A story from thinking clearly (logic) → to representing that thinking (sets, symbols) → to sending information (communication systems)

+0,2 5.3.2026

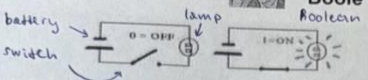
Massachusetts Institute of Technology (MIT)

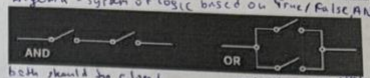
Lecture by Pr. Bob Gallagher

Boole (1815-1864) & **Shannon** (1916-2001) "father of information theory"

Shannon → he showed how info can be measured in bits

Boolean Algebra - system of logic based on True/False AND, OR, NOT





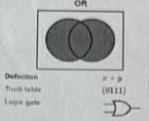
both should be closed — at least one switch must be closed

Logical addition (disjunction)

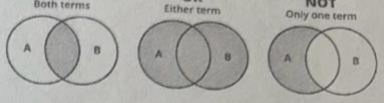
A	B	A ∨ B
True	True	True
True	False	True
False	True	True
False	False	False

A or B

Logical disjunction



BOOLEAN LOGIC



Boolean symbols:
∧ - and
∨ - or
¬ - not

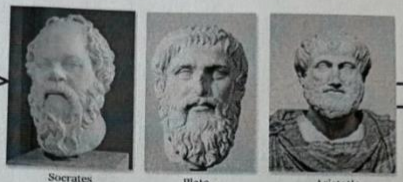
A	B	F=A∨B
0	0	0
0	1	1
1	0	1
1	1	1

A ∨ B is true if either or both are true

Good logic


Socrates

Socrates was a philosopher

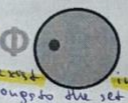


philosophers are men

Socrates was a man

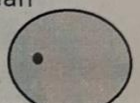
Difference:

Aristotelian logic
- we consider categories (men, Φ)
- we use Syllogisms (we have connecting term that exists in two claims but does not exist in conclusion)



Socrates belongs to the set of philosophers (Φ)

Philosophers are a subset of men (A)

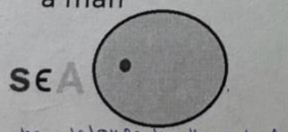


Socrates belongs to the set of men (A)

Boolean logic -
mathematical, symbolic
- we consider True/False values
- we use Truth Tables
- computers, circuits, programming

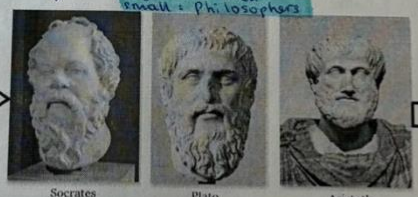
Bad logic

Socrates was a man

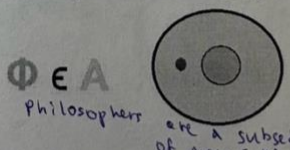


Socrates belongs to the set of men (A)

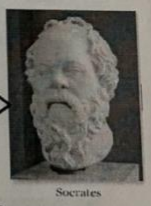
big circle: Men
small: Philosophers



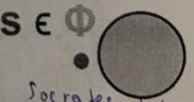
philosophers are men



Philosophers are A subset of men (A)

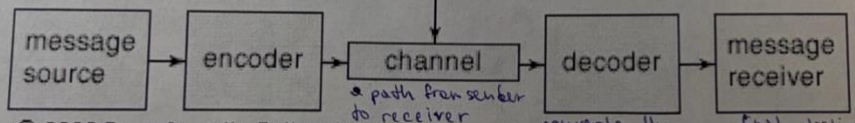


Socrates was a philosopher



Socrates belongs to Philosophers (Φ)

Shannon's communication model



anything that disturbs a signal while it travels (errors or less clear)

path from sender to receiver

converts the received signal back into a message

final destination of a message

Humans often use logic incorrectly when emotions, beliefs or power are involved.
All criminals are poor → you are poor → you are a criminal (example of a bad logic).
choosing only the facts that support your argument and ignoring the rest.

