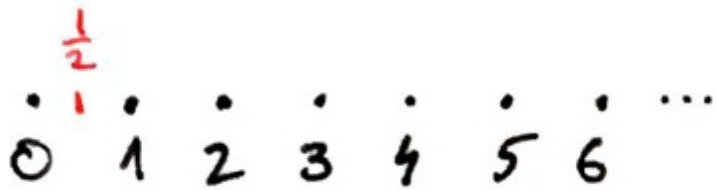
JUHUHU, RAZLOMCI SU NAJBOLJA STVAR NA SVIJETU. RAZLOMCI SU BOLJI OD SUPERMANA.

RAZLOMKE VOLIM JA. TRALALALALA

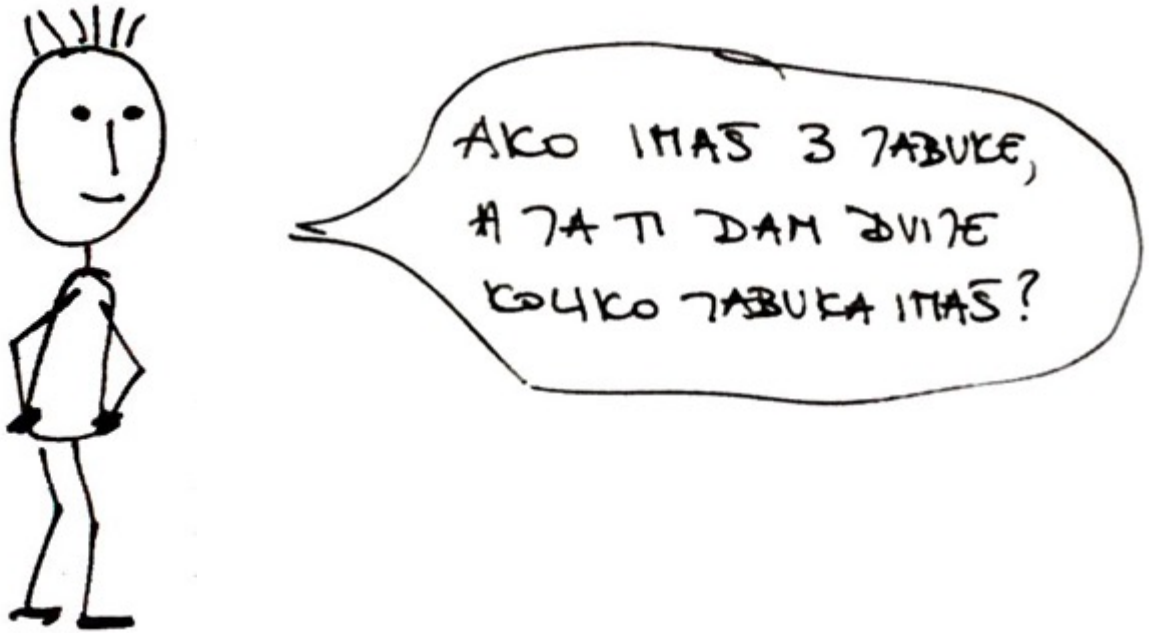


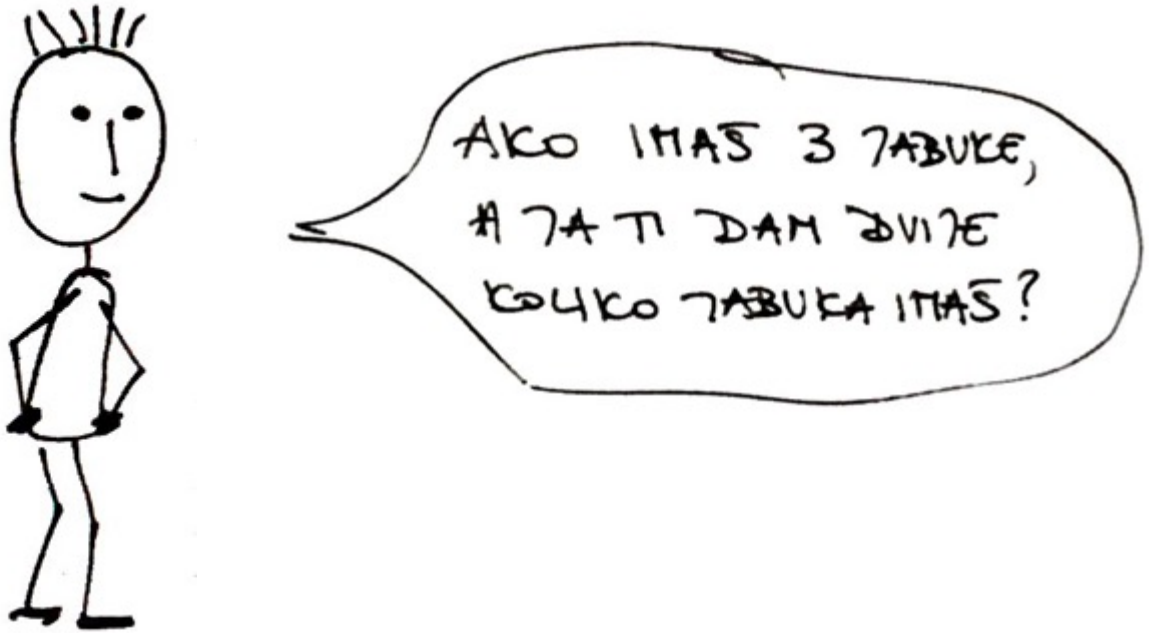
JUHU HU, RAZLOMCI SU NAJBOLJA STVAR NA SVIJETU. RAZLOMCI SU BOLJI OD SUPERMANA.

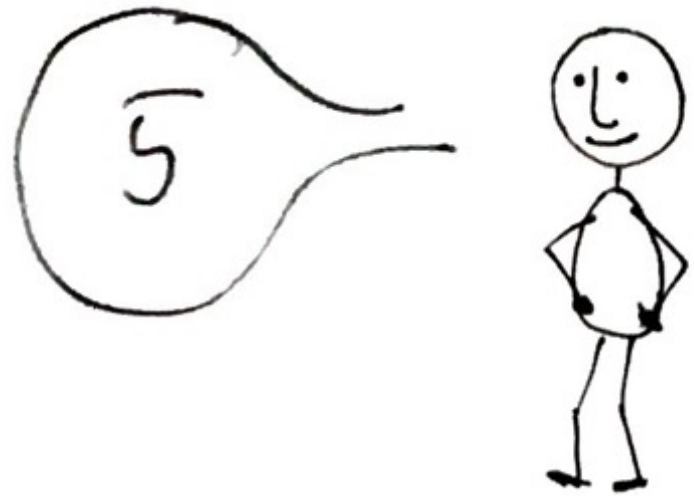
RAZLOMKE VOLIM JA. TRALALALALA

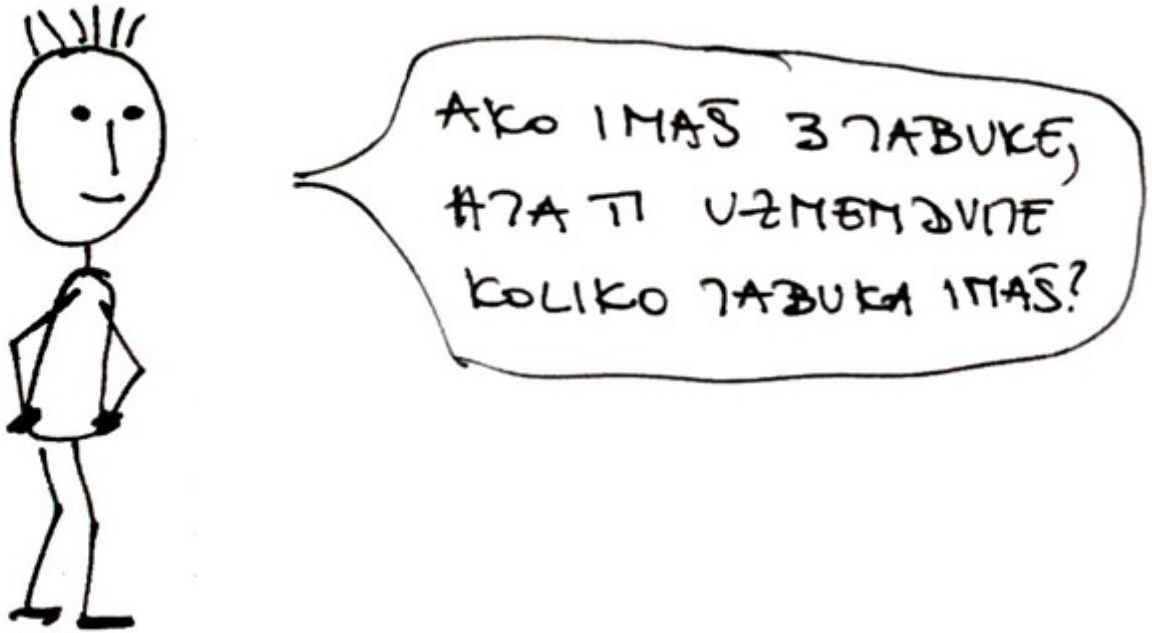


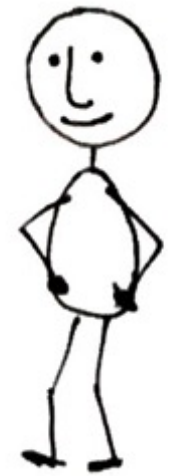
DOBRO, A JESU LI
SADA TO SVI
BROJEVI KOJE
TREBAMO?


AKO IMAŠ 3 JABUKE,
A JA TI DAM DVIJE
KOLIKO JABUKA IMAŠ?


AKO IMAŠ 3 JABUKE,
A JA TI DAM DVIJE
KOLIKO JABUKA IMAŠ?

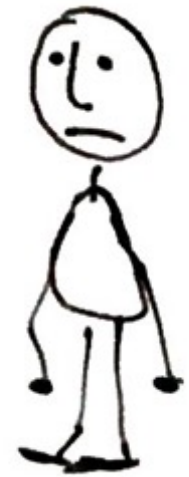

5

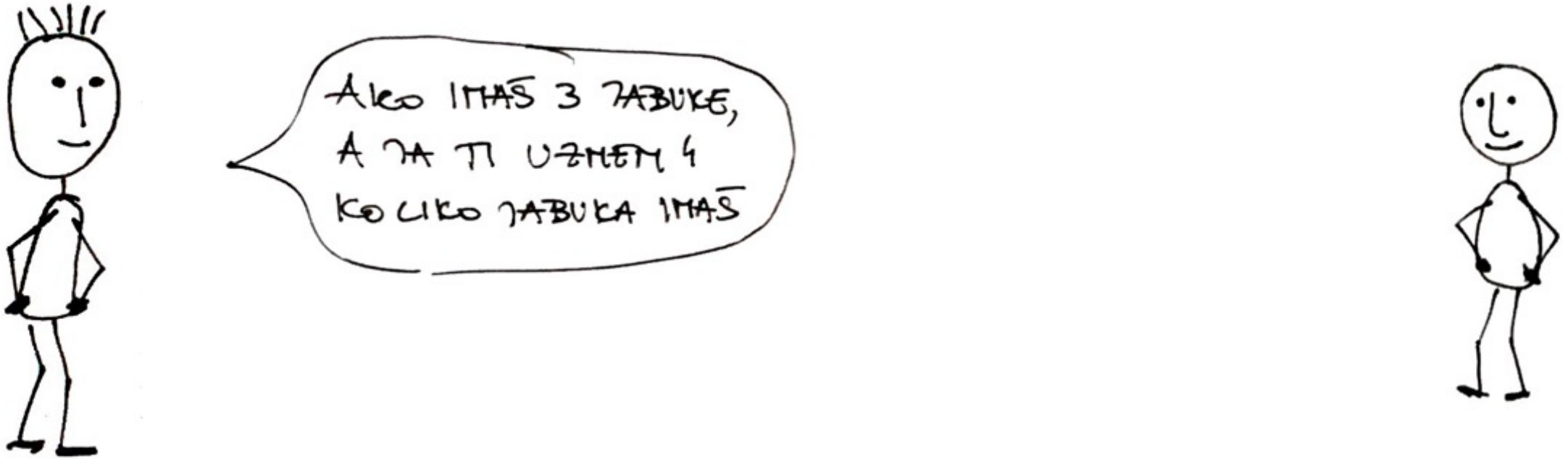

AKO IMAŠ 3 JABUKE,
A JA TI UZMEM DVIJE
KOLIKO JABUKA IMAŠ?



AKO IMAŠ 3 JABUKE, A JA TI UZMEM DVIJE KOLIKO JABUKA IMAŠ?

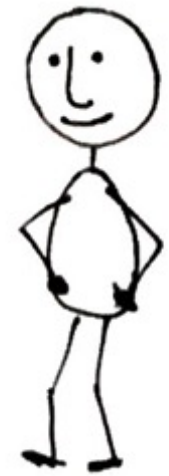
SAMO JEDNU, A ZA PITU TREBAM DVIJE... SMRC

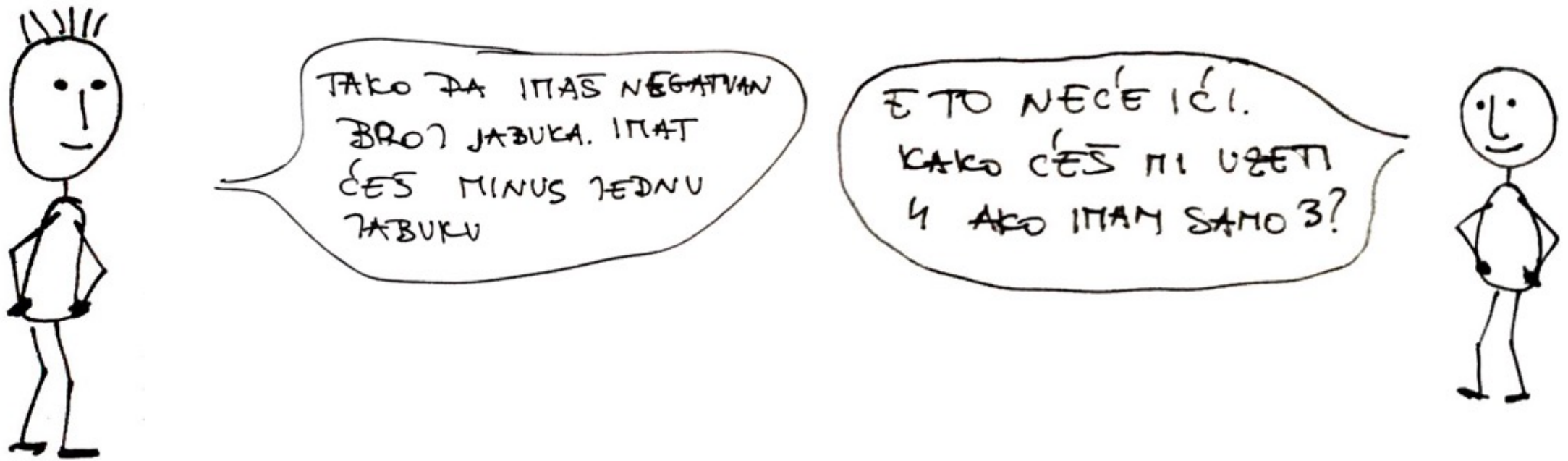



AKO IMAŠ 3 JABUKE,
A JA TI UZMEM 4
KOLIKO JABUKA IMAŠ

AKO IMAŠ 3 JABUKE, A JA TI UZMEM 4 KOLIKO JABUKA IMAŠ

E TO NEĆE IĆI. KAKO ĆEŠ MI UZETI 4 AKO IMAM SAMO 3?




