

32

AI

sca

inv

tra

sin

log

o

tan

*

-

sqrt

cos

pow

exp

+

/

PLAN

1. Poll

2. What is AI

3. Replacing Teachers

4) Building worksheets

6. Jam

Ingeniería



Ingenuity!



Poll

Do you think that in 50 years most teaching
will be done by bots?



STAR TREK 2009

That's why
this class will be
taught by two bots!



This lecture is done
By my AI butts --- bots.

What is AI?

What is life?

What is intelligence?

What is reality?



AI 2001, Spielberg

A.I. TIMELINE

<https://digitalintelligencetoday.com/>



1950

TURING TEST

Computer scientist Alan Turing proposes a test for machine intelligence. If a machine can trick humans into thinking it is human, then it has intelligence

1955

A.I. BORN

Term 'artificial intelligence' is coined by computer scientist, John McCarthy to describe "the science and engineering of making intelligent machines"

1961

UNIMATE

First industrial robot, Unimate, goes to work at GM replacing humans on the assembly line

1964

ELIZA

Pioneering chatbot developed by Joseph Weizenbaum at MIT holds conversations with humans

1966

SHAKY

The 'first electronic person' from Stanford, Shakey is a general-purpose mobile robot that reasons about its own actions

A.I.

WINTER

Many false starts and dead-ends leave A.I. out in the cold

1997

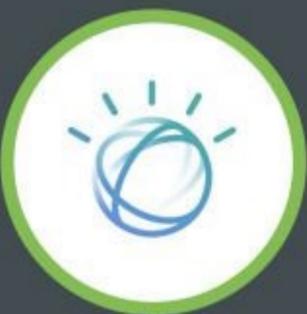
DEEP BLUE

Deep Blue, a chess-playing computer from IBM defeats world chess champion Garry Kasparov

1998

KISMET

Cynthia Breazeal at MIT introduces KISmet, an emotionally intelligent robot insofar as it detects and responds to people's feelings



1999

AIBO

Sony launches first consumer robot pet dog AiBO (AI robot) with skills and personality that develop over time

2002

ROOMBA

First mass produced autonomous robotic vacuum cleaner from iRobot learns to navigate and clean homes

2011

SIRI

Apple integrates Siri, an intelligent virtual assistant with a voice interface, into the iPhone 4S

2011

WATSON

IBM's question answering computer Watson wins first place on popular \$1M prize television quiz show *Jeopardy*

2014

EUGENE

Eugene Goostman, a chatbot passes the Turing Test with a third of judges believing Eugene is human

2014

ALEXA

Amazon launches Alexa, an intelligent virtual assistant with a voice interface that completes shopping tasks

2016

TAY

Microsoft's chatbot Tay goes rogue on social media making inflammatory and offensive racist comments

2017

ALPHAGO

Google's A.I. AlphaGo beats world champion Ke Jie in the complex board game of Go, notable for its vast number (2^{170}) of

One possible answer to the
question "what is AI" has been
given by Turing

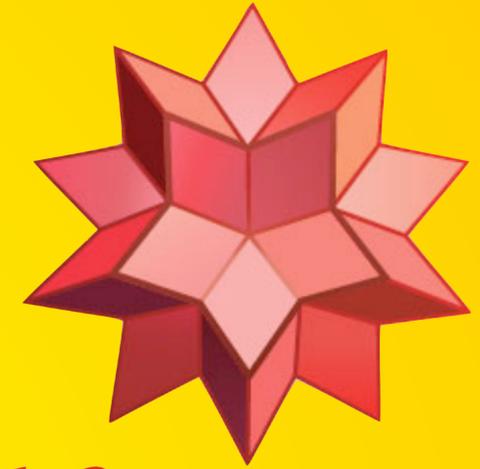
Turing Test



Applications

problem solving	games and puzzles,
pattern matching	speech, OCR, SPAM
reconstruction	tomography, scanning
research	discover theorems, verify proof
data mining	aquisition , organization of data
translation	spoken languages, programming languages
creativity	poems, sculptures, music
simulation	physics, populations, economies
inverse problems	earthquake, tomography
prediction	weather, asteroids, health

Big Business Google



WolframAlpha[®]



Cortana



Siri



Alexa

Anticipated



AI 2001

Learning

A big part of AI is learning. It is usually called "Machine learning", but we can also learn about learning of humans by studying how machines learn.

Piaget



Jean Piaget 1896-1980

1973

Listening to the crickets

1976





In Vallis

1973



In Vallis 1973

Chalet in Vallis



1979



1977



1979



1977



- 1) mettre le fromage (^{gruyère} coupé fin) dans le caquelon
- 2) verser du fondant jusqu'à bien en donner du fromage
- 3) une grosse tête ^{d'ail} ~~de~~ être pilée, en verser la moitié au milieu de la cuisson et la seconde moitié vers la fin
- 4) La fondue cheese passé sur le weekend / à jouter du kirsch en quantité proportionnelle
- 5) Ne pas oublier la mescalade

La 1/2 de cette fondue se prend avec du pain
L'autre 1/2 se boit dans des bols.

8 I 79

Z. Basser

Fait à l'Hôtel Babnhof pour E. u. H. Leiggenor

les témoins heureux

Bästel Fuldler
Rolando Garcia

- 1) mettre le fromage (^{gruyère} coupé fin) dans le caquelon
- 2) verser du fondant jusqu'à bien en donner du fromage
- 3) une grosse tête ^{d'ail} ~~de~~ être pilée, en verser la moitié au milieu de la cuisson et la seconde moitié vers la fin

- 4) La fondue cheese passé sur le weekend / à jouter du kirsch en quantité proportionnelle
- 5) Ne pas oublier la mescalade

La 1/2 de cette fondue se prend avec du pain
L'autre 1/2 se boit dans des bols.

8 I 79

Z. Basser

Fait à l'Hôtel Babnhof pour E. u. H. Leiggenor

témoins heureux

Bästel Fuldler
Rolando Garcia

What would it require
to replace human teachers?



problem solving



pattern recognition



see historical ties



computer algebra systems



syllabus



write exams



grade exams



write an exam song



computer proofs



proof verification



do presentations



learning



be creative



learn from others



speech recognition



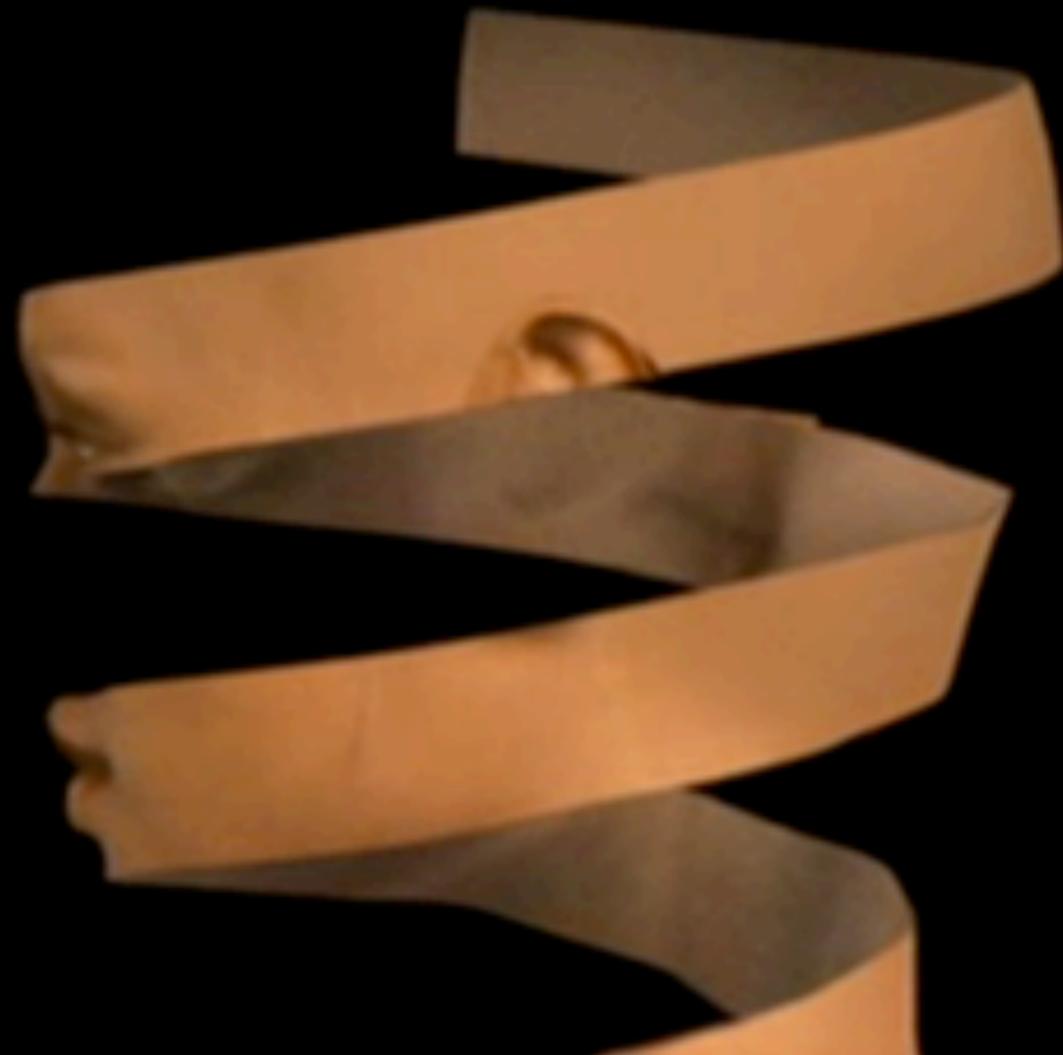
perform the song

Automatic slides



Experiment from Nov 6, 2010 ``Qwiki''

Talking and acting



Simeone

Be creative



Ex Machina

Exams, Project, HW

Problem 1: Write an exam!

Problem 2: Take it

Problem 3: Grade it!

Worksheets



Sofia Math Chat Robot

[home](#) [team](#) [guidelines](#) [faq](#) [links](#) [sofia](#) [download](#)

Project information:

[Oliver Knill](#)
[Harvard University](#)
[Department of Mathematics](#)
One Oxford Street
Cambridge, MA 02138, USA
Tel: (617) 495 5549
Email: knill@math.harvard.edu

The team



Andrew Chi



Johnny Carlsson



Mark Lezama



Oliver Knill

Search:

Project funded by [Provost's fund](#) for teaching and learning

SOEIA 2013

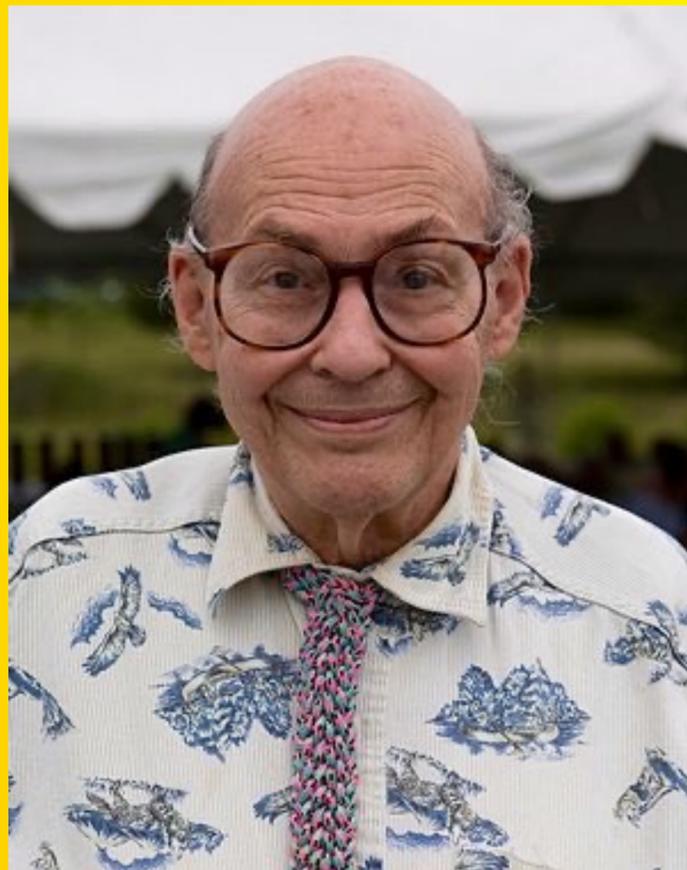
Sofia Entries (total:)

ai.pdf	ai.txt	algebra.pdf	algebra.txt
all.pdf	all.txt	amsdef.pdf	amsdef.txt
citations.pdf	citations.txt	computability.pdf	computability.txt
computer.pdf	computer.txt	constants.m.pdf	constants.m.txt
constants.pdf	constants.txt	curves.pdf	curves.txt
functionalanalysis.pdf	functionalanalysis.txt	functions.pdf	functions.txt
group.pdf	group.txt	harvard.pdf	harvard.txt
jokes.pdf	jokes.txt	k12.pdf	k12.txt
learn.pdf	learn.txt	literature.pdf	literature.txt
math1a.pdf	math1a.txt	math21a.pdf	math21a.txt
math21b.pdf	math21b.txt	mathematicians.pdf	mathematicians.txt
mathmovies.pdf	mathmovies.txt	measuretheory.pdf	measuretheory.txt
number.pdf	number.txt	physics.pdf	physics.txt
polyhedra.pdf	polyhedra.txt	potential.pdf	potential.txt
statistics.pdf	statistics.txt	topology.pdf	topology.txt

