

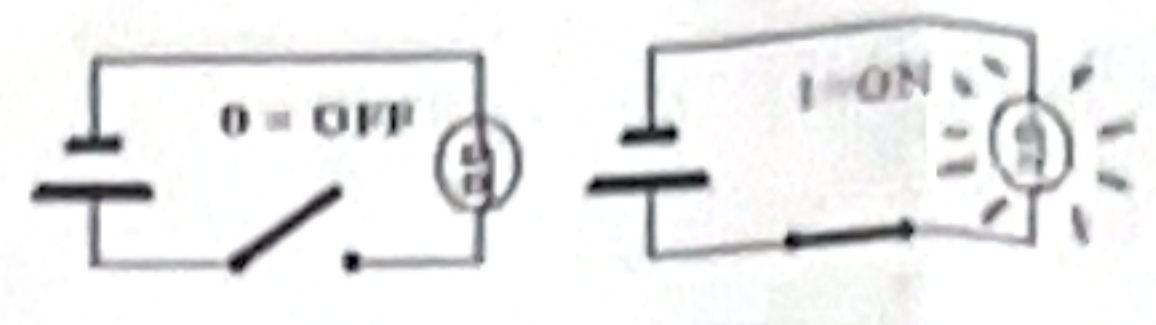
0.1 2026.03.05  
+ 0.1



Massachusetts Institute of Technology (MIT)



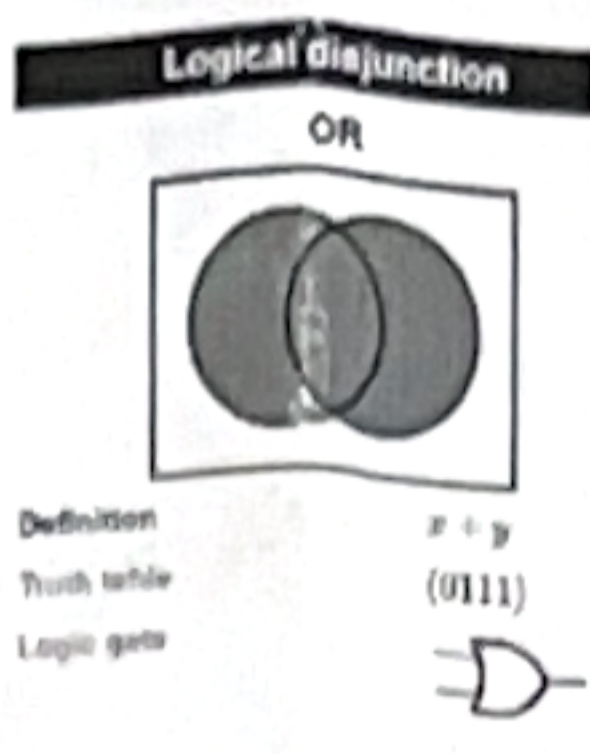
Lecture by Pr. Bob Gallager  
Boole (1815-1864) & Shannon (1916-2001)



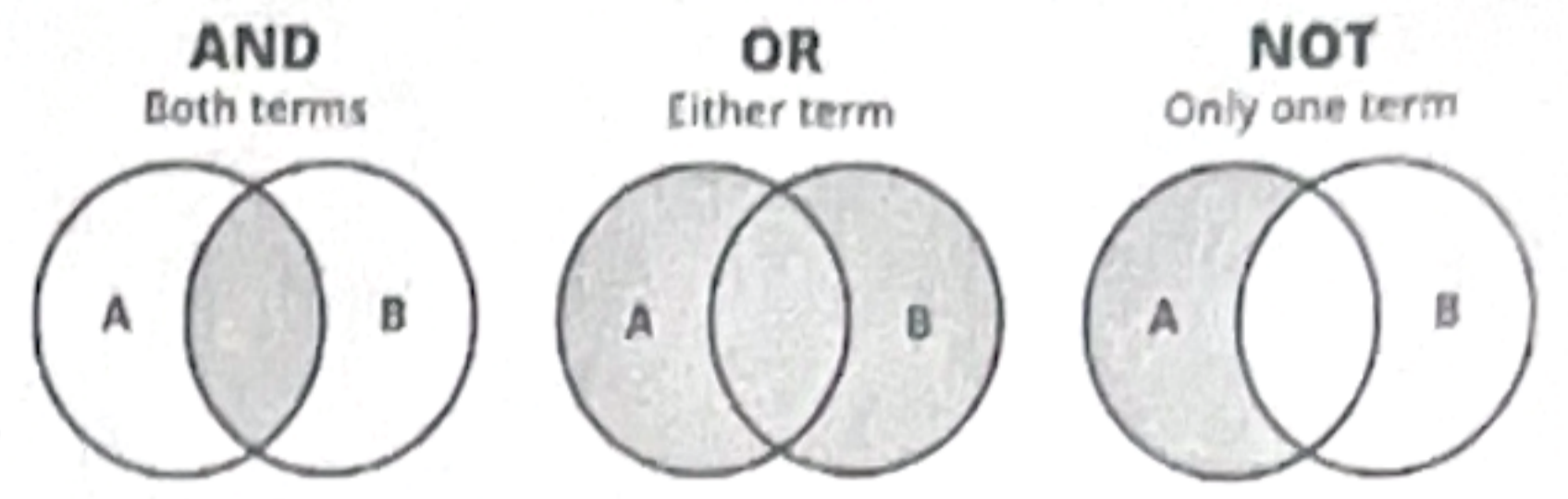
Logical addition (disjunction)

A	B	F=A∨B
0	0	0
0	1	1
1	0	1
1	1	1

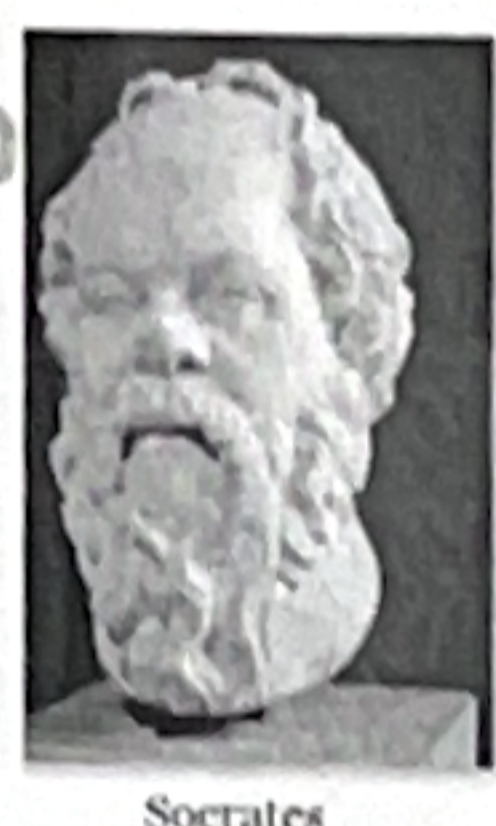
A	B	A ∨ B
True	True	True
True	False	True
False	True	True
False	False	False



BOOLEAN LOGIC

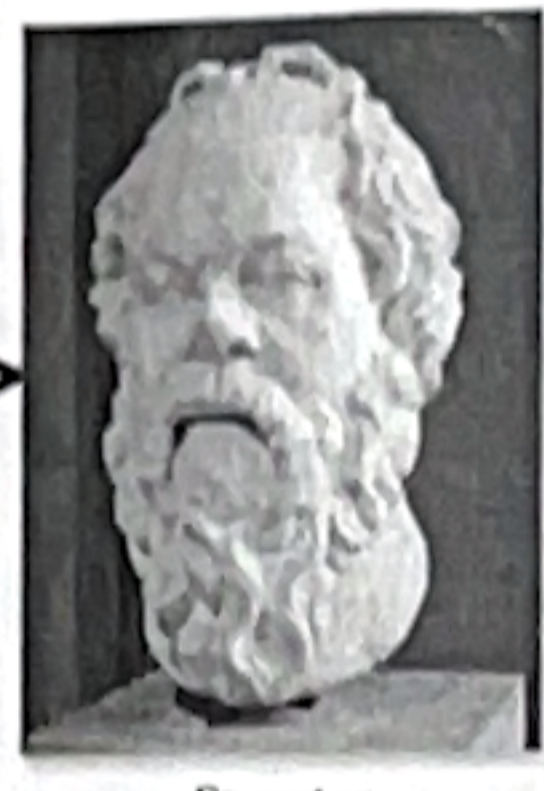


Good logic



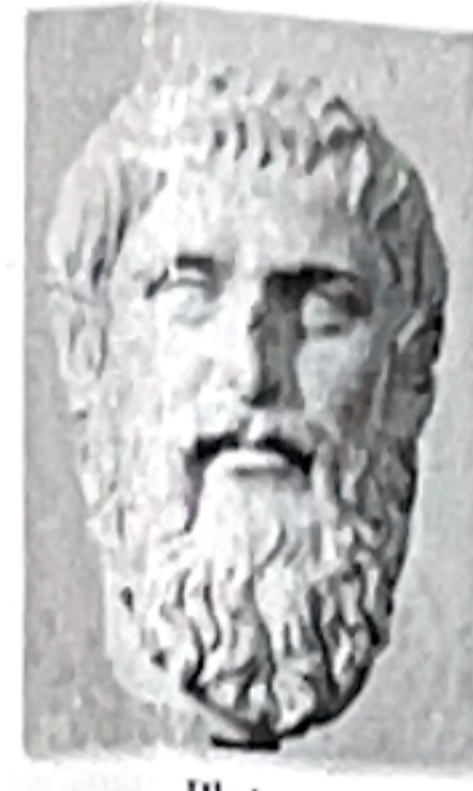
Socrates

Socrates was a philosopher

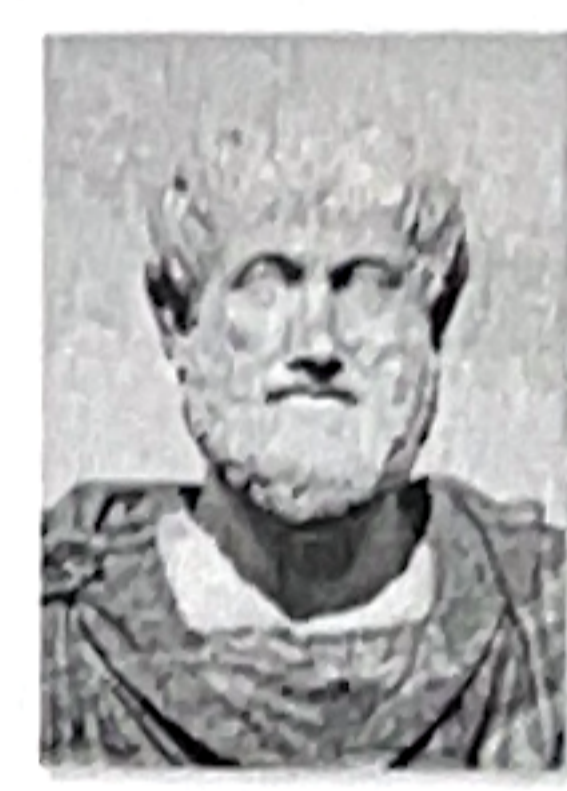


Socrates

philosophers are men



Plato



Aristotle



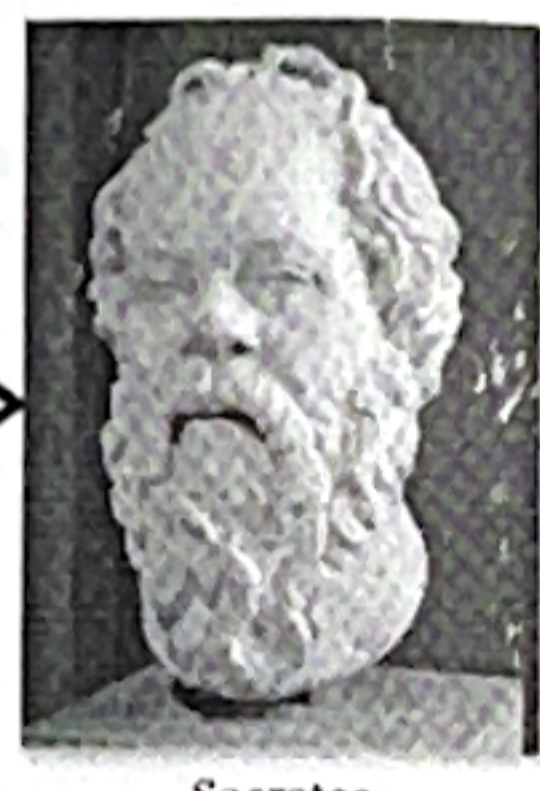
Socrates was a man



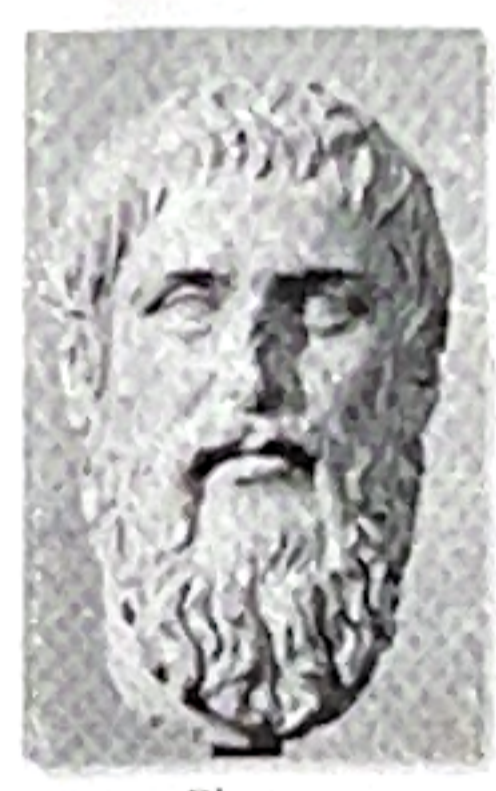
Bad logic



Socrates was a man



Socrates



Plato



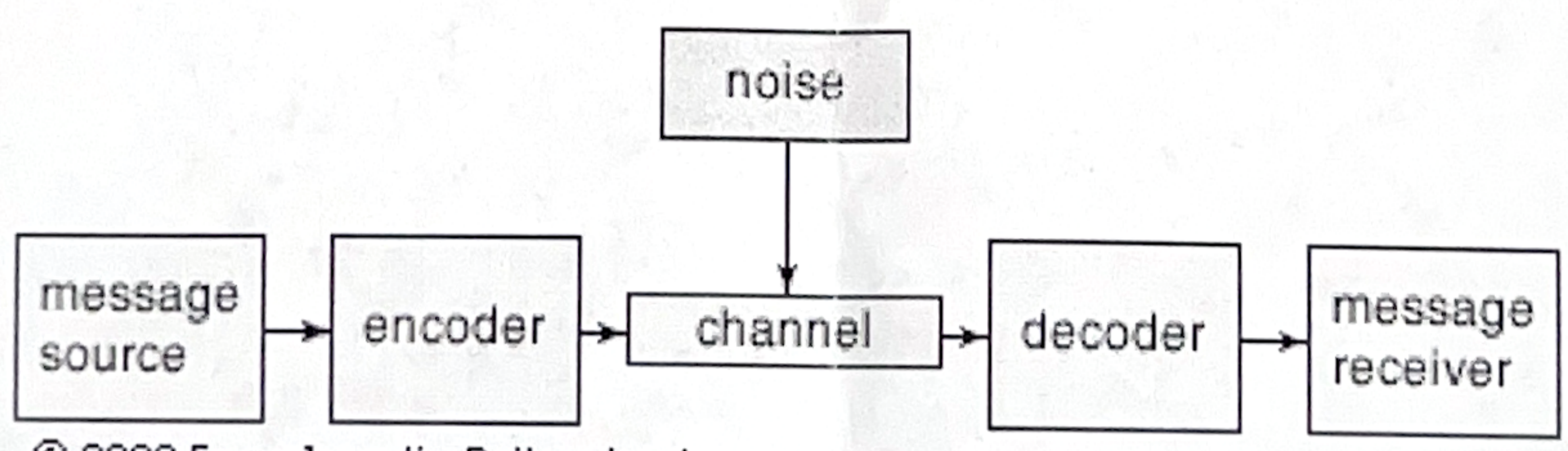
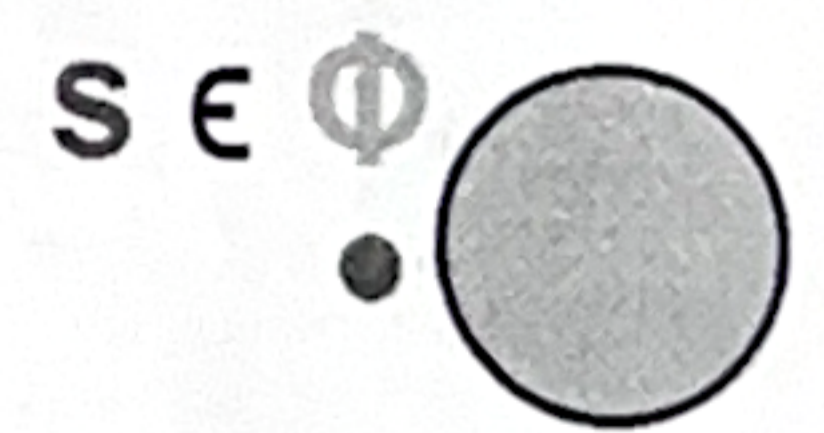
Aristotle