TAKO DA IMAŠ NEGATIVAN BROJ JABUKA. IMAT ĆEŠ MINUS JEDNU JABUKU
E TO NEĆE IĆI. KAKO ĆEŠ MI UZETI 4 AKO IMAM SAMO 3?

TAKO DA IMAŠ NEGATIVAN BROJ JABUKA. IMAT ĆEŠ MINUS JEDNU JABUKU

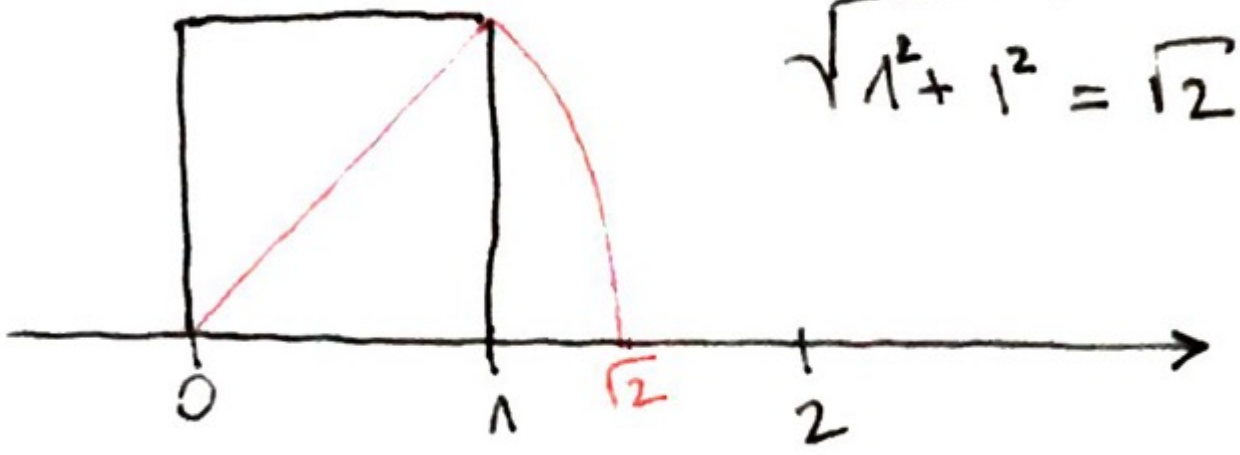
ŠTO JE TO NEGATIVAN BROJ? KAKO JABUKA MOŽE BITI NEGATIVNA?

MOŽE MOŽE. TO JE ANTIJABUKA. ŠTO NISI ČUO ZA ANTIMATERIJU

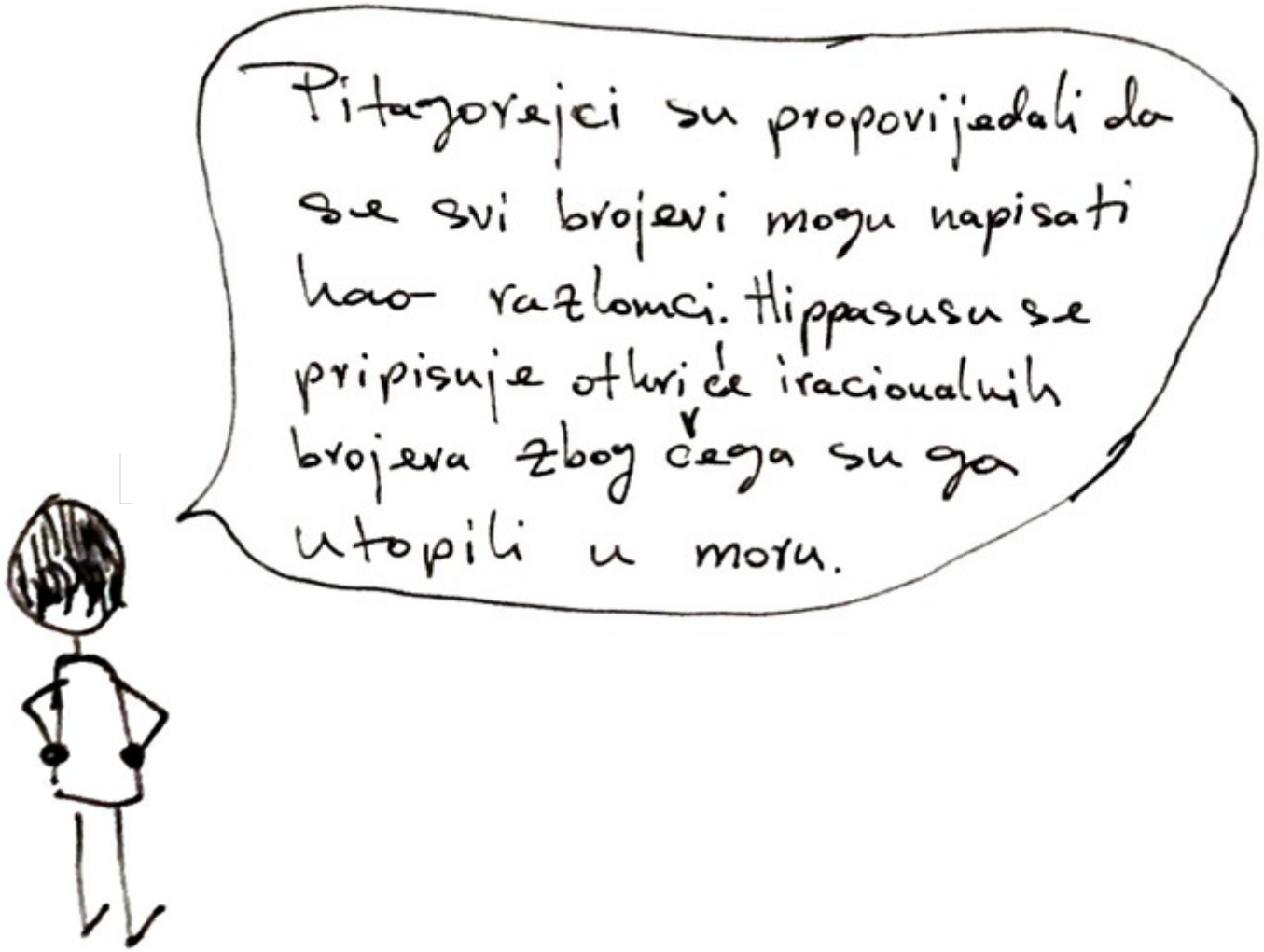
ŠTO JE TO NEGATIVAN BROJ? KAKO JABUKA MOŽE BITI NEGATIVNA?


NEGATIVNI BROJEVI
SU ODLIČNI ZA
BILJEŽENJE DUGOVA.
AKO MI JE DUŽAN 300 $
PISEM -300 $

DOBRO, A JESU LI
SADA TO SVI
BROJEVI KOJE
TREBAMO?

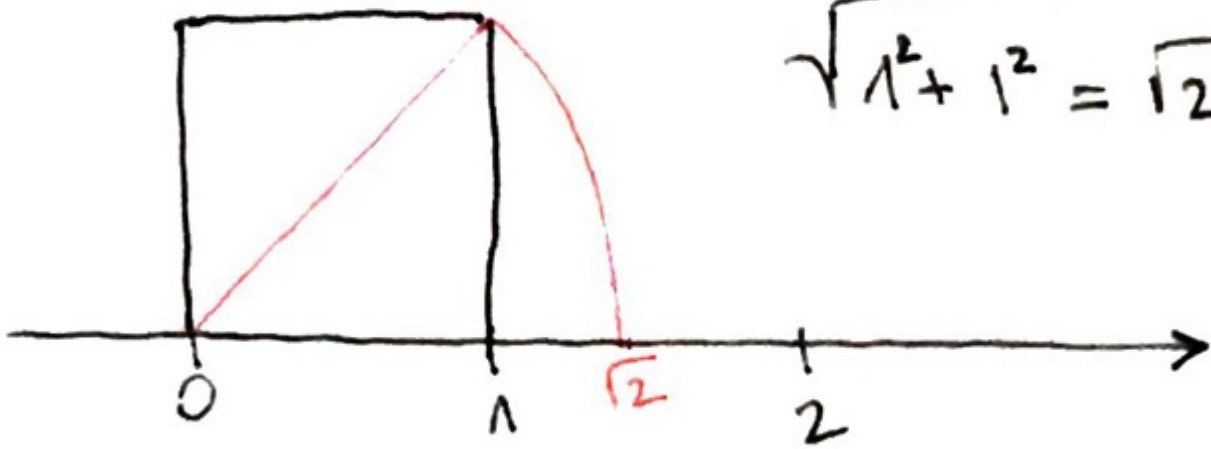


$$\sqrt{1^2 + 1^2} = \sqrt{2}$$



HIPPASUS

530 – 450. BC



$$\sqrt{1^2+1^2} = \sqrt{2}$$

Babilonci su dali aproksimaciju 1 24 51 10 u brojevnom sustavu s bazom 60

$$1 + \frac{24}{60} + \frac{51}{60^2} + \frac{10}{60^3} = 1.41421296$$

SADA MOŽEMO BEZ PROBLEMA

- ZBRAJATI
- ODUZIMATI
- MNOŽITI
- DIJELITI
- VADITI KORIJEN
- KVADRIRATI

⋮

JEDNADŽBA	RJEŠENJE	SKUP
$x-5=0$		
$x+2=0$		
$2x-1=0$		
$x^2-5=0$		
$x^2+1=0$		

JEDNADŽBA	RJEŠENJE	SKUP
$x-5=0$	$x=5$	$\mathbb{N}$
$x+2=0$		
$2x-1=0$		
$x^2-5=0$		
$x^2+1=0$		

JEDNADŽBA	RJEŠENJE	SKUP
$x-5=0$	$x=5$	$\mathbb{N}$
$x+2=0$	$x=-2$	$\mathbb{Z}$
$2x-1=0$		
$x^2-5=0$		
$x^2+1=0$		

JEDNADŽBA	RJEŠENJE	SKUP
$x-5=0$	$x=5$	$\mathbb{N}$
$x+2=0$	$x=-2$	$\mathbb{Z}$
$2x-1=0$	$x=\frac{1}{2}$	$\mathbb{Q}$
$x^2-5=0$		
$x^2+1=0$		

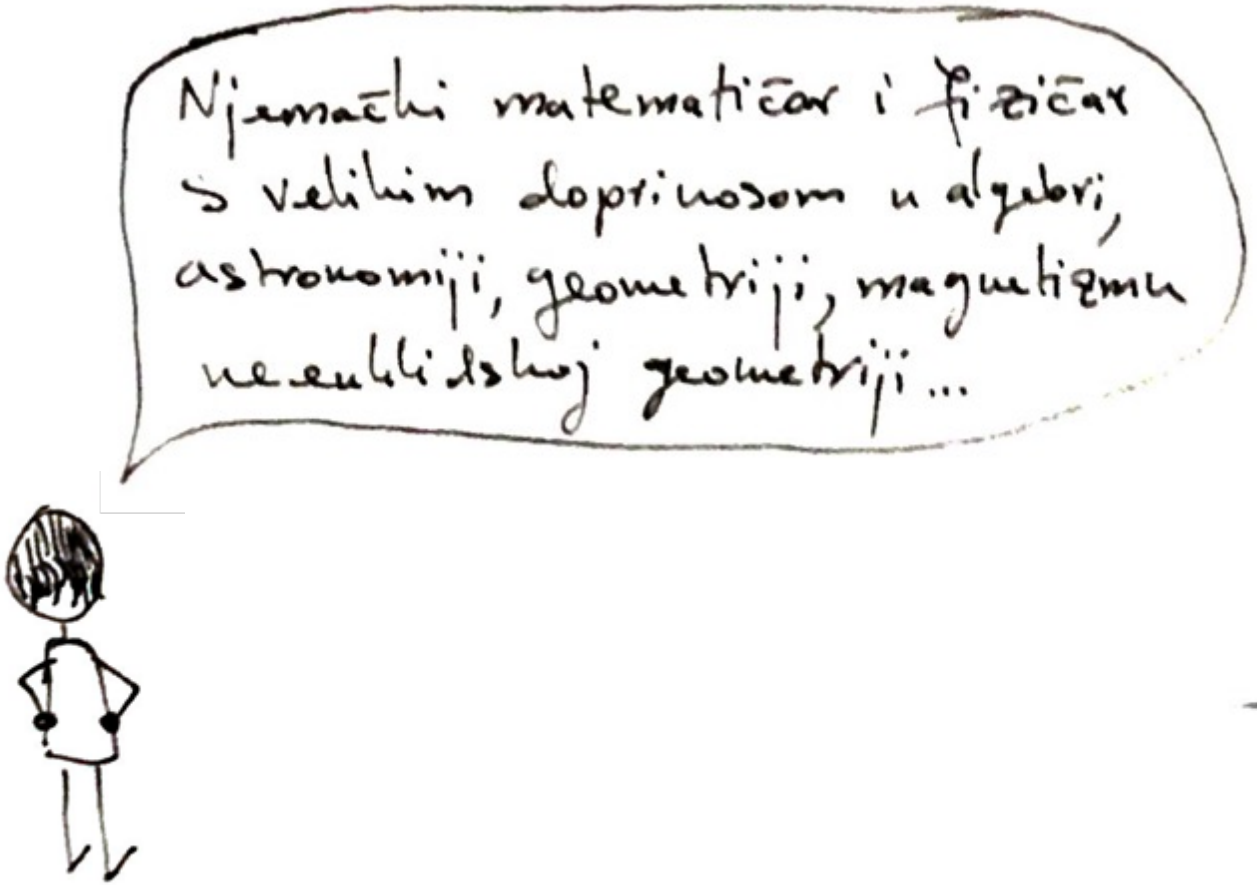
JEDNADŽBA	RJEŠENJE	SKUP
$x-5=0$	$x=5$	$\mathbb{N}$
$x+2=0$	$x=-2$	$\mathbb{Z}$
$2x-1=0$	$x=\frac{1}{2}$	$\mathbb{Q}$
$x^2-5=0$	$x=\pm\sqrt{5}$	$\mathbb{R}$
$x^2+1=0$		

KAKO RIJEŠITI $x^2+1=0$?

KAKO RIJEŠITI $x^2+1=0$?

ŠTO JE $\sqrt{-1}$?

TREBA LI NAM $\sqrt{-1}$?



JOHANN CARL FRIEDRICH GAUSS

30.4. 1777. – 23.2. 1855.

C. F. GAUSS : OSNOVNI TEOREM ALGEBRE

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0 = 0$$

IMA n NULTOČAKA

JOHANN CARL FRIEDRICH GAUSS

30. 4. 1777. – 23. 2. 1855.

C. F. GAUSS : OSNOVNI TEOREM ALGEBRE

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0 = 0$$

IMA n NULTOČAKA

$2x + 4 = 0 \qquad 2x = -4 \qquad x = -2$

JOHANN CARL FRIEDRICH GAUSS

30. 4. 1777. – 23. 2. 1855.

C. F. GAUSS : OSNOVNI TEOREM ALGEBRE

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0 = 0$$

IMA n NULTOČAKA

$2x + 4 = 0 \qquad 2x = -4 \qquad x = -2$

$x^2 - 9 = 0 \qquad x^2 = 9 \qquad x_1 = 3 \;,\; x_2 = -3$

JOHANN CARL FRIEDRICH GAUSS

30. 4. 1777. – 23. 2. 1855.

C. F. GAUSS : OSNOVNI TEOREM ALGEBRE

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0 = 0$$

IMA n NULTOČAKA

$$x^2 + 1 = 0$$

JOHANN CARL FRIEDRICH GAUSS

30. 4. 1777. – 23. 2. 1855.