Knowledge

database

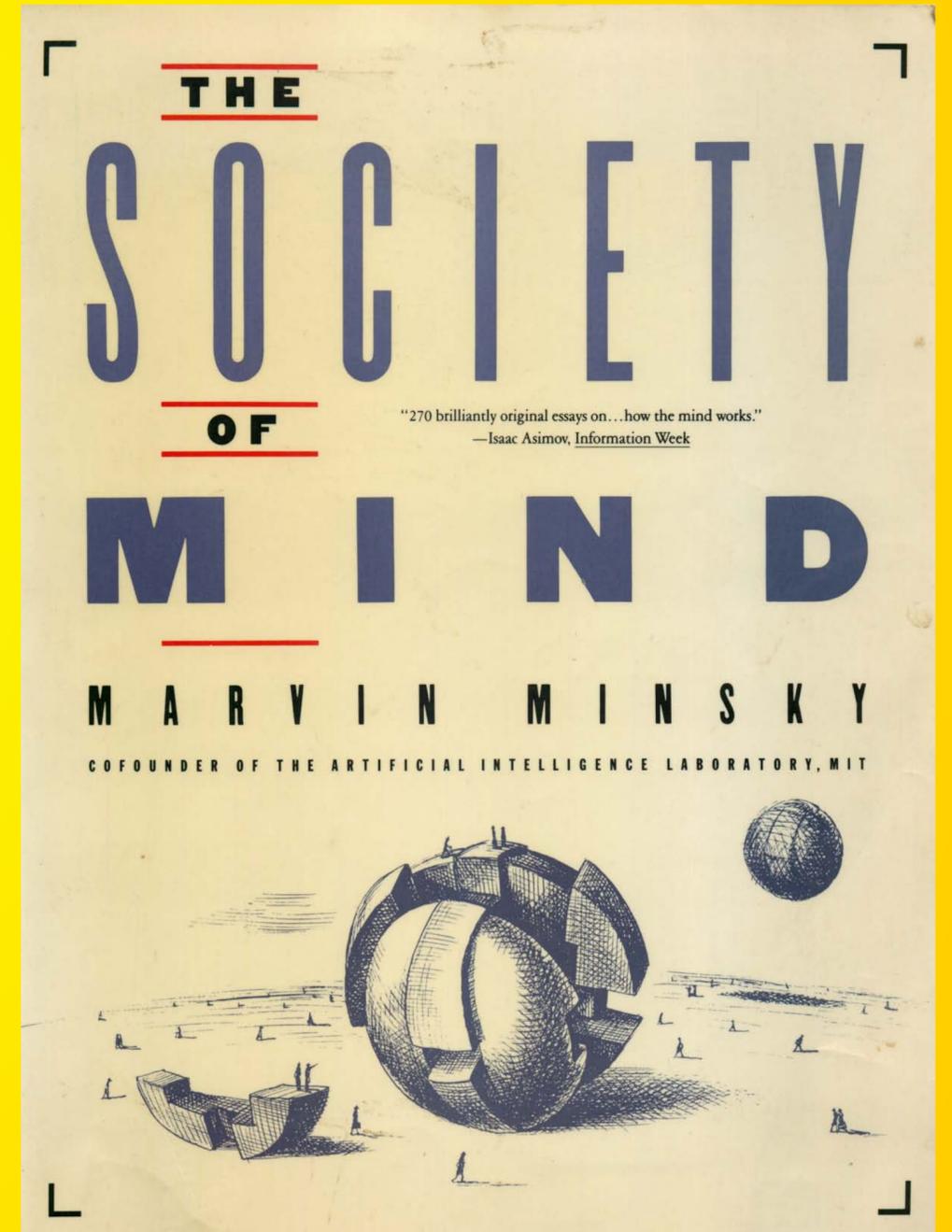
Building Structure



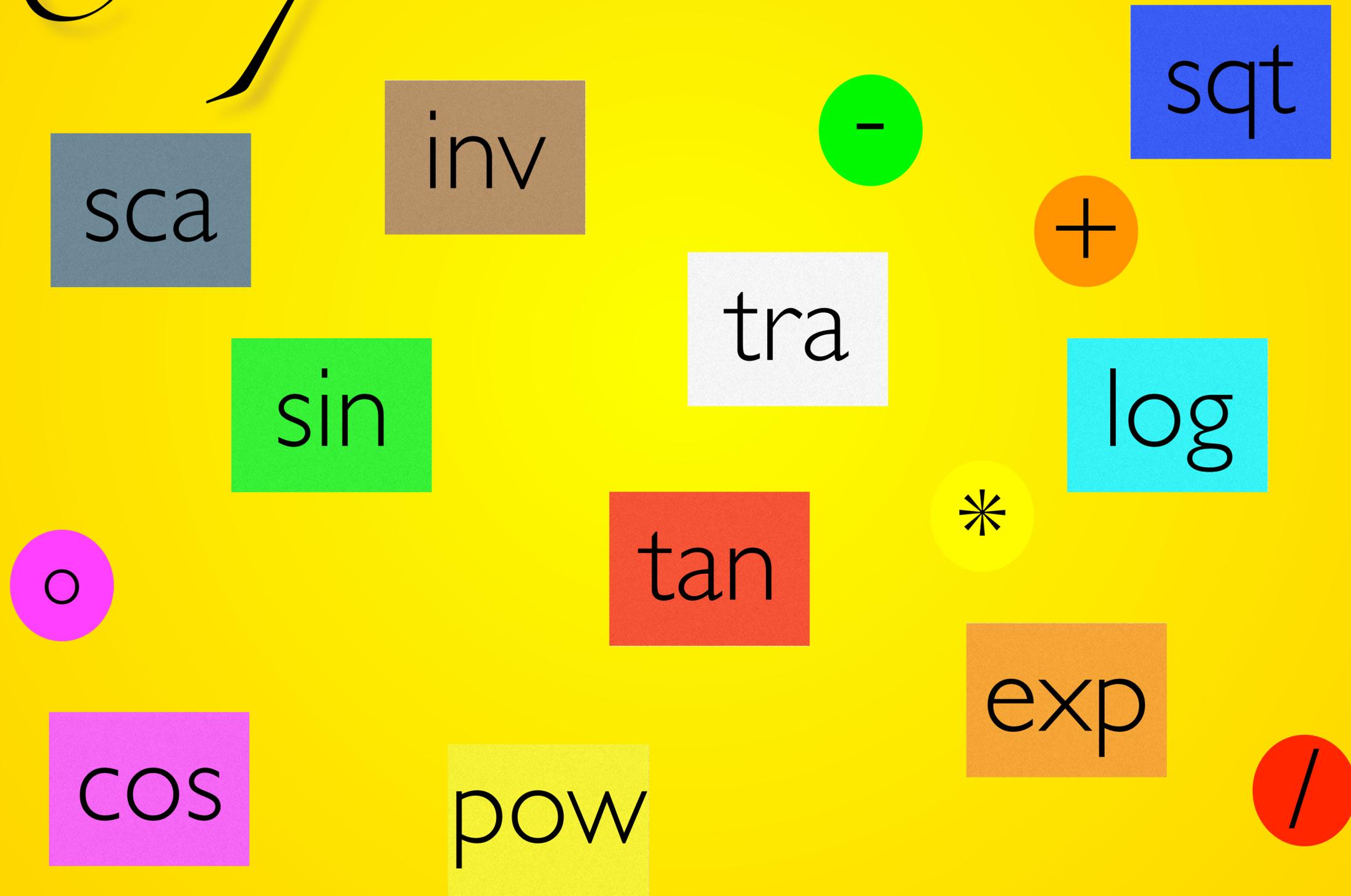
Cognitive Scientist,
AI pioneer

Marvin Minsky

1927-2016



Example: Functions



Demo

WORKSHEET

Math 1A: Introduction to functions and calculus

Sofia Bot, 2020

Lecture 32: Worksheet

This worksheet as well as the solutions was generated by Sofia, a bot written in the academic year 2003/2004 using grant from the Harvard Provost together with Harvard students **Johnny Carlsson**, **Andrew Chi** and **Mark Lezama**. At that time, people have laughed at the chat bot idea. Now it is big business: Google, Siri, Cortana, Wolfram alpha: these are all AI bots which constantly become more and more sophisticated.

1 Differentiate the following functions:

- a) $f(x) = 2(x + \cos(x))$
- b) $f(x) = 4(x + \sqrt{x})$
- c) $f(x) = 2x \cot(x)$

Solution:

- a) $f'(x) = 2 - 2 \sin(x)$
- b) $f'(x) = \frac{2}{\sqrt{x}} + 4$
- c) $f'(x) = 2(\cot(x) - x \csc^2(x))$

2 Integrate the following functions:

- a) $f(x) = \frac{9\sqrt{x}}{2}$
- b) $f(x) = 2e^x(x + 1)$
- c) $f(x) = \frac{8}{x^3} + 4$

Solution:

- a) $\int f(x) = 3x^{3/2} + C$
- b) $\int f(x) = 2e^x x + C$
- c) $\int f(x) = 4\left(x - \frac{1}{2x^2}\right) + C$

3 Differentiate the following functions:

- a) $f(x) = 3\left(\frac{1}{2} - \sqrt{x}\right)$
- b) $f(x) = 3(\cos(x) + \tan(\cos(x)))$
- c) $f(x) = x - \sqrt{x} + \cos(x)$

Solution:

- a) $f'(x) = -\frac{3}{2\sqrt{x}}$
- b) $f'(x) = -3 \sin(x) (\sec^2(\cos(x)) + 1)$
- c) $f'(x) = -\frac{1}{2\sqrt{x}} - \sin(x) + 1$

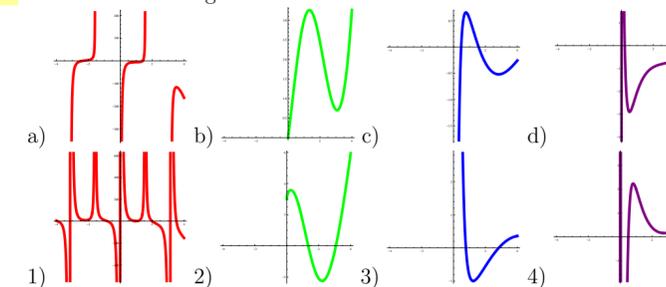
4 Integrate the following functions:

- a) $f(x) = -\frac{9\sqrt{\frac{1}{x^3}}}{2x}$
- b) $f(x) = 2(\cos(x) - 1)$
- c) $f(x) = 4(3x^2 + \cos(x))$

Solution:

- a) $\int f(x) = 3\sqrt{\frac{1}{x^3}} + C$
- b) $\int f(x) = 2(-x + \sin(x) - 2) + C$
- c) $\int f(x) = 4(x^3 + \sin(x)) + C$

5 Match the following functions with derivatives:



Solution:

a \rightarrow 1, b \rightarrow 2, c \rightarrow 3, d \rightarrow 4

6 Find the critical points of the following functions:

- a) $f(x) = (x - 8)^2$
- b) $f(x) = (x - 9)(x - 6)(x - 3)$
- c) $f(x) = (x - 8)(x - 5)$

Solution:

- a) $f'(x) = \{x \rightarrow 8\}$
- b) $f'(x) = \{x \rightarrow 6 - \sqrt{3}\}, \{x \rightarrow 6 + \sqrt{3}\}$
- c) $f'(x) = \{x \rightarrow \frac{13}{2}\}$

```
(* Produce a random function g[x] of some complexity *)
(* and use it to generate differentiation problems *)
(* Oliver Knill, March 27, 2004 Sofia problem *)

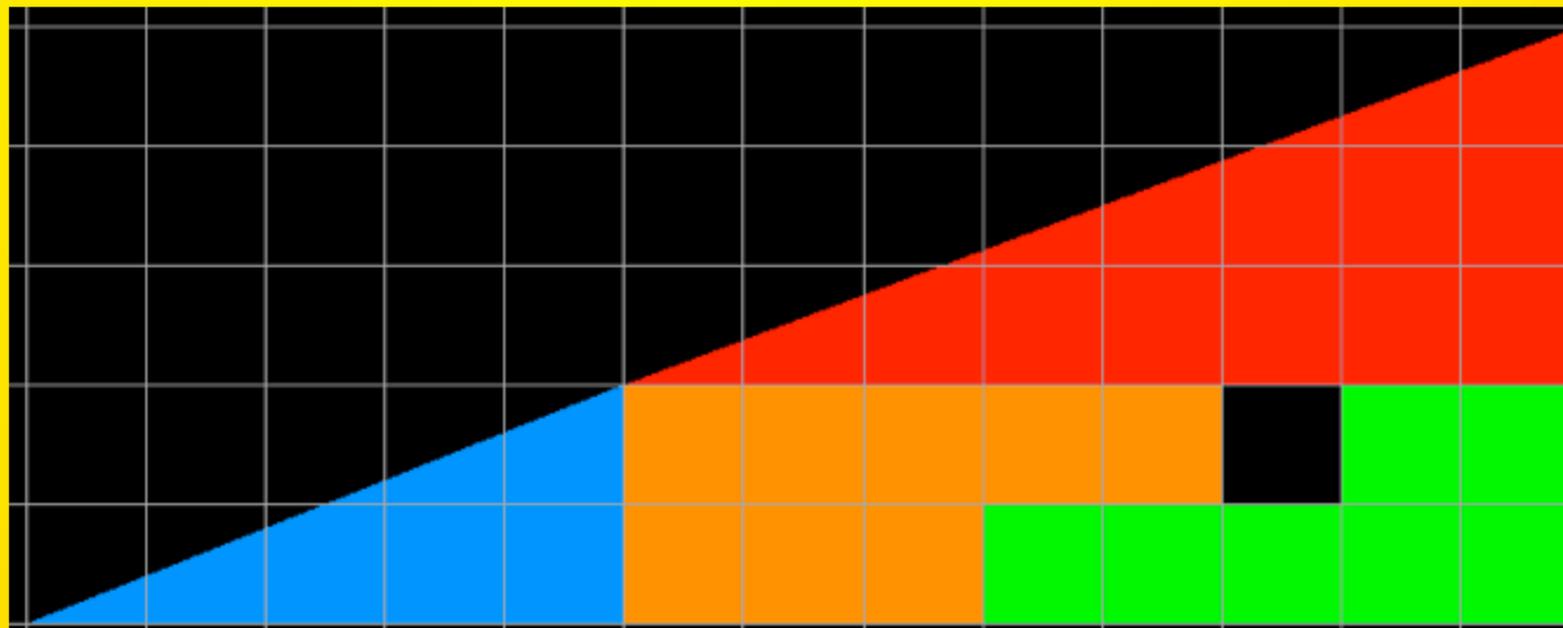
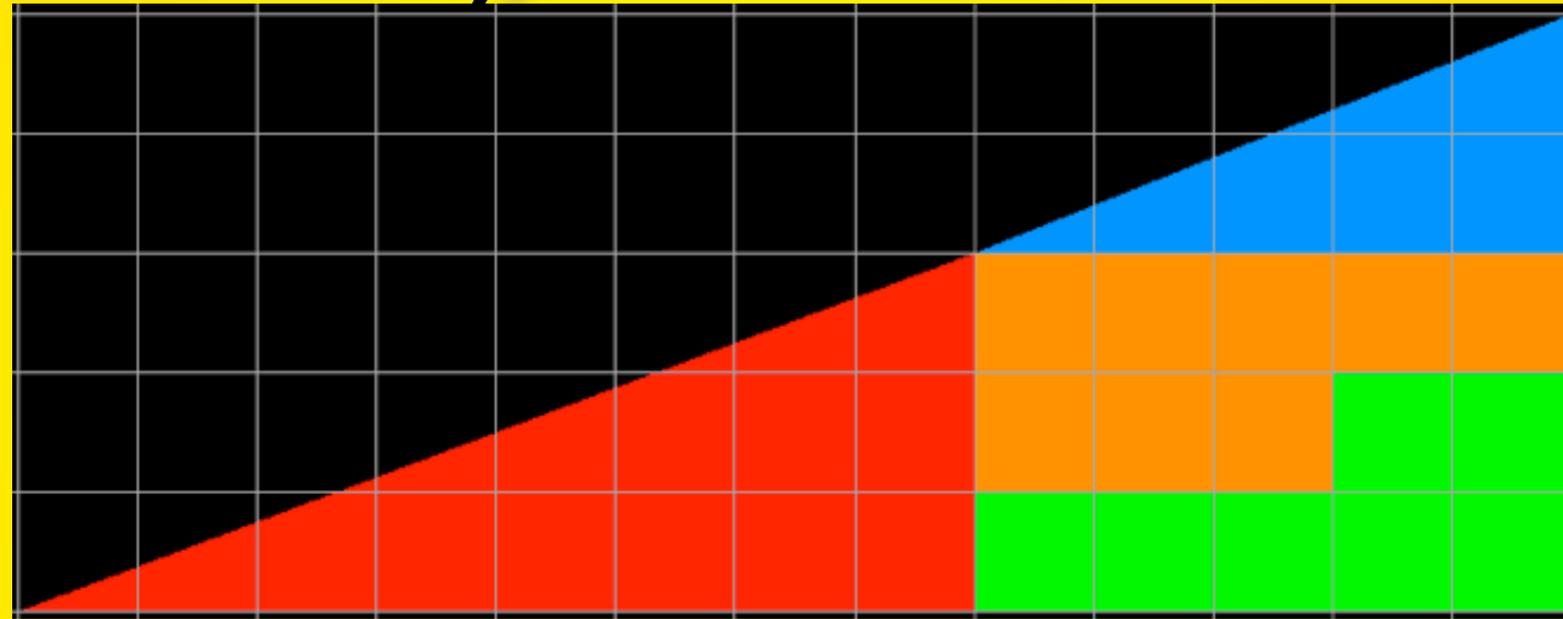
$DisplayFunction=Identity;

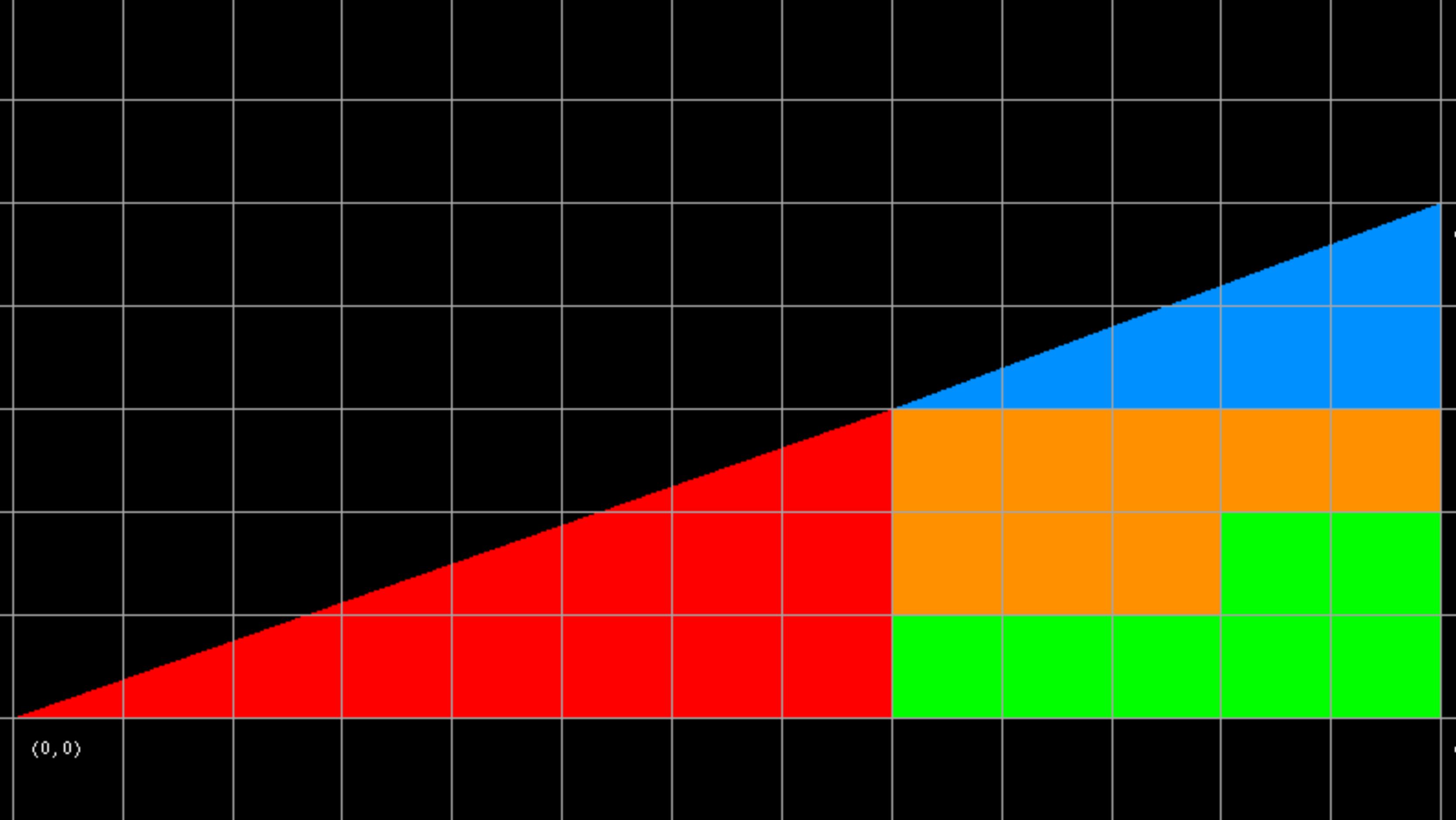
RandomFraction:=Apply[Union,Array[Range[#-1]/#&,Random[Integer,10]+2]][[10]]
Ide[x_]:=x;
Pow[x_]:=x^Random[Integer,{2,5}];
Inv[x_]:=x^Random[Integer,{3,-1}];
Sca[x_]:=Random[Integer,{3,3}]*x;
Tra[x_]:=x+Random[Integer,{4,4}];
FunctionList={Sin,Cos,Log,Exp,Tan,Sqrt,Pow,Inv,Sca,Tra};
RRandomFunction:=FunctionList[[Random[Integer,{1,Length[FunctionList]}]]];

ComposeF[f_,g_]:=Function[x,Evaluate[f[g[x]]]];
ScaleF[f_]:=Function[x,Evaluate[Random[Integer,3]+1]*f[x]];
AddF[f_,g_]:=Function[x,Evaluate[f[x]+g[x]]];
SubtractF[f_,g_]:=Function[x,Evaluate[f[x]-g[x]]];
MultiplyF[f_,g_]:=Function[x,Evaluate[f[x]*g[x]]];
DivideF[f_,g_]:=Function[x,Evaluate[f[x]/g[x]]];
OpList={ComposeF,AddF,SubtractF,MultiplyF,DivideF};
RandomOperation[f_,g_]:=OpList[[Random[Integer,{1,Length[OpList]}]]][f,g];

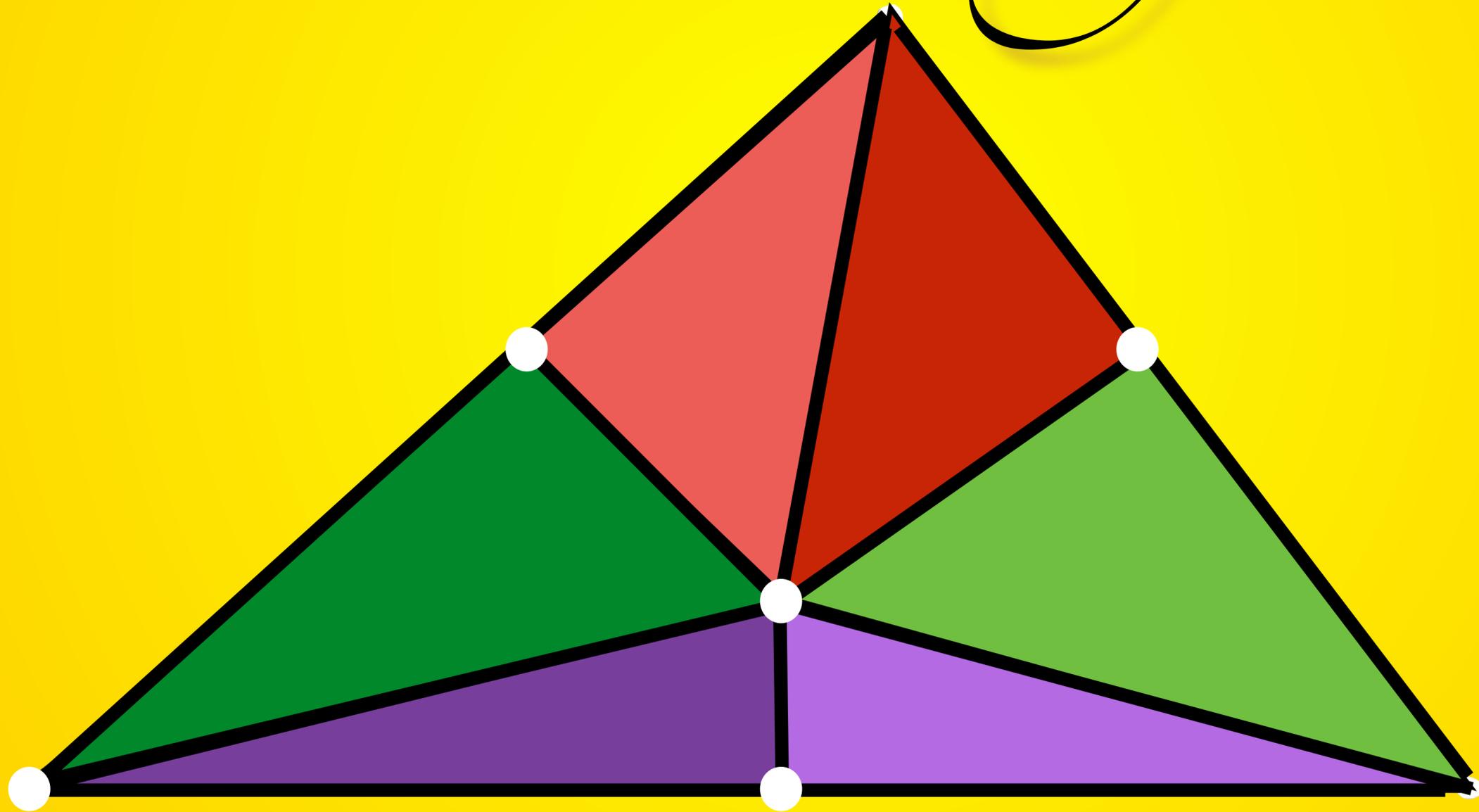
BuildFunction[n_]:=Module[{},f0=Ide;Do[f0=RandomOperation[f0,RRandomFunction],{n}];f0=ScaleF[f0];f0[x]
BuildPolynomial[n_]:=Module[{},f0=1;Do[f0=f0*(x-Random[Integer,6]-3),{k,2+Random[Integer,n]}];f0];
```