philosophers are men



Socrates

Socrates was a philosopher



# Resume of Lecture by Pr. Bob Gallagher from MIT

George Boole (1815-1864) developed Boolean logic

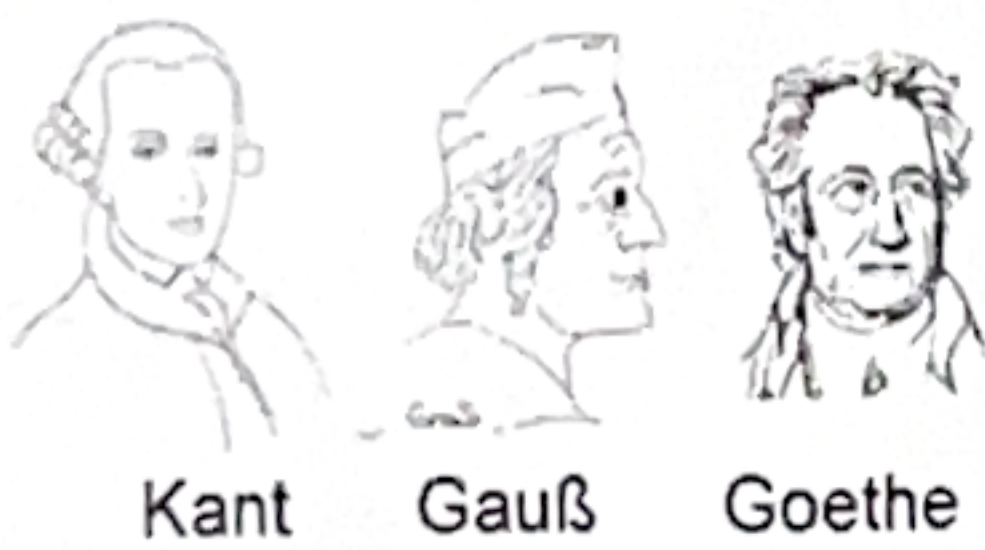
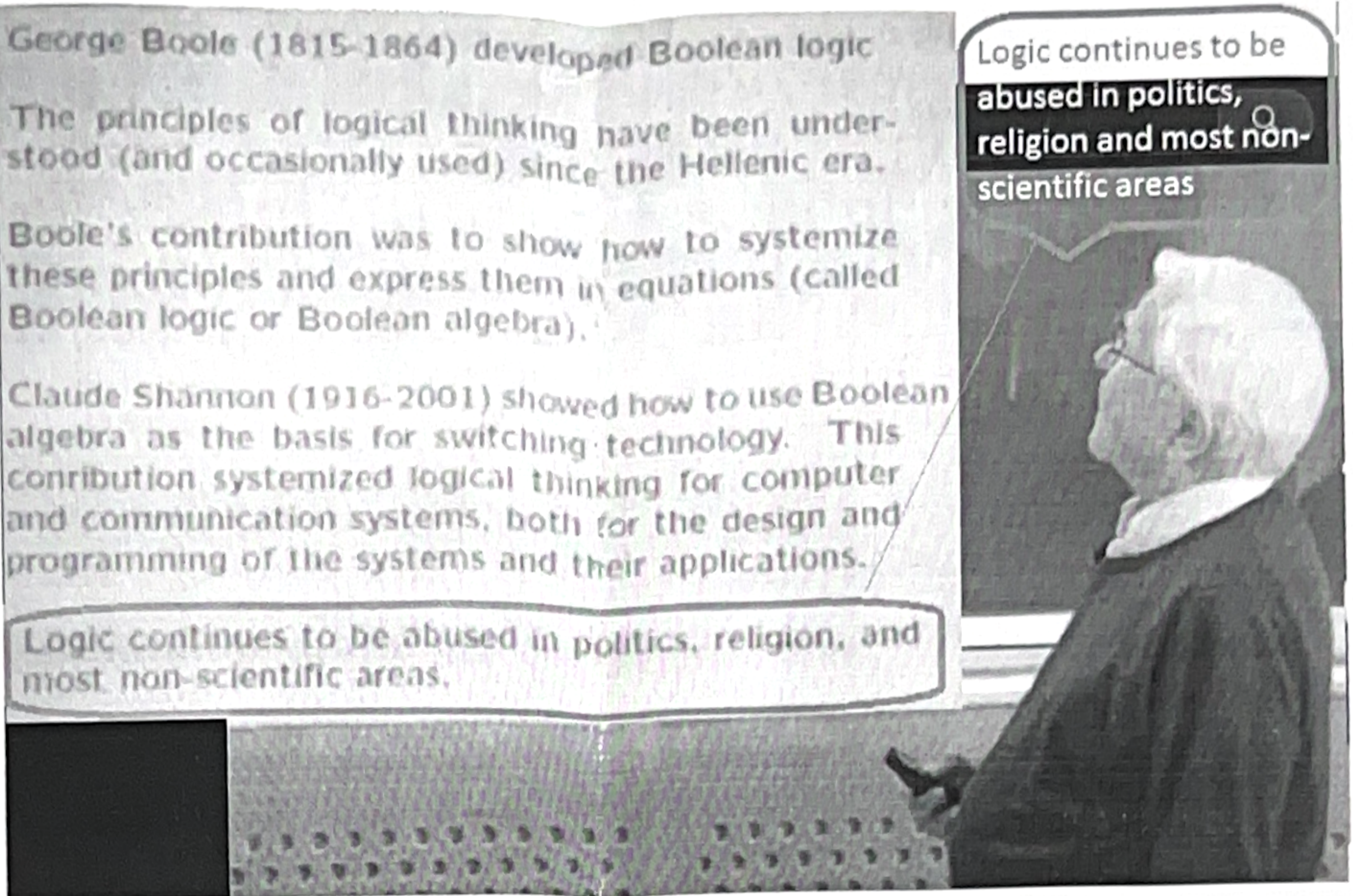
The principles of logical thinking have been understood (and occasionally used) since the Hellenic era.

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 contribution 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.

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



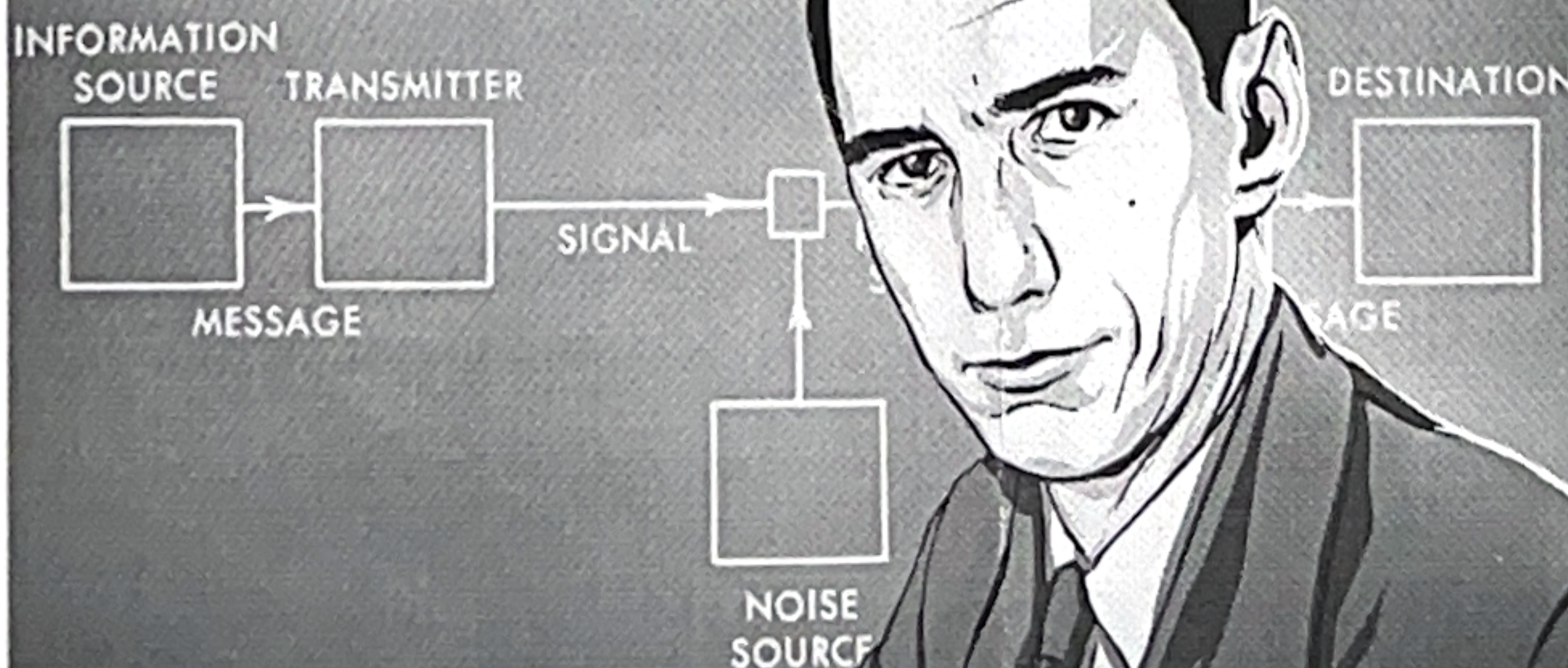
Kant Gauß Goethe

*A little nationalistic, but this is an example of right logic*



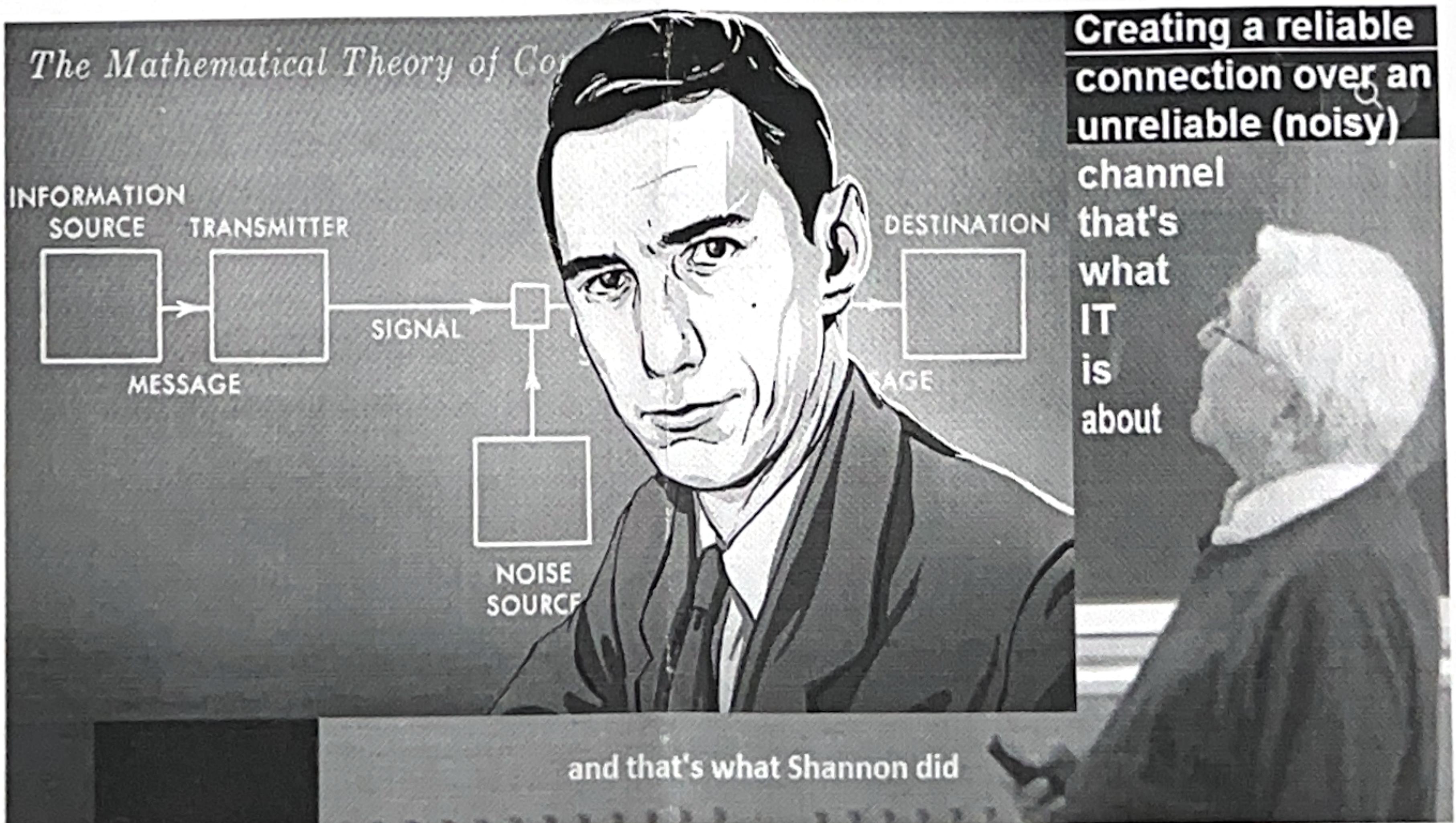
Bad logic (abuse of logic)

*The Mathematical Theory of Communication*



Creating a reliable connection over an unreliable (noisy) channel that's what IT is about