C. F. GAUSS : OSNOVNI TEOREM ALGEBRE

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0 = 0$$

IMA n NULTOČAKA

$$x^2 + 1 = 0 \Rightarrow x^2 = -1$$

JOHANN CARL FRIEDRICH GAUSS

30. 4. 1777. – 23. 2. 1855.

C. F. GAUSS : OSNOVNI TEOREM ALGEBRE

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0 = 0$$

IMA n NULTOČAKA

$$x^2 + 1 = 0 \Rightarrow x^2 = -1$$

$$x_1 = \sqrt{-1}, \quad x_2 = -\sqrt{-1}$$

JOHANN CARL FRIEDRICH GAUSS

30. 4. 1777. – 23. 2. 1855.

ZBOG LAKŠEG PISANJA $\sqrt{-1} = i$ (imaginarni)

ZBOG LAKŠEG PISANJA $\sqrt{-1} = i$ (imaginarni)

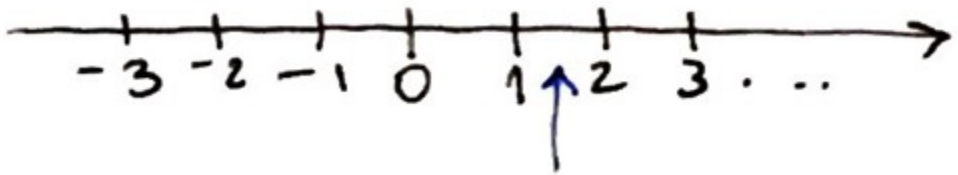
3 – REALAN BROJ

$2i$ – IMAGINARAN BROJ

$3 + 2i$ ← KOMPLEKSAN BROJ

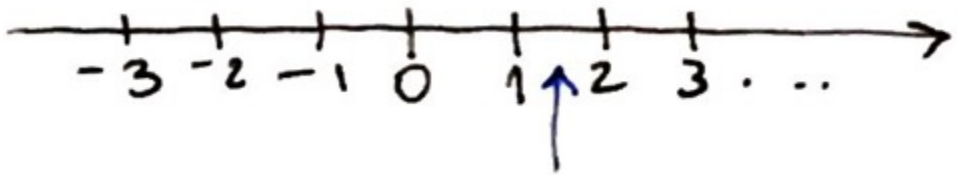
↑ REALAN

↖ IMAGINARAN



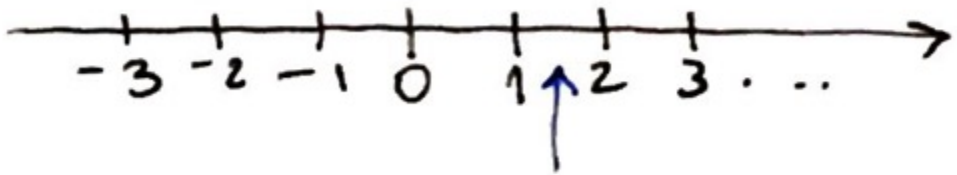
SVI BROJEVI KOJE SMO SPOMENULI ISPUNJAVAJU BROJEVNI PRAVAC. NEMA VIŠE RUPA.

GDJE STAVITI $\sqrt{-1}$?



U JEDNOJ DIMENZIJI
NEMA VIŠE PROSTORA.

SVI BROJEVI KOJE SMO
SPOMENULI ISPUNJAVAJU
BROJEVNI PRAVAC.
NEMA VIŠE RUPA.

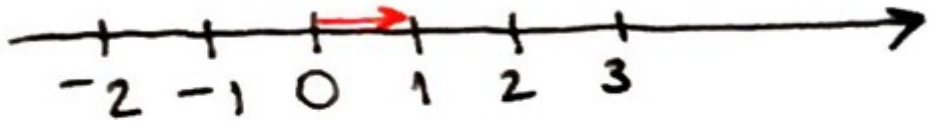


SVI BROJEVI KOJE SMO SPOMENULI ISPUNJAVAJU BROJEVNI PRAVAC. NEMA VIŠE RUPA.

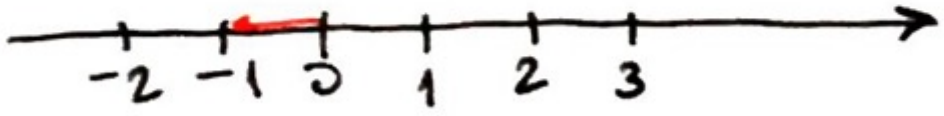
GDJE STAVITI $\sqrt{-1}$?

U JEDNOJ DIMENZIJI NEMA VIŠE PROSTORA.

TREBAMO JOŠ PROSTORA, JOŠ SLOBODE :-)

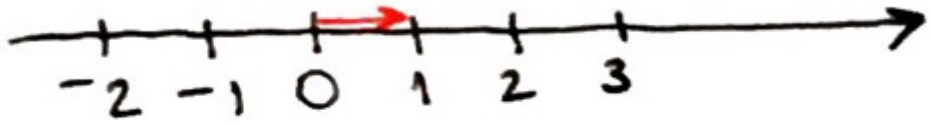


$$1 \cdot 2 = 2$$

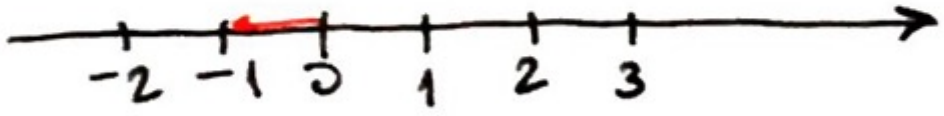


$$(-1) \cdot 2 = -2$$

$$(-1) \cdot (-2) = 2$$



$1 \cdot 2 = 2$



$(-1) \cdot 2 = -2$

$(-1) \cdot (-2) = 2$

VEKTOR JE PROMIJENIO KUT

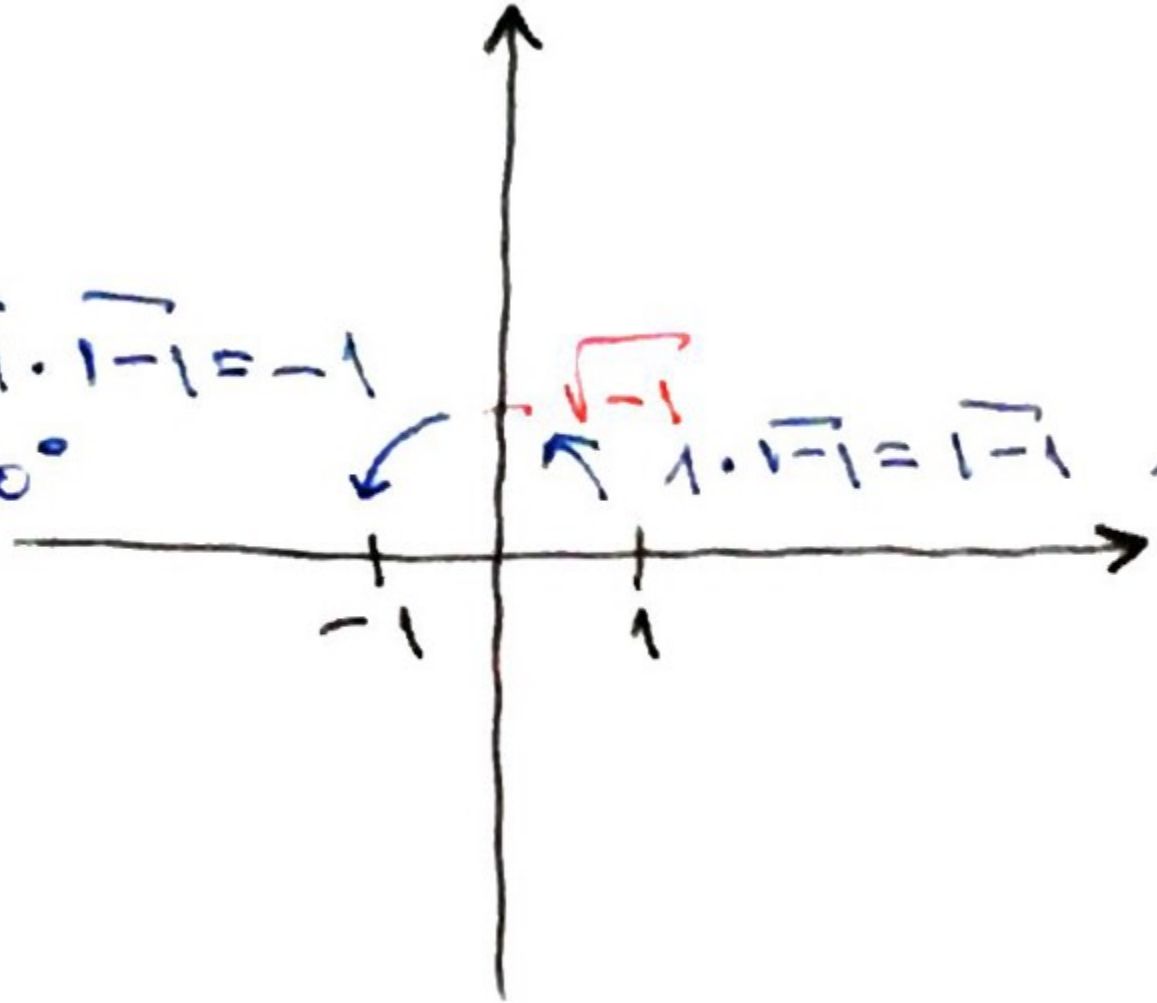
-1 je pod kutem od $180°$, ali

$(-1)^2$ je pod kutem od $0°$

$(\sqrt{-1})^2 = -1$ je pod kutem od $180°$

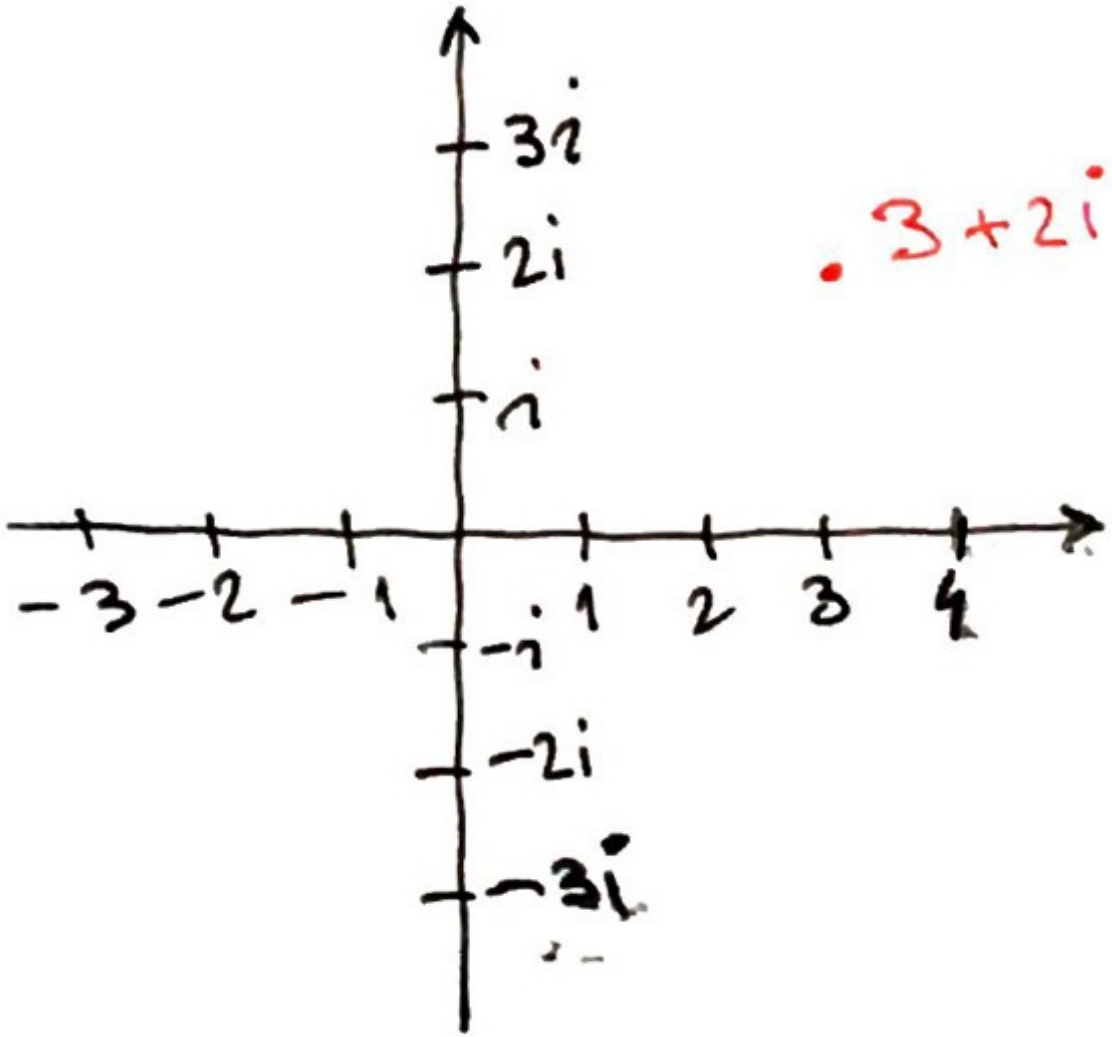
$\sqrt{-1} \cdot \sqrt{-1} = -1$

180°



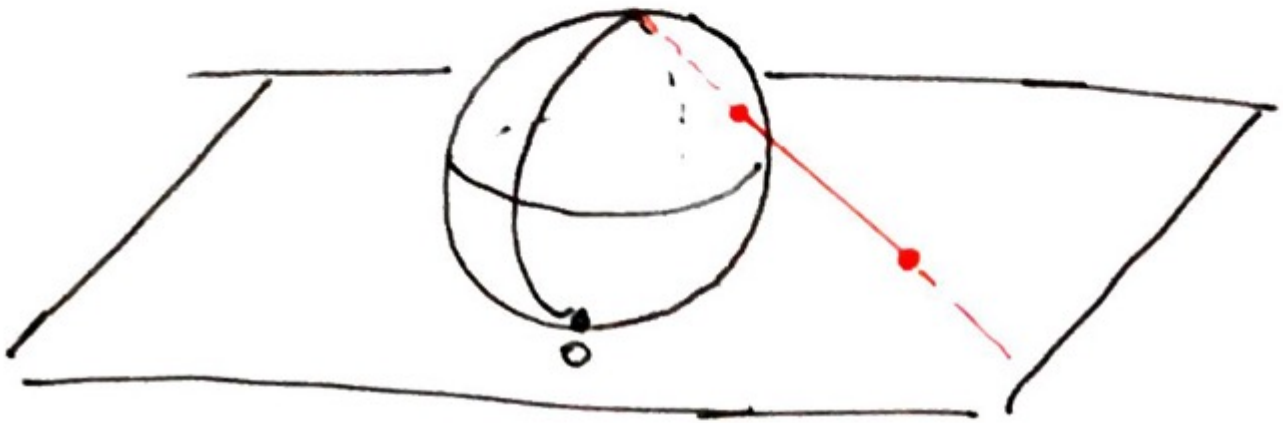
$1 \cdot \sqrt{-1} = \sqrt{-1}$ i bent od 90°

KOMPLEKSNA RAVNINA $\mathbb{C}$

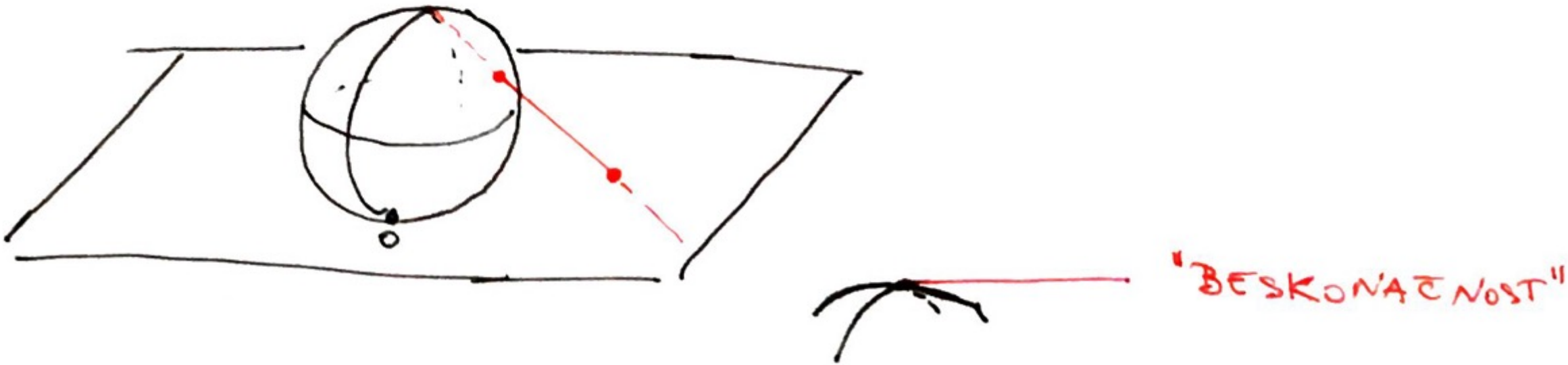


KOJEG JE OBLIKA KOMPLEKSNA RAVNINA?