People defend identity, not truth.

Resume of Lecture by Pr. Bob Gallagher from MIT

Massachusetts Institute of Technology (MIT)

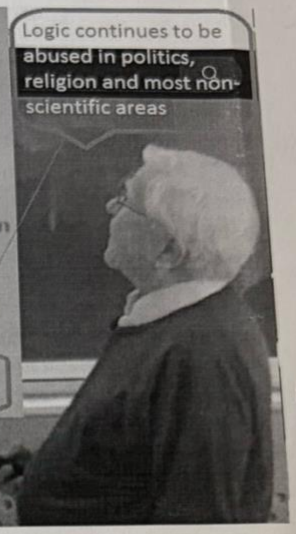
George Boole (1815-1864) developed Boolean logic

The principles of logical thinking have been understood (and occasionally used) since the Hellenic era.

Boole's contribution was to show how to systemize these principles and express them in equations (called Boolean logic or Boolean algebra).

Claude Shannon (1916-2001) showed how to use Boolean algebra as the basis for switching technology. This conribution systemized logical thinking for computer and communication systems, both for the design and programming of the systems and their applications.

Logic continues to be abused in politics, religion, and most non-scientific areas.

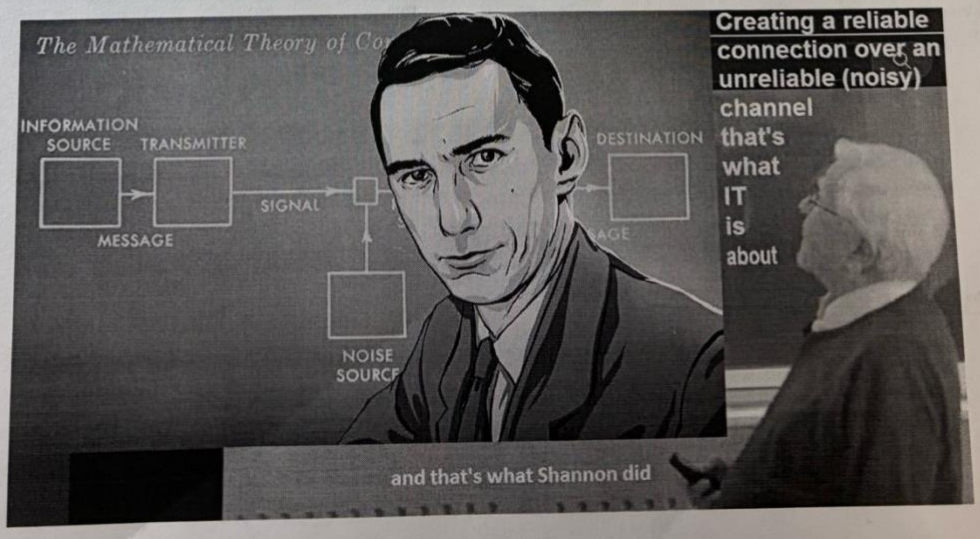


Kant Gauß Goethe

A little nationalistic, but this is an sample of right logic

Kant, Gauss, Goethe are great → Kant, Gauss, Goethe - Germans → Germany Great

Bad logic (abuse of logic)



Step 5.

Now we need to compile the file using the compiler csc.exe which is in the folder

C:\Windows\Microsoft.NET\Framework\v3.5

C:\WINDOWS\Microsoft.NET\Framework\v3.5\csc.exe ABBA.cs

the result is a file ABBA.exe that can already be run (which is located in the same folder). If you have taken the 1st step, then this means that the education-process has begun. This is victory. csc /target:library ABBA.cs - will make ABBA.dll.

```
>ABBA
ABBA
```