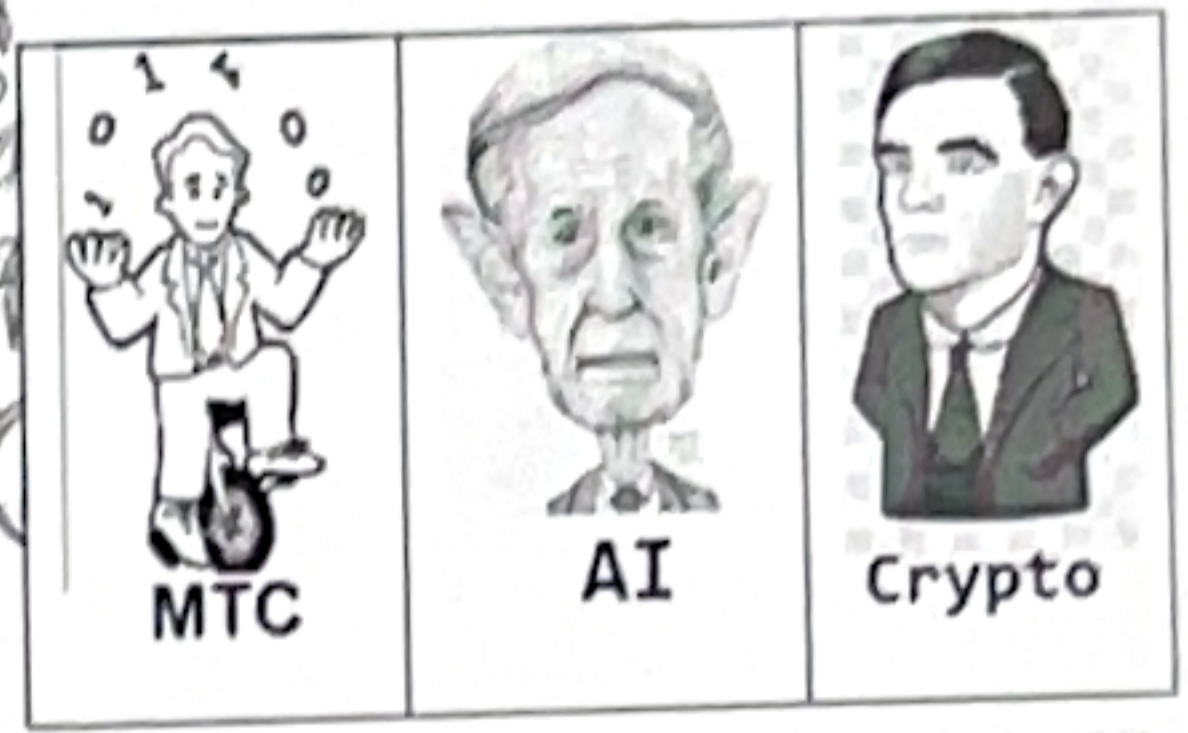
and that's what Shannon did



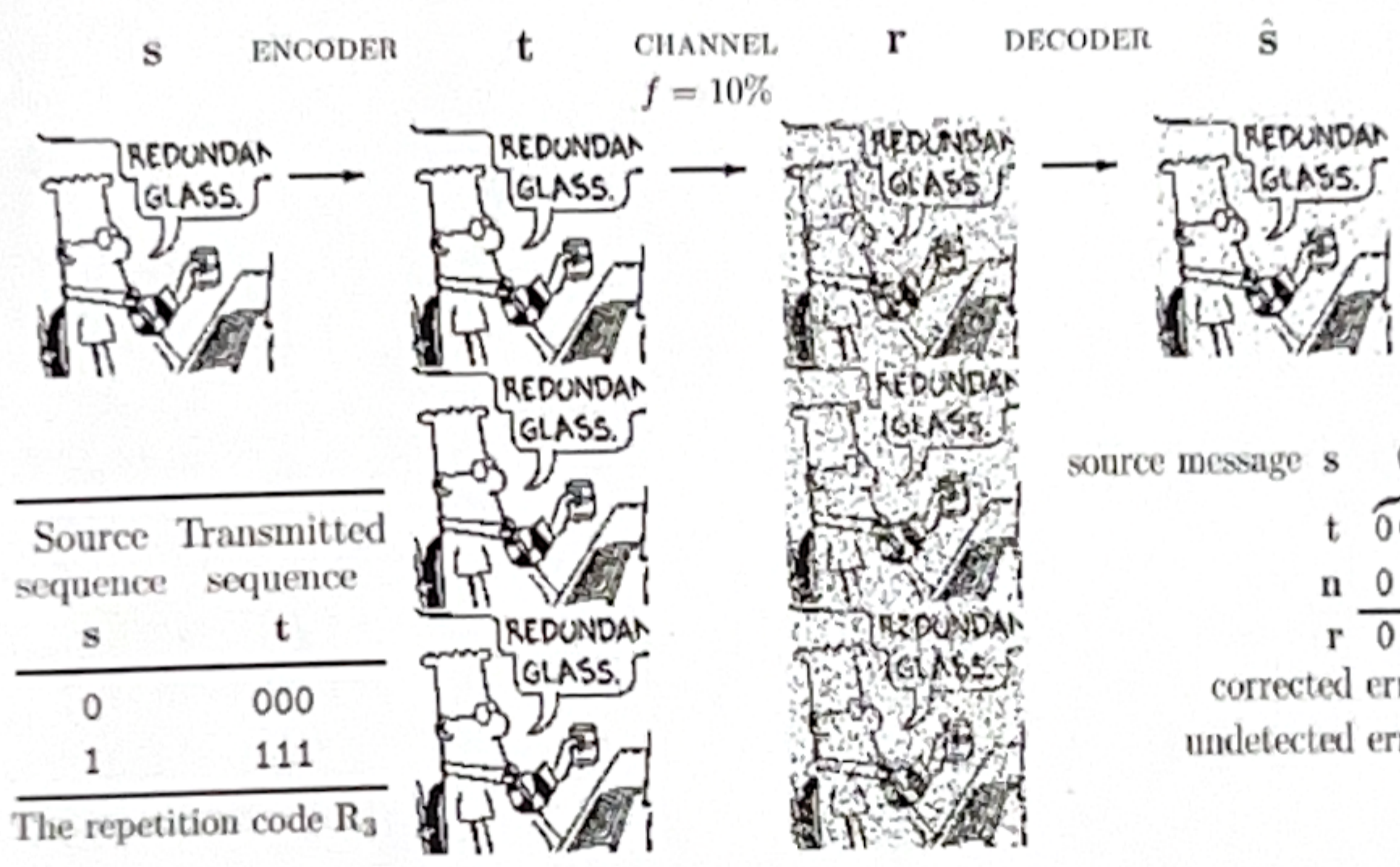
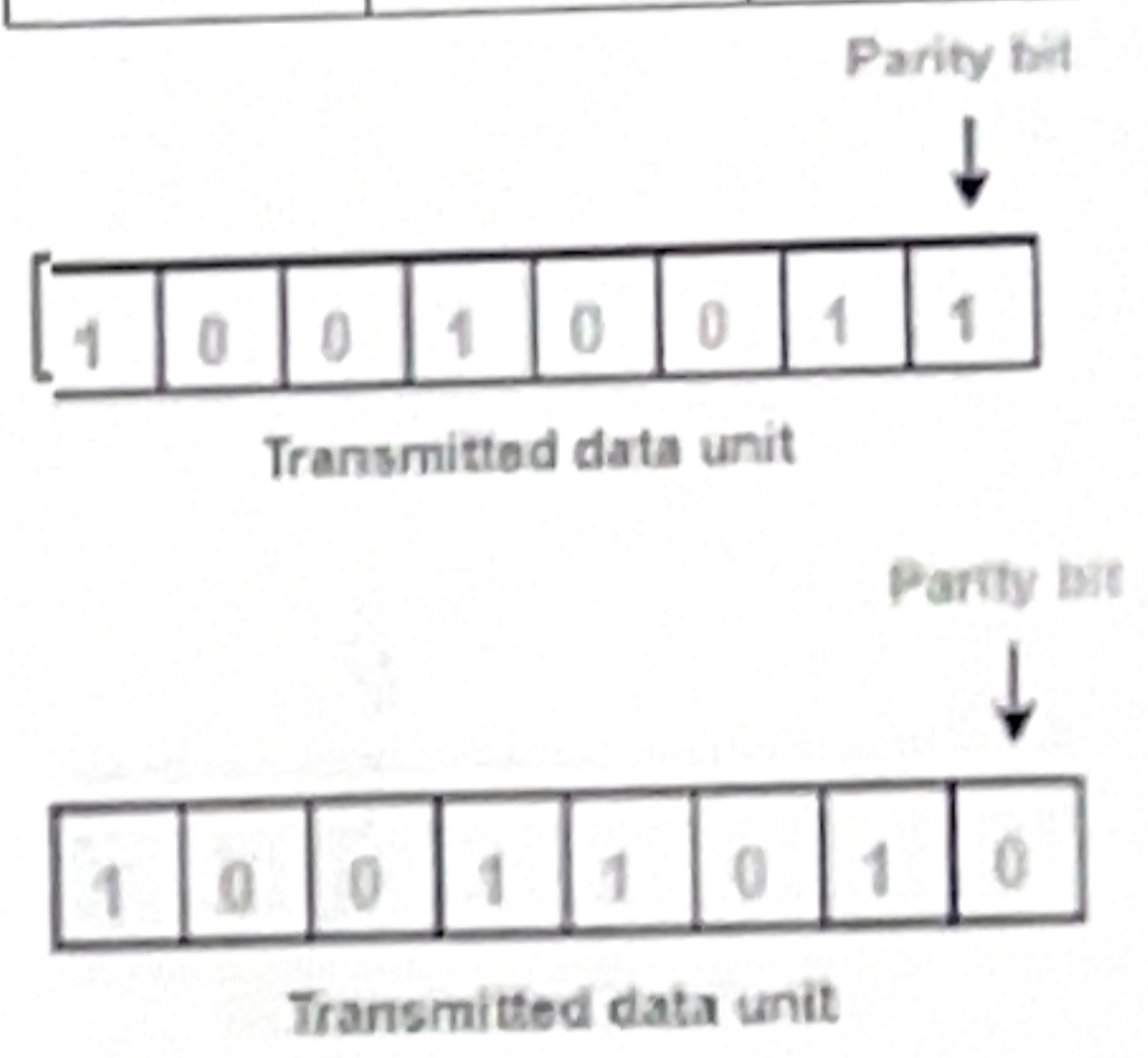
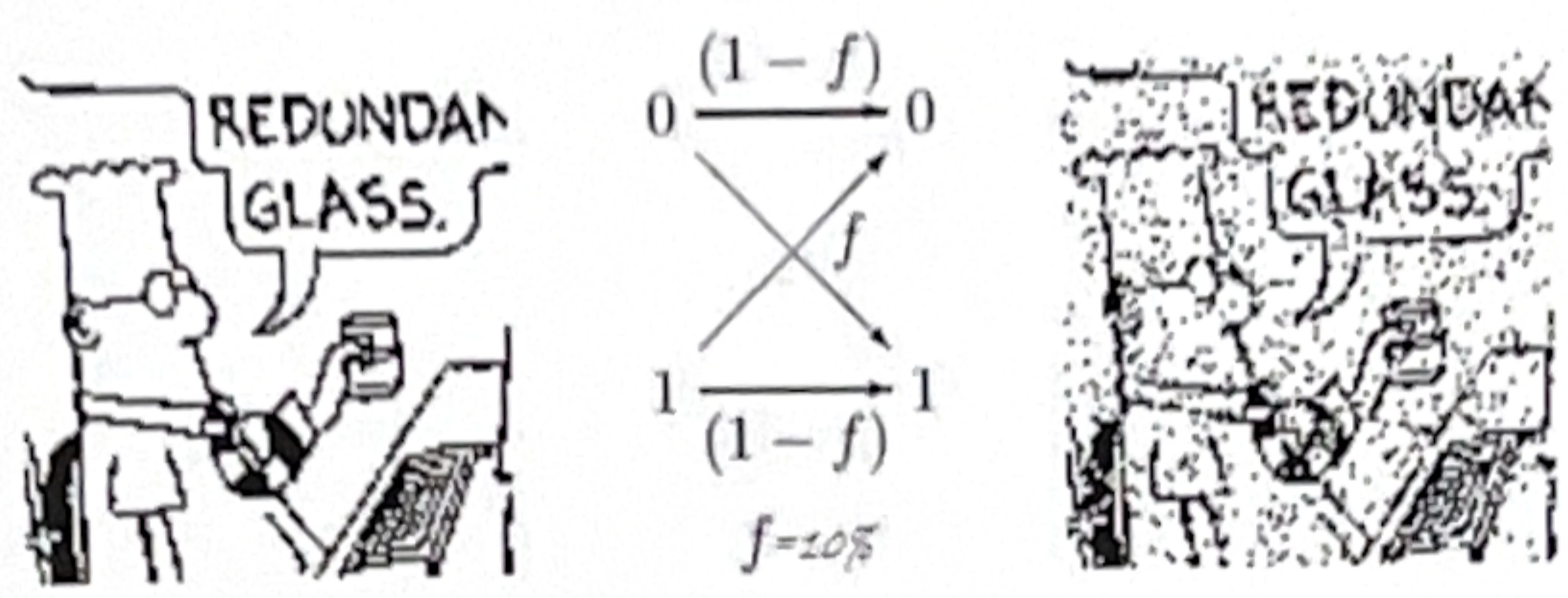
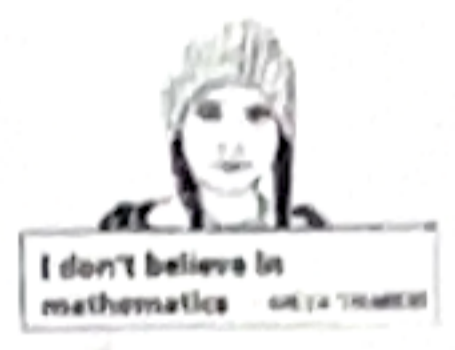
+0.1 7.4