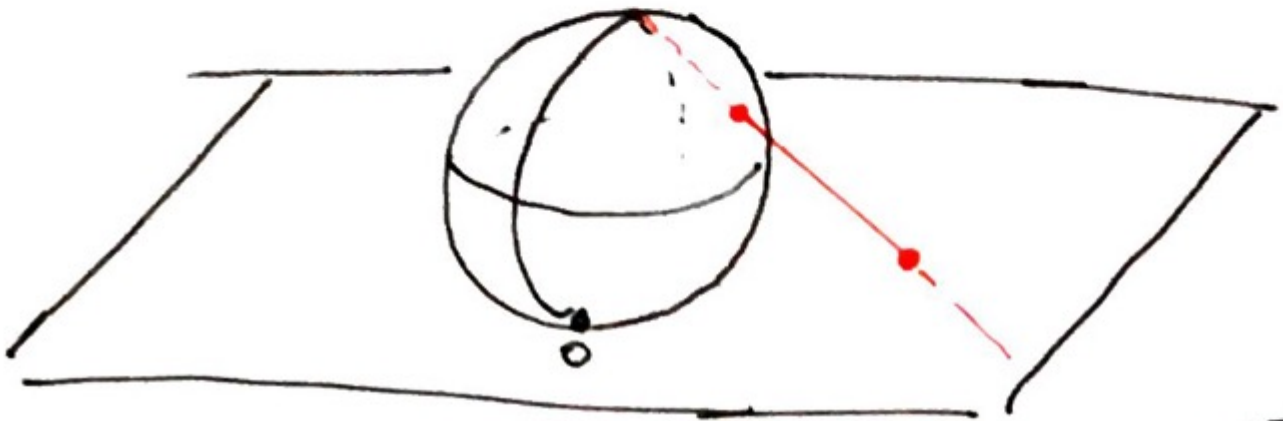
KOJEG JE OBLIKA KOMPLEKSNA RAVNINA?



KOJEG JE OBLIKA KOMPLEKSNA RAVNINA?



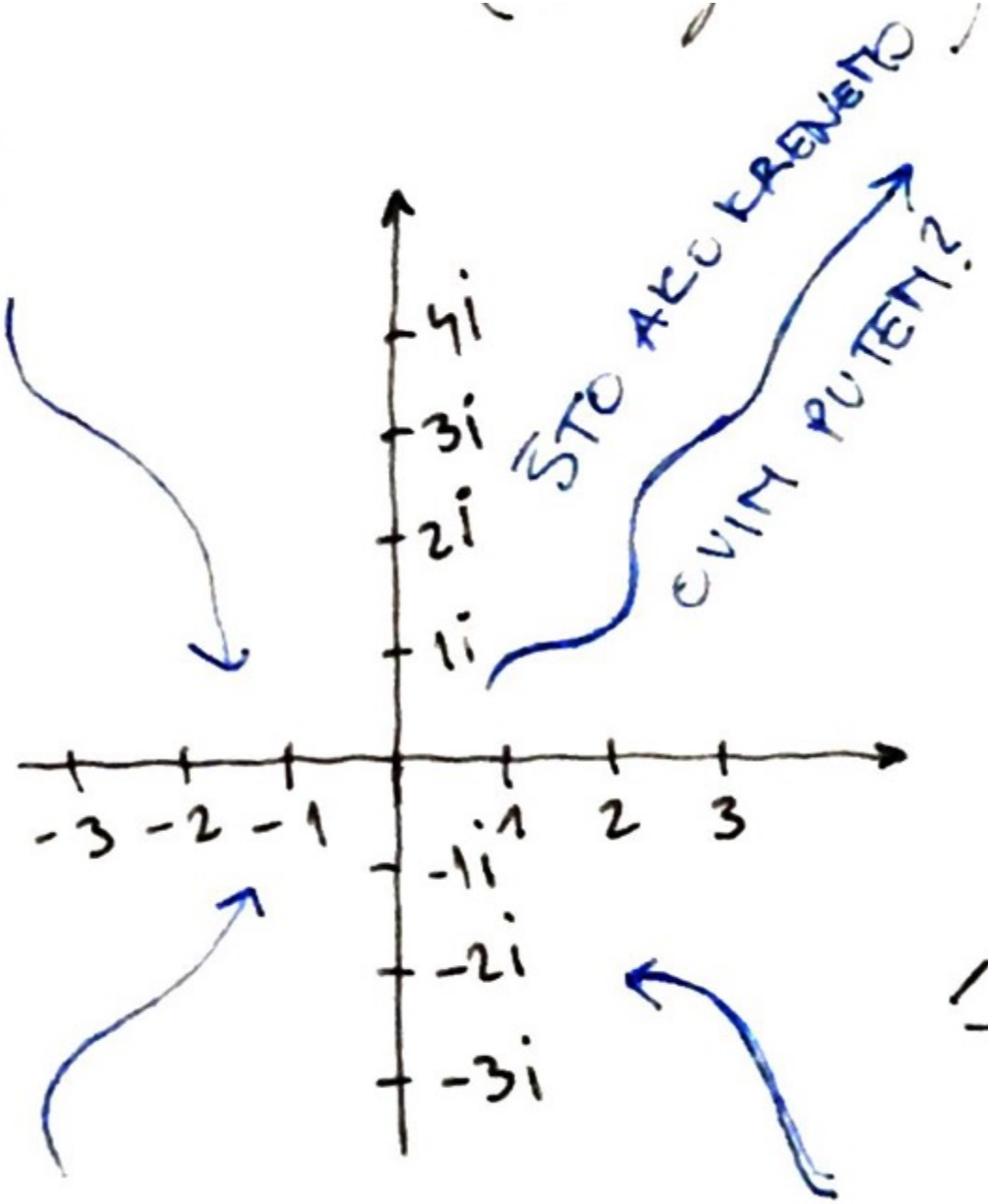
KOJEG JE OBLIKA KOMPLEKSNA RAVNINA?

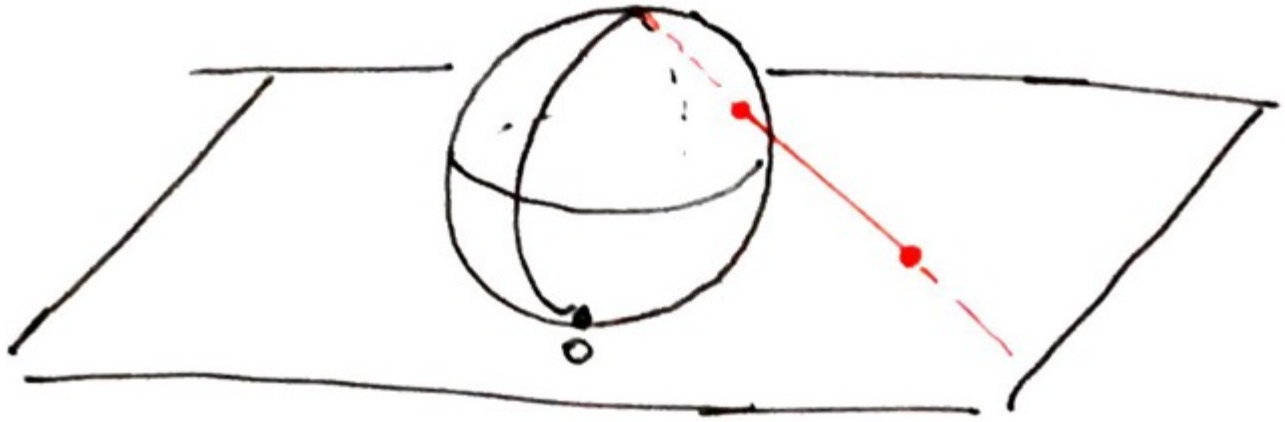


"BESKONAČNOST"

KOMPLEKSNA RAVNINA JE LOPTA :-)

$\mathbb{C}$





$$1 + 1 + 1 + 1 + \dots + 1 + 1 + \dots =$$

$$1 + 1 + 1 + 1 + \dots + 1 + 1 + \dots = +\infty$$

$$1 + 1 + 1 + 1 + \dots + 1 + 1 + \dots = +\infty$$

$$1 + 2 + 3 + 4 + 5 + \dots + n + (n+1) + (n+2) + \dots =$$

$$1 + 1 + 1 + 1 + \dots + 1 + 1 + \dots = +\infty$$

$$1 + 2 + 3 + 4 + 5 + \dots + n + (n+1) + (n+2) + \dots = -\frac{1}{12}$$

$$1 + 1 + 1 + 1 + \dots + 1 + 1 + \dots = +\infty$$

$$1 + 2 + 3 + 4 + 5 + \dots + n + (n+1) + (n+2) + \dots = -\frac{1}{12}$$

$$1 + 2 + 4 + 8 + 16 + \dots + 2^n + 2^{n+1} + \dots =$$

$$1 + 1 + 1 + 1 + \dots + 1 + 1 + \dots = +\infty$$

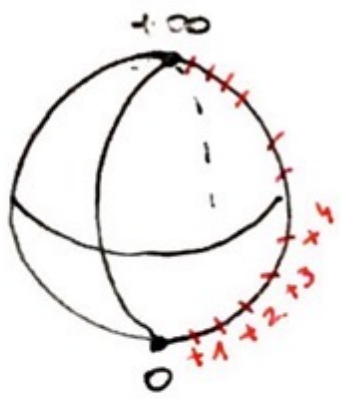
$$1 + 2 + 3 + 4 + 5 + \dots + n + (n+1) + (n+2) + \dots = -\frac{1}{12}$$

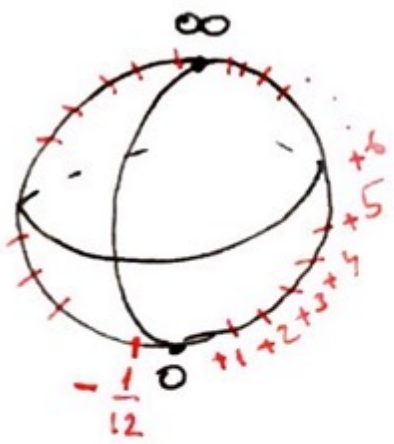
$$1 + 2 + 4 + 8 + 16 + \dots + 2^n + 2^{n+1} + \dots = -1$$

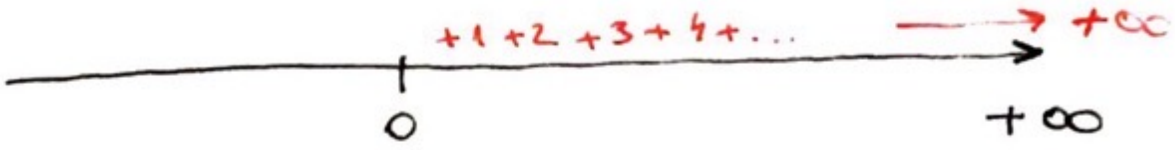
$$1+1+1+1+\dots+1+1+\dots = +\infty$$

$$1+2+3+4+5+\dots+n+(n+1)+(n+2)+\dots = -\frac{1}{12}$$

$$1+2+4+8+16+\dots+2^n+2^{n+1}+\dots = -1$$



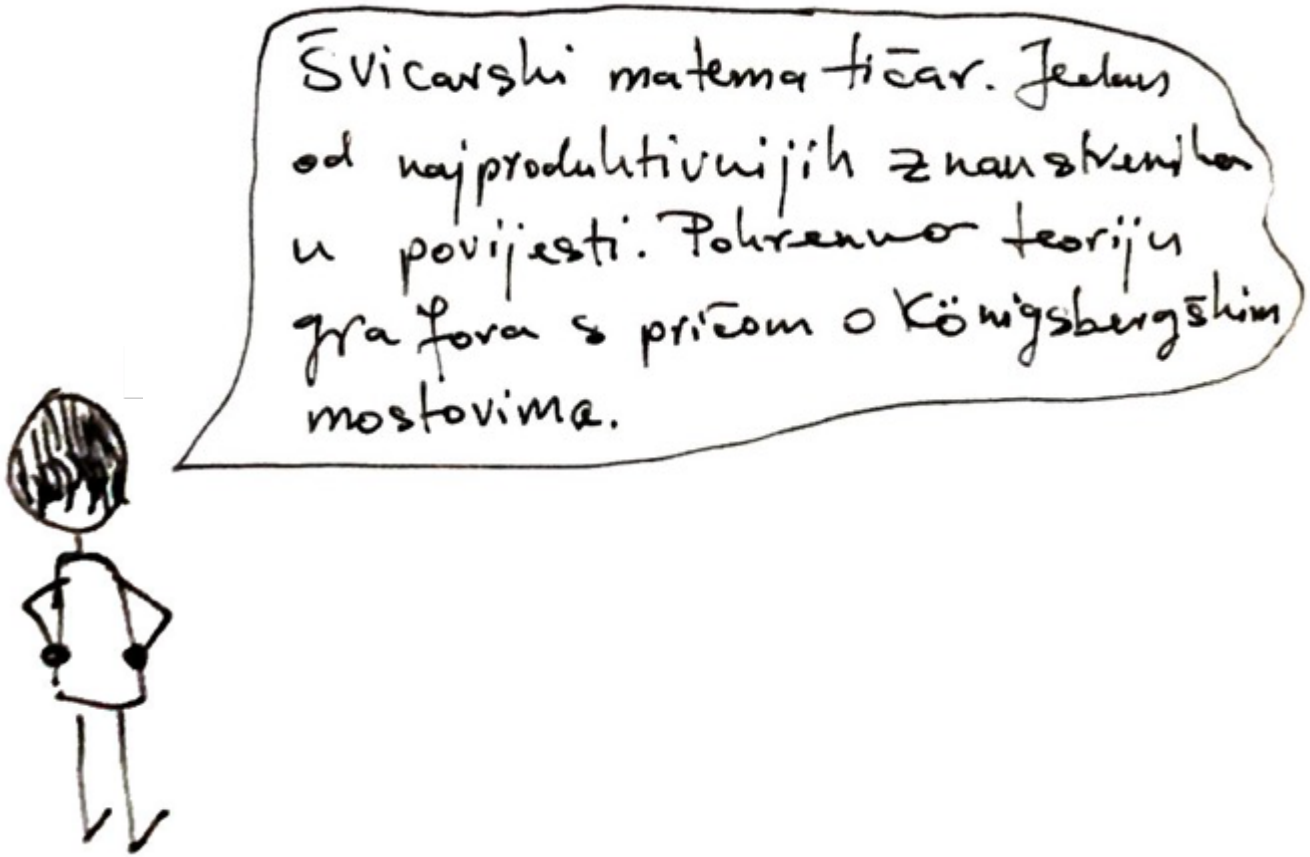




KAKO MNOŽITI KOMPLEKSNE BROJEVE?