Step 6. Modify the file as follows

```
using System;

class ABBA
{
  static int Factorial(int n)
  {
    if (n == 1) return 1;
    return n * Factorial(n - 1);
  }

  static void Main(string[] args)
   // Here's a method called main.
   {
        System.Console.WriteLine("ABBA -"+
                                  Factorial(4));
   }
  }
```

```
>C:\WINDOWS\Microsoft.NET\Framework\v3.5\csc.exe ABBA.cs

>ABBA
ABBA – 24
```

Step 7. Modify the file as follows

```
using System;

class ABBA
{
  static int Factorial(int n)
  {
   if (n == 1) return 1;
    return n * Factorial(n - 1);
  }

public static void Main()
  {
   System.Console.WriteLine("ABBA");
   System.Console.Write("Enter number of Vovels:");
   string s = Console.ReadLine();
   int vovels=int.Parse(s);
   System.Console.Write("Enter number of Consonants:");
   s=System.Console.ReadLine();
   int consonants=int.Parse(s);
   Console.WriteLine(Factorial(vovels)*Factorial(consonants) );
  }
}
```

```
>ABBA
ABBA
Enter number of Vovels:2
Enter number of Consonants:2
4
```

```
>ABBA
ABBA
Enter number of Vovels:3
Enter number of Consonants:3
36
```

1 2 3 4

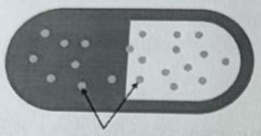
+0.1 17.6

This is the program we need to write today

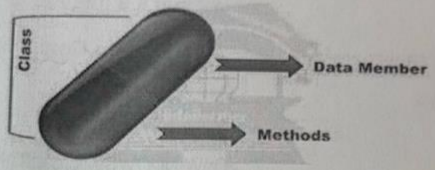
```
class ABBA
 {
 static void Main(string[] args)
                    // Here's a method called Main.
 {
    System.Console.WriteLine("ABBA!");
 }
}
```

So there's the keyword class. Unlike C++, in C# all code must be placed in a class.

Encapsulated in a class.



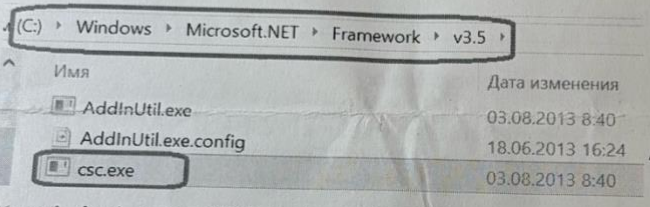
Medicines Inside Capsule



A ≠ a

C# is case sensitive

C:\WINDOWS\Microsoft.NET\Framework\v3.5\ csc.exe



ABBA.cs ⇒ csc.exe = ABBA.exe

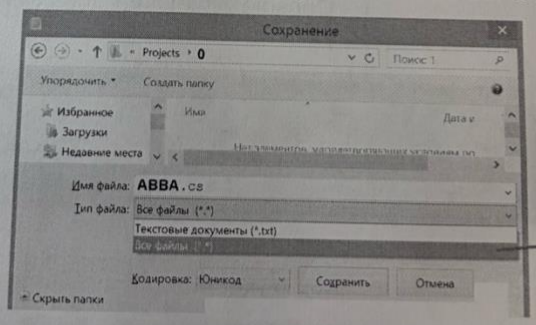
C# Compiler

Step 1. And on my HDD, I also make a folder with the same name D:\ IT

Step 2. In the folder **E:** IT\ we make the folder of the **Projects** - **E:\ IT\Projects**

And in the **Project** folder make folder **0 - E:\ IT\Projects\0** where our today's practical work will be stored

Step 3. As I mentioned above, C# is a built-in language of Windows. Notepad is enough to write a program



You need to switch from *.txt (Text documents) to *.* (all files)