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



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



Source sequence s	Transmitted sequence t
0	000
1	111

The repetition code  $R_3$

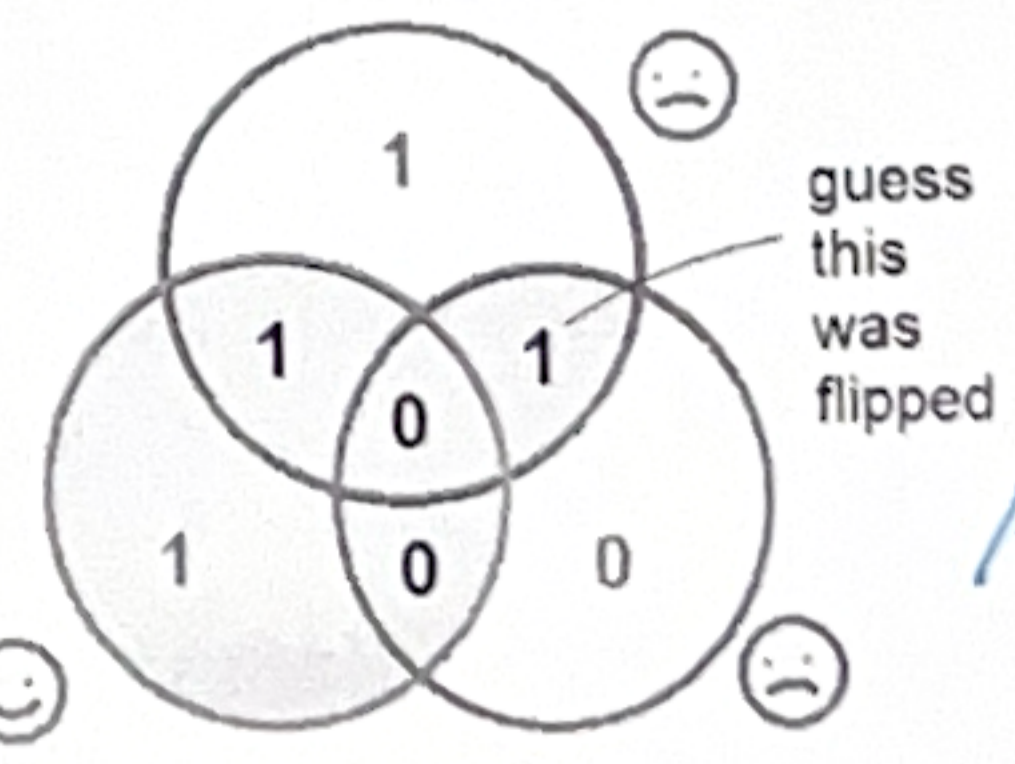
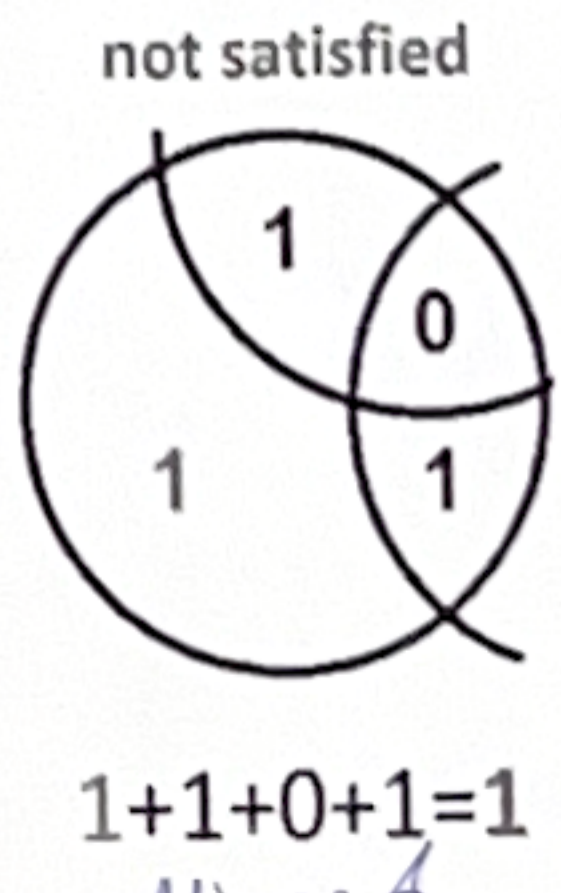
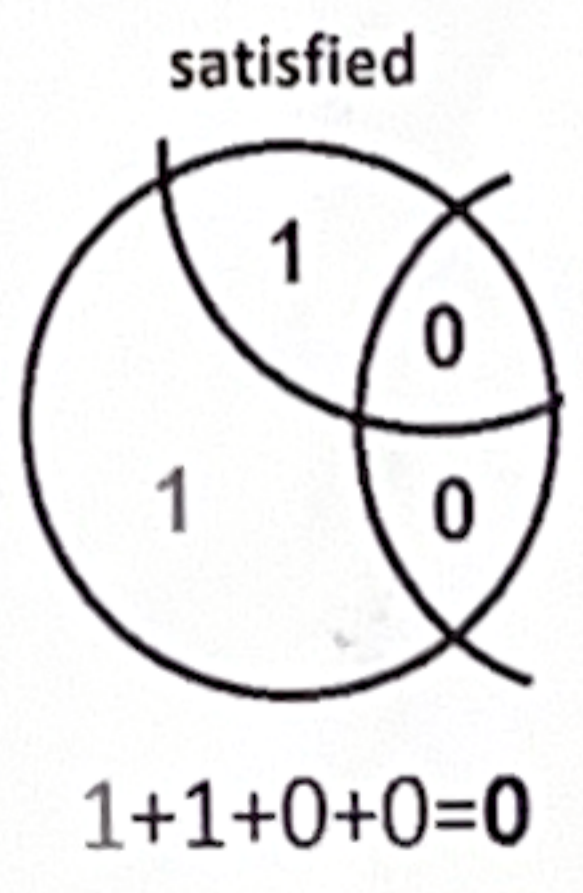
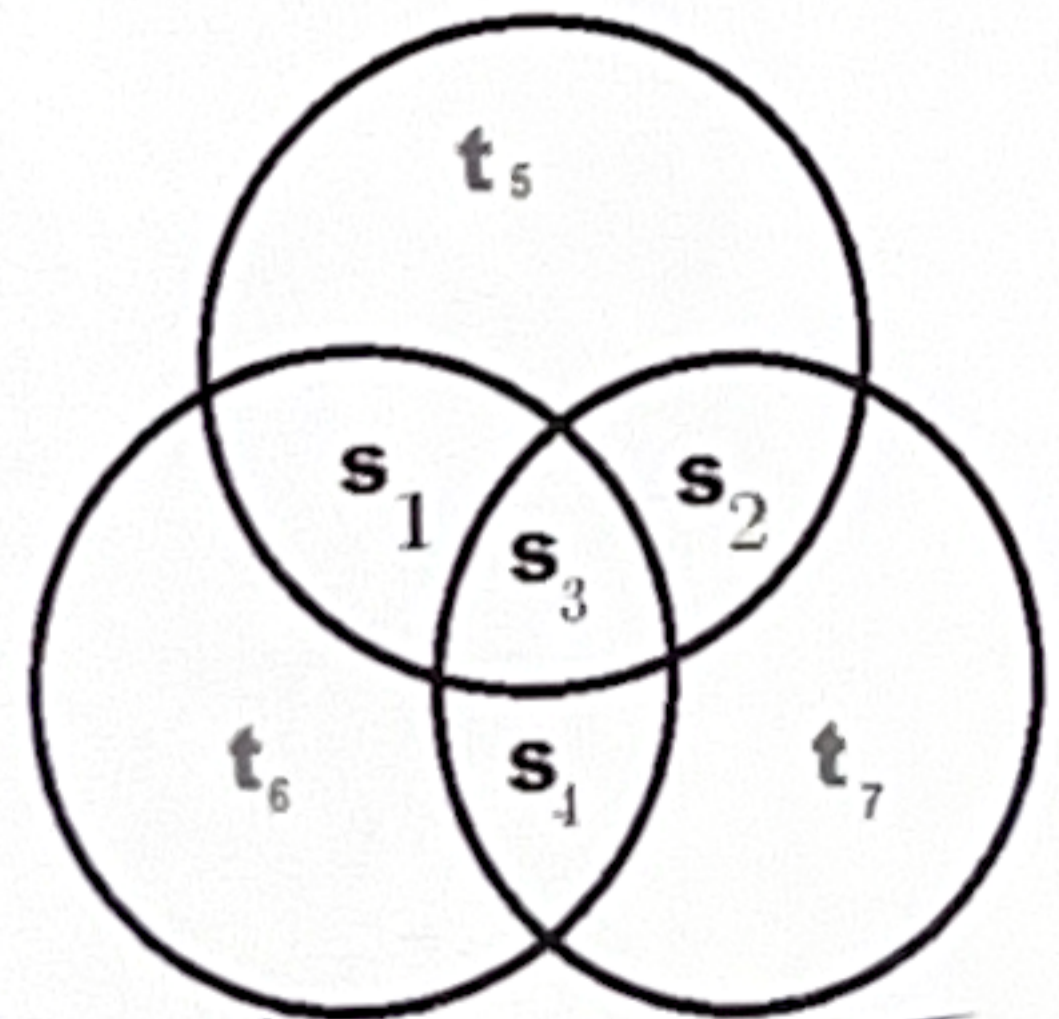
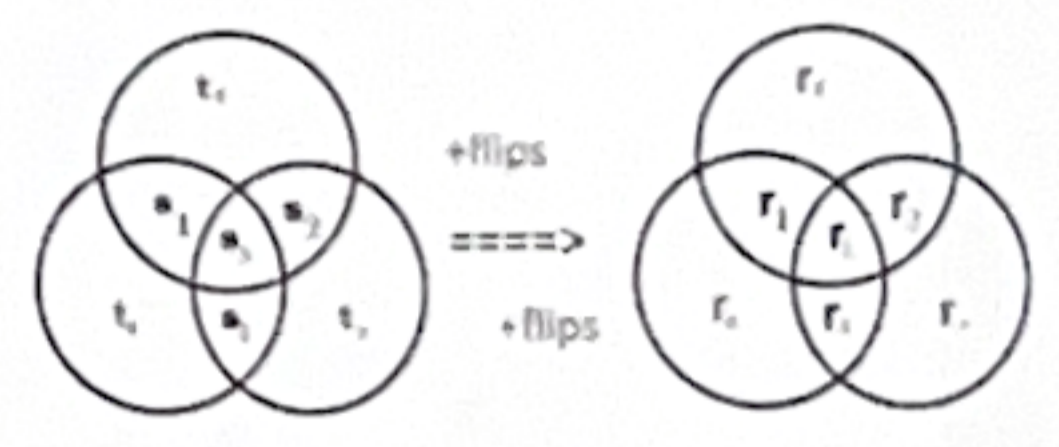
source message s	0	0	1	0	1	1	0
t	000	000	111	000	111	111	000
n	000	001	000	000	101	000	000
r	000	001	111	000	010	111	000