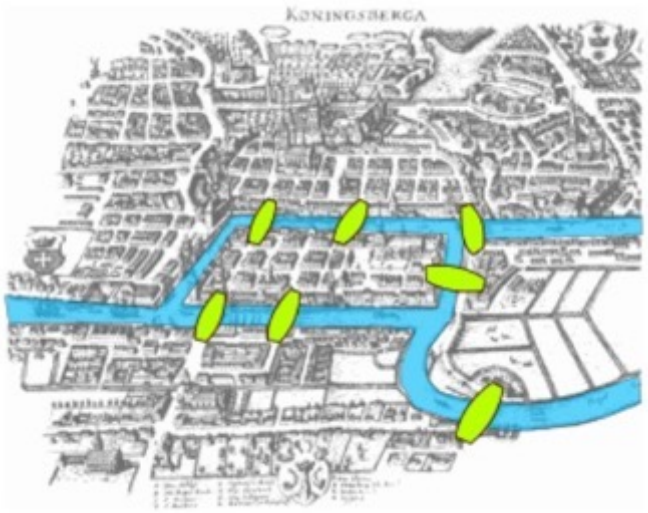
KAKO MNOŽITI KOMPLEKSNE BROJEVE?

$$(2+i)\cdot(4+2i) = 2\cdot 4 + 2\cdot 2i + i\cdot 4 + i\cdot 2i$$
$$= 8 + 4i + 4i + 2i^2 = 8 + 8i - 2$$
$$= 6 + 8i$$

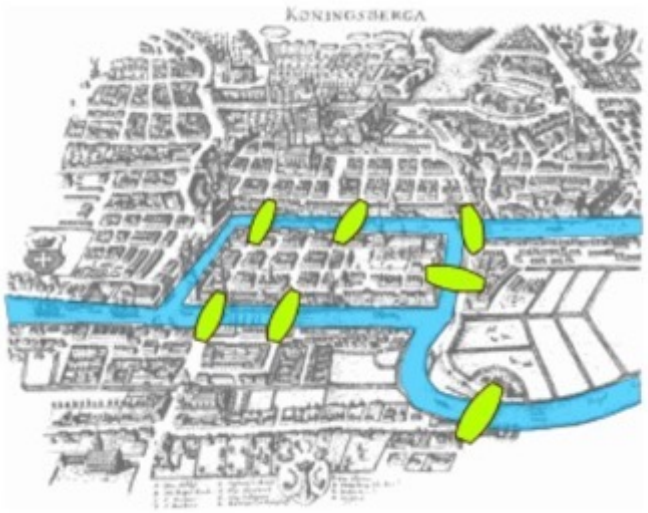


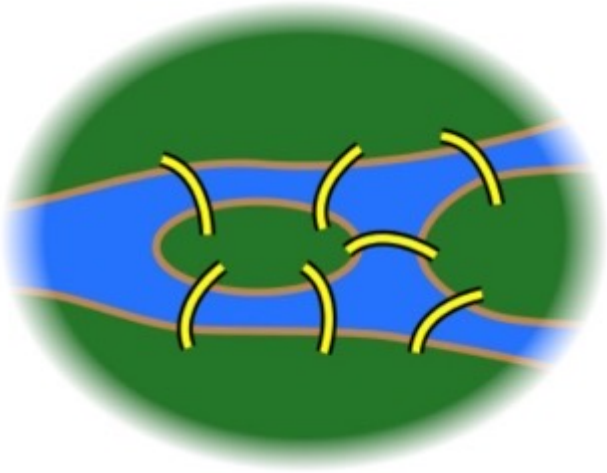
LEONHARD EULER
15.4.1707. – 18.9.1783.

SEVEN BRIDGES OF KÖNIGSBERG

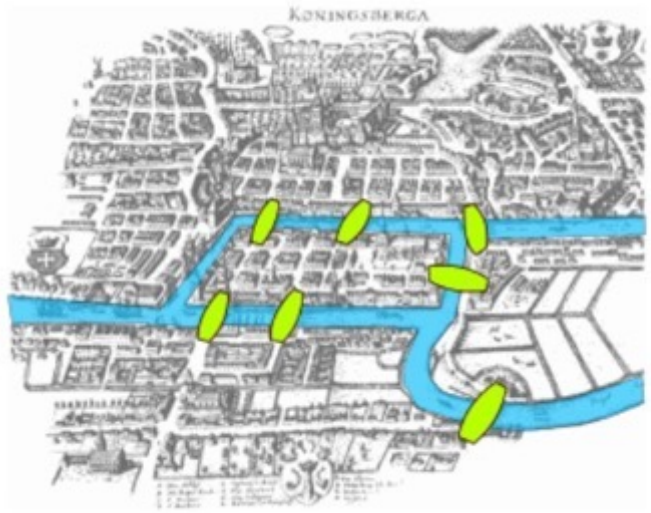


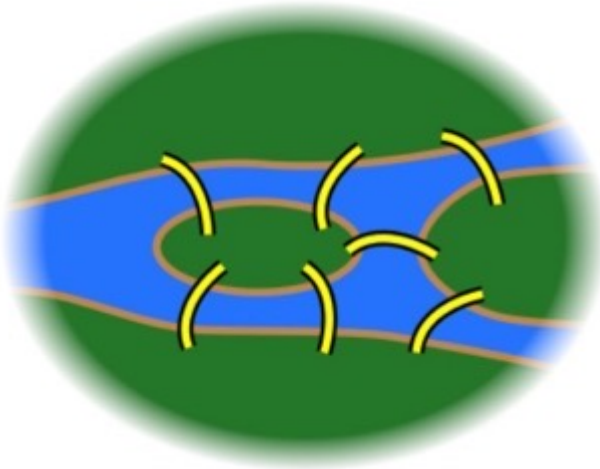
SEVEN BRIDGES OF KÖNIGSBERG

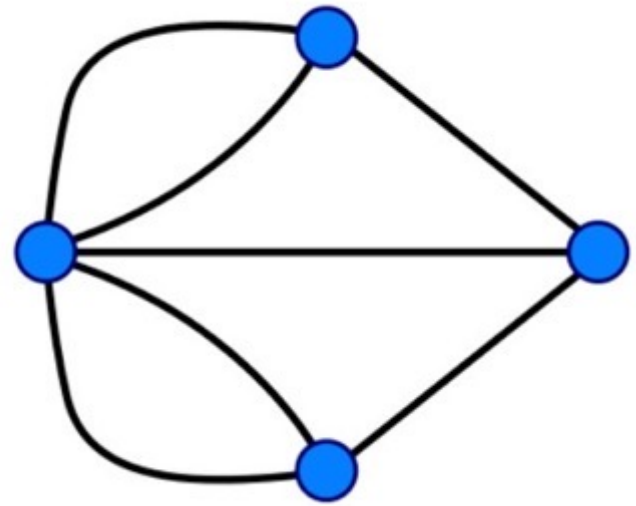


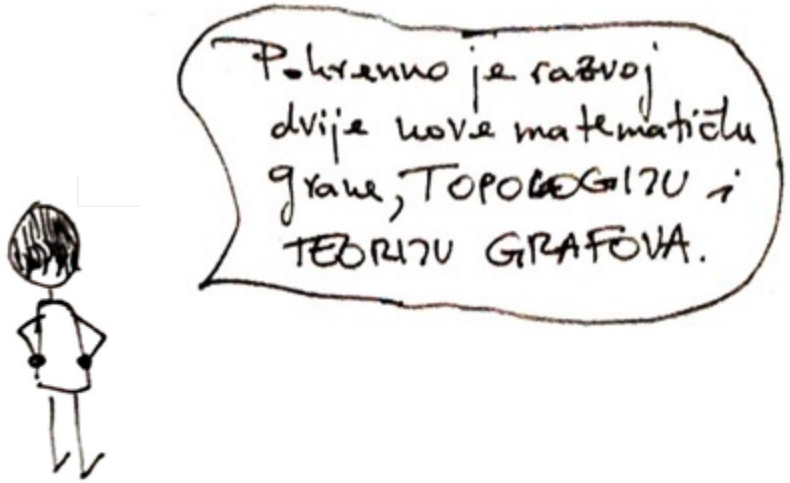


SEVEN BRIDGES OF KÖNIGSBERG









EULEROVA FORMULA

$$e^{ix} = \cos(x) + i \sin(x)$$

LEONHARD EULER
15.4.1707. – 18.9.1783.

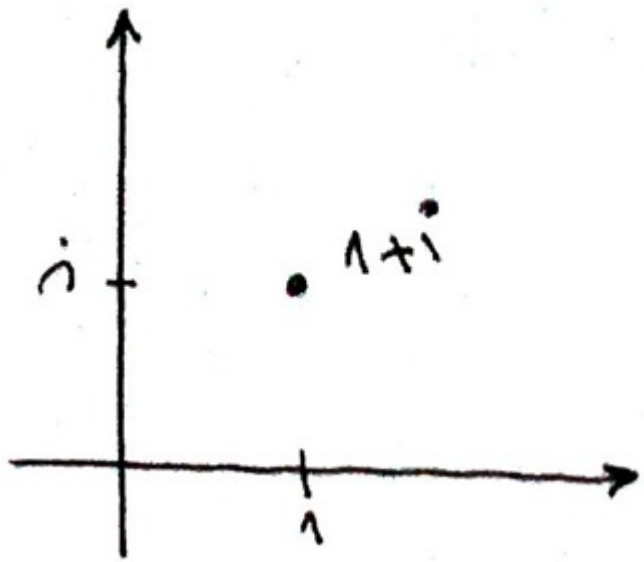
EULEROVA FORMULA

$$e^{ix} = \cos(x) + i \sin(x)$$

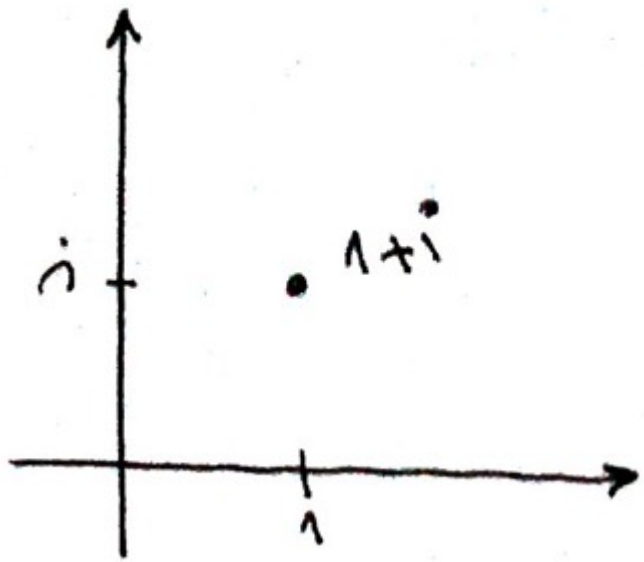
$$e^{i\pi} + 1 = 0$$

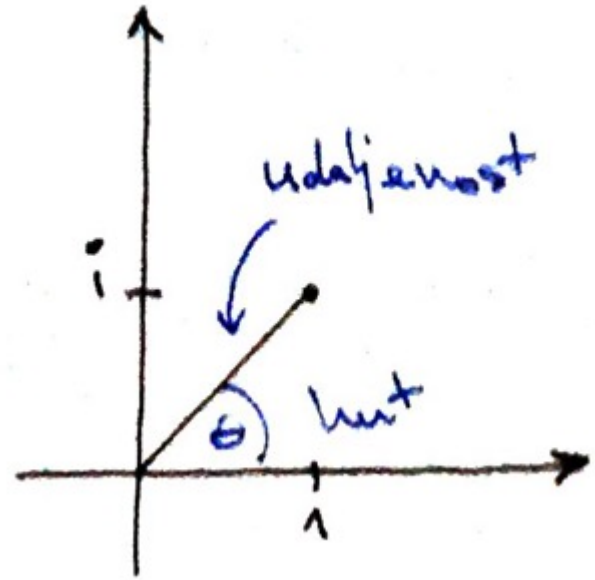
LEONHARD EULER
15.4.1707. – 18.9.1783.

KAKO MNOŽITI KOMPLEKSNE BROJEVE?

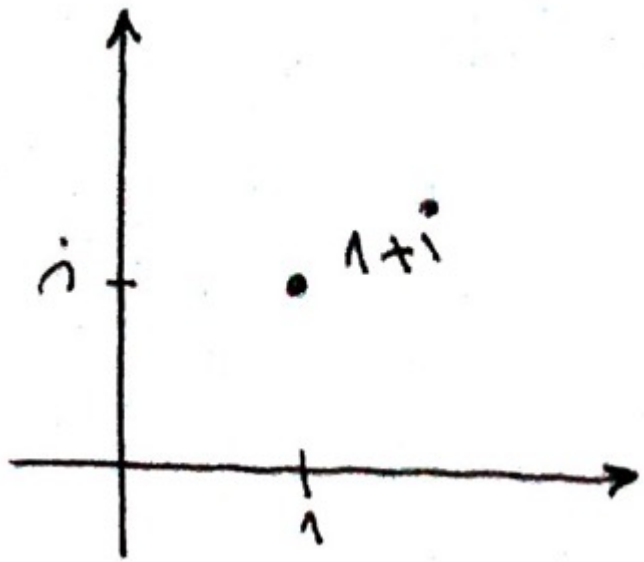


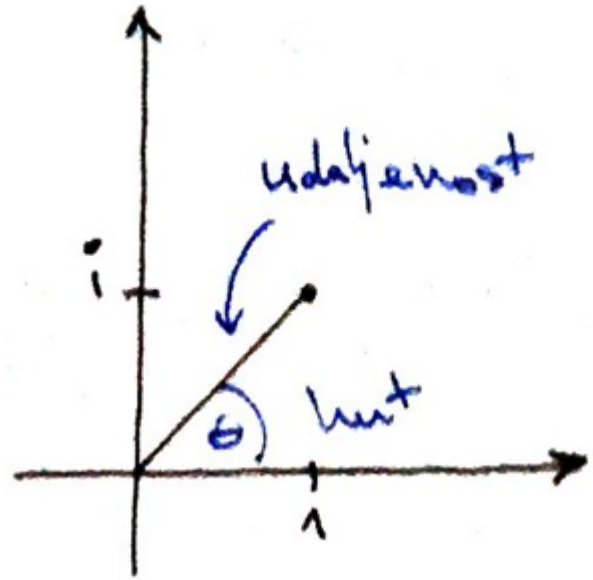
KAKO MNOŽITI KOMPLEKSNE BROJEVE?





KAKO MNOŽITI KOMPLEKSNE BROJEVE?