Otherwise, notepad with *.txt extension

Step 4.Entering command mode

Start=>Run=>cmd

cd E: - After that go to the folder IT/Projects/0/

cd IT -Then go to the folder Projects

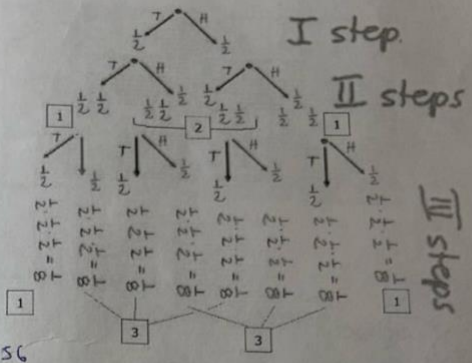
cd projects - Then go to the folder 0

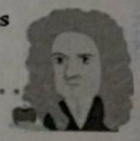
cd 0 –

```
E:\>cd IT
E:\IT>cd Projects
E:\IT\Projects>cd 0
E:\IT\Projects\0>
```

Pascal's triangle

1								← 1
1	1							← 2
1	2	1						← 4
1	3	3	1					← 8
1	4	6	4	1				← 16
1	5	10	10	5	1			← 32
1	6	15	20	15	6	1		← 64
1	7	21	35	35	21	7	1	← 128
1	8	28	56	70	56	28	8	1 ← 256





Newton's Binomial

$$(a+b)^0 = 1$$

$$(a+b)^1 = a + b$$

$$(a+b)^2 = a^2 + 2ab + b^2$$

$$(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$

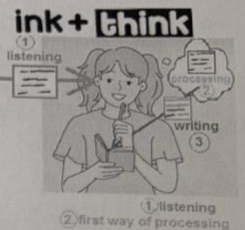
$$(a+b)^4 = a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$$

$$(a+b)^5 = a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5$$

$$(a+b)^6 = a^6 + 6a^5b + 15a^4b^2 + 20a^3b^3 + 15a^2b^4 + 6ab^5 + b^6$$

$$(a+b)^8 = a^8 + 8a^7b + 28a^6b^2 + 56a^5b^3 + 70a^4b^4 + 56a^3b^3 + 28a^2b^6 + 8ab^7 + b^8$$

(+0.1) 11.2.26



from abstract learning at school

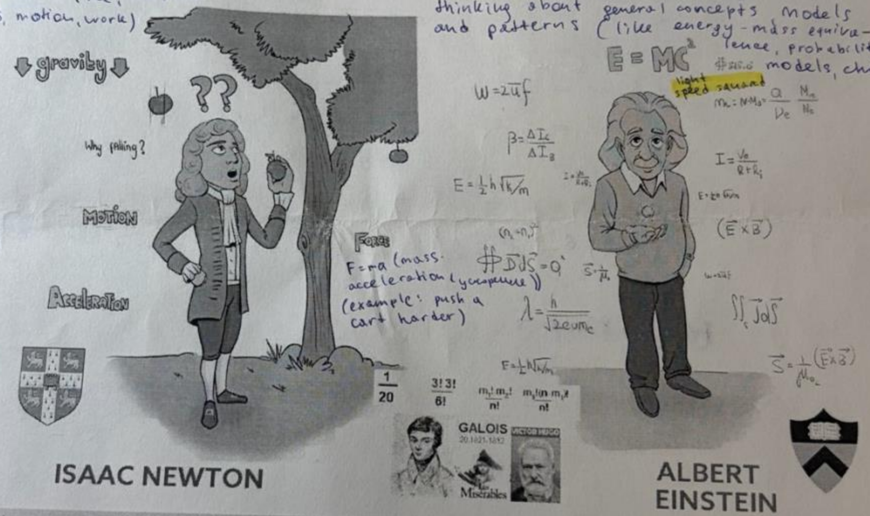
School ⇩ gravity ⇩ MOTION ==formalism==> University $E = MC^2$