corrected errors \*

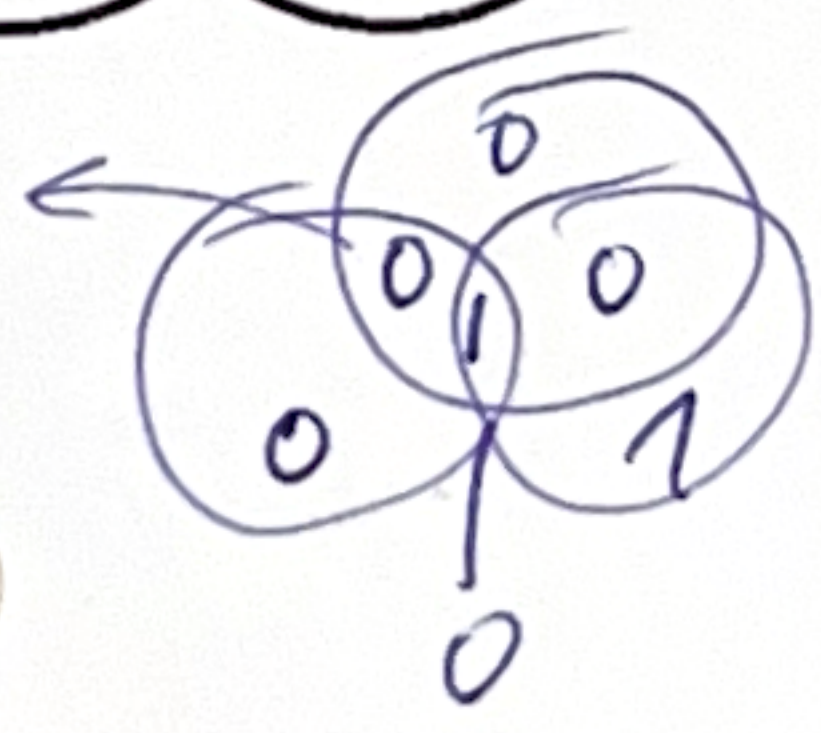
undetected errors \*

### 7.4. Hamming code.

$$\frac{4}{\Sigma} \rightarrow \frac{7}{t}$$



Slipped



Slipped

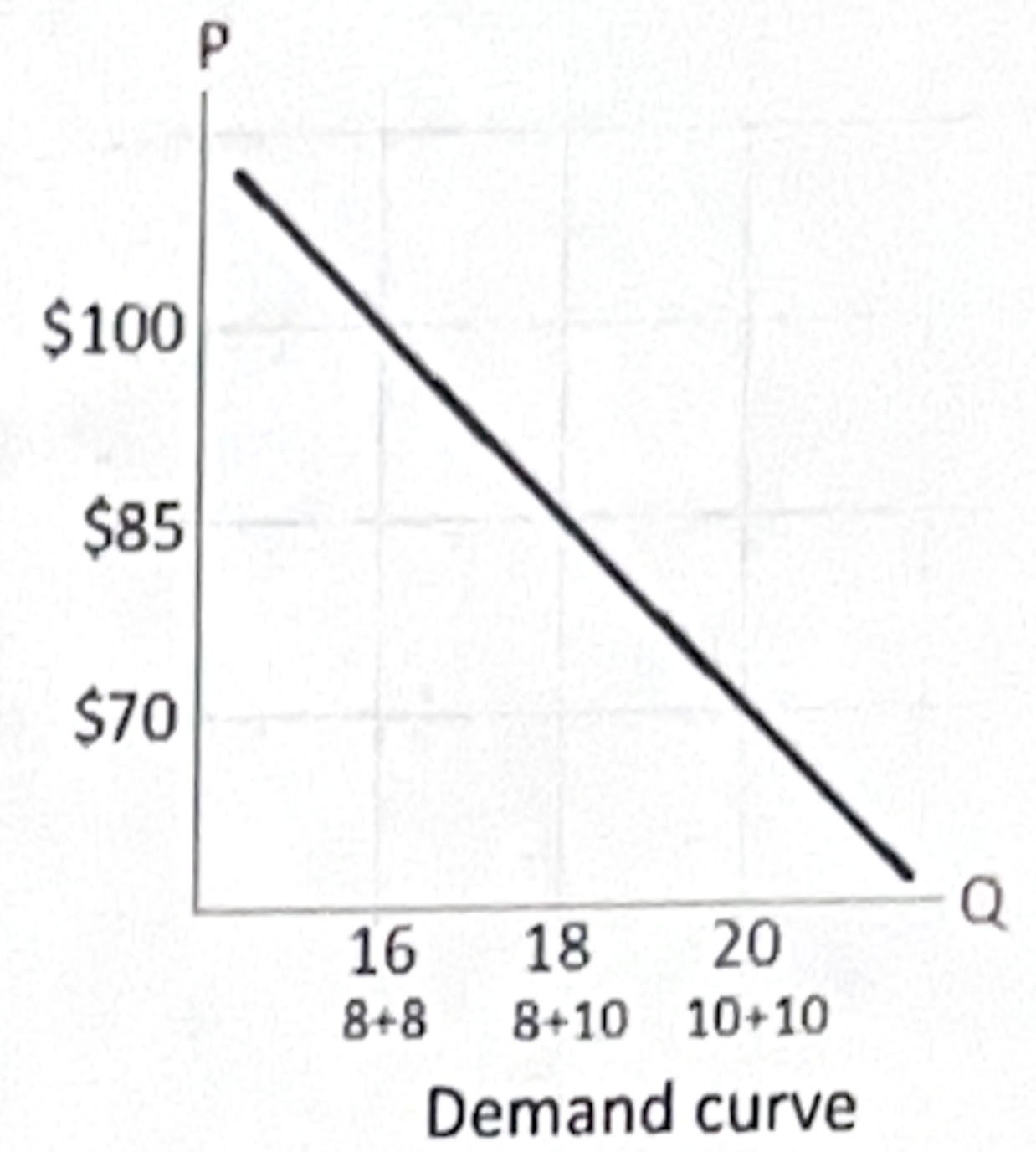



















+0.1 7.4

Flipped Flips

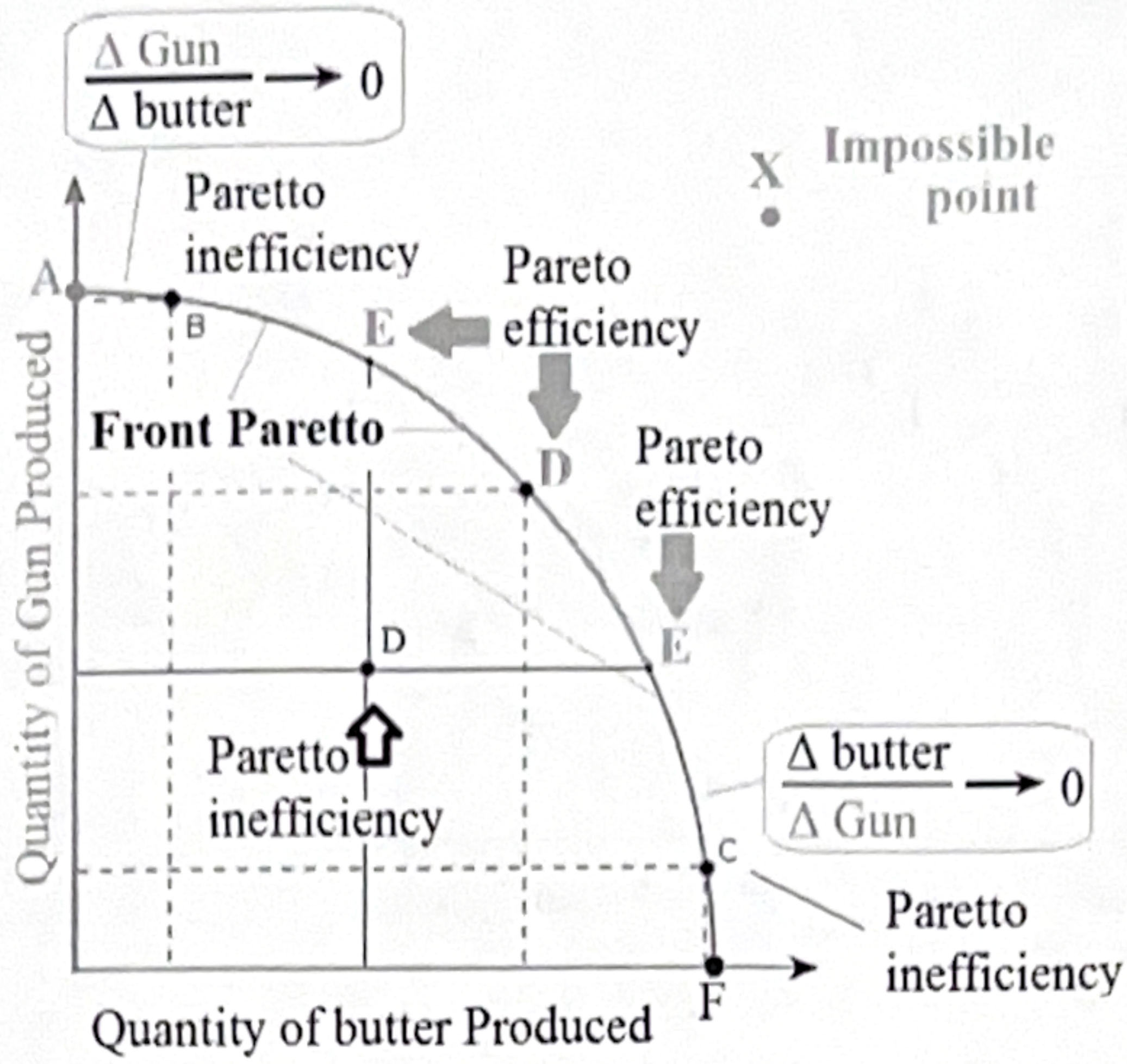
# Oil price hits 18-year low

Brent crude, US dollars per barrel



Barrel		1.	2.
		$8 \cdot 10^6$  /day	$10 \cdot 10^6$  /day
1.	$8 \cdot 10^6$ 	 <b>\$800</b> millions per day \$100   <b>\$800</b> millions per day	 <b>\$850</b> millions per day \$85   <b>\$680</b>
2.	$10 \cdot 10^6$  /day	 <b>\$680</b> millions per day \$85   <b>\$850</b> millions per day	 <b>\$700</b> millions per day \$70   <b>\$700</b> millions per day





by Vilfredo Pareto  
1848-1923

The orange sector E-D-E is the most Pareto efficient - since an increase in one indicator leads to a decrease in another.

Prisoners' dilemma

		prisoner B	
		confess	remain silent
prisoner A	confess	5 years, 5 years	0 year, 20 years
	remain silent	20 years, 0 year	1 year, 1 year

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\*\* => Nash equilibrium

	$H_2(x)$	Recognition;	Non-recognition;
	Player 2		
$H_1(x)$	Player 1	1	2
Recognition;	1	-5*	-20
Non-recognition;	2	-20	-1

-1-1  
Pareto Optimality





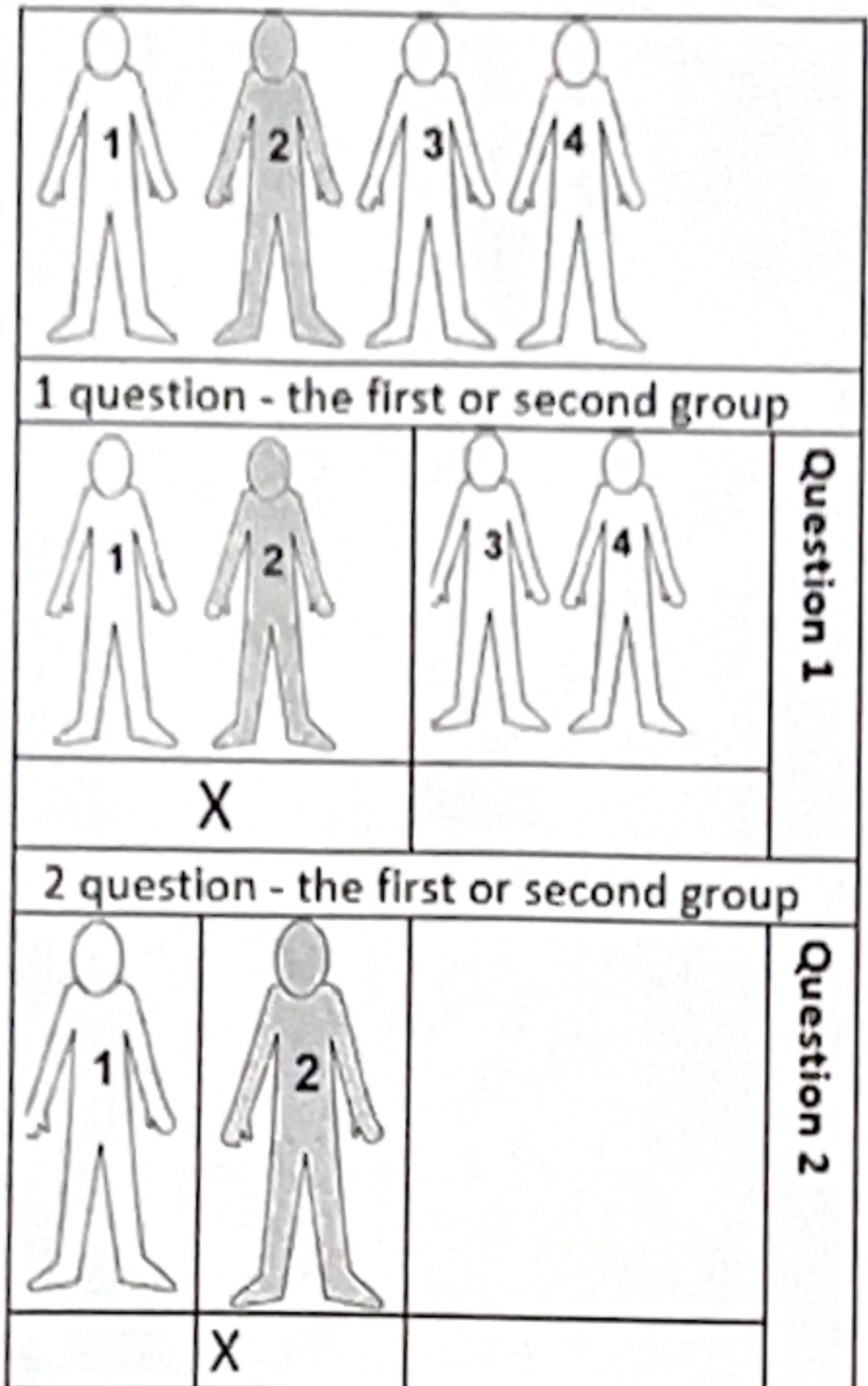
Say NO to the first



Say YES to the second if it is better than the first



Say NO to the third only if it is worse than all the others

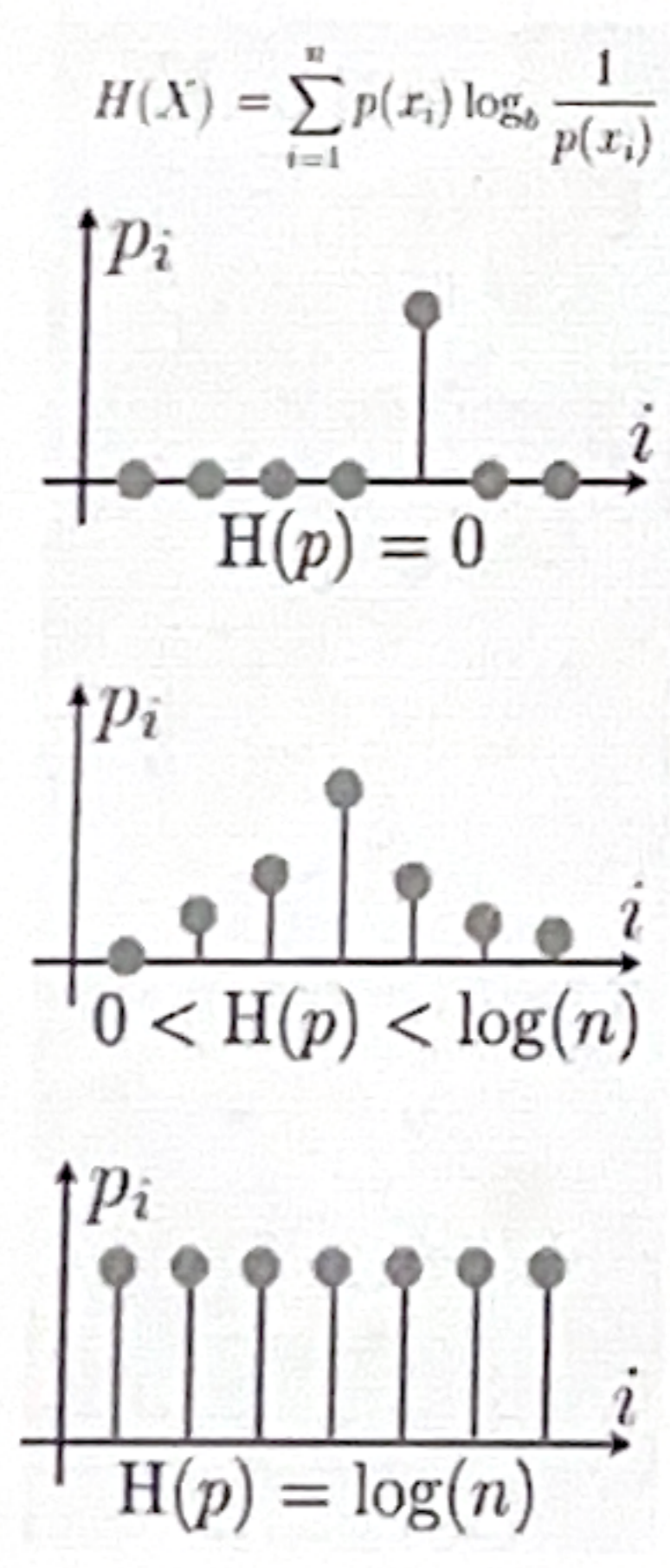


Average number of questions =  $2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 = 2$

Average number of questions =

$1 \cdot 0.5 +$	$2 \cdot 0.25 +$	$3 \cdot 0,125 +$	$3 \cdot 0,125$

Question 1. Is this Zuckerberg?	50%	$1 \cdot 0.5$
Question 2. Is this Sergey Brin?	25%	$2 \cdot 0.25$
Question 3. Is this Stefan from BMW?	12,5%	$3 \cdot 0,125$
So Prince Saud	12,5%	$3 \cdot 0,125$
Average number of questions =		1,75



$$H(X) = \sum_{i=1}^n p(x_i) \log_b \frac{1}{p(x_i)}$$

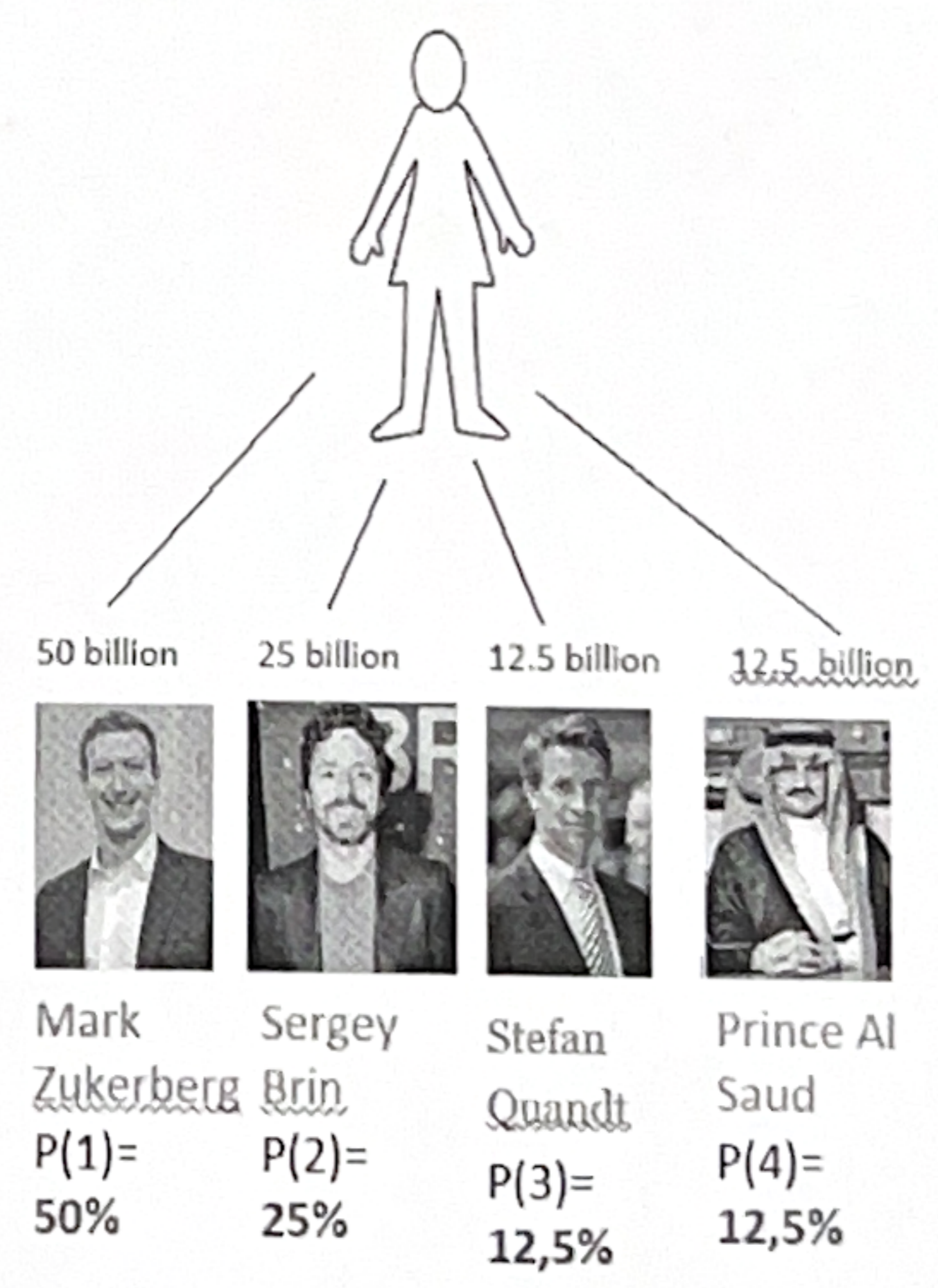
$$\sum_{i=1}^n p(i) \log_2 \frac{1}{p(i)}$$