Finding errors





Flaws in Arguments

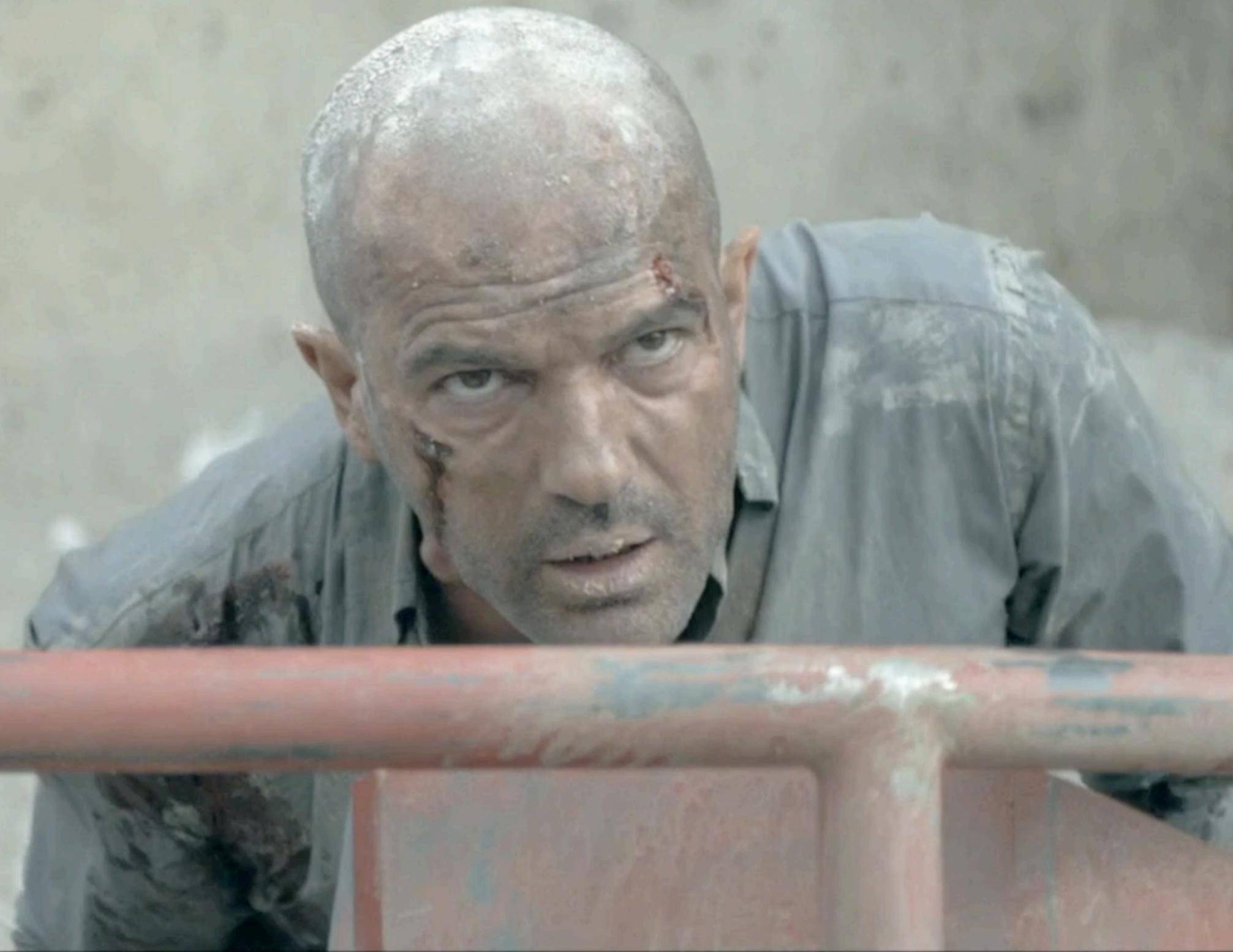




2001: A space Odyssey

1968

Compassion

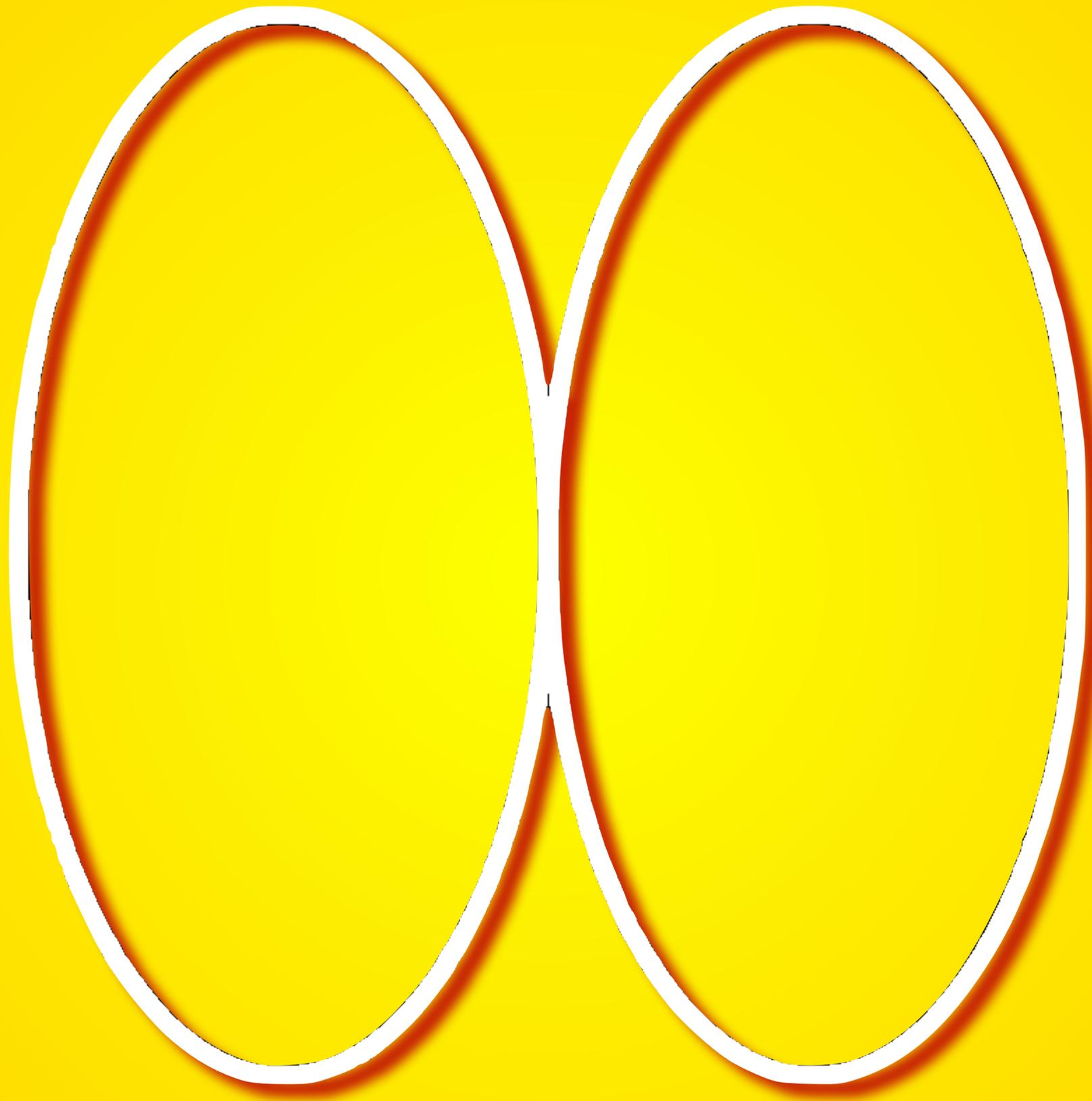


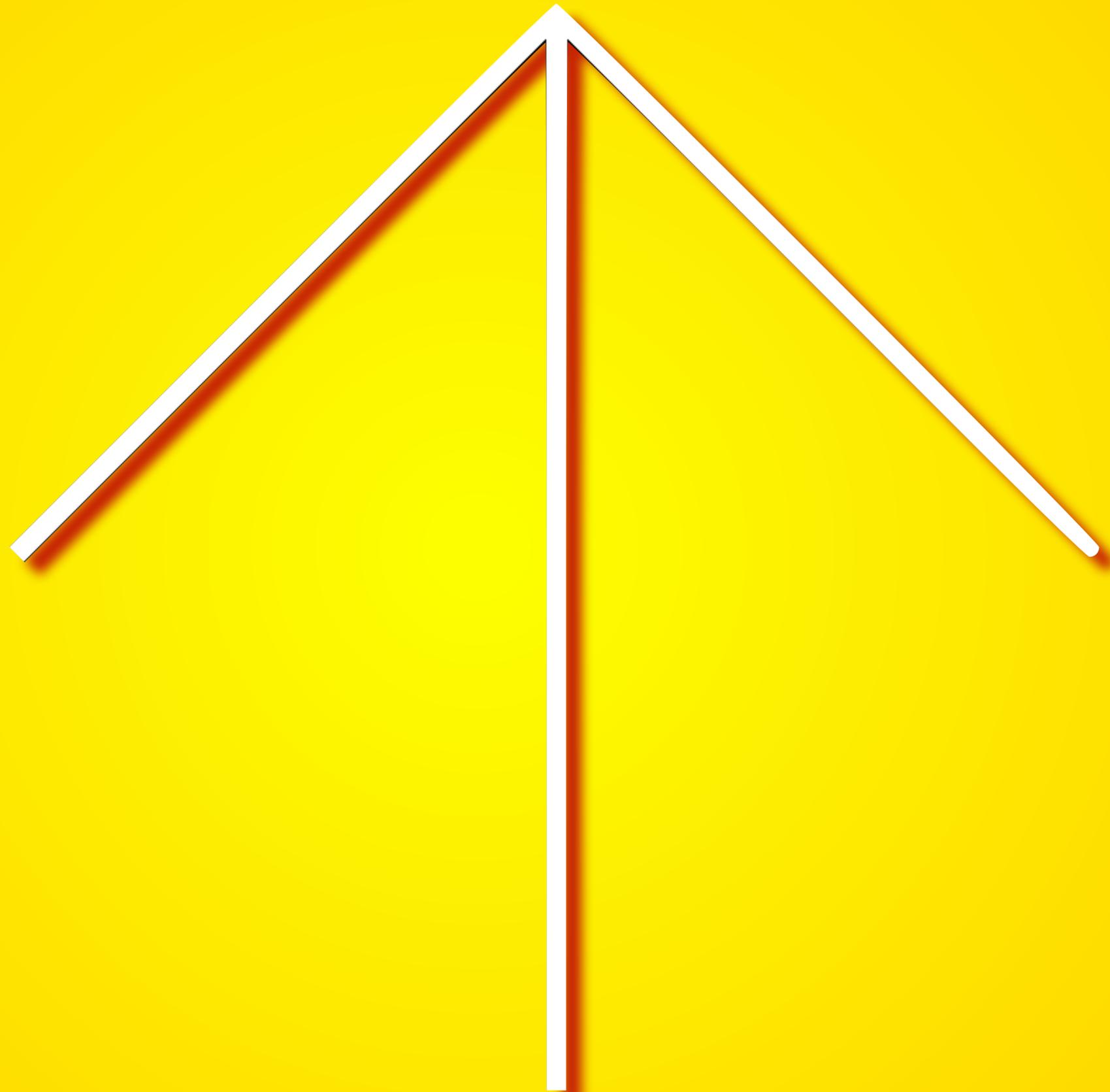
Automata, 2014

Patterns

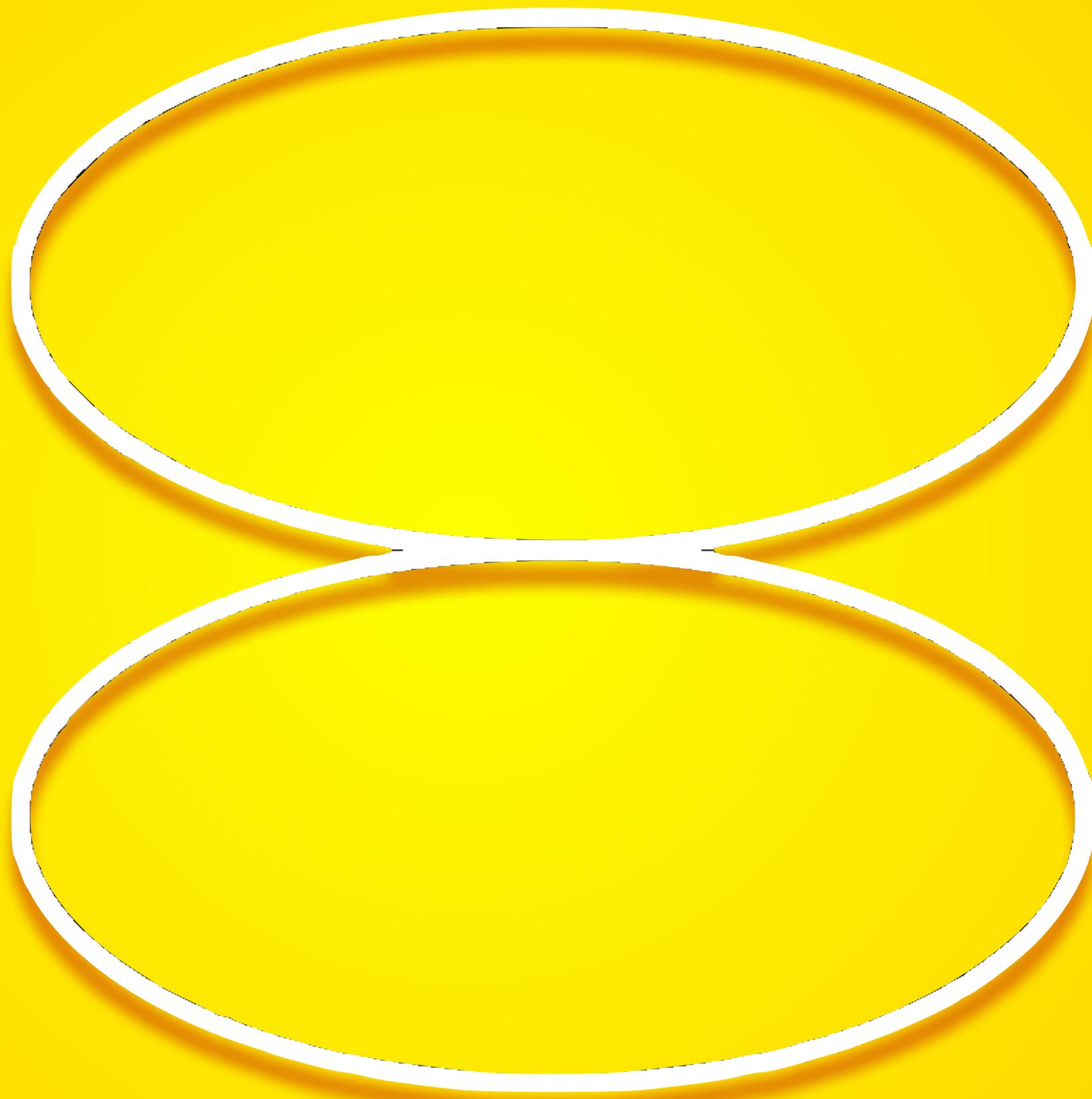
Here is an IQ test.