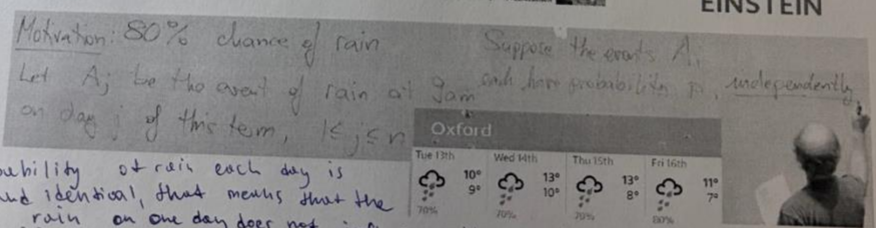
to formal in uni

CONCRETE AND ABSTRACT THINKING

thinking about real, physical things that you can touch, see, measure (forces, motion, work)

thinking about general concepts models and patterns (like energy-mass equivalence, probability models, chaos)



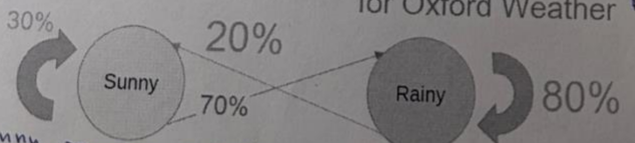


If the probability of rain each day is independent and identical, that means that the occurrence of rain on one day does not influence its occurrence on another day.

Markoff Chain Probability Model for Oxford Weather

Single day prob. = 0.8

Prob. of rain for n days independently = 0.8^n



30% to stay sunny, 70% to switch to rainy

80% chance to stay rainy, 20% switch to sunny

+0.1 +0.1

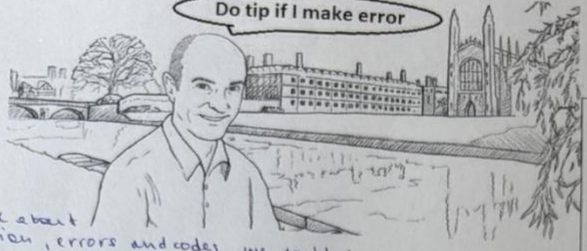
British Information theorist and professor in Cambridge

J.

Sir **Dr. D. MacKay,**
University of Cambridge
(22 April 1967 – 14 April 2016)

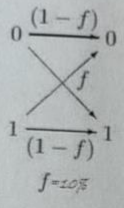
graphy

Machine Translation and coding

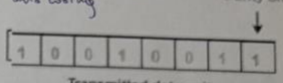


When we talk about communication, errors and codes, we don't just "believe" things – we calculate them with maths.

"I believe in clean energy, but I also believe in mathematics"

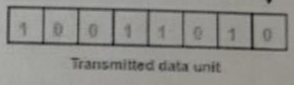


Parity bit



Transmitted data unit

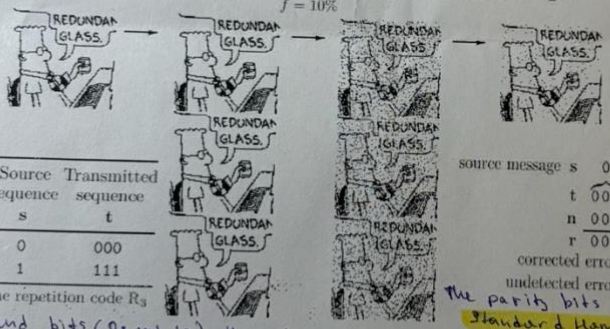
Parity bit



Transmitted data unit

+0.1

s ENCODER t CHANNEL $f = 10\%$ r DECODER ŝ



Source sequence s	Transmitted sequence t
0	000
1	111

The repetition code R_3

source message	s	0	0	1	0	1	1	0
	t	000	000	111	000	111	111	000
	n	000	001	000	000	101	000	000
	r	000	001	111	000	010	111	000
corrected errors						*		
undetected errors							*	

We want to send bits (0s and 1s) through a noisy channel where some bits might flip. A Hamming code adds extra bits so that if one bit flips, we can detect it and even correct it.