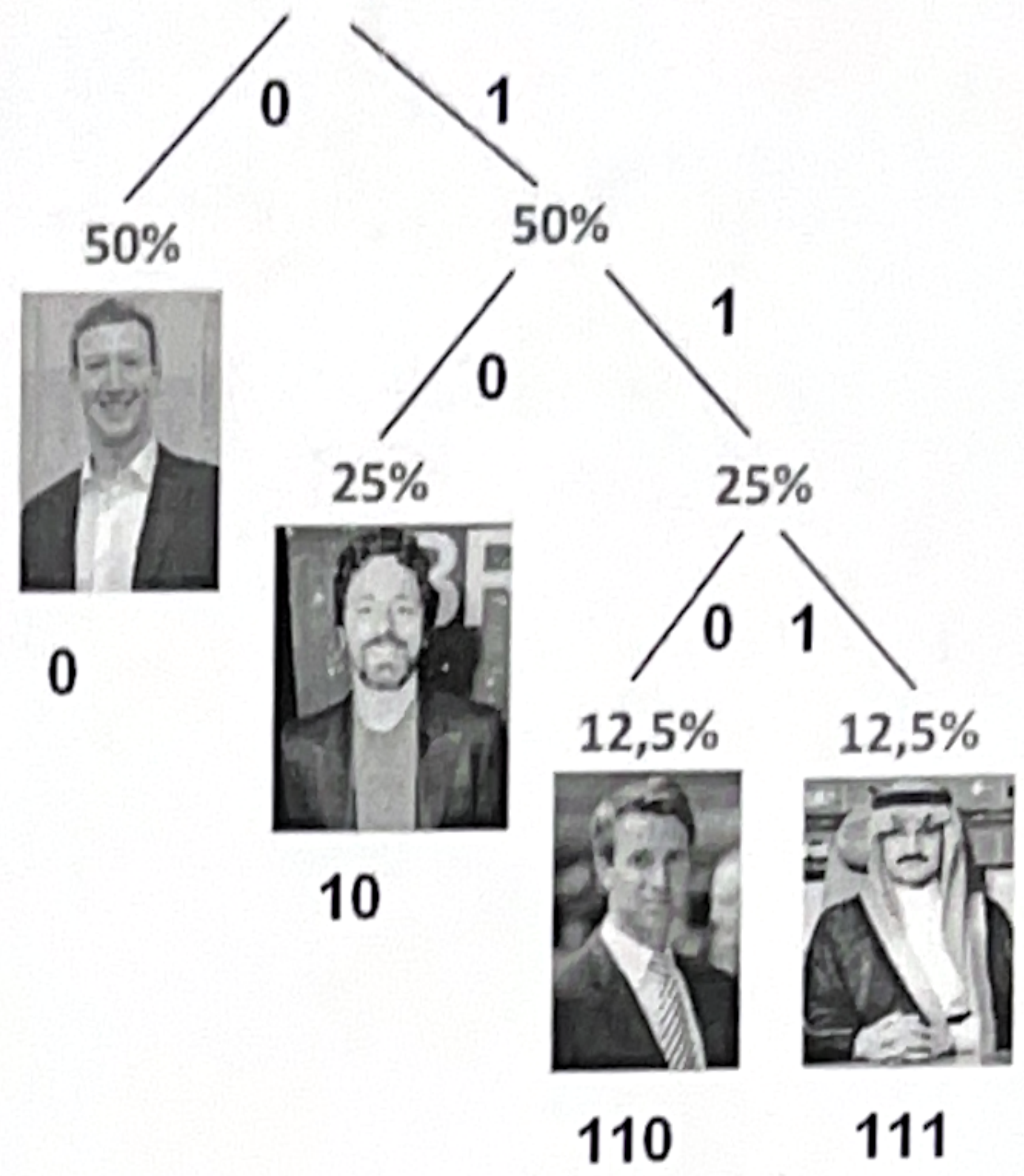
Quantifying information

$$I(x_i) = \log_2 \left( \frac{1}{p_i} \right)$$

number of bits required to encode choice

$$\sum_{i=1}^n p(x_i) I(x_i)$$





First-order approximation  
(symbols independent but with frequencies of Belarusian txt).

Мама мыла ра			
М - 3	— 30%	1-3	М
а - 4	— 40%	4-7	а
ы - 1	— 10%	8 -ы	
л - 1	— 10%	9 -л	
р - 1	— 10%	10 -р	
10			
лла <span style="border: 1px solid black; padding: 2px;">мамма</span> р			

Мама мыла ра

Ма - 2	22%	1-2	ма
ам - 2	22%	3-4	ам
мы - 1	11%	5	мы
ыл - 1	11%	6	ыл
ла - 1	11%	7	ла
ар - 1	11%	8	ар
ра - 1	11%	9	ра
9			

0. 4 6 7 3 1 9 1 6 7 3 5  
 ам ыл ла ам ма ра ма ыл ла ам мы  
 мылла рама



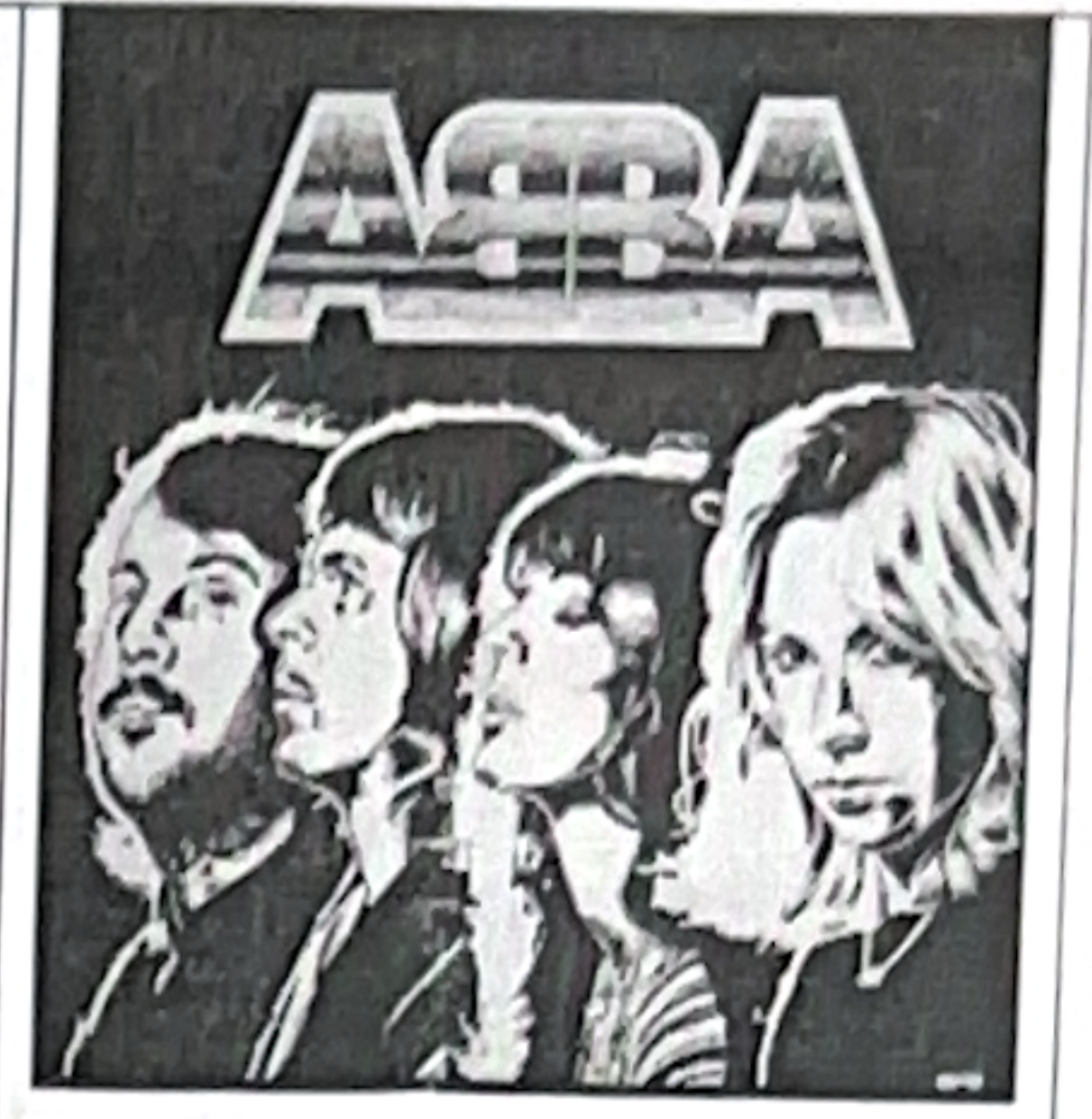
Second-order approximation (digram (2-symbols) structure as in Belarusian)

This is the program we need to write today

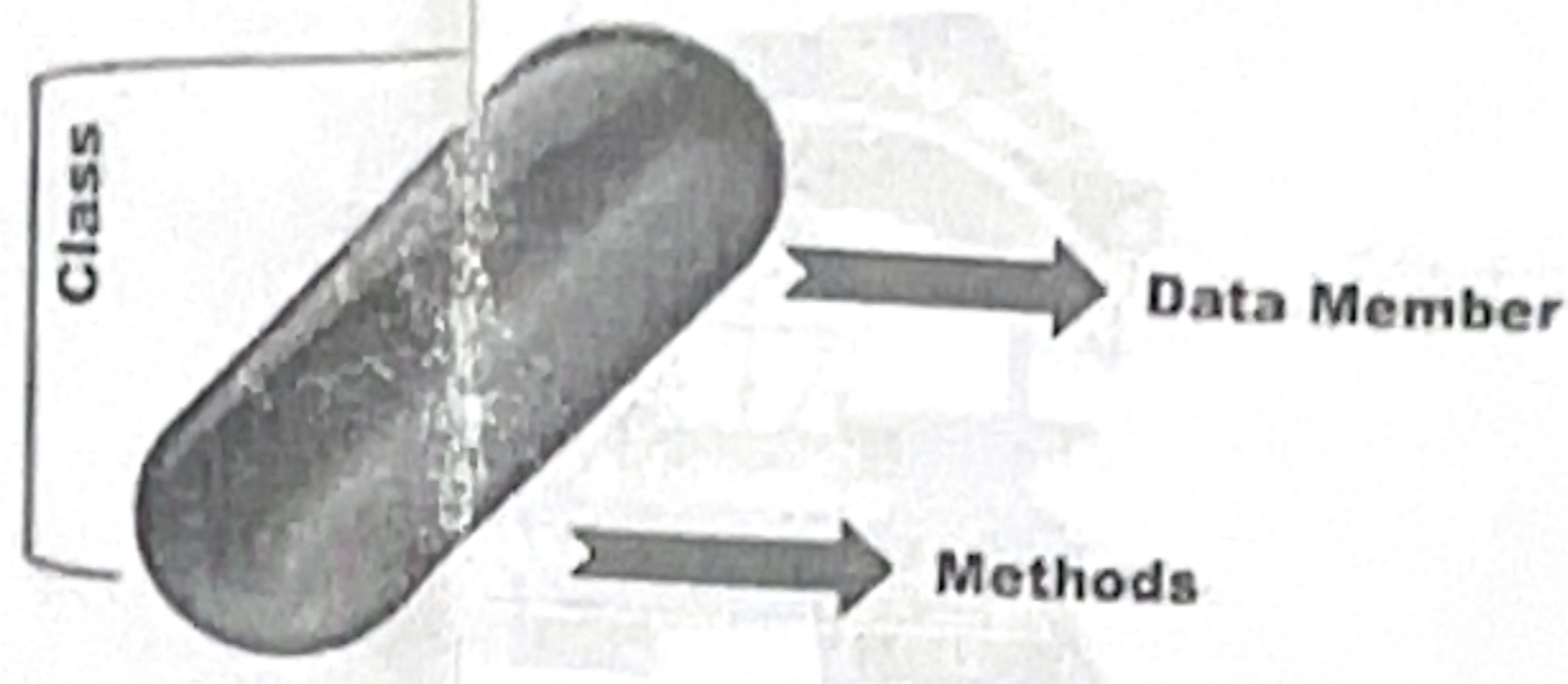
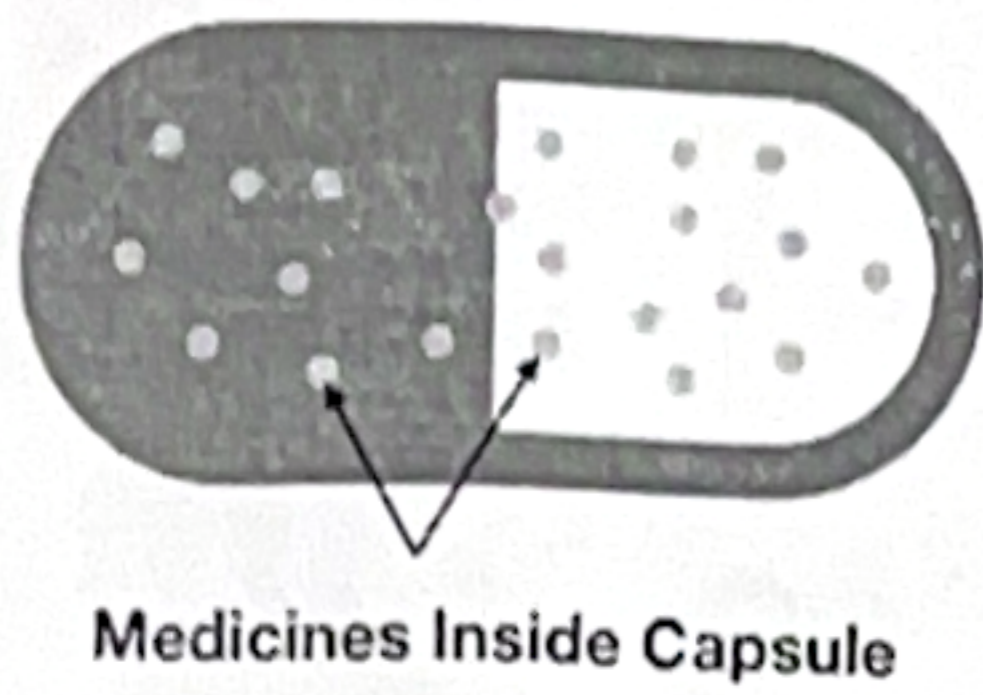
```

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

```



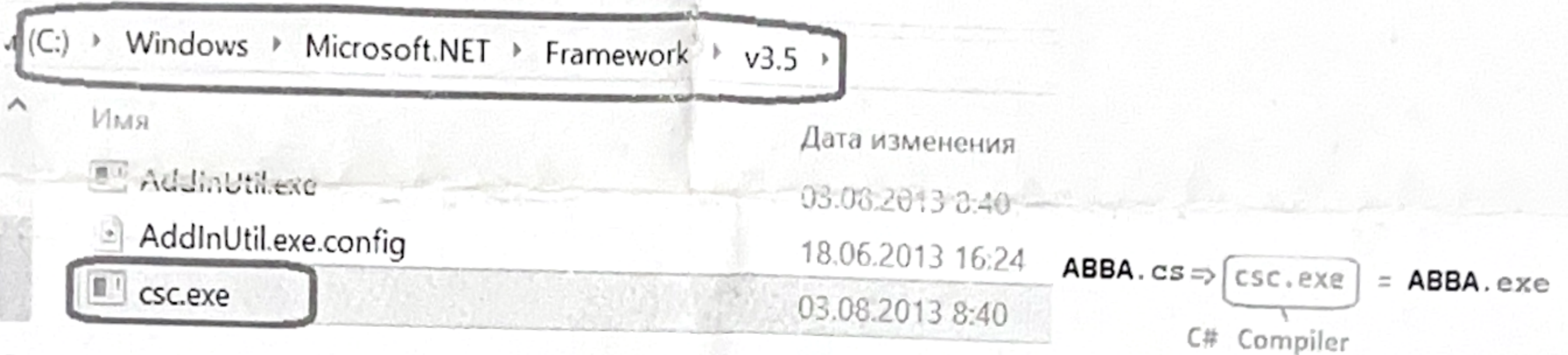
So there's the keyword class. Unlike C++, in C# all code must be placed in a class. Encapsulated in a class.