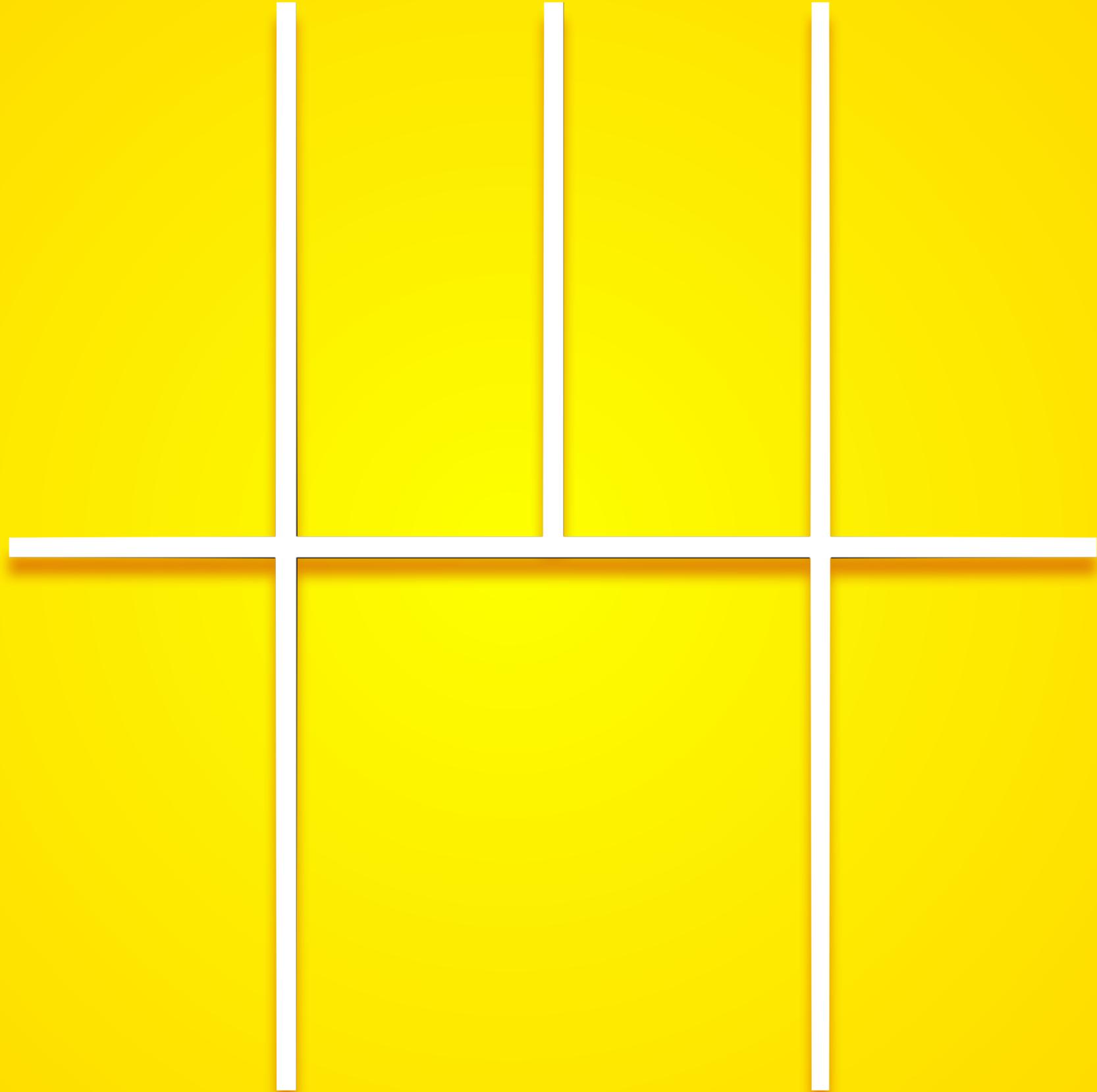
Tell if you see the pattern!