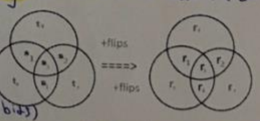
The parity bits $t_1, t_2, t_3 \ldots$ are computed as sums (mod 2) of certain data bits.

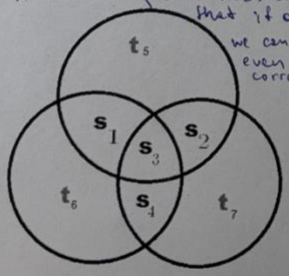
Standard Hamming

7.4. Hamming code.

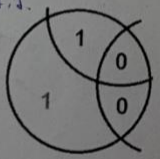
$\sum$ sum → $\frac{4}{7}$ (7,4) 4 into bits encode into 7 bits

Parity (3+4 parity bits)



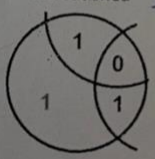


satisfied



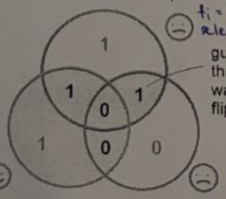
1+1+0+0=**0**

not satisfied



1+1+0+1=1

In Hamming code, each parity bit is t_i = (sum of some selected bits) mod 2



$C_m^n = \frac{m!}{n!(m-n)!}$

Binomial coefficient

$(x+y)^2 = x^2 + 2xy + y^2$

$(x+y)^3 = x^3 + 3x^2y + 3xy^2 + y^3$

$(x+y)$

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1

Events & probabilities

Consider an experiment which has a set of Ω of outcomes

$\omega \in \Omega$ - sample space

For example:

a. tossing a coin → $\Omega = \{H, T\}$

b. throwing a dice → 

$\Omega \{(i,j) \quad i,j \in [1,2,3,4,5,6]$

A subset of Ω is called an event

a) coin comes up tail $A = \{T\}$

b) We observe of total of 9

$A = \{(3,6), (4,5), (5,4), (6,3)\}$ - events

If $w \in \Omega$ is the outcome, we say A occur if $w \in A$

Compliment of A

↳ A^c occurs if A does not occur

$\overline{A} =$

Union: $A \cup B$ occurs if A or B occur

Intersection: $A \cap B$ occurs if both A and B occur ↕ (both)

Set difference: $A \setminus B = A \cap B^c$

A occurs / B doesn't occur

Disjoint: A and B disjoint if $A \cap B = \emptyset$

A and B cannot occur together

We assign a probability $P(A)$ of each A

Simplest case: Ω is finite and all outcomes are equally likely

Intersection: $A \cap B$ occurs if both main 4

a) $|\Omega| = 2$, $|A| = 1$ $\Big\}$ $P(A) = \frac{1}{2}$

Heur

b) $|\Omega| = 36$, $|A| = 4$ $\Big\}$ $\Rightarrow P(A) = \frac{4}{36} = \frac{1}{9}$

Elementary combinatorics

Arrangements of distinguishable objects

Suppose we have not distinguishable objects

How many ways are there to order them?

$n = 3$

6 3!

$n!$

$n = 3$ 24 $= 4 \cdot 3 \cdot 2 \cdot 1$

GALOIS how many ways to order letters in the word?

$3! \cdot 3!$

6!

BAAA

ABBA

BABA

AABB

$6! / A_1, A_2, B_1, B_2$ ABAB

$4!$

$\frac{4!}{2! \cdot 2!}$

A_1, A_2 B_1, B_2

A_2, A_1 B_1, B

BAAB

P(x)

$\frac{1}{6}$

$C_4^1 = \frac{4!}{1! \cdot 3!} = \frac{24}{6} = 4$

$C_4^2 = \frac{4!}{2! \cdot 2!} = \frac{4 \cdot 3}{2} \cdot \frac{12}{2} = 6$