UDALJENOST $= \sqrt{1^2+1^2} = \sqrt{2}$

KUT $= 45^\circ$

$$1+i = \sqrt{2}\,\angle 45^\circ$$

$$1+i = \sqrt{2}\, e^{i\frac{\pi}{4}}$$

KAKO MNOŽITI KOMPLEKSNE BROJEVE?

$$(1+i)\cdot i = i + i\cdot i = i + i^2 = -1 + i$$

KAKO MNOŽITI KOMPLEKSNE BROJEVE?

$$(1+i)\cdot i = i + i\cdot i = i + i^2 = -1 + i$$

$$1+i = \sqrt{2}\, e^{i\frac{\pi}{4}}$$

$$i = 1\, e^{i\frac{\pi}{2}}$$

KAKO MNOŽITI KOMPLEKSNE BROJEVE?

$$(1+i)\cdot i = i + i\cdot i = i + i^2 = -1+i$$

$$1+i = \sqrt{2}\, e^{i\frac{\pi}{4}}$$

$$i = 1\, e^{i\frac{\pi}{2}}$$

$$(1+i)\cdot i = \sqrt{2}\, e^{i\frac{\pi}{4}} \cdot 1\, e^{i\frac{\pi}{2}}$$

$$= \sqrt{2}\cdot 1 \cdot e^{i\left(\frac{\pi}{4}+\frac{\pi}{2}\right)}$$

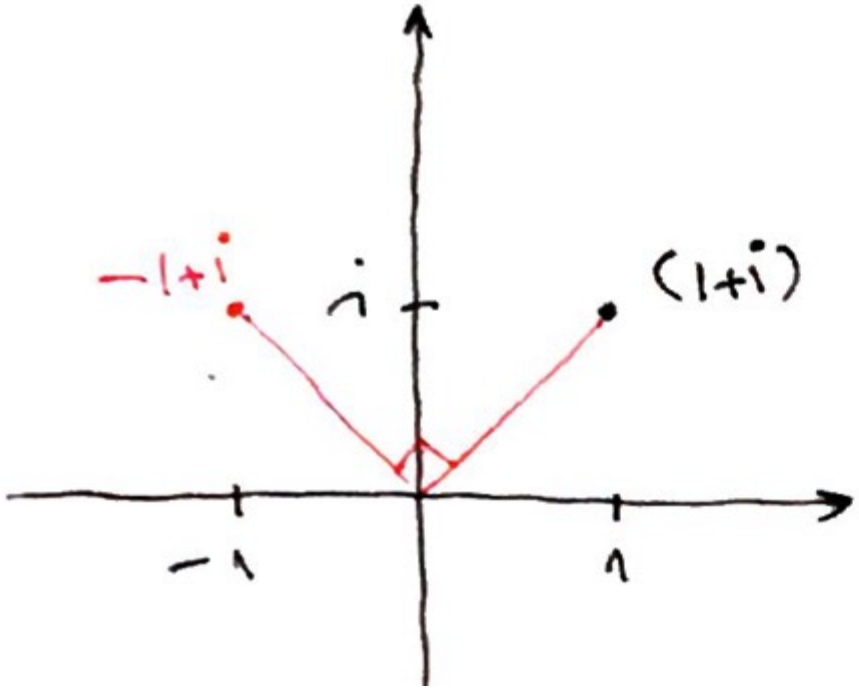
$$= \sqrt{2}\, e^{i\frac{3\pi}{4}}$$

$$= \sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$$

$$= \sqrt{2}\cdot\left(-\frac{\sqrt{2}}{2} + i\,\frac{\sqrt{2}}{2}\right) = -1+i$$

KAKO MNOŽITI KOMPLEKSNE BROJEVE?

$$(1+i)\cdot i = i + i\cdot i = i + i^2 = -1 + i$$



MNOŽENJE S i ROTIRA BROJ $1+i$ ZA $90°$

$$x^3 = 1$$

$$x^3 = 1$$

$$x \cdot x \cdot x = 1$$

$$x^3 = 1$$

$$x \cdot x \cdot x = 1$$

$$1\angle^* \cdot 1\angle^* \cdot 1\angle^* = 1\angle 0 \quad \text{ili } 1\angle 360^\circ$$

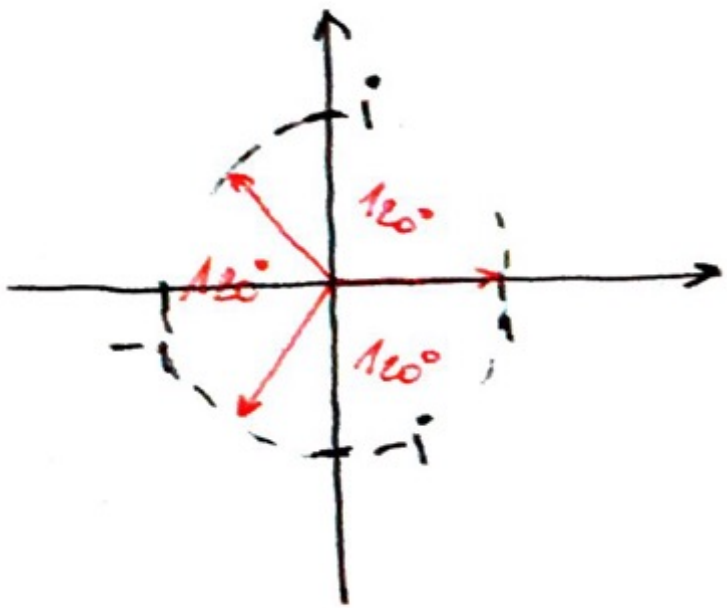
$$\angle^* + \angle^* + \angle^* = 360 \Rightarrow \angle^* = \angle 120^\circ$$

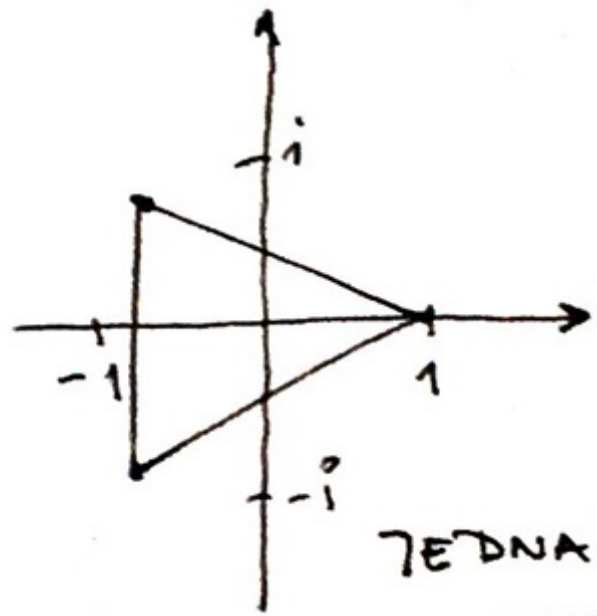
$$x^3 = 1$$

$$x \cdot x \cdot x = 1$$

$$1\angle^* \cdot 1\angle^* \cdot 1\angle^* = 1\angle 0 \quad \text{ili } 1\angle 360^\circ$$

$$\angle^* + \angle^* + \angle^* = 360 \Rightarrow \angle^* = \angle 120^\circ$$





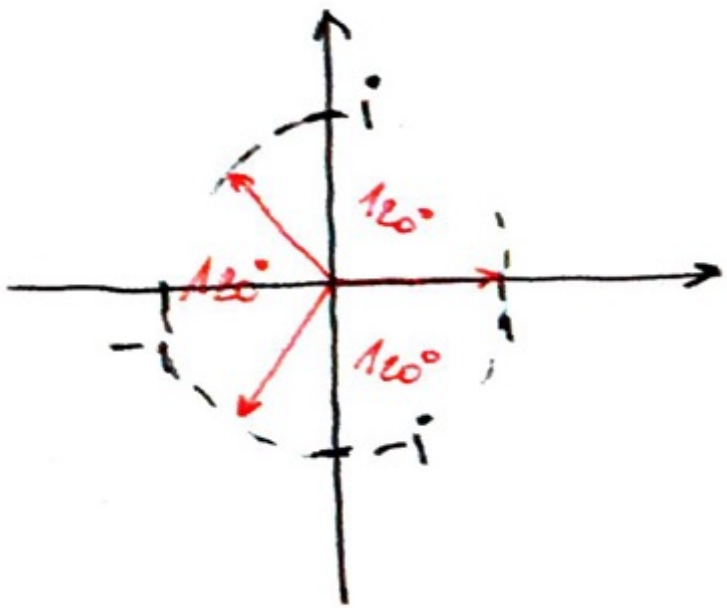
JEDNAKOSTRANIČAN TROKUT

$x^3 = 1$

$x \cdot x \cdot x = 1$

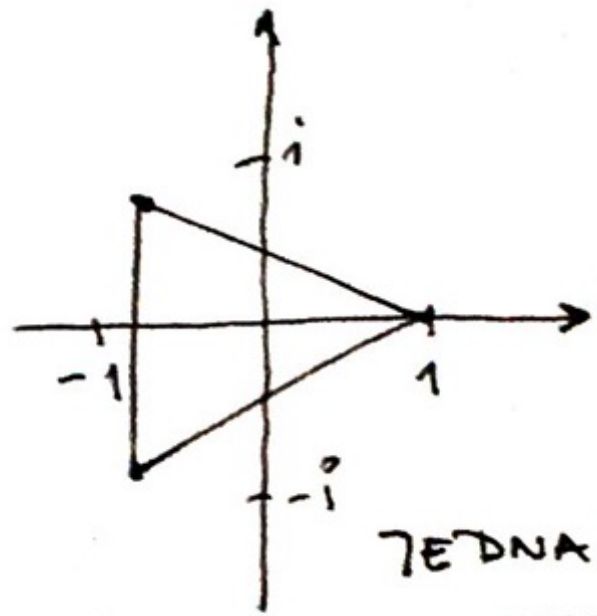
$1\angle^* \cdot 1\angle^* \cdot 1\angle^* = 1\angle 0$ ili $1\angle 360$

$\angle^* + \angle^* + \angle^* = 360 \Rightarrow \angle^* = \angle 120°$



$x^7 = 1$ DAJE JEDNAKOSTRANIČAN SEDMEROKUT

$x^n = 1$ DAJE PRAVILNI n-TEROKUT



JEDNAKOSTRANIČAN TROKUT

BRZA FOURIEROVA TRANSFORMACIJA (FFT)

Složenost proračuna pada s $O(N^2)$ na $O(N \log N)$

BRZA FOURIEROVA TRANSFORMACIJA (FFT)

Složenost proračuna pada s $\mathcal{O}(N^2)$ na $\mathcal{O}(N \log N)$

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i\frac{2\pi k n}{N}}$$

kompleksni korijen iz jedinice

BRZA FOURIEROVA TRANSFORMACIJA (FFT)

Složenost proračuna pada s $O(N^2)$ na $O(N \log N)$

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i\frac{2\pi k n}{N}}$$

kompleksni korijen iz jedinice

TOP 10 ALGORITAMA

BRZA FOURIEROVA TRANSFORMACIJA (FFT)

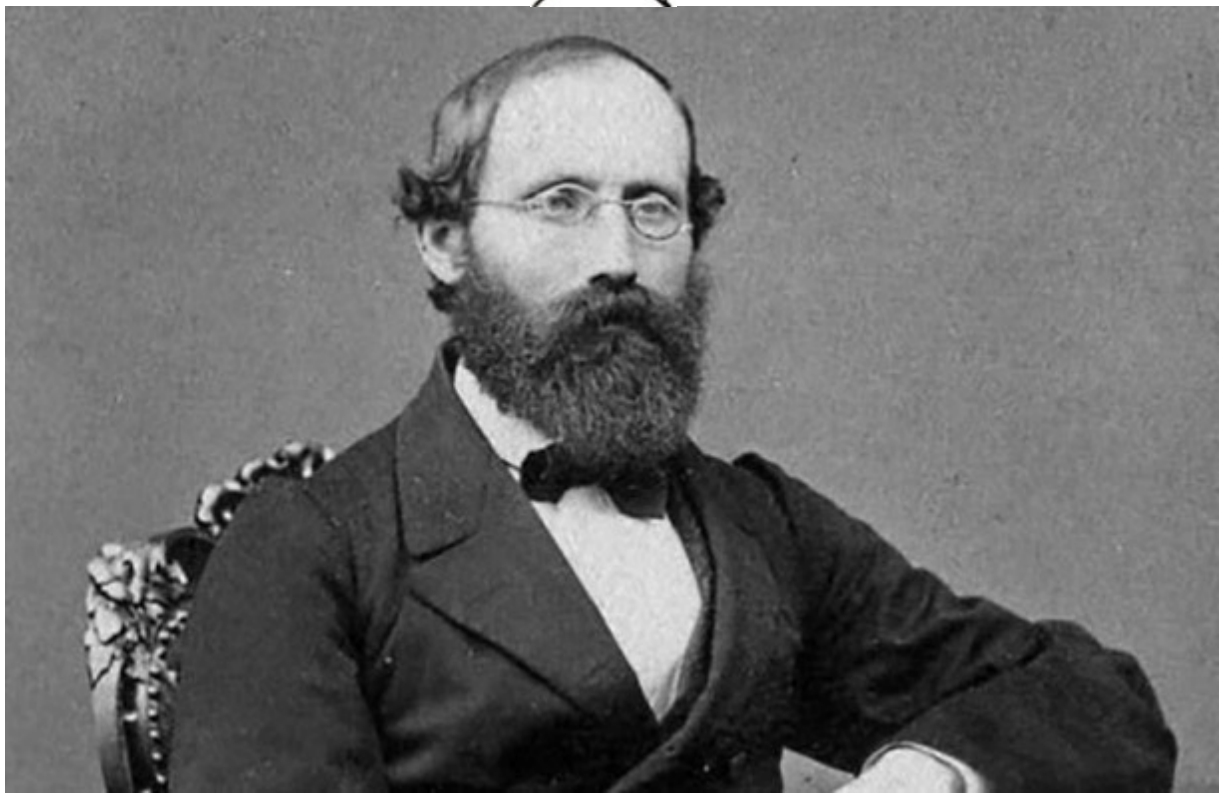
Složenost proračuna pada s $O(N^2)$ na $O(N \log N)$

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i\frac{2\pi k n}{N}}$$

kompleksni korijen iz jedinice

TOP 10 ALGORITAMA

An algorithm is a sequence of finite computational steps that transforms an input into an output.



BERNHARD RIEMANN

17.9.1826. – 20.7.1866.