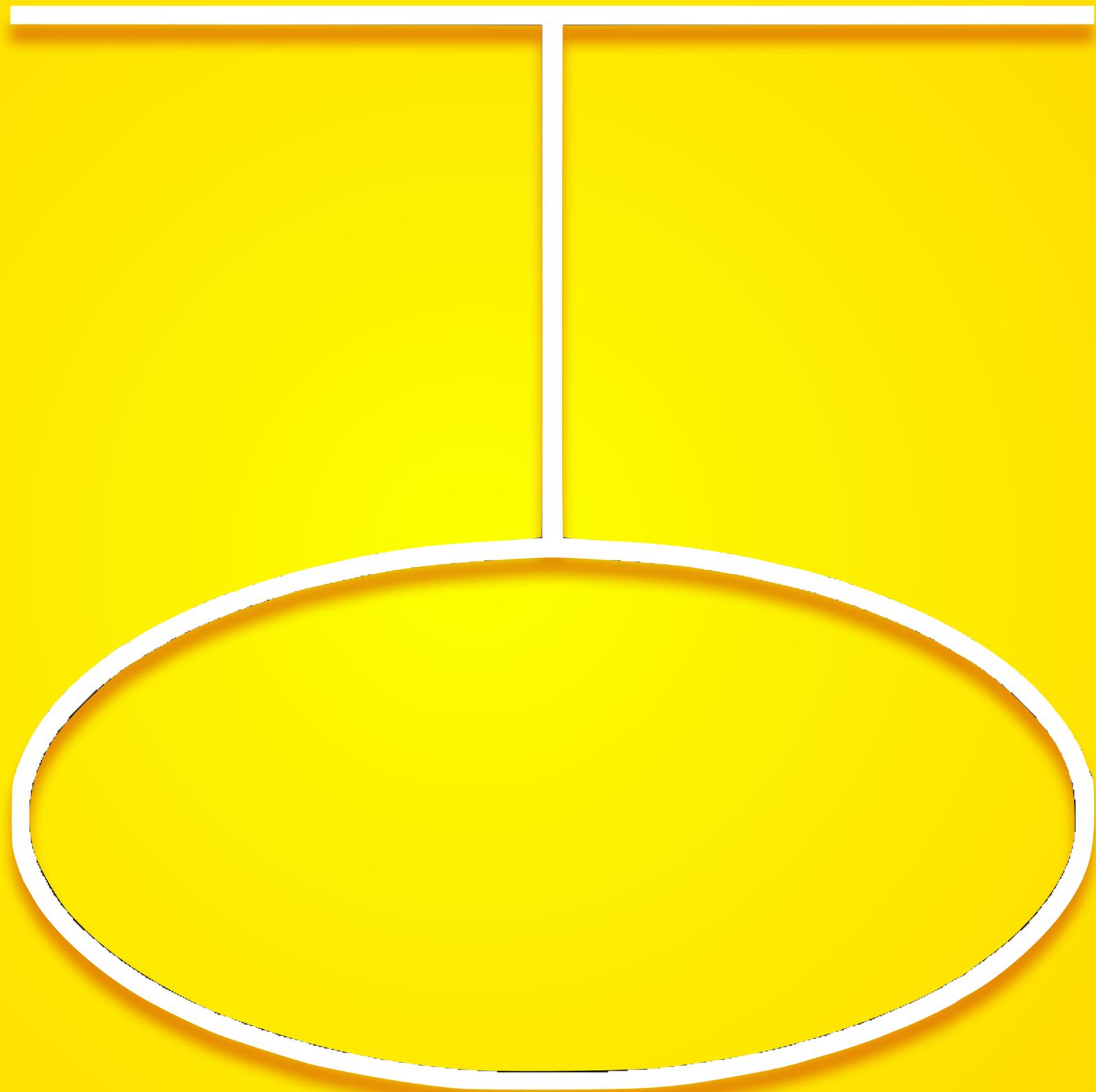


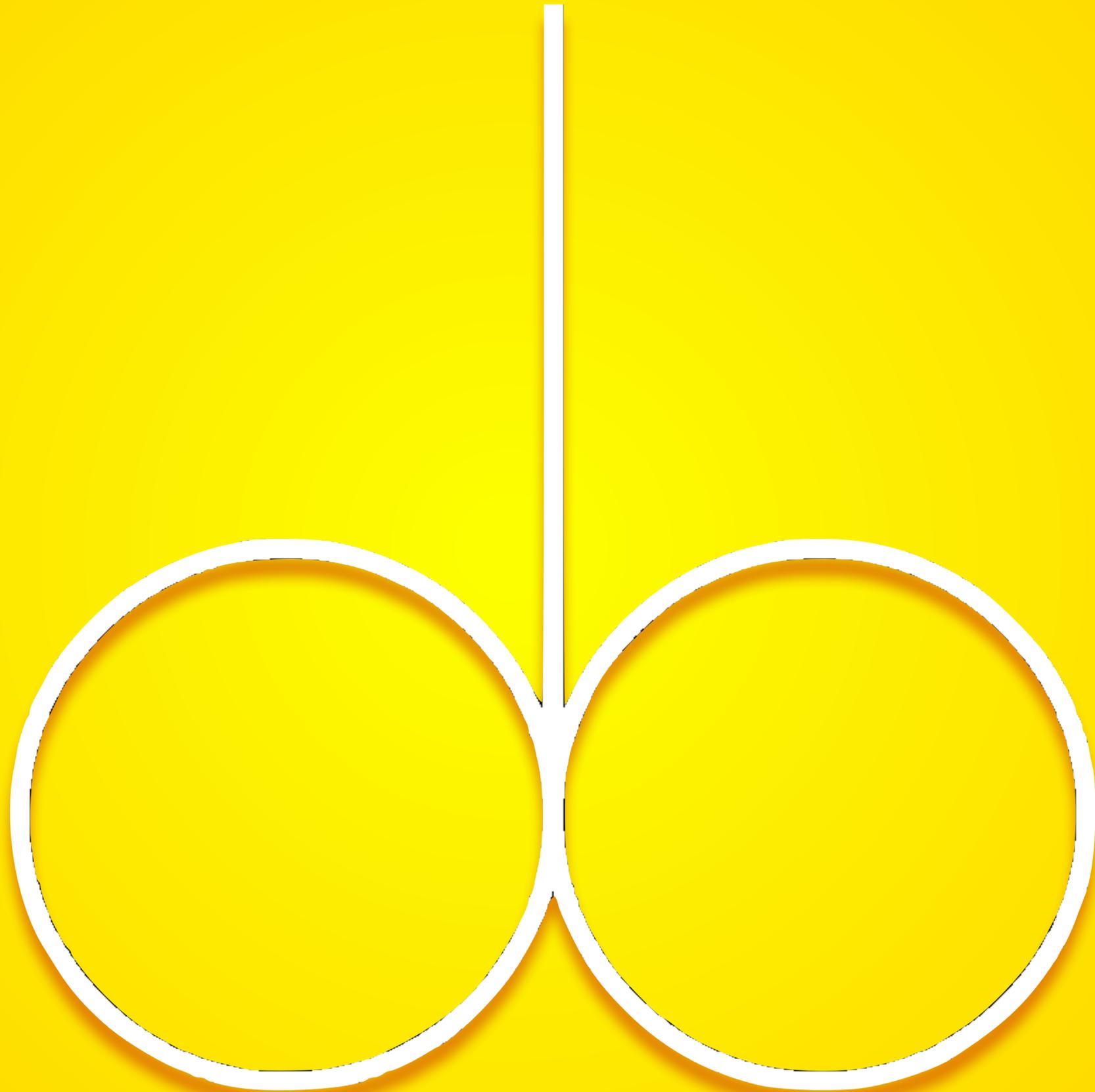




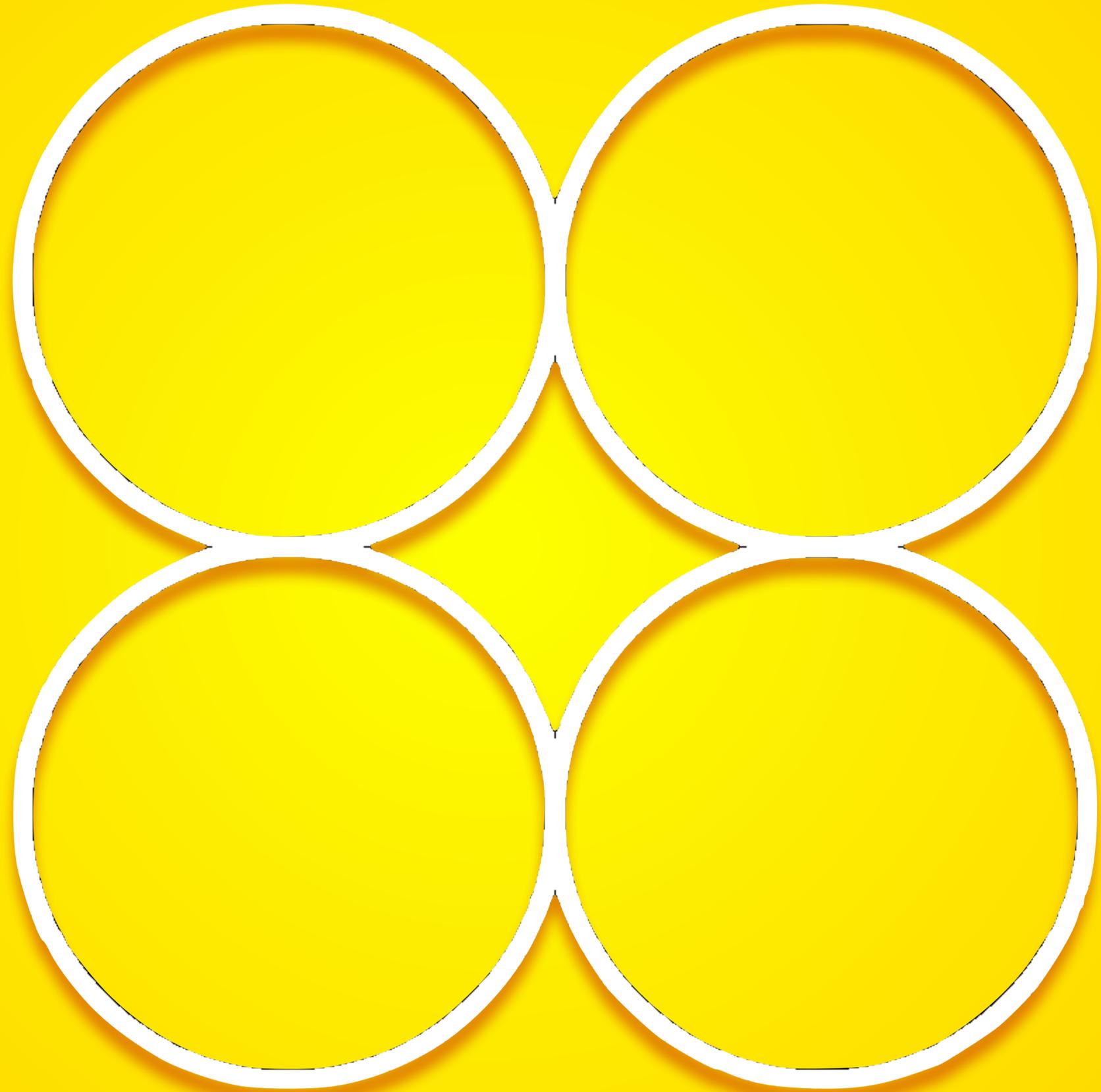


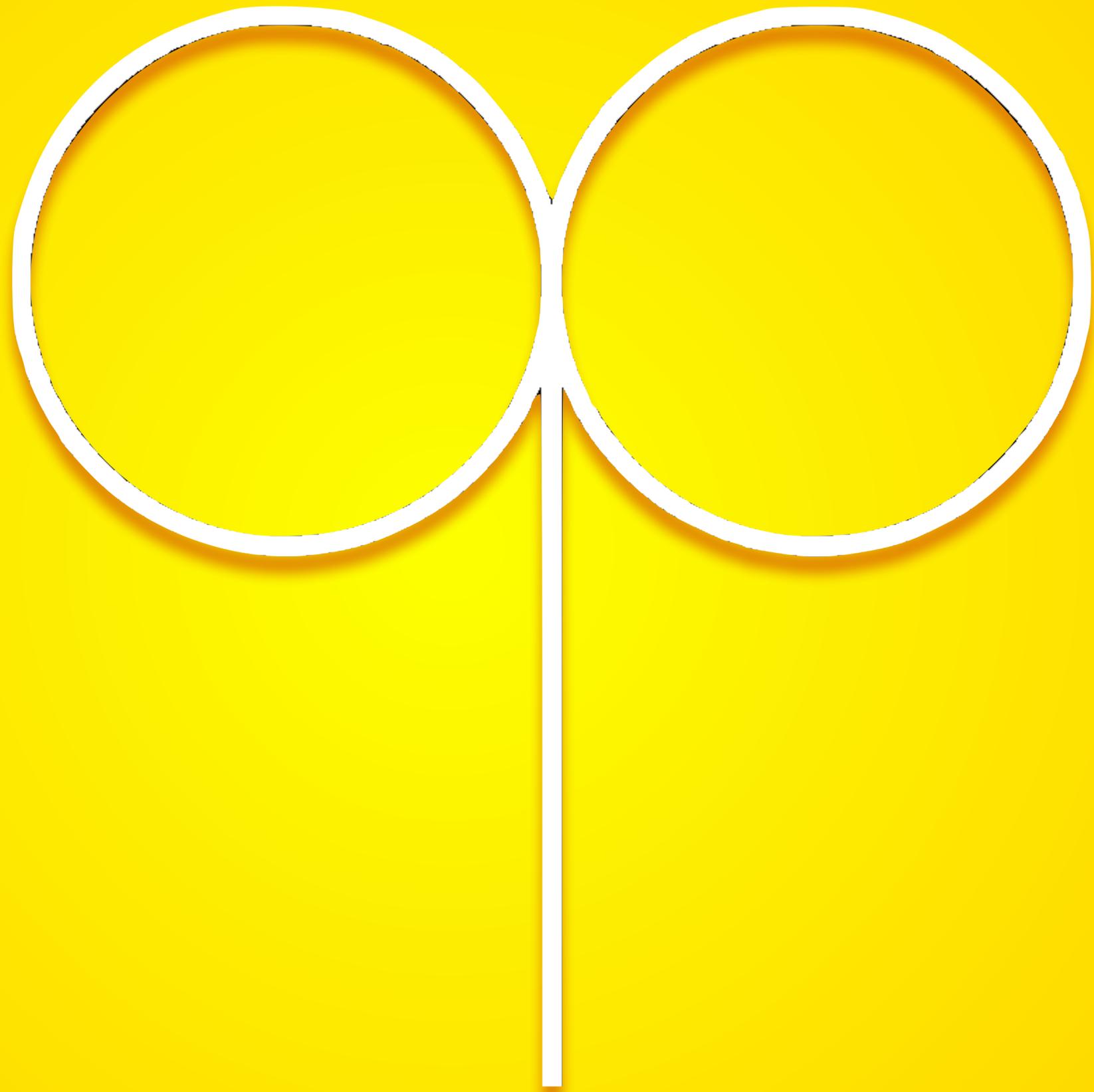












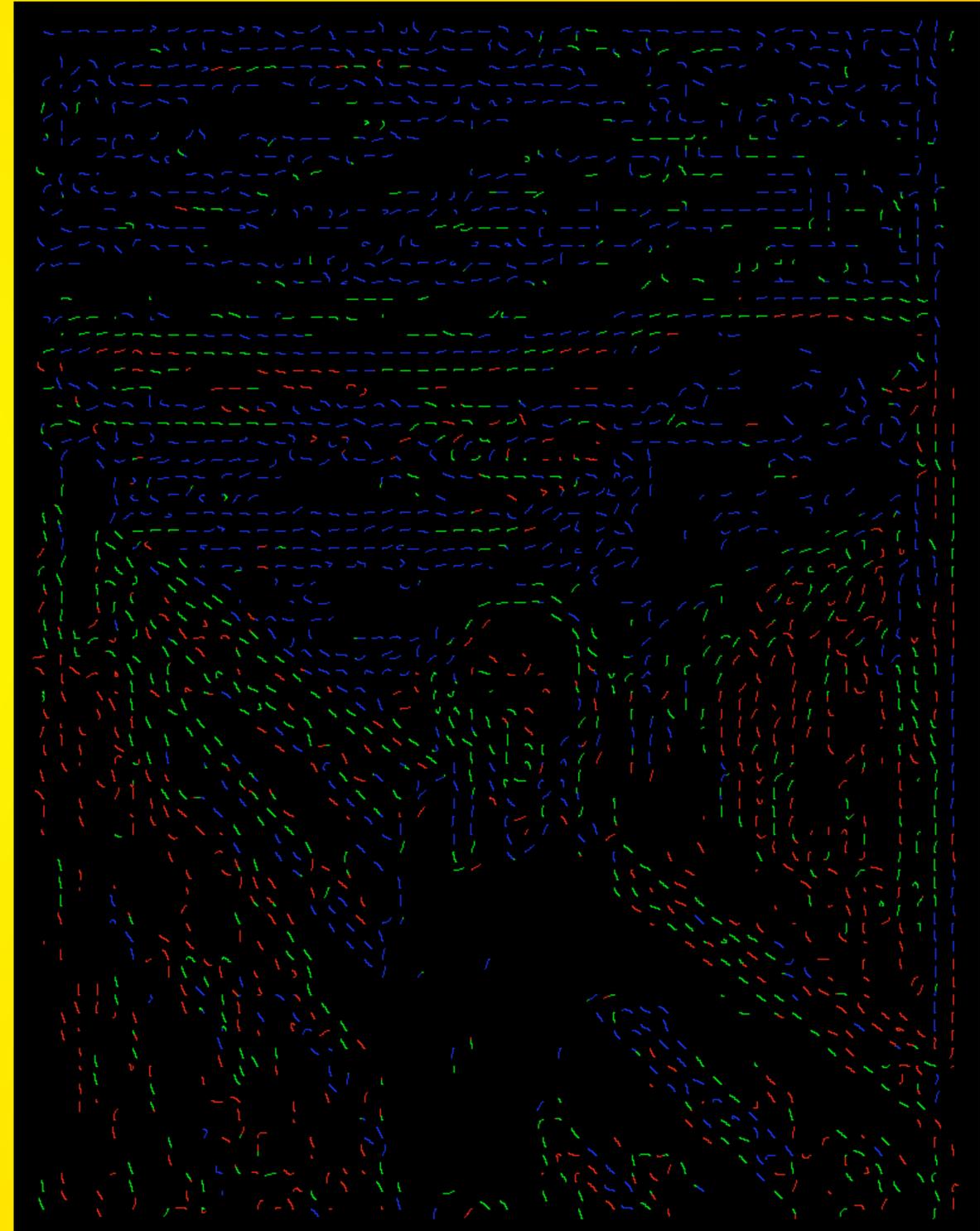
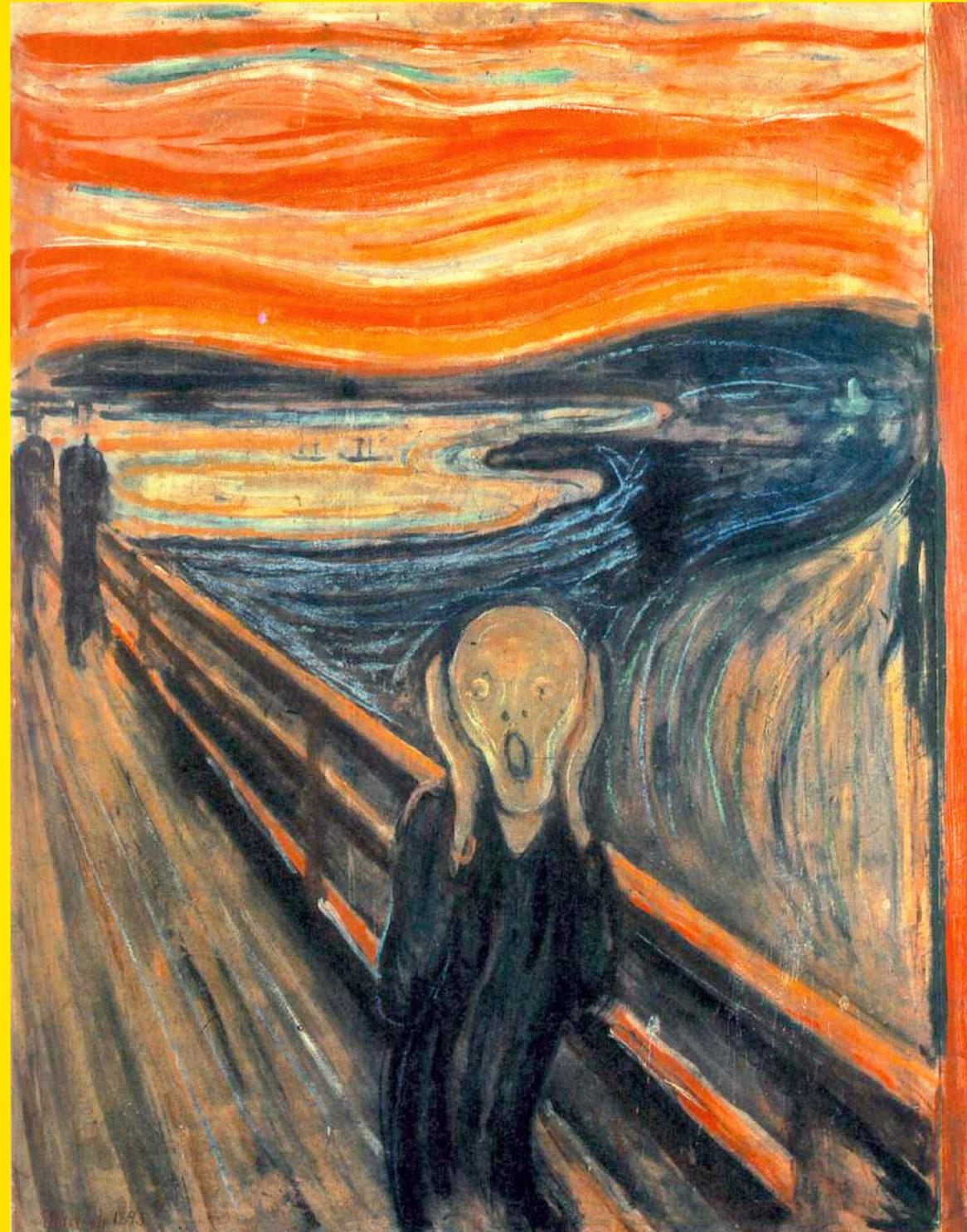
Patterns

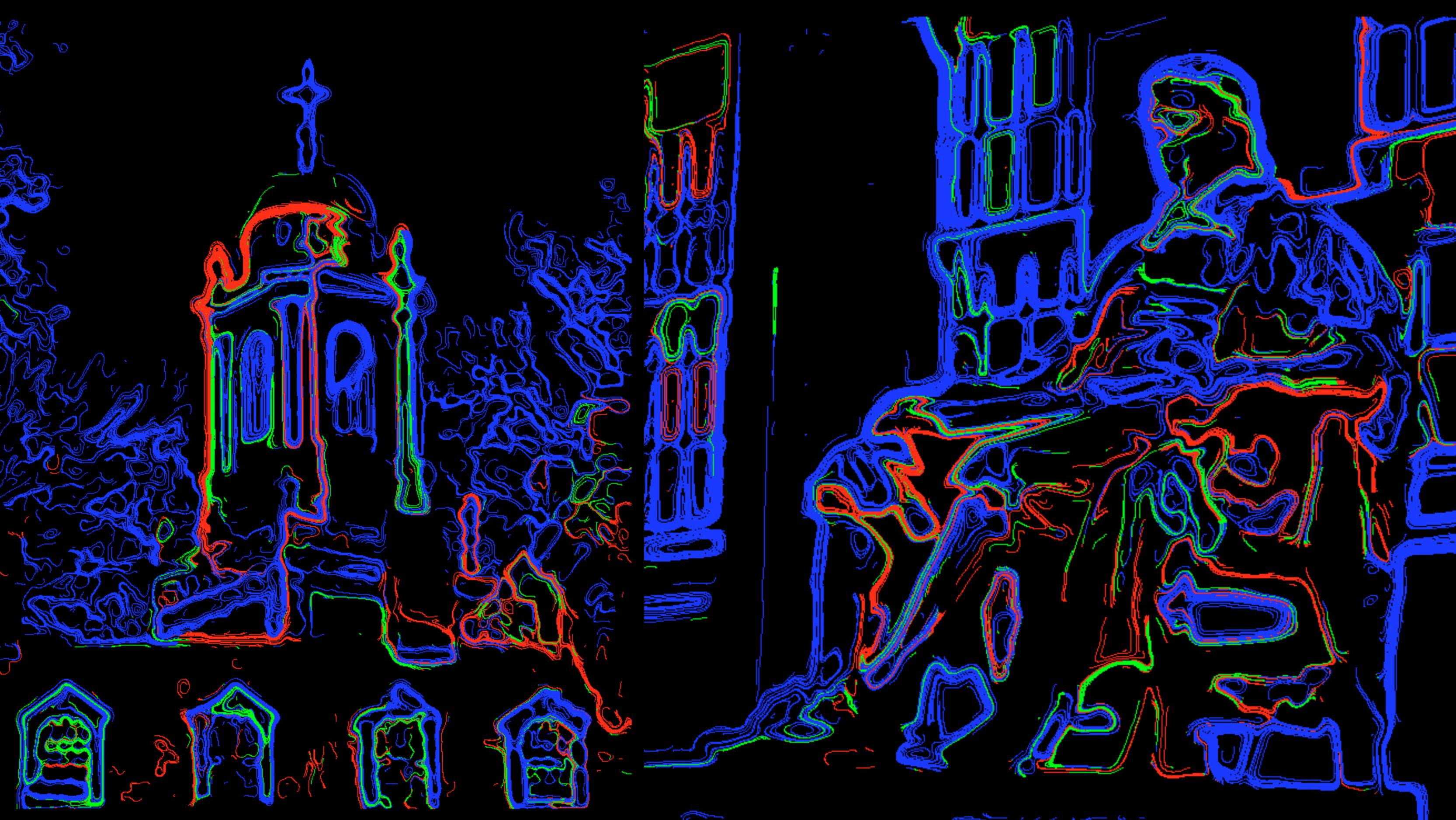