A ≠ a

C# is case sensitive

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



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

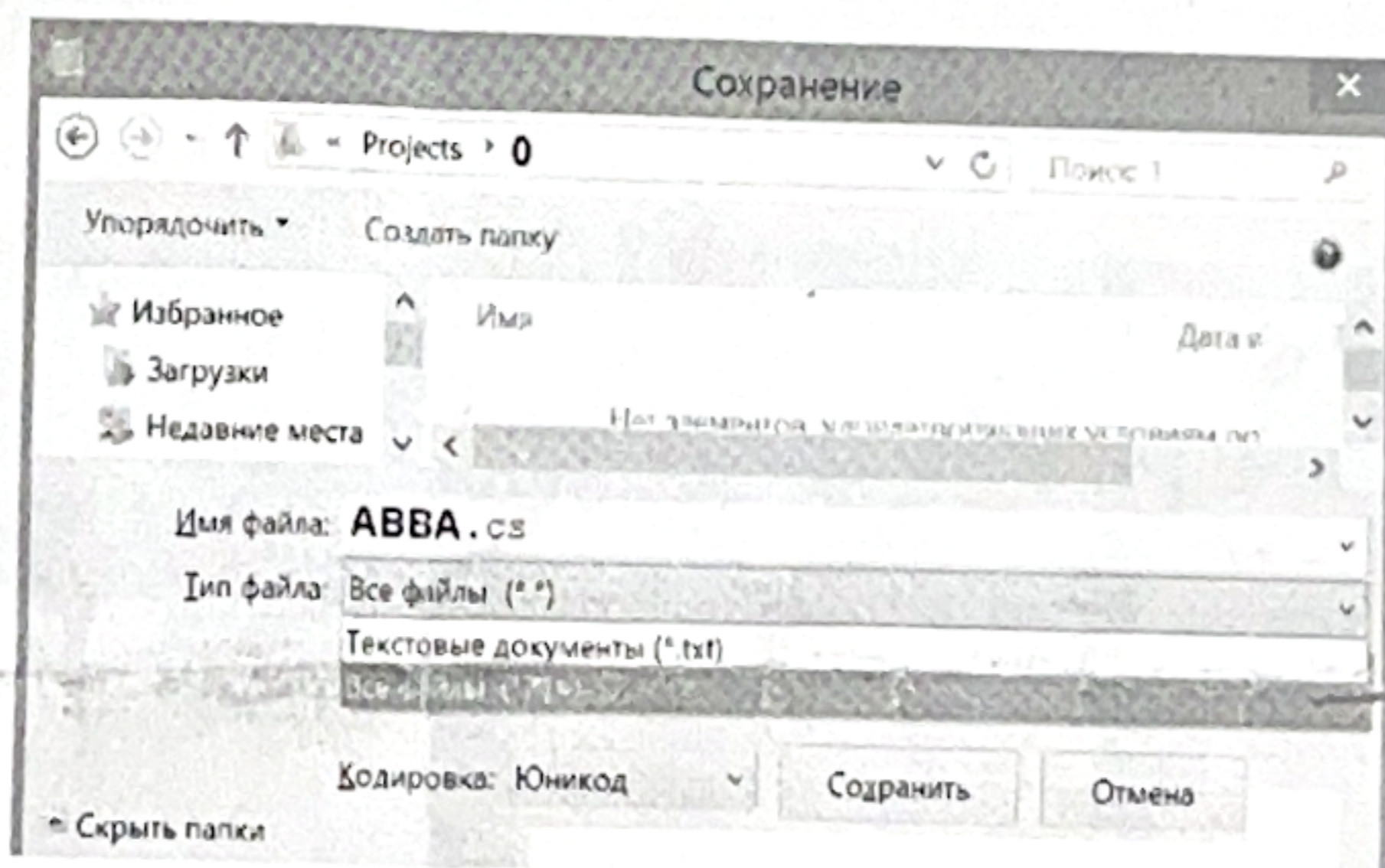
Step 2. In the folder E:\IT\ we make the folder of the Projects - E:\IT\Projects

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>

```

### 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`.



**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`

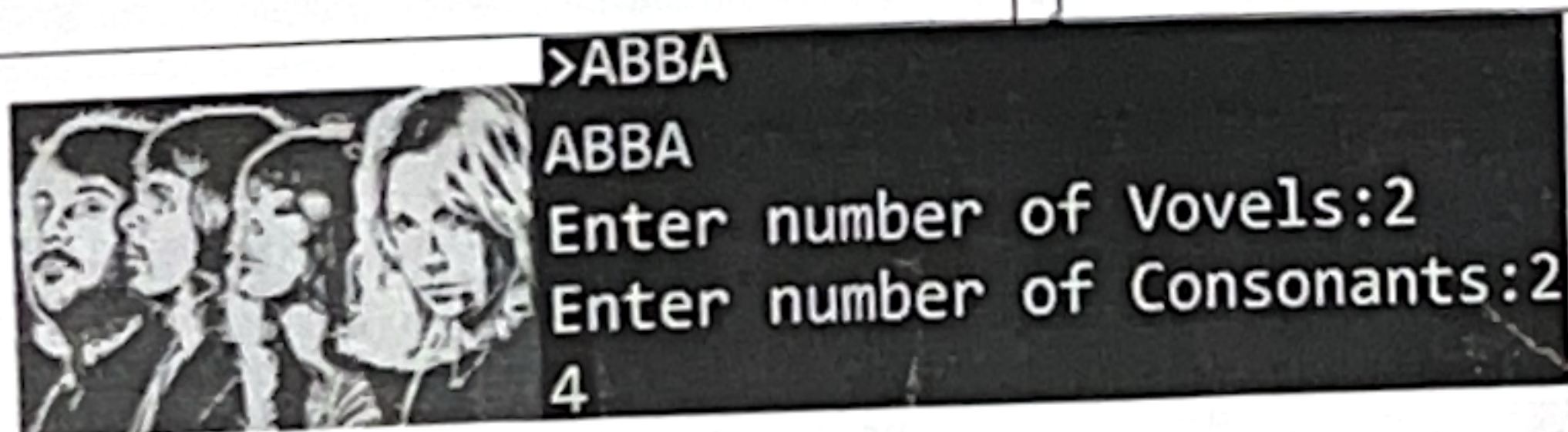
`>ABBA`  
`ABBA - 24`

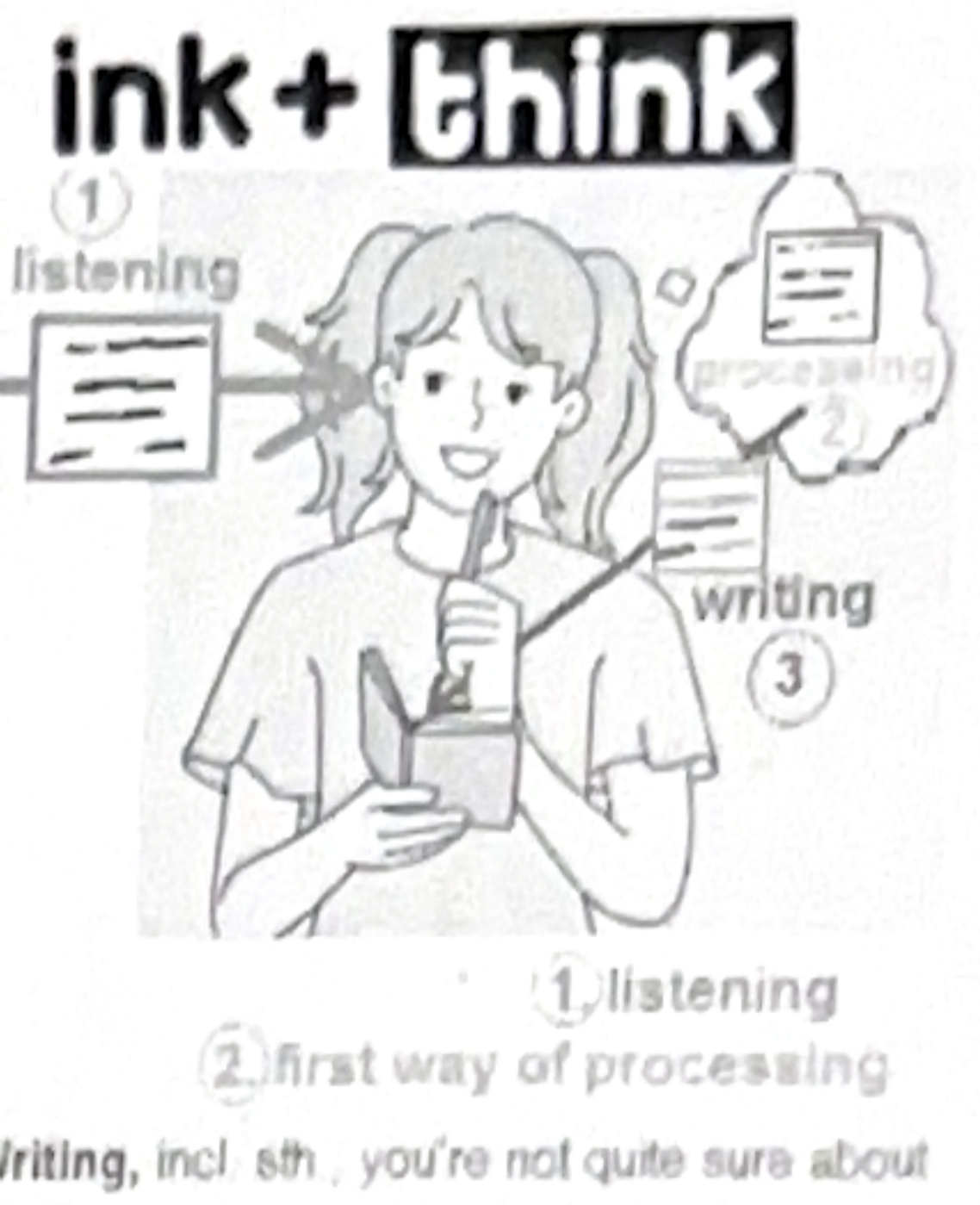
**Step 7.** Modify the file as follows

```
using System;

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

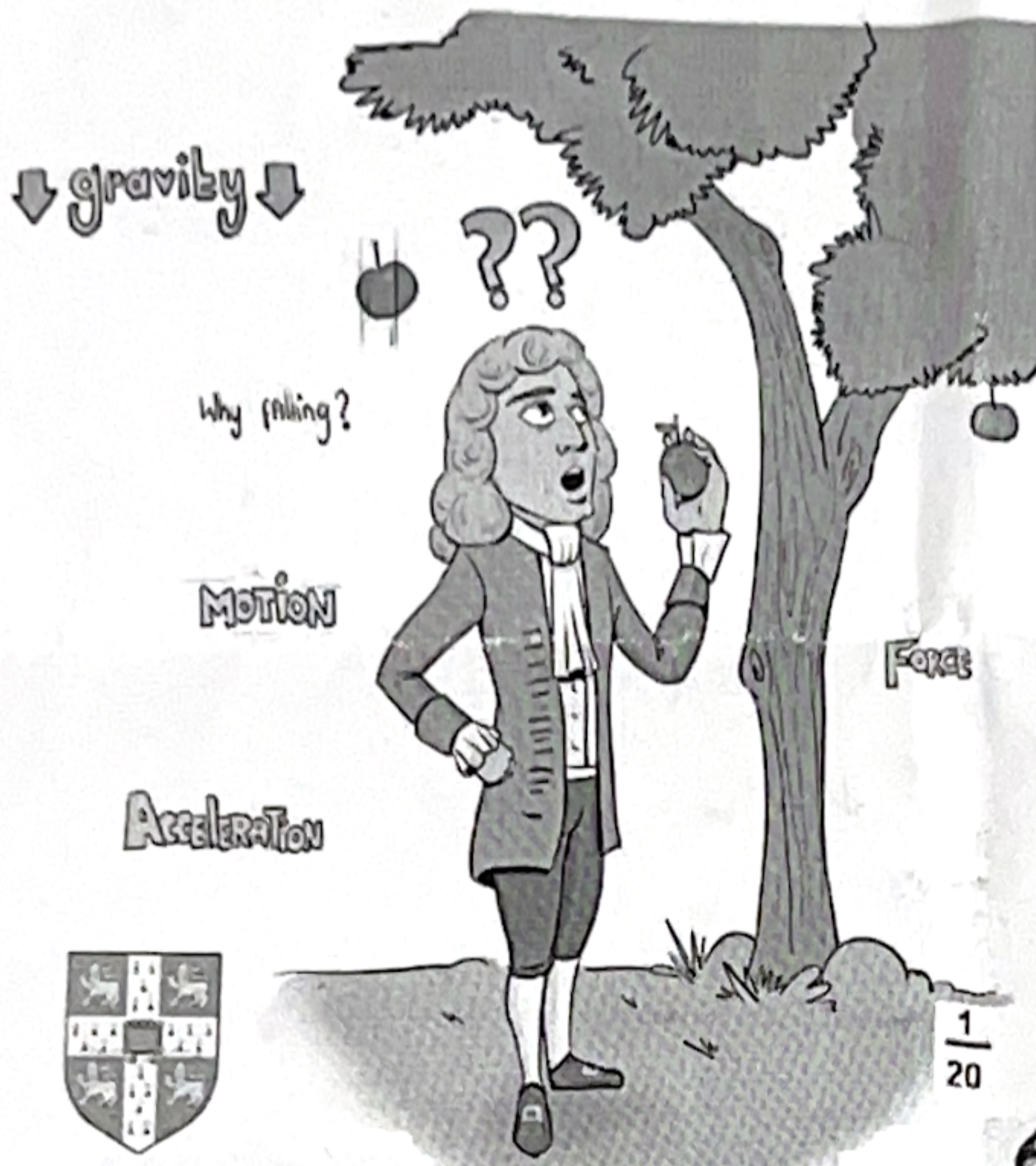
    public static void Main()
    {
        System.Console.WriteLine("ABBA");
        System.Console.Write("Enter number of Vowels:");
        string s = Console.ReadLine();
        int vowels=int.Parse(s);
        System.Console.Write("Enter number of Consonants:");
        s=System.Console.ReadLine();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