Njemački matematičar s ogromnim doprinosom u analizi, teoriji brojeva, kompleksnoj analizi i diferencijalnoj geometriji. Postavio temelje opće teorije relativnosti. Najpoznatiji je po RIEMANNOVOJ HIPOTEZI

RIEMANNOVA ZETA FUNKCIJA

$$\zeta(z) = \sum_{n=1}^{\infty} \frac{1}{n^z} = \frac{1}{1^z} + \frac{1}{2^z} + \frac{1}{3^z} + \dots$$

RIEMANNOVA ZETA FUNKCIJA

$$\zeta(z) = \sum_{n=1}^{\infty} \frac{1}{n^z} = \frac{1}{1^z} + \frac{1}{2^z} + \frac{1}{3^z} + \dots$$

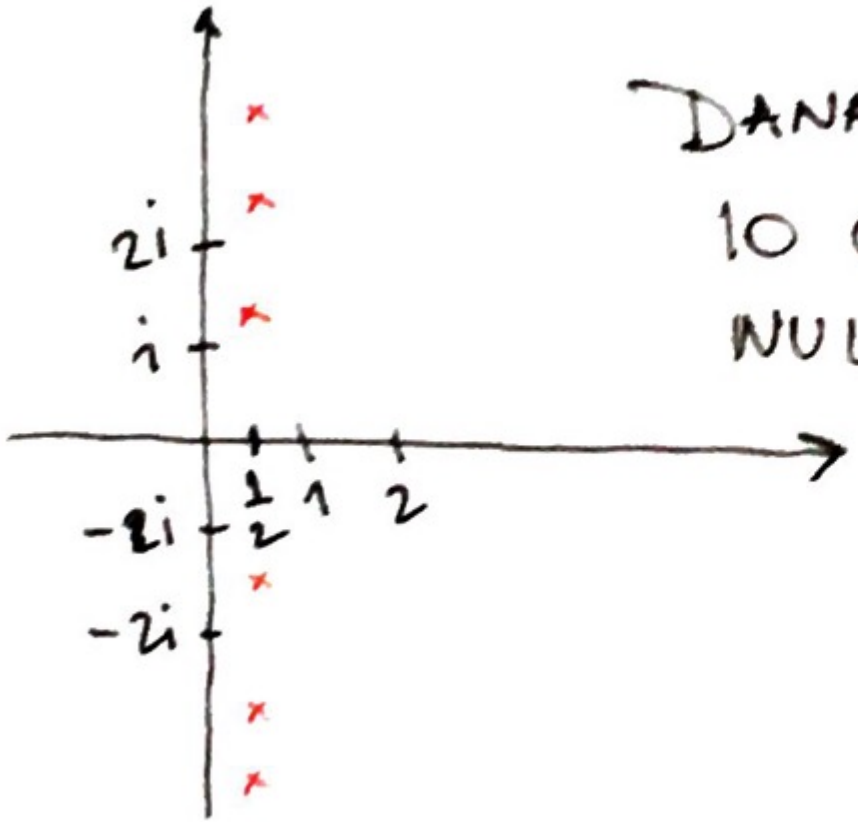
RIEMANNOVA ZETA FUNKCIJA

$$\zeta(z) = \sum_{n=1}^{\infty} \frac{1}{n^z} = \frac{1}{1^z} + \frac{1}{2^z} + \frac{1}{3^z} + \dots$$

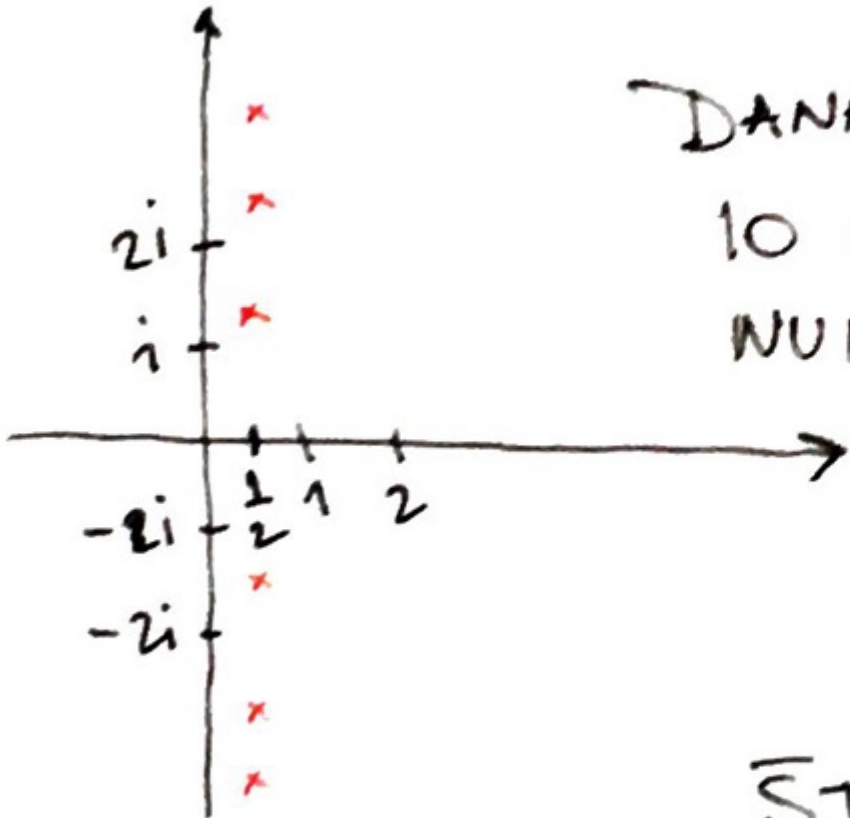
MILENIJSKI PROBLEM

RIEMANNOVA HIPOTEZA

Sve netrivijalne nultočke Riemannove zeta funkcije imaju realni dio jednak $\frac{1}{2}$.



DANAS ZNAMO PRVIH
10 000 000 000 000
NULTOČAKA I SVE
IMAJU REALNI
DIO JEDNAK $\frac{1}{2}$



DANAS ZNAMO PRVIH
10 000 000 000 000
NULTOČAKA I SVE
IMAJU REALNI
DIO JEDNAK $\frac{1}{2}$

ŠTO JE 10 000 000 000 000
NAPRAMA BESKONAČNOSTI?

David Hilbert je jedan od najvećih matematičara u povijesti. Radio na razvoju varijacijskog računa, algebre, algebarske teorije brojeva, geometrije, teorije operatora, fizike i temelja matematike. Radio s Einsteinom na općoj relativnosti

DAVID HILBERT

23.1.1862. – 14.2.1943

HILBERT: 23 NAJBITNIJA PROBLEMA
KOJA TREBA RIJEŠITI U 20. STOLJEĆU

DAVID HILBERT
23.1.1862. – 14.2.1943

HILBERT: 23 NAJBITNIJA PROBLEMA KOJA TREBA RIJEŠITI U 20. STOLJEĆU

Problem	Brief explanation	Status	Year Solved
1st	The continuum hypothesis (that is, there is no set whose cardinality is strictly between that of the integers and that of the real numbers)	Proven to be impossible to prove or disprove within Zermelo–Fraenkel set theory with or without the Axiom of Choice (provided Zermelo–Fraenkel set theory is consistent, i.e., it does not contain a contradiction). There is no consensus on whether this is a solution to the problem.	1940, 1963
2nd	Prove that the axioms of arithmetic are consistent.	There is no consensus on whether results of Gödel and Gentzen give a solution to the problem as stated by Hilbert. Gödel's second incompleteness theorem, proved in 1931, shows that no proof of its consistency can be carried out within arithmetic itself. Gentzen proved in 1936 that the consistency of arithmetic follows from the well-foundedness of the ordinal ε_0.	1931, 1936
3rd	Given any two polyhedra of equal volume, is it always possible to cut the first into finitely many polyhedral pieces that can be reassembled to yield the second?	Resolved. Result: No, proved using Dehn invariants.	1900
4th	Construct all metrics where lines are geodesics.	Too vague to be stated resolved or not.[6]	–
5th	Are continuous groups automatically differential groups?	Resolved by Andrew Gleason, depending on how the original statement is interpreted. If, however, it is understood as an equivalent of the Hilbert–Smith conjecture, it is still unsolved.	1953?
6th	Mathematical treatment of the axioms of physics (a) axiomatic treatment of probability with limit theorems for foundation of statistical physics (b) the rigorous theory of limiting processes "which lead from the atomistic view to the laws of motion of continua"	Partially resolved depending on how the original statement is interpreted.[8] Items (a) and (b) were two specific problems given by Hilbert in a later explanation.[9] Kolmogorov's axiomatics (1933) is now accepted as standard. There is some success on the way from the "atomistic view to the laws of motion of continua."[10]	1933–2002?
7th	Is a^b transcendental, for algebraic $a \neq 0,1$ and irrational algebraic b ?	Resolved. Result: Yes, illustrated by Gelfond's theorem or the Gelfond–Schneider theorem.	1934
8th	The Riemann hypothesis ("the real part of any non-trivial zero of the Riemann zeta function is ½") and other prime number problems, among them Goldbach's conjecture and the twin prime conjecture	Unresolved.	–
9th	Find the most general law of the reciprocity theorem in any algebraic number field.	Partially resolved.[11]	–
10th	Find an algorithm to determine whether a given polynomial Diophantine equation with integer coefficients has an integer solution.	Resolved. Result: Impossible; Matiyasevich's theorem implies that there is no such algorithm.	1970
11th	Solving quadratic forms with algebraic numerical coefficients.	Partially resolved.[11]	–
12th	Extend the Kronecker–Weber theorem on Abelian extensions of the rational numbers to any base number field.	Unresolved.	–
13th	Solve 7-th degree equation using algebraic (variant: continuous) functions of two parameters.	The problem was partially solved by Vladimir Arnold based on work by Andrei Kolmogorov.[3]	1957
14th	Is the ring of invariants of an algebraic group acting on a polynomial ring always finitely generated?	Resolved. Result: No, a counterexample was constructed by Masayoshi Nagata.	1959
15th	Rigorous foundation of Schubert's enumerative calculus.	Partially resolved.	–
16th	Describe relative positions of ovals originating from a real algebraic curve and as limit cycles of a polynomial vector field on the plane.	Unresolved, even for algebraic curves of degree 8.	–
17th	Express a nonnegative rational function as quotient of sums of squares.	Resolved. Result: Yes, due to Emil Artin. Moreover, an upper limit was established for the number of square terms necessary.	1927
18th	(a) Is there a polyhedron that admits only an anisohedral tiling in three dimensions? (b) What is the densest sphere packing?	(a) Resolved. Result: Yes (by Karl Reinhardt). (b) Widely believed to be resolved, by computer-assisted proof (by Thomas Callister Hales). Result: Highest density achieved by close packings, each with density approximately 74%, such as face-centered cubic close packing and hexagonal close packing.[4]	(a) 1928 (b) 1998
19th	Are the solutions of regular problems in the calculus of variations always necessarily analytic?	Resolved. Result: Yes, proven by Ennio de Giorgi and, independently and using different methods, by John Forbes Nash.	1957
20th	Do all variational problems with certain boundary conditions have solutions?	Resolved. A significant topic of research throughout the 20th century, culminating in solutions for the non-linear case.	?
21st	Proof of the existence of linear differential equations having a prescribed monodromic group	Partially resolved. Result: Yes/No/Open depending on more exact formulations of the problem.	?
22nd	Uniformization of analytic relations by means of automorphic functions	Unresolved.	?
23rd	Further development of the calculus of variations	Too vague to be stated resolved or not.	–

DAVID HILBERT

23.1.1862. – 14.2.1943

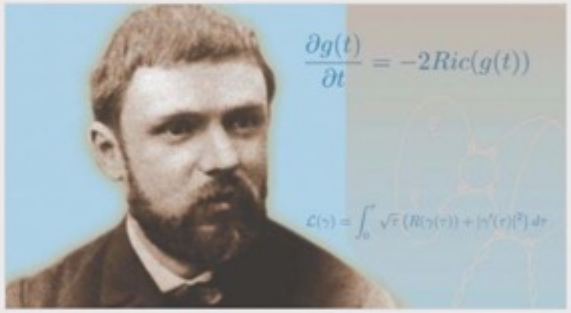
Clay Mathematics Institute

Dedicated to increasing and disseminating mathematical knowledge

ABOUT PROGRAMS MILLENNIUM PROBLEMS PEOPLE PUBLICATIONS EVENTS EUCLID

Call for Proposals

CMI invites proposals under the Enhancement and Partnership Program for fiscal year 2020-21 (1 October 2020-30 September 2021) and later. The principal aim of the program is to enhance activities that are already planned and financially viable. The next deadline for submissions is 1 September 2019.



Millennium Problems

Yang–Mills and Mass Gap

Experiment and computer simulations suggest the existence of a "mass gap" in the solution to the quantum versions of the Yang-Mills equations. But no proof of this property is known.

News

Royal Society Fellows

Congratulations to former Clay Research Fellows Manjul Bhargava (Princeton) and Akshay Venkatesh (IAS) and former Clay Senior Scholar Christopher Hacon (Utah) on their election as Fellows of the...

2019 Clay Research Fellows

The Clay Mathematics Institute is pleased to announce that Ewain Gwynne and Antoine Song have been awarded Clay Research Fellowships. Ewain Gwynne obtained his PhD in 2018 from the Massachusetts...

More news

Events

Quantum Field Theory and Manifold Invariants
Sunday, June 30, 2019

Thermodynamic Formalism: Applications to Probability, Geometry and Fractals
Monday, July 1, 2019

Aspects of Geometric Group Theory
Monday, July 8, 2019

PROMYS Europe
Sunday, July 14, 2019

2019 Clay Research Conference and Workshops
Sunday, September 29, 2019

More events

2000. 8 MILENIJSKIH PROBLEMA

– nagrada MILIJUN DOLARA

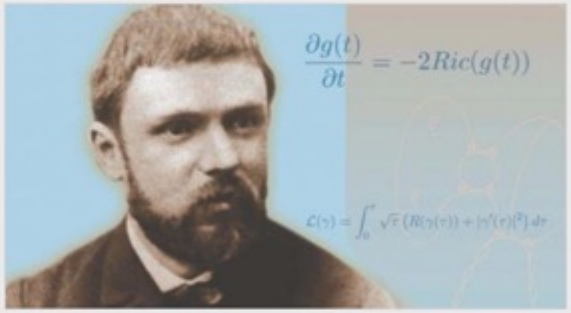
Clay Mathematics Institute

Dedicated to increasing and disseminating mathematical knowledge

ABOUT PROGRAMS MILLENNIUM PROBLEMS PEOPLE PUBLICATIONS EVENTS EUCLID

Call for Proposals

CMI invites proposals under the Enhancement and Partnership Program for fiscal year 2020-21 (1 October 2020-30 September 2021) and later. The principal aim of the program is to enhance activities that are already planned and financially viable. The next deadline for submissions is 1 September 2019.



Millennium Problems

Yang–Mills and Mass Gap

Experiment and computer simulations suggest the existence of a "mass gap" in the solution to the quantum versions of the Yang-Mills equations. But no proof of this property is known.

News

Royal Society Fellows

Congratulations to former Clay Research Fellows Manjul Bhargava (Princeton) and Akshay Venkatesh (IAS) and former Clay Senior Scholar Christopher Hacon (Utah) on their election as Fellows of the...

2019 Clay Research Fellows

The Clay Mathematics Institute is pleased to announce that Ewain Gwynne and Antoine Song have been awarded Clay Research Fellowships. Ewain Gwynne obtained his PhD in 2018 from the Massachusetts...

More news

Events

Quantum Field Theory and Manifold Invariants
Sunday, June 30, 2019

Thermodynamic Formalism: Applications to Probability, Geometry and Fractals
Monday, July 1, 2019

Aspects of Geometric Group Theory
Monday, July 8, 2019

PROMYS Europe
Sunday, July 14, 2019

2019 Clay Research Conference and Workshops
Sunday, September 29, 2019

More events

2000. 8 MILENIJSKIH PROBLEMA

– nagrada MILIJUN DOLARA

P versus NP
Hodge Conjecture
Riemann Hypothesis
Yang-Mills existence and mass gap
Navier-Stokes existence and smoothness
Birch and Swinnerton-Dyer Conjecture

Poincare Conjecture

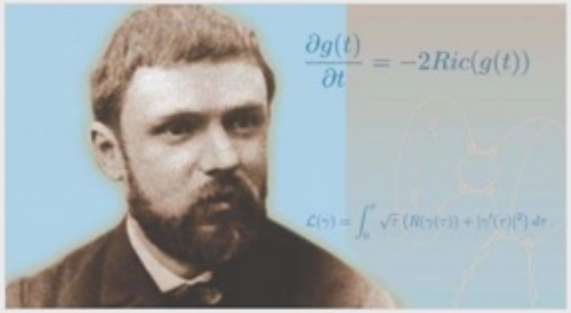
Clay Mathematics Institute

Dedicated to increasing and disseminating mathematical knowledge

ABOUT PROGRAMS MILLENNIUM PROBLEMS PEOPLE PUBLICATIONS EVENTS EUCLID

Call for Proposals

CMI invites proposals under the Enhancement and Partnership Program for fiscal year 2020-21 (1 October 2020-30 September 2021) and later. The principal aim of the program is to enhance activities that are already planned and financially viable. The next deadline for submissions is 1 September 2019.