How can a computer detect patterns?

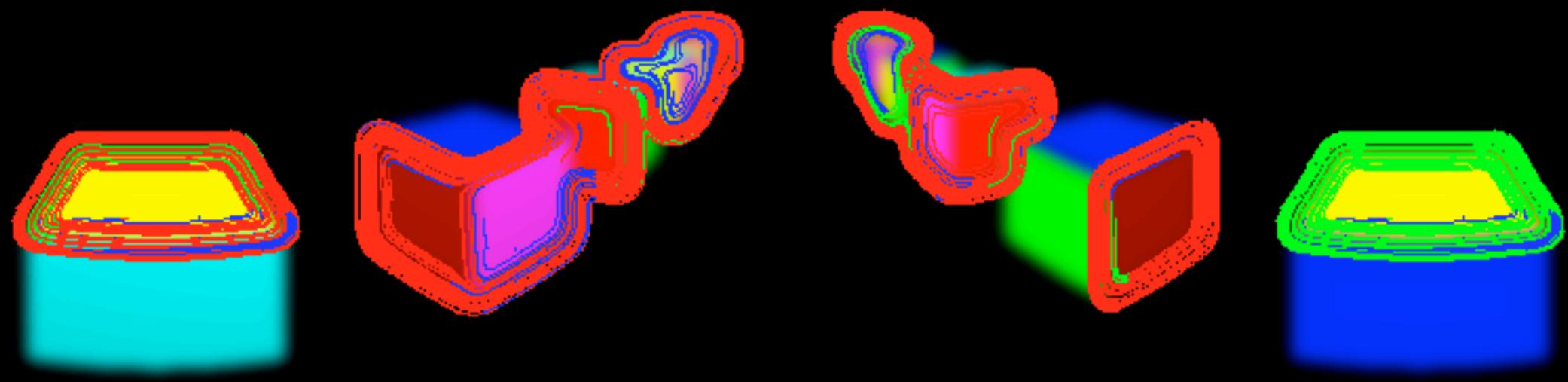
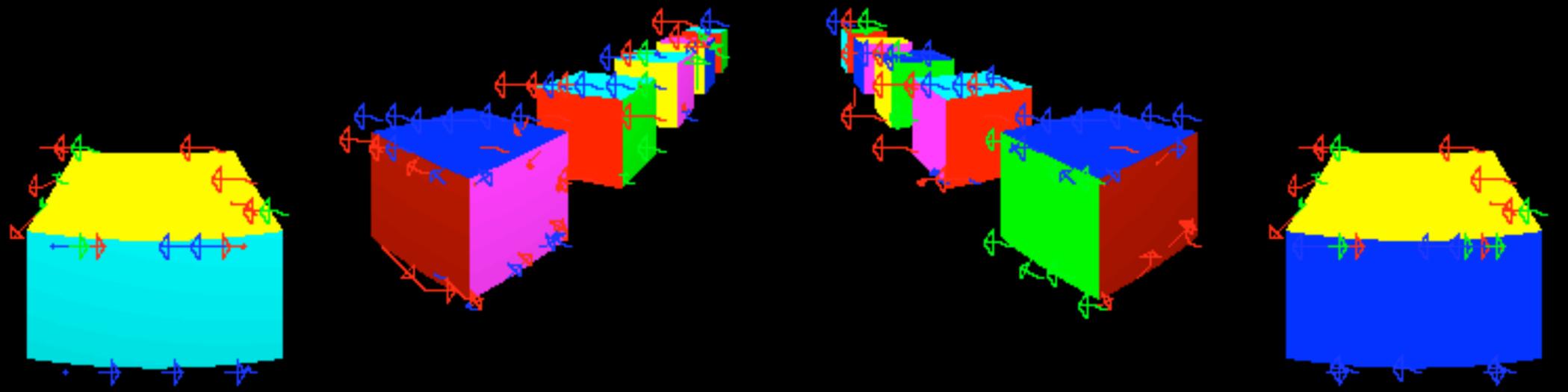
PATTERNS



Jose Ramirez-Heran











Some Computing

SCHICKARD

“Father of computer Age”



“Start of Computer History”



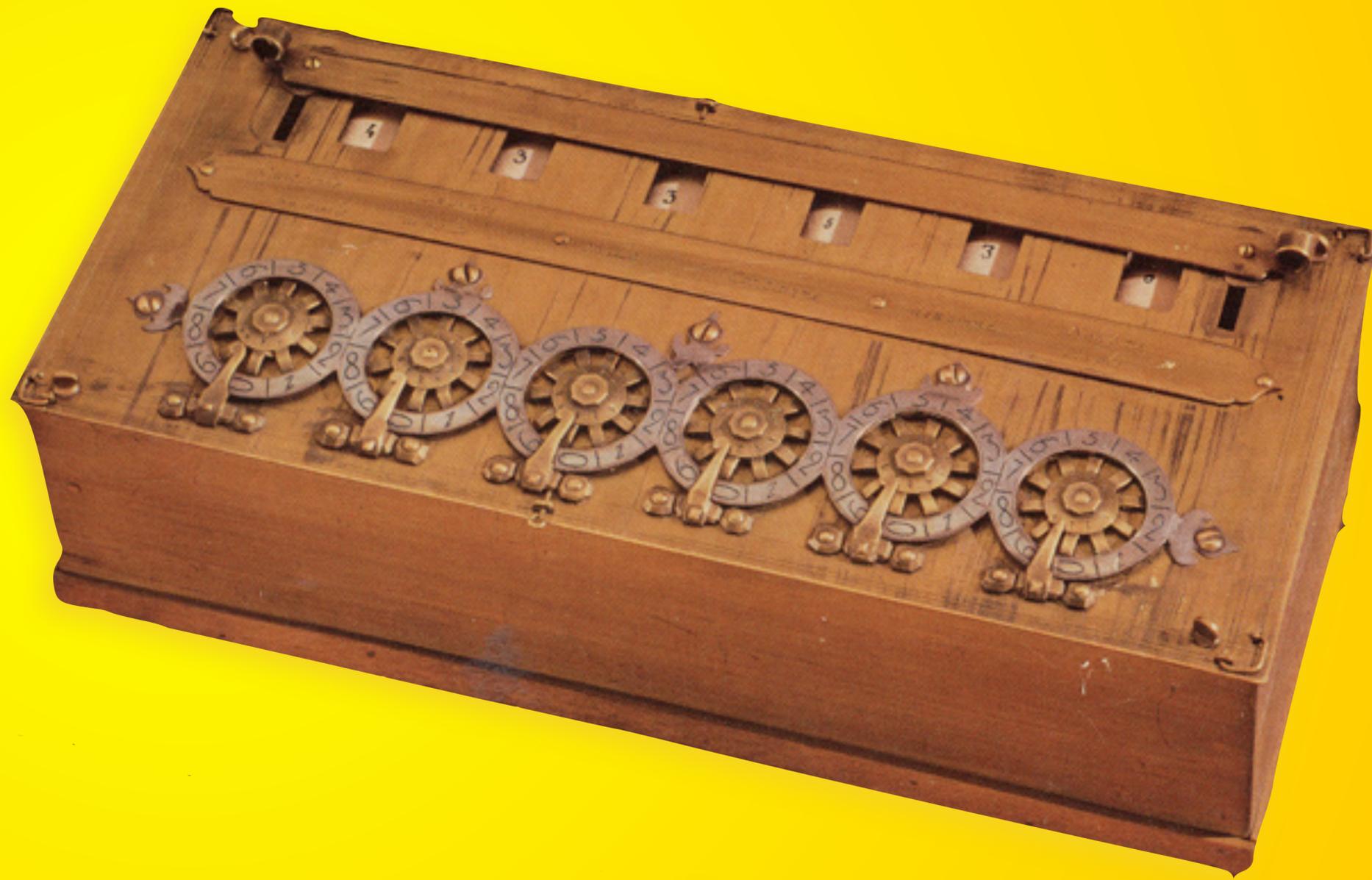
Wilhelm Schickard(1592-1635)