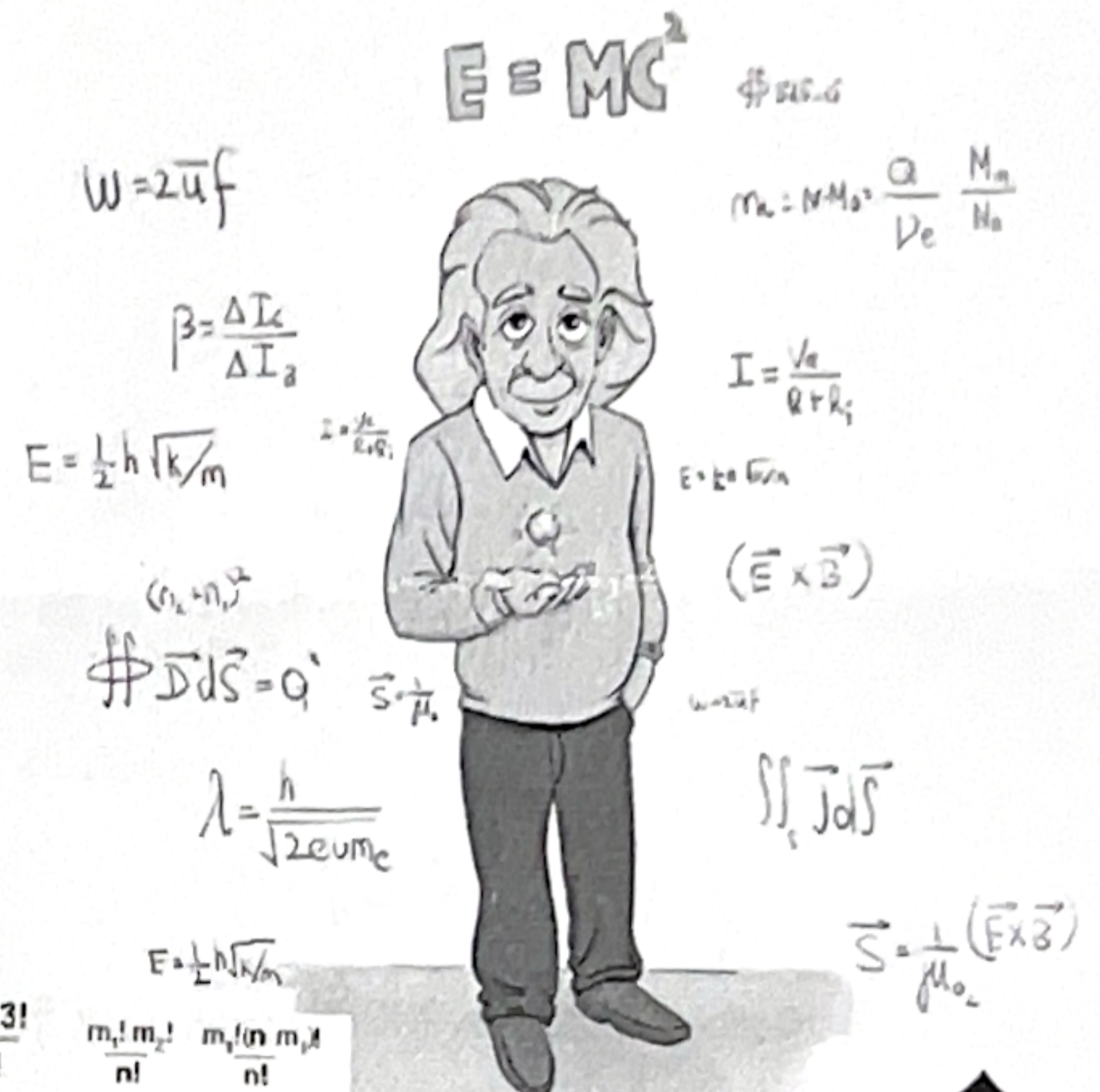


School  $\downarrow$  gravity  $\downarrow$  MOTION ==formalism==> University  $E = MC^2$   $\oint \vec{A} \cdot d\vec{s} = 0$   $\iint \vec{J} \cdot d\vec{S}$

## CONCRETE AND ABSTRACT THINKING



ISAAC NEWTON



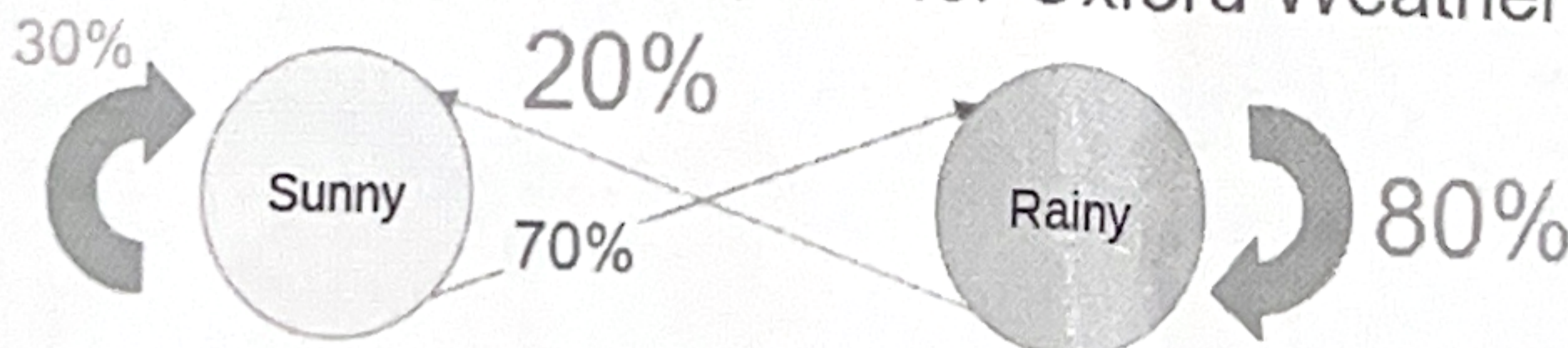
ALBERT EINSTEIN

Motivation: 80% chance of rain  
 Let  $A_j$  be the event of rain at 9am on day  $j$  of this term,  $1 \leq j \leq n$ .  
 Suppose the events  $A_j$  are independent, each have probability  $p$ .

Oxford			
Tue 13th	Wed 14th	Thu 15th	Fri 16th
10° 9° 70%	13° 10° 70%	13° 8° 70%	11° 7° 80%

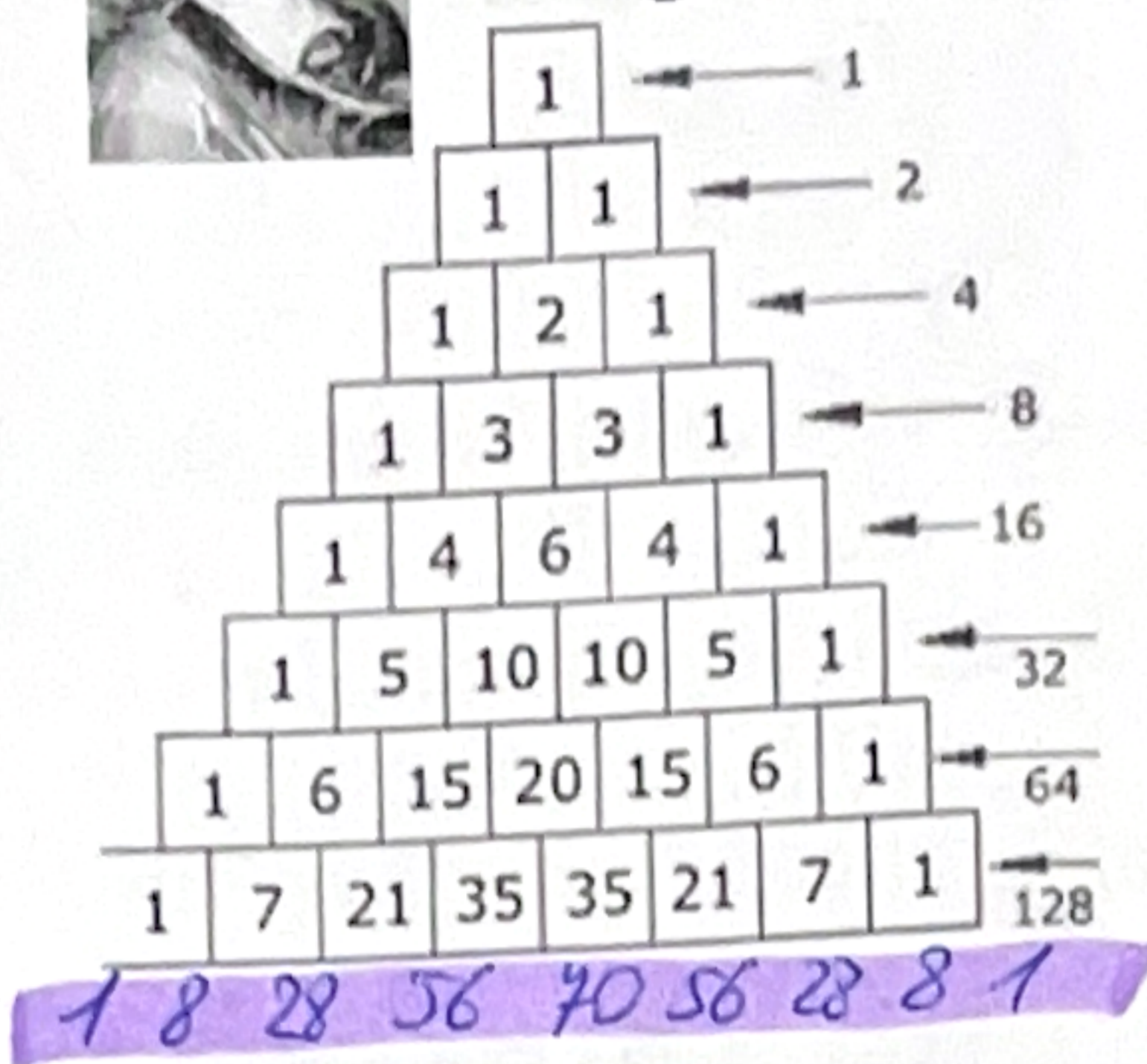
Markoff Chain Probability Model

for Oxford Weather





# Pascal's triangle



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

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

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

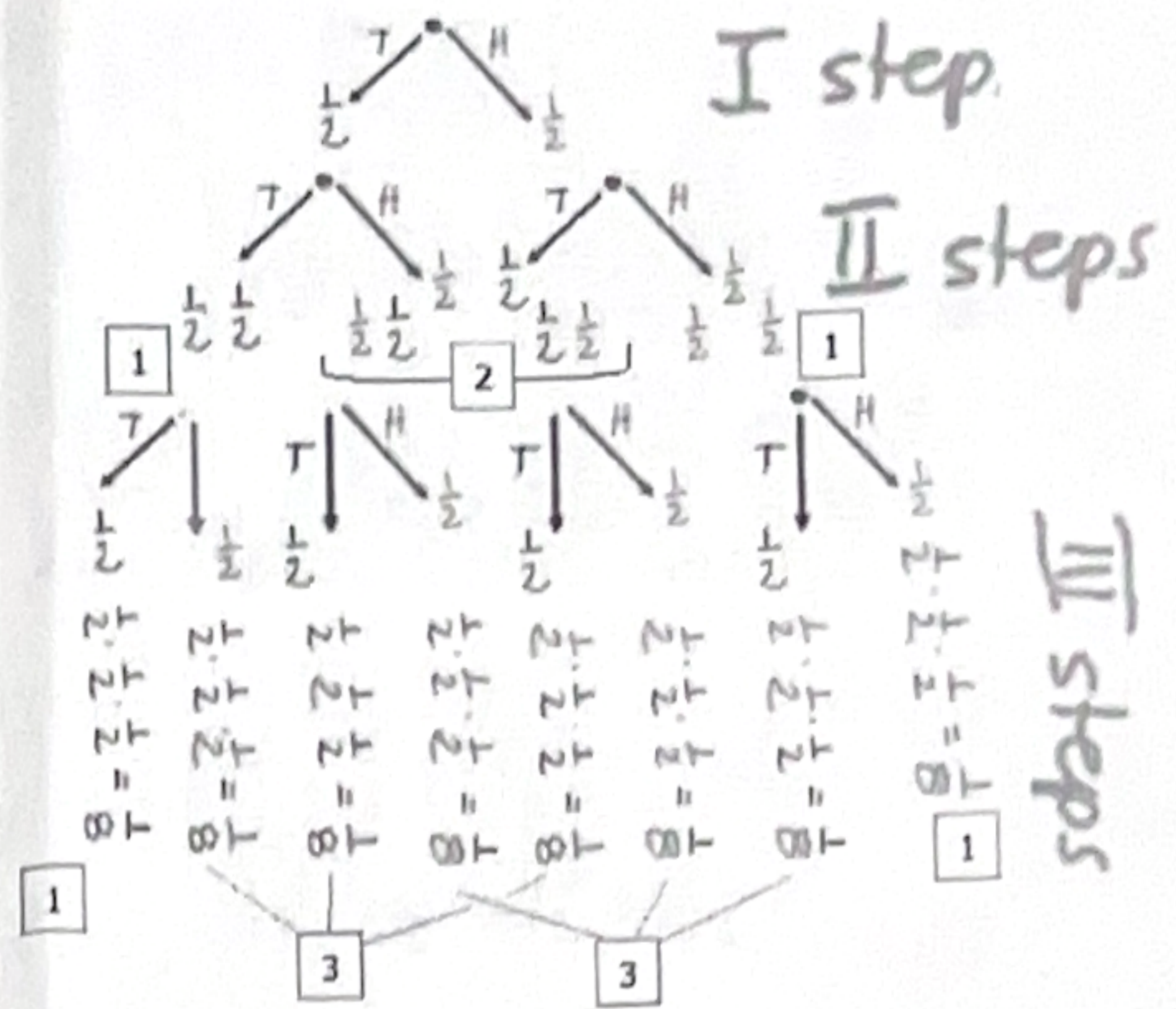
$$(a + b)^3 =$$

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

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

$$(a + b)^7 = a^7 + 7a^6b + 21a^5b^2 + 35a^4b^3 + 35a^3b^4 + 21a^2b^5 + 7ab^6 + b^7$$

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



# Newton's Binomial



$$a + b$$

$$a^2 + 2ab + b^2$$

$$a^3 + 3a^2b + 3ab^2 + b^3$$

$$a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4$$

$$a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5$$

$$a^7 + 7a^6b + 21a^5b^2 + 35a^4b^3 + 35a^3b^4 + 21a^2b^5 + 7ab^6 + b^7$$

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