2000. 8 MILENIJSKIH PROBLEMA

– nagrada MILIJUN DOLARA

Millennium Problems

Yang–Mills and Mass Gap

Experiment and computer simulations suggest the existence of a "mass gap" in the solution to the quantum versions of the Yang-Mills equations. But no proof of this property is known.

News

Royal Society Fellows

Congratulations to former Clay Research Fellows Manjul Bhargava (Princeton) and Akshay Venkatesh (IAS) and former Clay Senior Scholar Christopher Hacon (Utah) on their election as Fellows of the...

2019 Clay Research Fellows

The Clay Mathematics Institute is pleased to announce that Ewain Gwynne and Antoine Song have been awarded Clay Research Fellowships. Ewain Gwynne obtained his PhD in 2018 from the Massachusetts...

More news

Events

Quantum Field Theory and Manifold Invariants
Sunday, June 30, 2019

Thermodynamic Formalism: Applications to Probability, Geometry and Fractals
Monday, July 1, 2019

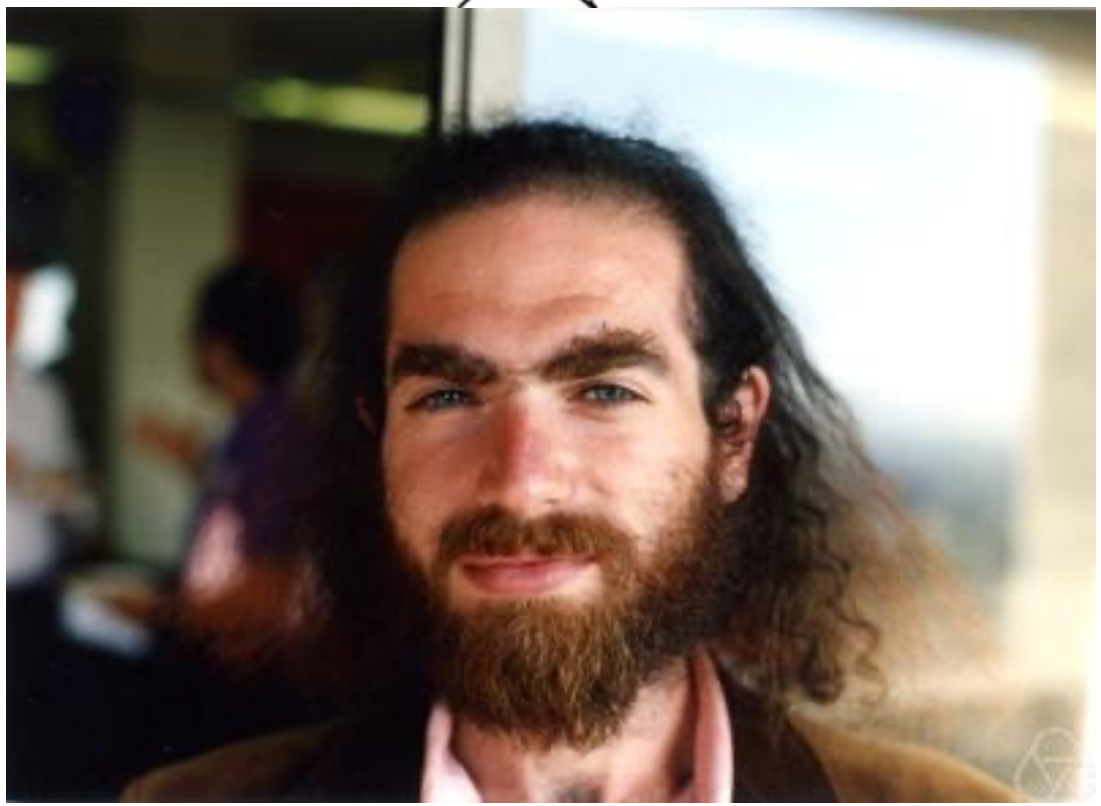
Aspects of Geometric Group Theory
Monday, July 8, 2019

PROMYS Europe
Sunday, July 14, 2019

2019 Clay Research Conference and Workshops
Sunday, September 29, 2019

More events

IMA I LAKŠIH NAČINA ZA ZARADITI MILIJUN DOLARA



GRIGORI YAKOVLEVICH PERELMAN

13.6. 1966. –

2002. godine objavio na internetu znanstvene radove u kojima je dokazao Poincareovu slutnju. Odbio Fieldsovu medalju i milijun dolara nagrade. Ne daje intervjue. Kaže da su znanstvenici podvaćeni i da kradu ideje te da on ne želi sudjelovati u tome.

Francuski matematičar. Pokrenuo polje TOPOLOGIJE u današnjem smislu. Prvi je predvidio postojanje gravitacijskih valova, razumio relativnost i napisao $E=mc^2$

JULES HENRI POINCARÉ
29. 4. 1854. – 17. 7. 1912.

POINCAREOVA SLUTNJA

2-sfera

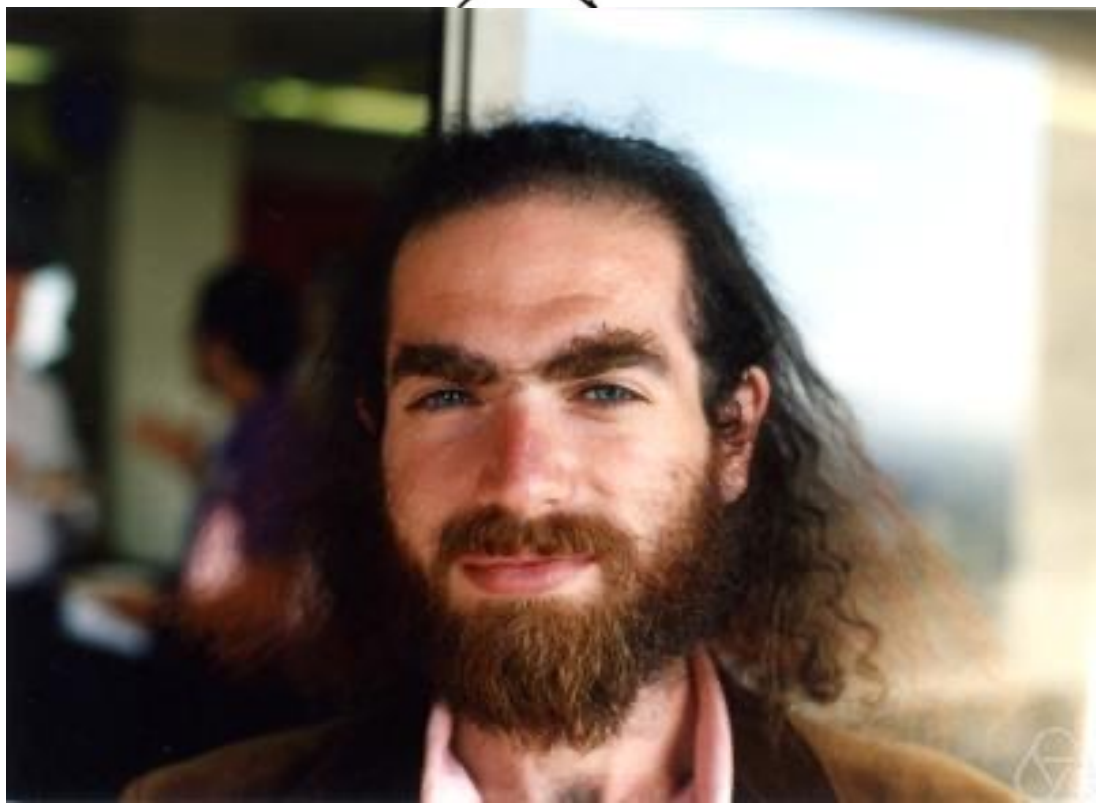
POINCAREOVA SLUTNJA

2-sfera

Svaka petlja može se stisnuti u točku

POINCAREOVA SLUTNJA

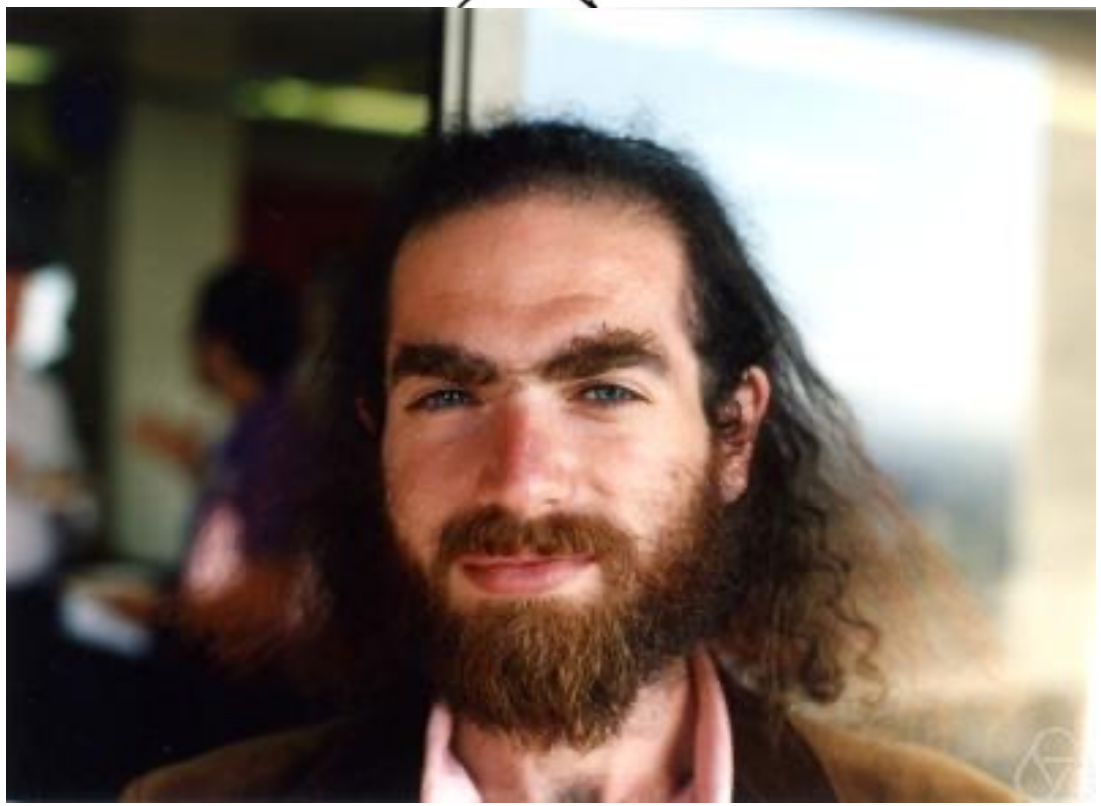
Every simply connected, closed 3-manifold is homeomorphic to the 3-sphere.



GRIGORI YAKOVLEVICH PERELMAN

13.6. 1966. —

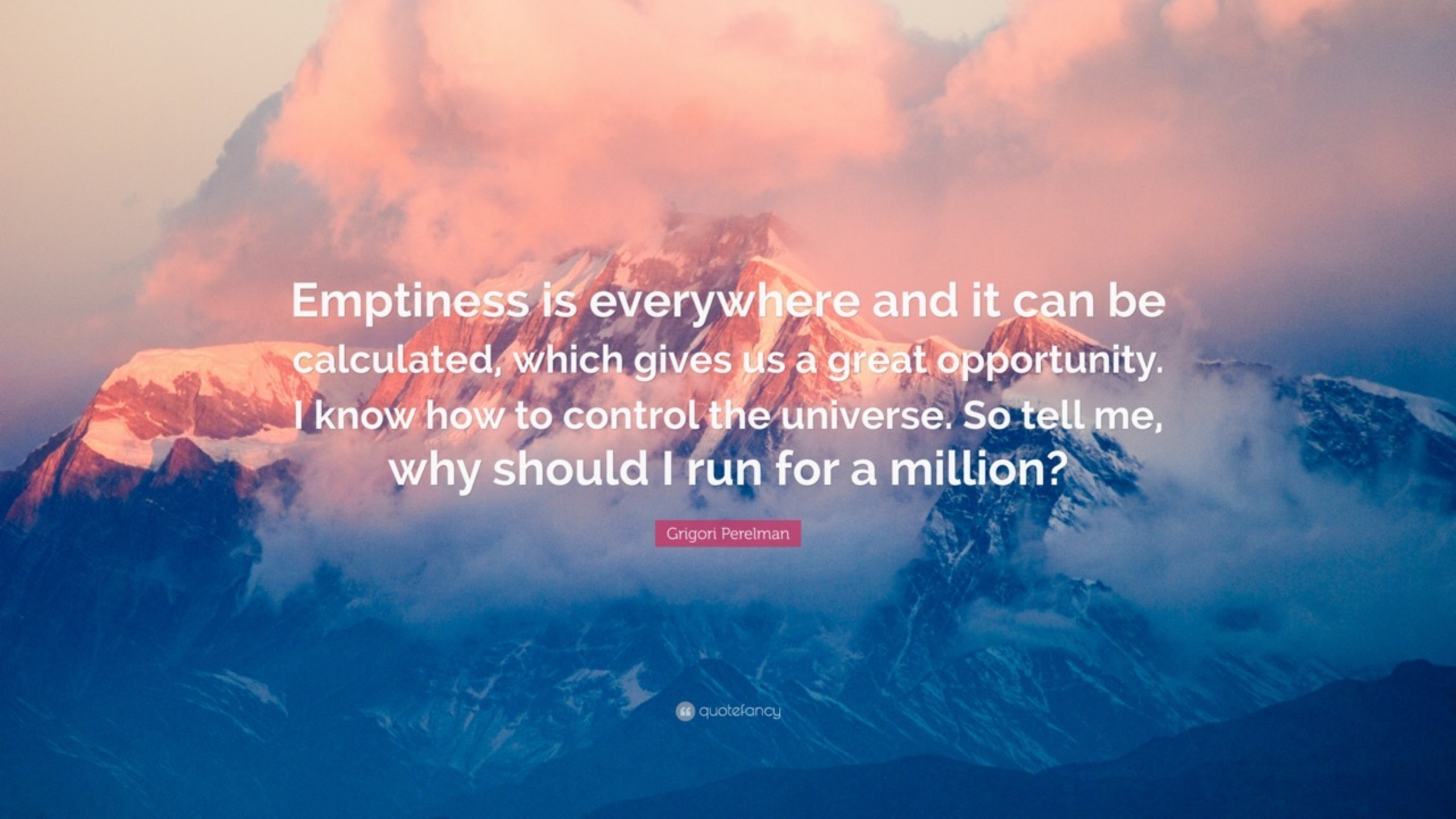
Odbio je milijun dolara i nakon čega je zvao PUTIN osobno.



GRIGORI YAKOVLEVICH PERELMAN

13.6. 1966. —

Emptiness is everywhere and it can be calculated, which gives us a great opportunity. I know how to controll the universe. So tell me, why should I run for a million?


Emptiness is everywhere and it can be calculated, which gives us a great opportunity. I know how to control the universe. So tell me, why should I run for a million?
Grigori Perelman
quotefancy


OK. To su sada valjda
svi brojevi koje
trebamo.


OK. To su sada valjda svi brojevi koje trebamo.
Čekaj, čekaj, a HIPERKOMPLEKSNI BROJEVI, KVATERNIONI...

KRAJ