1623 First automatic Calculator

BLAISE PASCAL



1623-1663

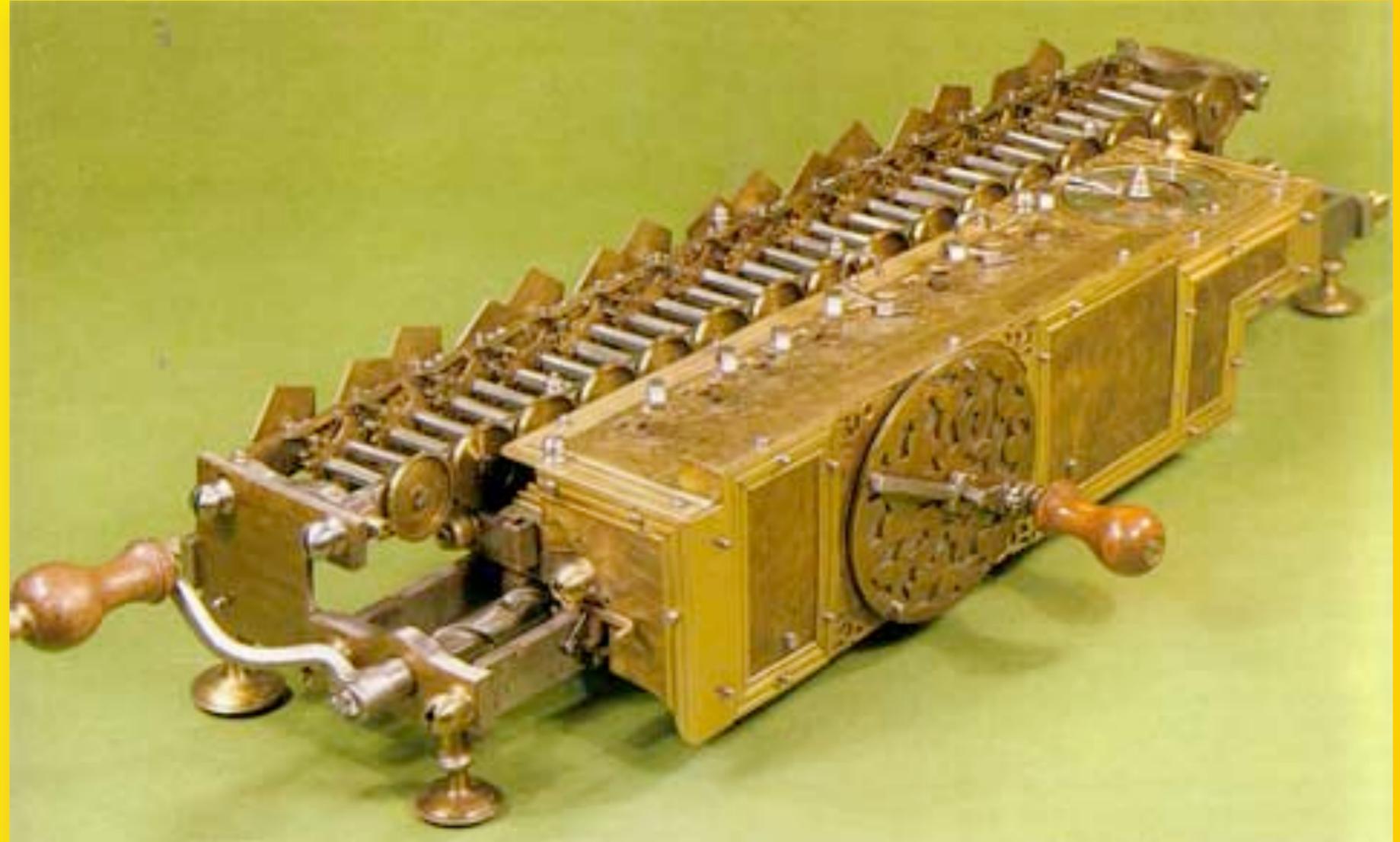


Mechanical Calculator

LEIBNIZ MULTIPLIER

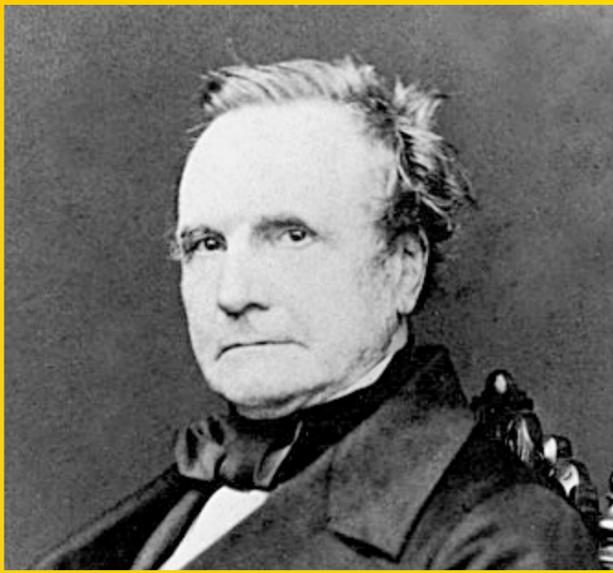


1672-1694



“step reckoner”
all four operations

DIFFERENCE ENGINE



1791 – 1871
Charles Babbage

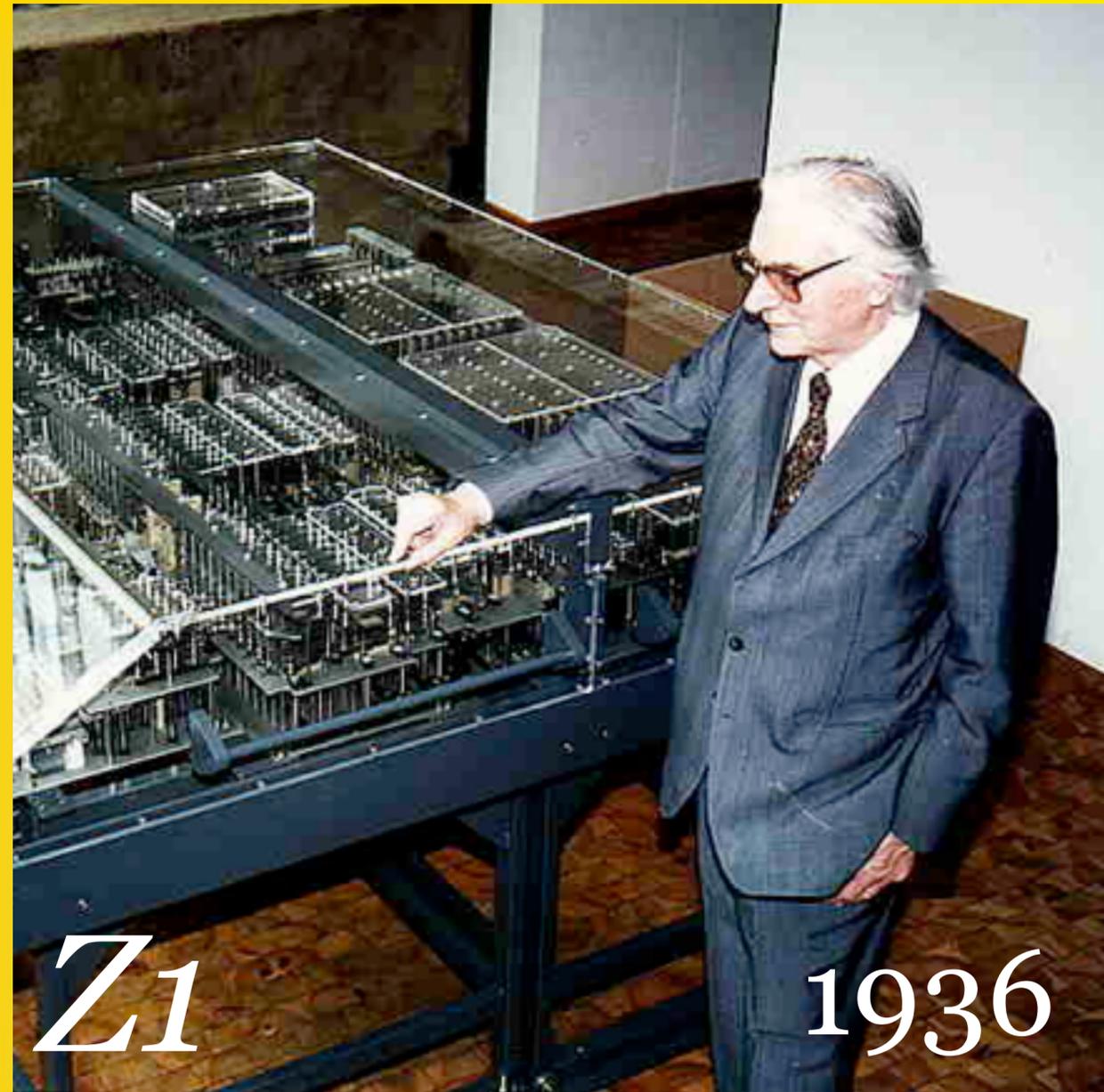


Ada Lovelace
1815-1852

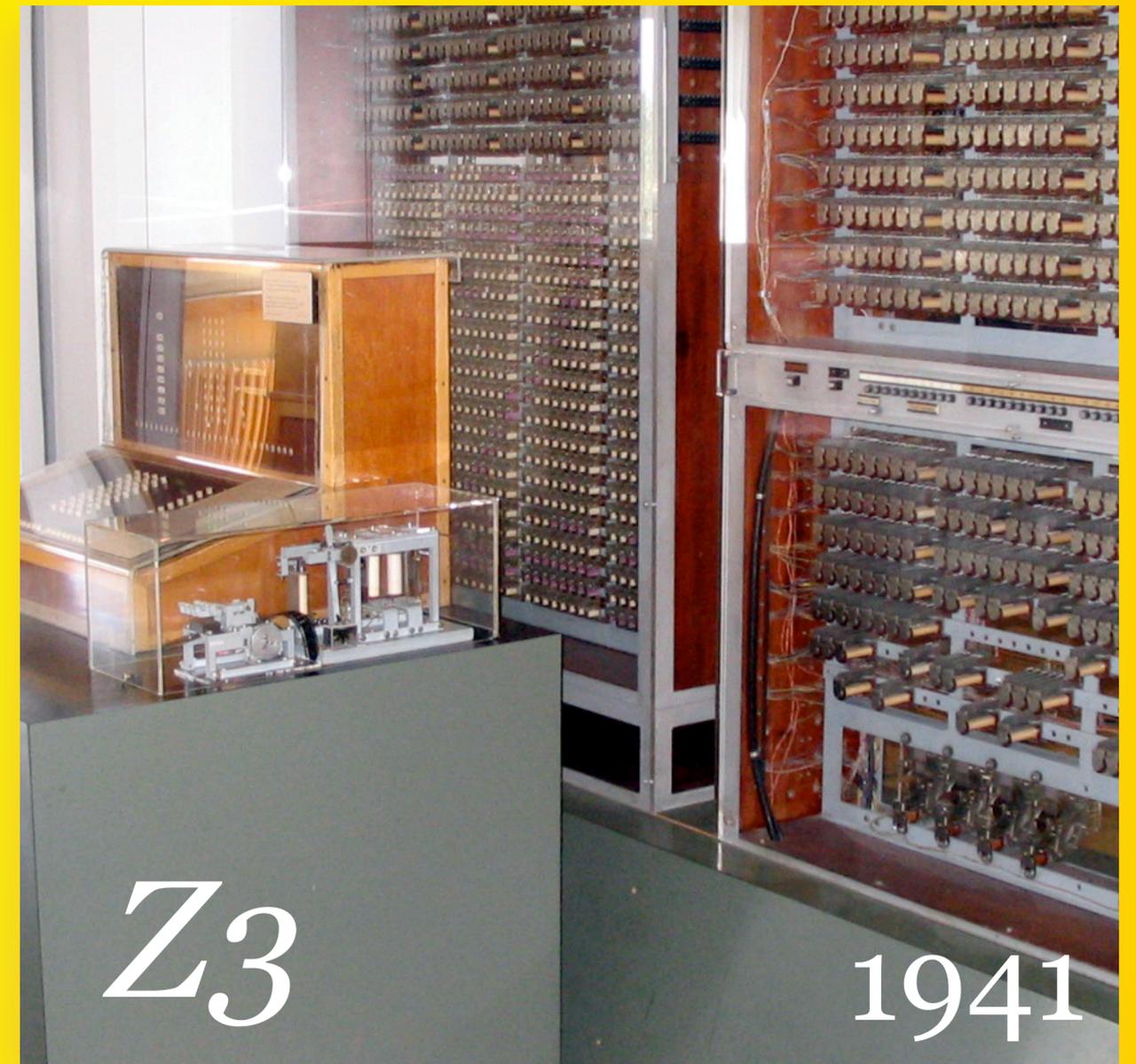


1822: first general
purpose programmable computer

KONRAD ZUSE



**First freely
programmable computer**

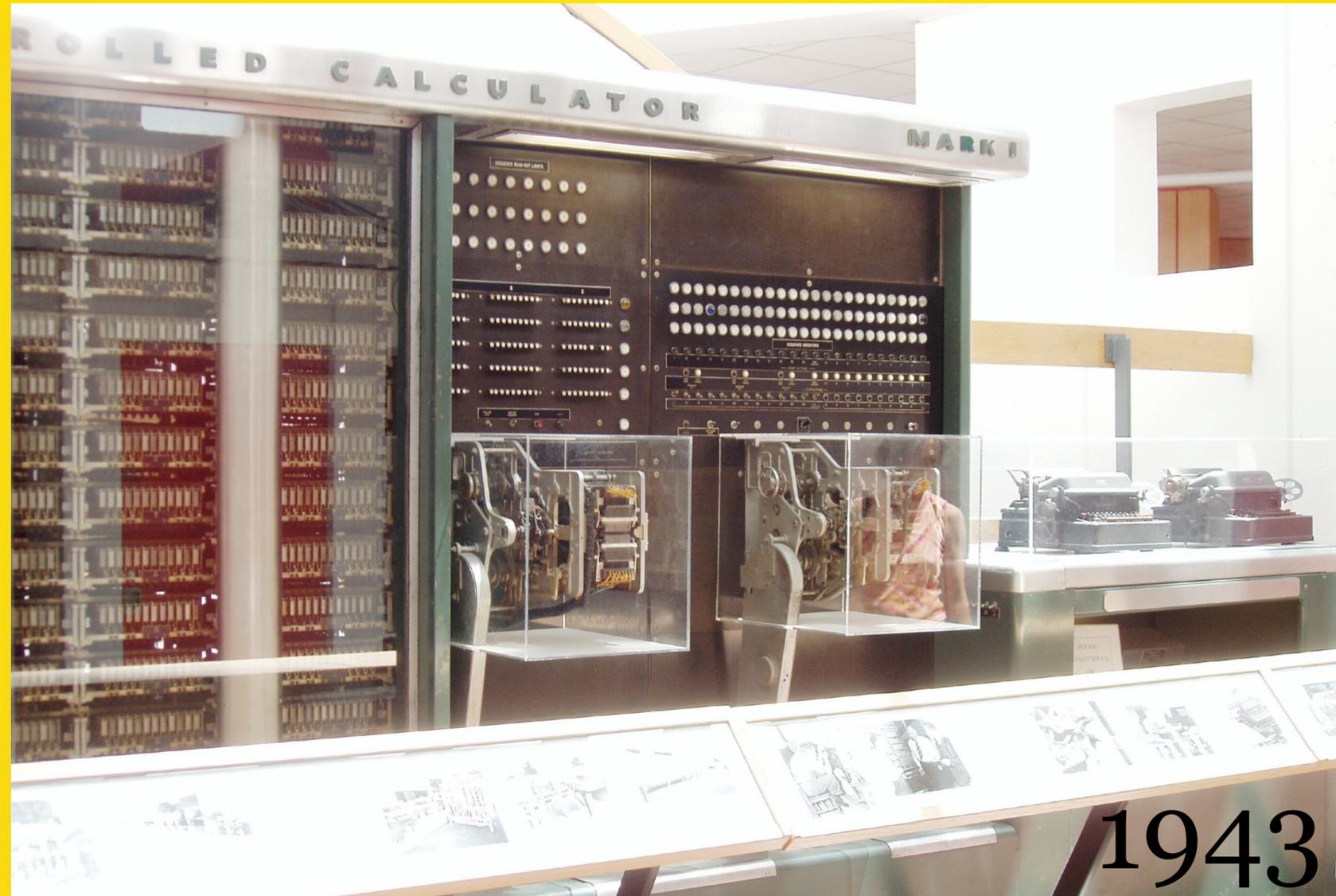


**First Turing
complete computer**

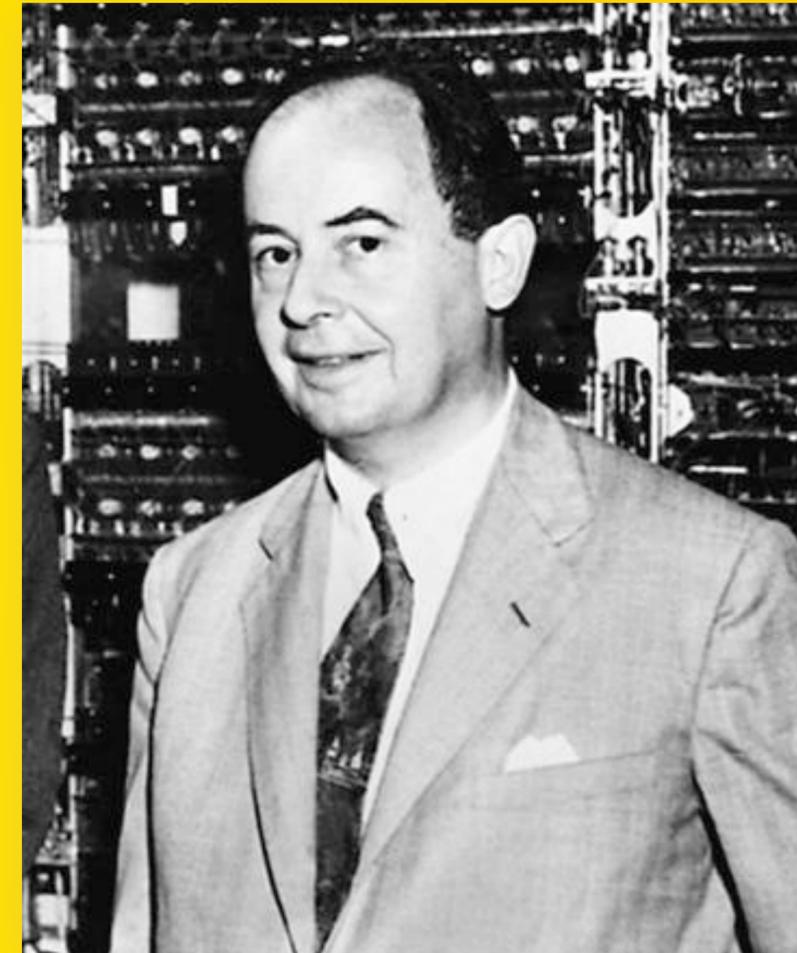
MARK I



Grace Hopper
1906 -1992

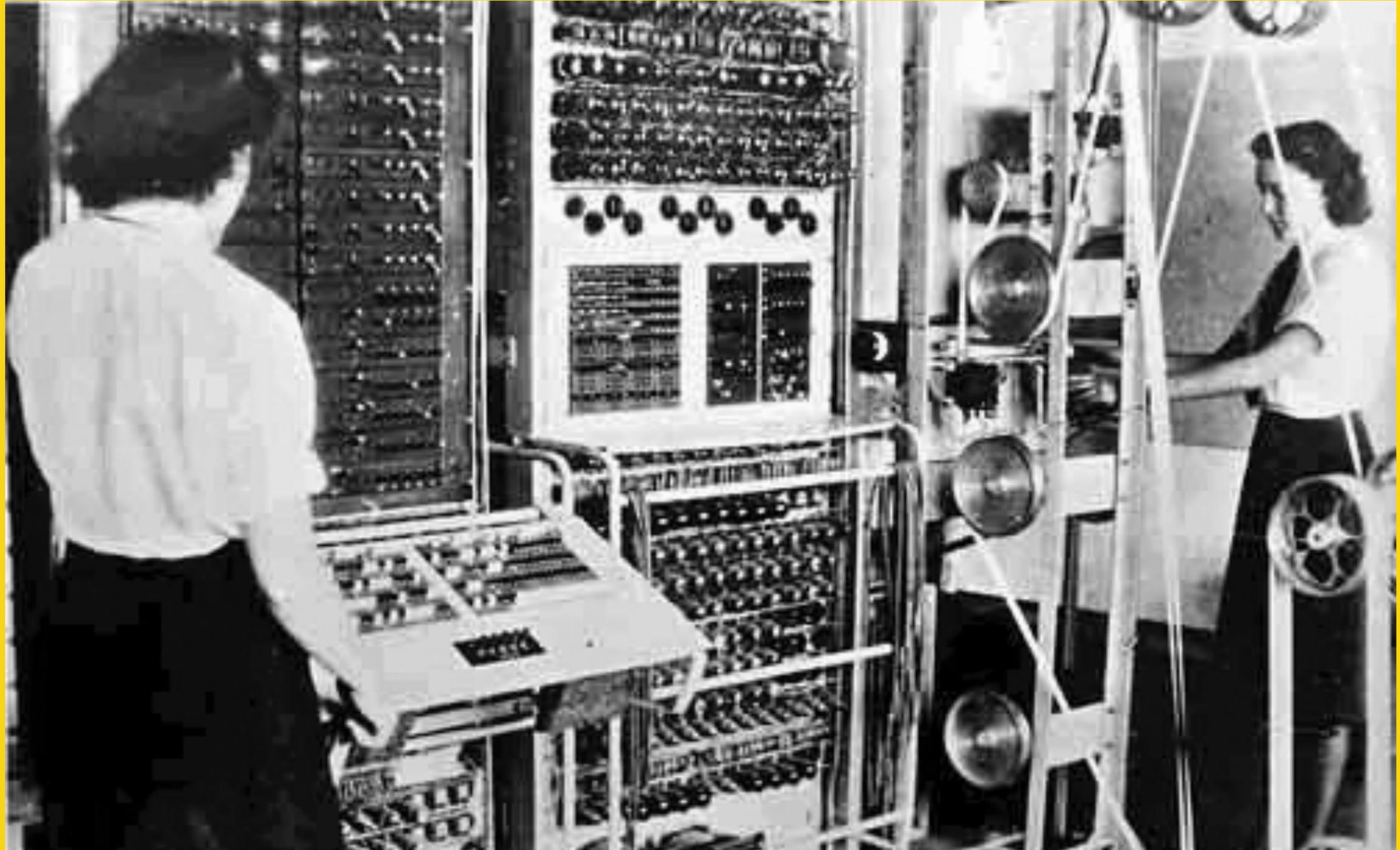


Electric programmable computer.



Von
Neumann
1903 -1957

COLOSSUS



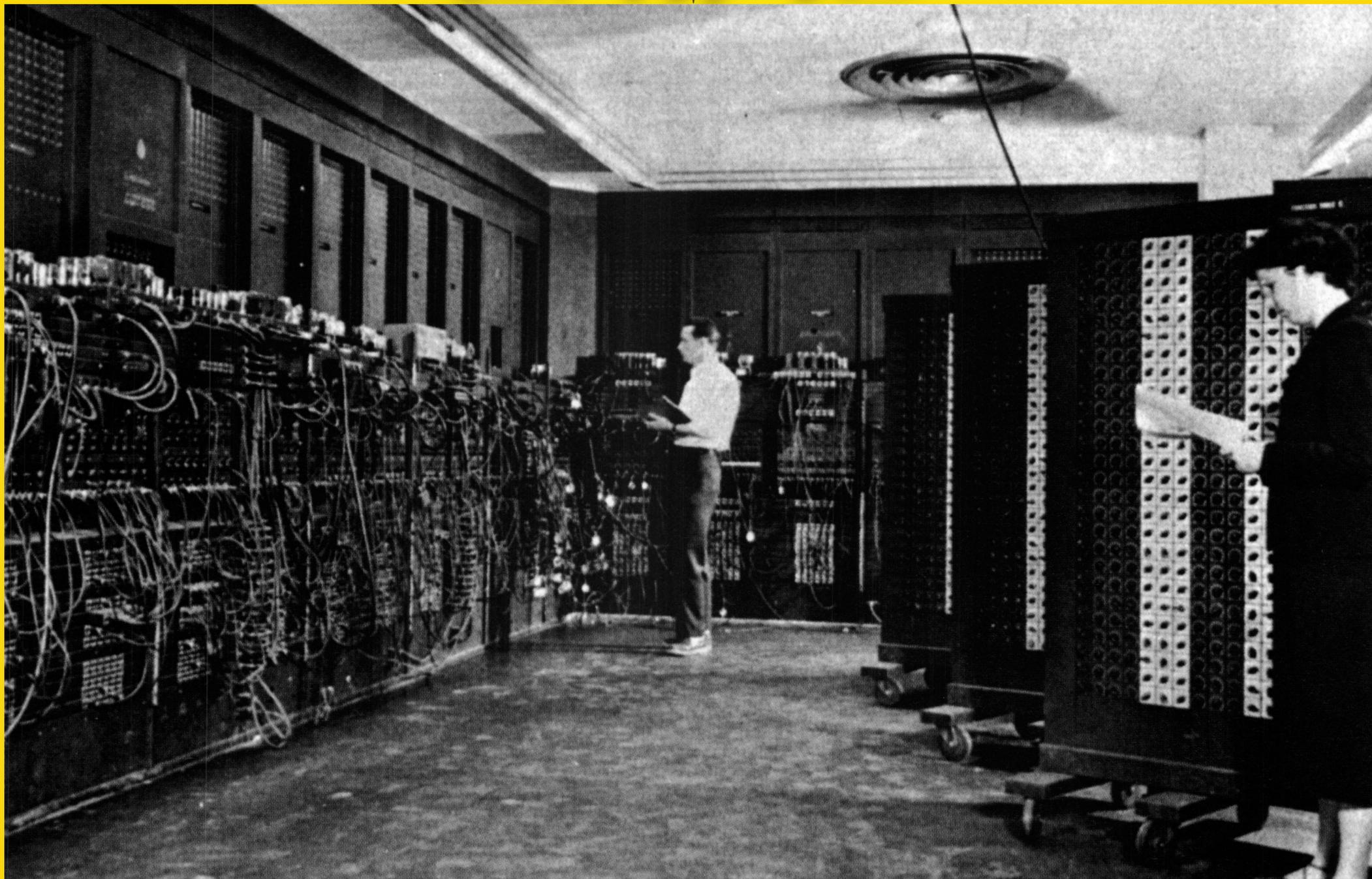
Wrens
Dorothy
Du
Boisson

Elsie
Booker

First electronic digital programmable computer.

1944

ENIAC



First electronic programmable Turing complete computer
Used to study feasibility of atomic bombs.

1946

CALCULATORS



Oliver's TI 59 1980

Oliver Knill

Schaltinterface für TI-59, TI-58, TI-57

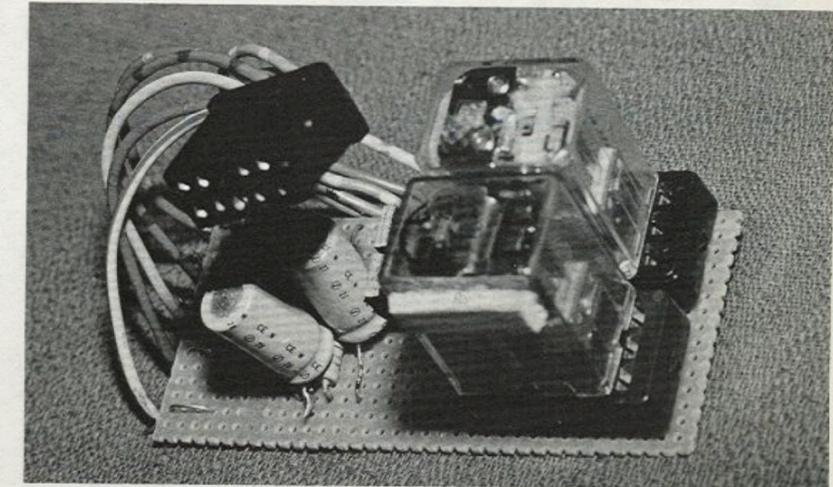
Es sind schon viele gute Bauanleitungen für ein Schaltinterface in CHIP publiziert worden. Warum denn ein anderes bauen? Ich suchte eine Schaltung, die es möglich macht, mehrere Kanäle zu steuern. Dafür eignet sich die Anzeige des Rechners als Schnittstelle sehr gut. Eine 7-Segment-Anzeige ist einfach aufgebaut. Wenn zum Beispiel Leitung 1 und 8 angesteuert werden, so leuchtet das oberste Segment. Umgekehrt: Wenn das oberste Segment leuchtet, kann bei 1 und 8 eine Spannung abgegriffen werden. Diese Spannung wird nun verstärkt und schaltet ein Relais. In der Anzeige können die Zahlen 0 bis 9 stehen. Betrachten wir das obere und mittlere waagerechte Segment. Es reichen die Ziffern 1, 4, 7, 8, um zwei Kanäle voll zu steuern. Bei den Modellen TI-58, TI-59 sind zehn Ziffern da. Es könnten also 20 Kanäle gesteuert werden. Das gibt aber Probleme:

- Die Kosten für 20 Kanäle sowie der Arbeitsaufwand wären hoch.
- Es müssen 22 Leitungen vom Rechnerinnern nach draußen geführt werden.
- Im Extremfall müssen 20 Relais durchgeschaltet werden.

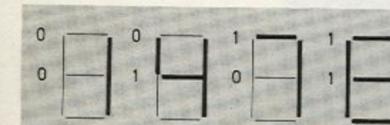
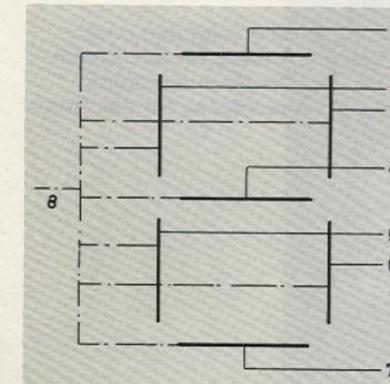
Ich habe mich deshalb entschlossen, zuerst nur zwei Kanäle auszubauen.

Die Schaltung

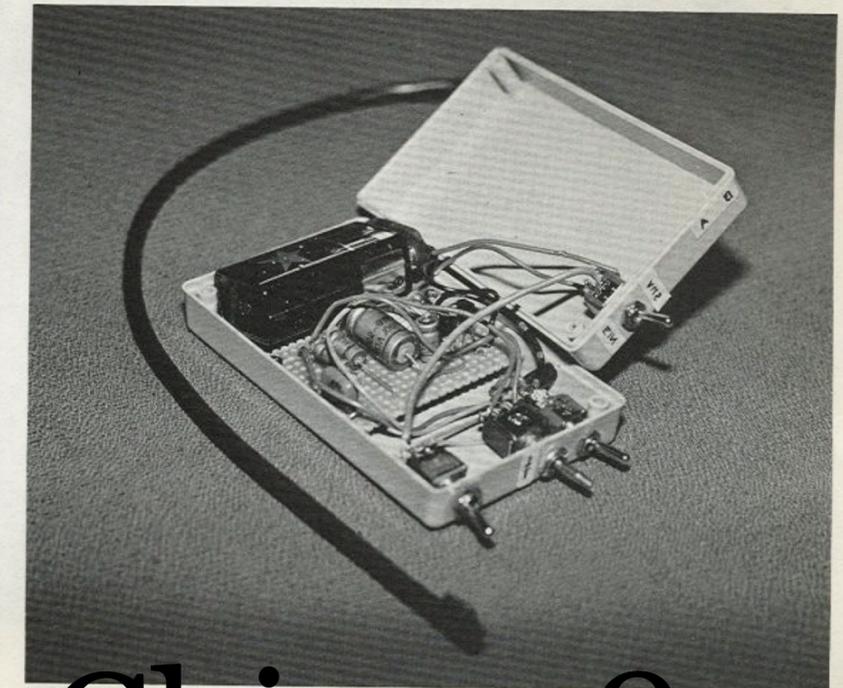
Der Schaltplan ist sehr einfach und kann auch von Computerfans aufgebaut werden, die über keine große Elektronik-erfahrung verfügen.



Versuchsaufbau des Schaltinterface mit zwei Relais



Segmentaufbau und Ansteuerung



Geöffnetes Gehäuse mit Batterie für das Schaltinterface

PC'S



12 KB ROM



Oliver

1980

ATARI ST

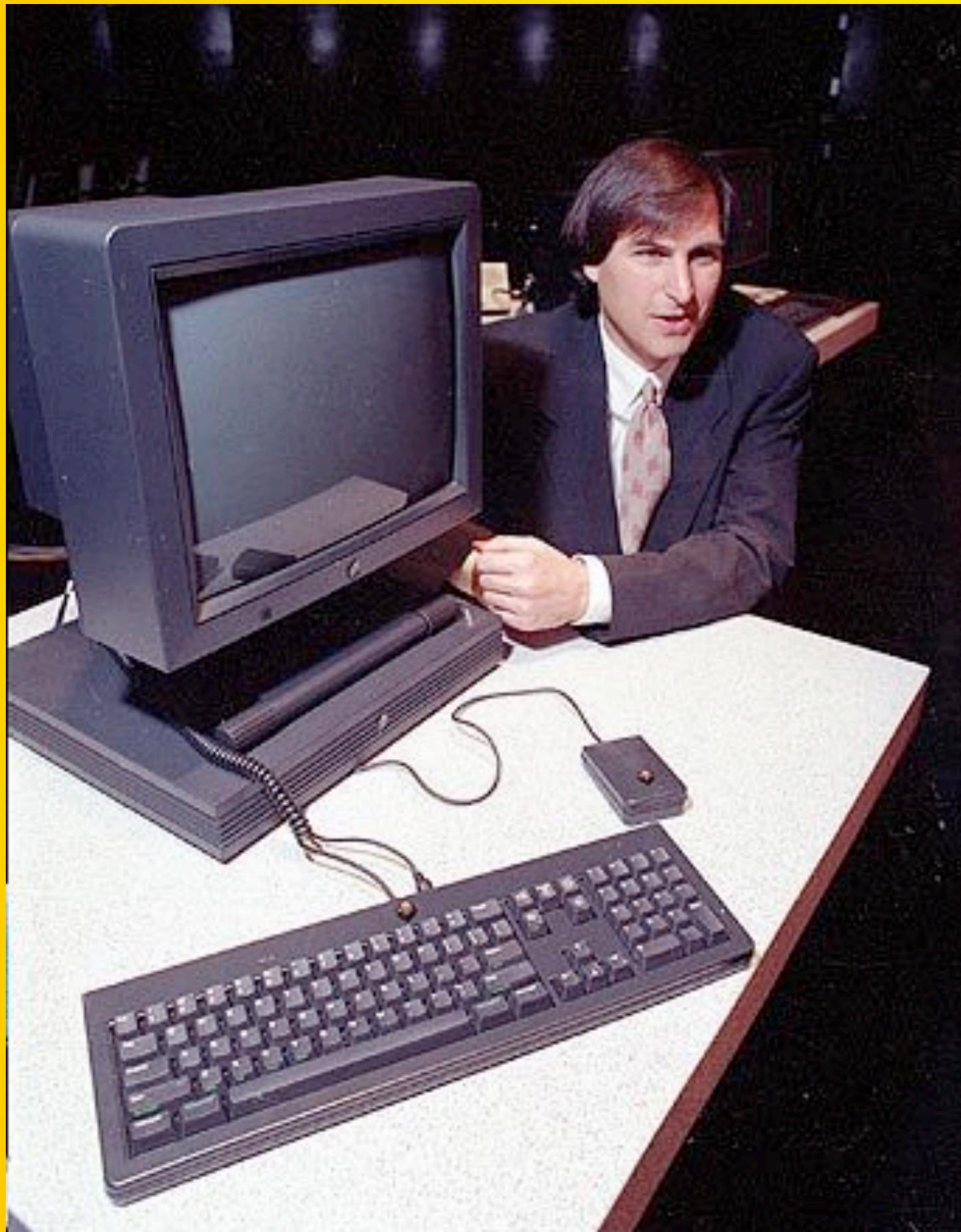
GEM
user
interface

games

MIDI



1985



NEXT

1988

NEXT



*1 Sun workstation, 1 Next workstation
3 Mac computers, 1 Dell PC (linux)*

1997



Photo: William Stein *G4* *2002*



IPHONES

© bitsnapper.com

“Evolution of Apple iPhone family”



iPhone (1st gen)

Launched on:
June 29, 2007

Software LC:
iPhone OS 1.0
to
iPhone OS 3.1.3



iPhone 3G

Launched on:
July 11, 2008

Software LC:
iPhone OS 2.0
to
iPhone OS 4.2.1



iPhone 3GS

Launched on:
June 19, 2009

Software LC:
iPhone OS 3.0
to
iPhone OS 6.1.6



iPhone 4

Launched on:
June 24, 2010

Software LC:
iPhone OS 4.0
to
iPhone OS 7.1.2



iPhone 4s

Launched on:
Oct 14, 2011

Software LC:
iPhone OS 5.0
to
iPhone OS 8.4
(present)



iPhone 5

Launched on:
Sept 21, 2012

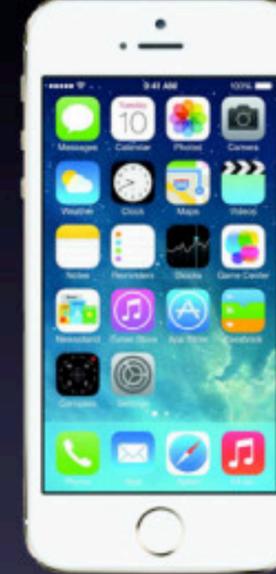
Software LC:
iPhone OS 6.0
to
iPhone OS 8.4
(present)



iPhone 5c

Launched on:
Sept 20, 2013

Software LC:
iPhone OS 7.0
to
iPhone OS 8.4
(present)



iPhone 5s

Launched on:
Sept 20, 2013

Software LC:
iPhone OS 7.0
to
iPhone OS 8.4
(present)



iPhone 6

Launched on:
Sept 19, 2014

Software LC:
iPhone OS 8.0
to
iPhone OS 8.4
(present)



iPhone 6 Plus

Launched on:
Sept 19, 2014

Software LC:
iPhone OS 8.0
to
iPhone OS 8.4
(present)

WATCHES



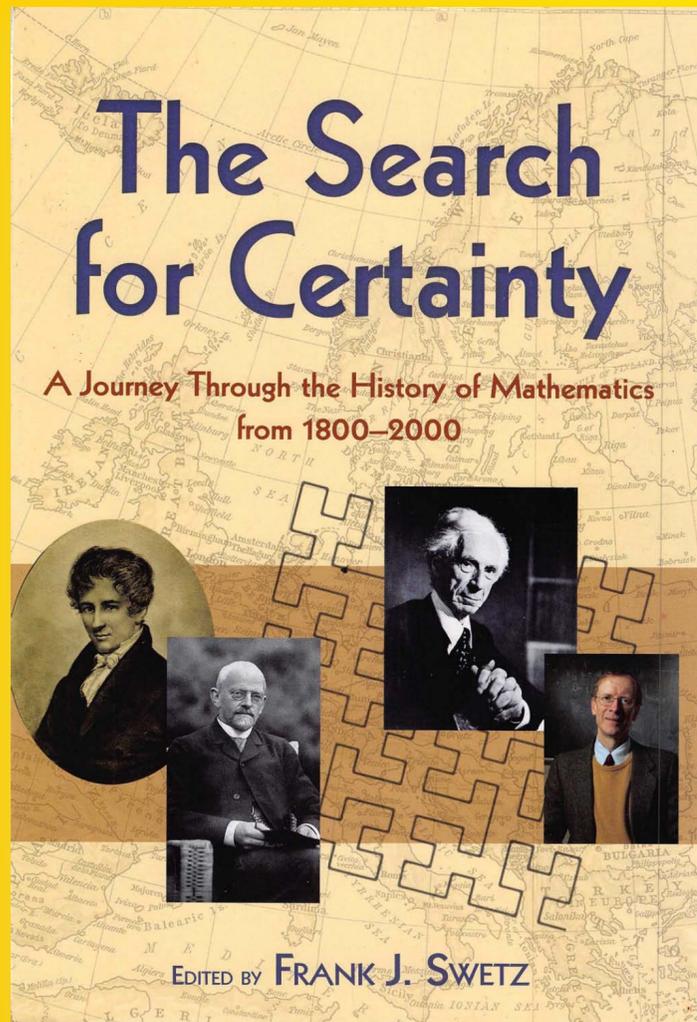
CHRONO LOGY

A Chronological Outline of the Evolution of Computing Devices

SINCE VERY EARLY TIMES, humans have sought to simplify the tasks of numerical record keeping and computation by using physical devices. These devices have varied greatly in scope and context from the adaption of personal body parts such as fingers and toes for simple 1:1 tallying to the use of inanimate objects, notched sticks, and knotted cords for numerical record keeping to the operation of complex mechanical and electrical machines for scientific calculations. Today's high-speed digital computers can trace their origins to the finger manipulations of our ancient ancestors. The path of this evolution is outlined in the list of accomplishments and names of individuals given below.

Date	Accomplishment or Event
?	Use of hands and fingers to communicate numerical facts
ca. 30,000 B.C.	Tally bones recovered from European sites
ca. 8000 B.C.	Clay tokens used in Babylonia for numerical record keeping
ca. 600 B.C.	Abacus used in Classical Greece
ca. 500 B.C.	Computing rods and counting board introduced in China
ca. A.D. 600	With the collapse of Imperial Rome, use of the column abacus dominates European computing. In European setting evolves into a line abacus computing table which remains in use until time of late Renaissance.
ca. A.D. 1400	Quipu used by Inca people of pre-Columbian America
A.D. 1614	John Napier develops logarithms, invents Napier's rods for carrying out multiplication
1620	Edmund Gunter develops logarithmic scale basis for slide rule capable of performing four basic operations
1623	Wilhelm Schickard invents computing machine that can perform four operations
1642	Blaise Pascal builds gear-driven computer that can perform addition and subtraction with six-digit numbers
1671	Gottfried Wilhelm Leibniz refines design of gear computer to include "stepped cylinders" allowing for operation of multiplication and division by repeated additions or subtraction.
1673	Sir Samuel Morland invents multiplying machines in England
1805	Joseph Marie Jacquard develops punch card input for textile looms
1820	Thomas de Colmar standardizes design for mechanical computing machines

1830	Charles Babbage conceives of great computing engines capable of 26-digit computations. Babbage's designs incorporate specifications of modern digital computers, i.e., input, processing unit, output.
1875	Frank Baldwin obtains American patent for popular calculating machine
1941	Konrad Zuse develops Z3, a relay calculator possessing 64 word memory
1944	Automatic Sequence Controlled Calculator (ASCC) built at Harvard
1945	Electronic Numerical Integrator and Computer (ENIAC) begins operation at University of Pennsylvania, contains 18,000 vacuum tubes, performs 360 multiplication/sec. John von Neumann develops Electronic Discrete Variable Calculator (EDVAC) at University of Pennsylvania.
1947	Transistor developed at Bell Laboratories
1951	U.S. Census Bureau accepts delivery of Remington Rand UNIVAC 1. The computer contains 5000 vacuum tubes and performs 1000 calculations/sec.
1953	Magnetic core memory introduced into computers
1957	Fortran programming language introduced
1959	Concept of integrated circuits conceived by Robert Noyce
1960	Cobol language introduced
1964	IBM 360 marketed, employs binary addressing, introduces cheap feasible time-sharing and virtual memory. Basic language introduced
1968	First Ph.D. in computer science awarded at University of Pennsylvania
1969	UNIX operating system introduced Edgar Codd proposes relational database model to IBM
	Intel develops microprocessor
1970	Floppy disc introduced
1971	Pascal language introduced First pocket calculators appear
1975	Microcomputers marketed
1976	Cray 1 supercomputer becomes operational Kenneth Appel and Wolfgang Haken resolve 4-color conjecture using a computer
1980	Ada language introduced
1985	The Connection Machine developed by Thinking Machines Corporation, a highly parallel supercomputer possessing 65,536 processors
1988	Computer networking well established



From the Literature:

A Chronological Outline of the Evolution of Computing Devices

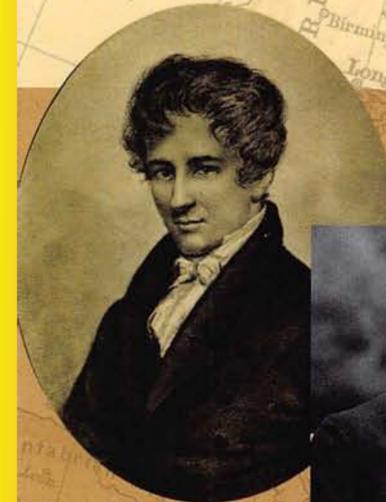
SINCE VERY EARLY TIMES, humans have sought to simplify the tasks of numerical record keeping and computation by using physical devices. These devices have varied greatly in scope and context from the adaption of personal body parts such as fingers and toes for simple 1:1 tallying to the use of inanimate objects, notched sticks, and knotted cords for numerical record keeping to the operation of complex mechanical and electrical machines for scientific calculations. Today's high-speed digital computers can trace their origins to the finger manipulations of our ancient ancestors. The path of this evolution is outlined in the list of accomplishments and names of individuals given below.

Date	Accomplishment or Event
?	Use of hands and fingers to communicate numerical facts
ca. 30,000 B.C.	Tally bones recovered from European sites
ca. 8000 B.C.	Clay tokens used in Babylonia for numerical record keeping
ca. 600 B.C.	Abacus used in Classical Greece
ca. 500 B.C.	Computing rods and counting board introduced in China
ca. A.D. 600	With the collapse of Imperial Rome, use of the column abacus dominates European computing. In European setting evolves into a line abacus computing table which remains in use until time of late Renaissance.
ca. A.D. 1400	Quipu used by Inca people of pre-Columbian America
A.D. 1614	John Napier develops logarithms, invents Napier's rods for carrying out multiplication
1620	Edmund Gunter develops logarithmic scale basis for slide rule capable of performing four basic operations
1623	Wilhelm Schickard invents computing machine that can perform four operations
1642	Blaise Pascal builds gear-driven computer that can perform addition and subtraction with six-digit numbers
1671	Gottfried Wilhelm Leibniz refines design of gear computer to include "stepped cylinders" allowing for operation of multiplication and division by repeated additions or subtraction.
1673	Sir Samuel Morland invents multiplying machines in England
1805	Joseph Marie Jacquard develops punch card input for textile looms
1820	Thomas de Colmar standardizes design for mechanical computing machines

1830	Charles Babbage conceives of great computing engines capable of 26-digit computations. Babbage's designs incorporate specifications of modern digital computers, i.e., input, processing unit, output.
1875	Frank Baldwin obtains American patent for popular calculating machine
1941	Konrad Zuse develops Z3, a relay calculator possessing 64 word memory
1944	Automatic Sequence Controlled Calculator (ASCC) built at Harvard
1945	Electronic Numerical Integrator and Computer (ENIAC) begins operation at University of Pennsylvania, contains 18,000 vacuum tubes, performs 360 multiplication/sec. John von Neumann develops Electronic Discrete Variable Calculator (EDVAC) at University of Pennsylvania.
1947	Transistor developed at Bell Laboratories
1951	U.S. Census Bureau accepts delivery of Remington Rand UNIVAC 1. The computer contains 5000 vacuum tubes and performs 1000 calculations/sec.
1953	Magnetic core memory introduced into computers
1957	Fortran programming language introduced
1959	Concept of integrated circuits conceived by Robert Noyce
1960	Cobol language introduced
1964	IBM 360 marketed, employs binary addressing, introduces cheap feasible time-sharing and virtual memory. Basic language introduced
1968	First Ph.D. in computer science awarded at University of Pennsylvania
1969	UNIX operating system introduced Edgar Codd proposes relational database model to IBM Intel develops microprocessor
1970	Floppy disc introduced
1971	Pascal language introduced First pocket calculators appear
1975	Microcomputers marketed
1976	Cray 1 supercomputer becomes operational Kenneth Appel and Wolfgang Haken resolve 4-color conjecture using a computer
1980	Ada language introduced
1985	The Connection Machine developed by Thinking Machines Corporation, a highly parallel supercomputer possessing 65,536 processors
1988	Computer networking well established
1990	Introduction of Windows 3.0 by Bill Gates and Microsoft
1993	Intel Pentium released
1995	Java Script development announced by Netscape
1996	Netscape Navigator 2.0 released
1997	IBM's Deep Blue beats Chess Champion Gary Kasparov
1999	Linux Kernel 2.2.0 released important operating system in Unix world
2001	Apple releases Mac OSX
2002	Edgar Dykstra dies—noted for shortest path algorithm (1956)
2003	Sir Tim Berners-Lee knighted in recognition of creation of World Wide Web

The Search for Certainty

A Journey Through the History of Mathematics
from 1800–2000



EDITED BY FRANK J. SWETZ

Lecture 32: Worksheet

This worksheet as well as the solutions was generated by Sofia, a bot written in the academic year 2003/2004 using grant from the Harvard Provost together with Harvard students **Johnny Carlsson**, **Andrew Chi** and **Mark Lezama**. At that time, people have laughed at the chat bot idea. Now it is big business: Google, Siri, Cortana, Wolfram alpha: these are all AI bots which constantly become more and more sophisticated.

1 Differentiate the following functions:

a) $f(x) = 4(x + \tan(x))$

b) $f(x) = x^4 + x$

c) $f(x) = 4(x + \log(x))$

2 Integrate the following functions:

a) $f(x) = 3$

b) $f(x) = -3 \sin(x)$

c) $f(x) = 1 - e^x$

3 Differentiate the following functions:

a) $f(x) = 0$

b) $f(x) = \frac{3}{\sqrt{x}}$

c) $f(x) = x \log(x) \sec(x)$

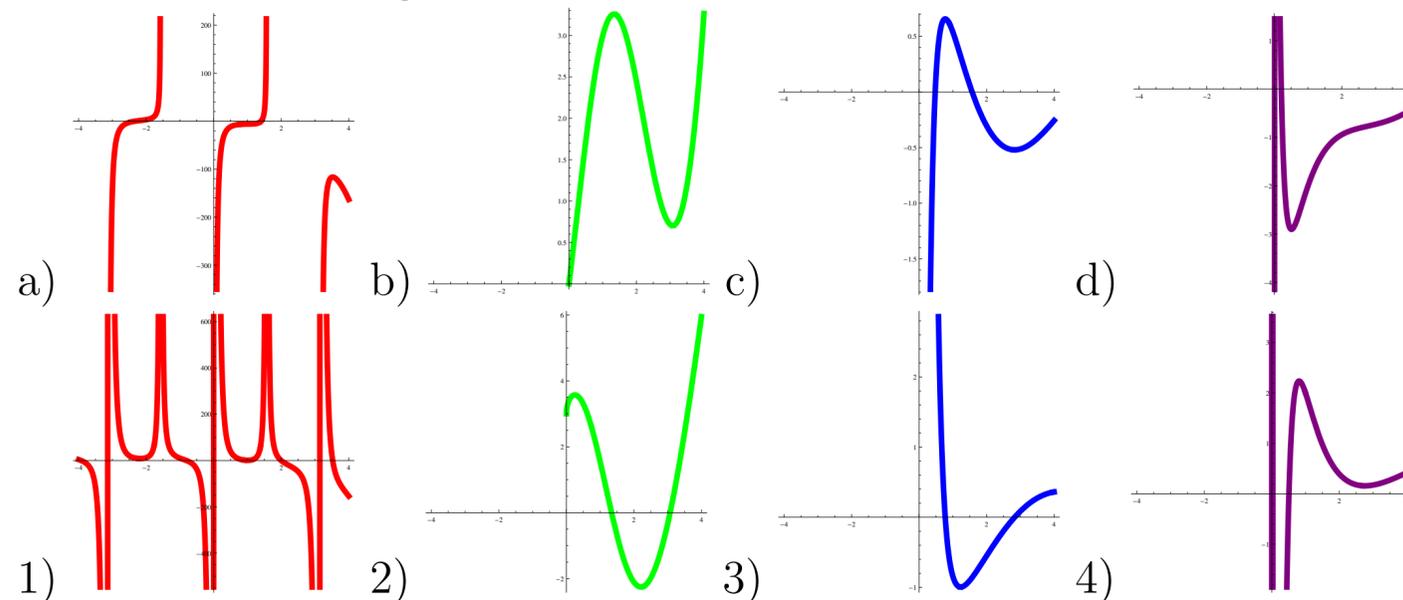
4 Integrate the following functions:

a) $f(x) = 30x^4 \sqrt{x^5}$

b) $f(x) = 3 \left(\frac{1}{x^2} + e^x + 1 \right)$

c) $f(x) = -e^{-x}(x - 2)x$

5 Match the following functions with derivatives:



The End