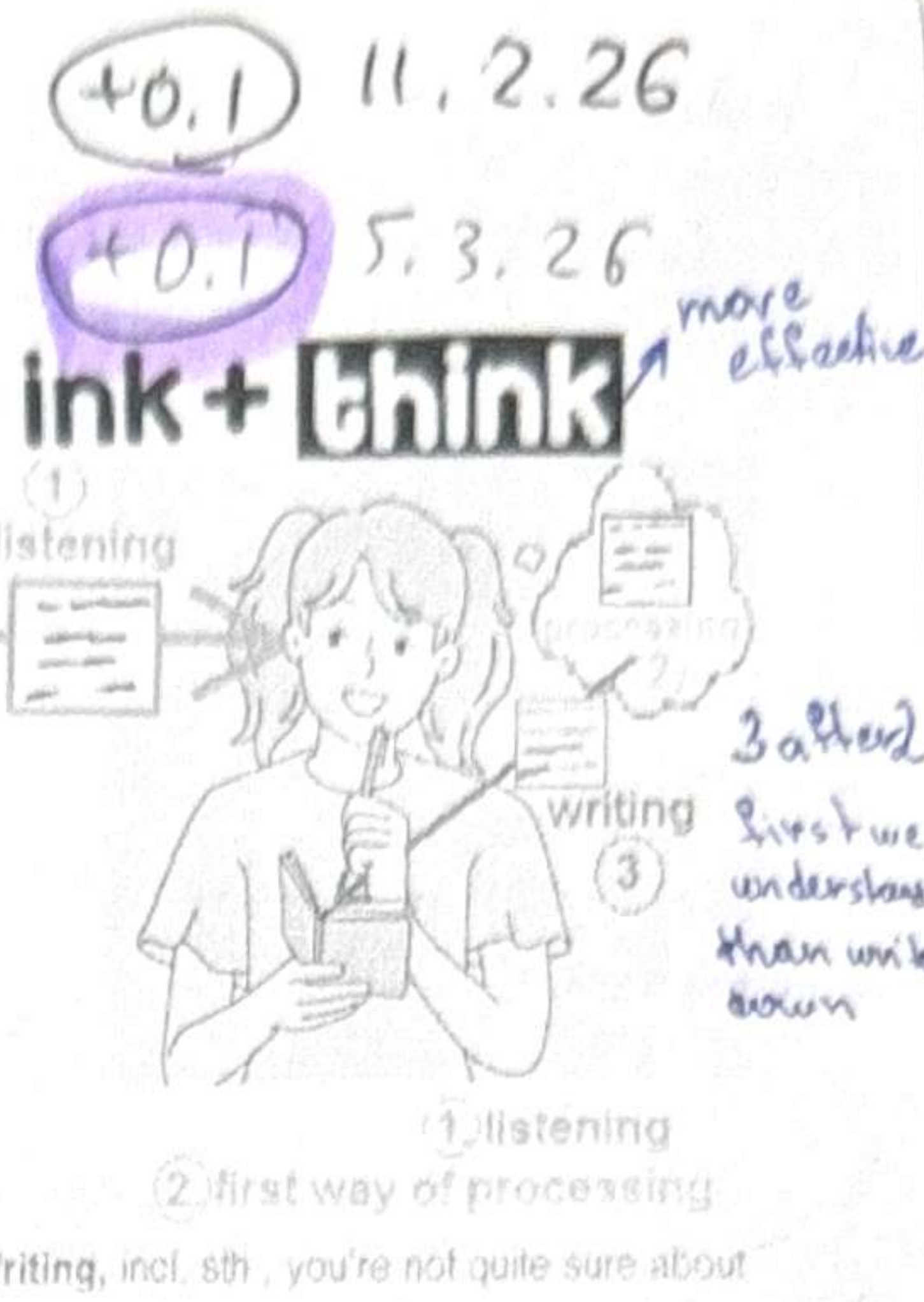
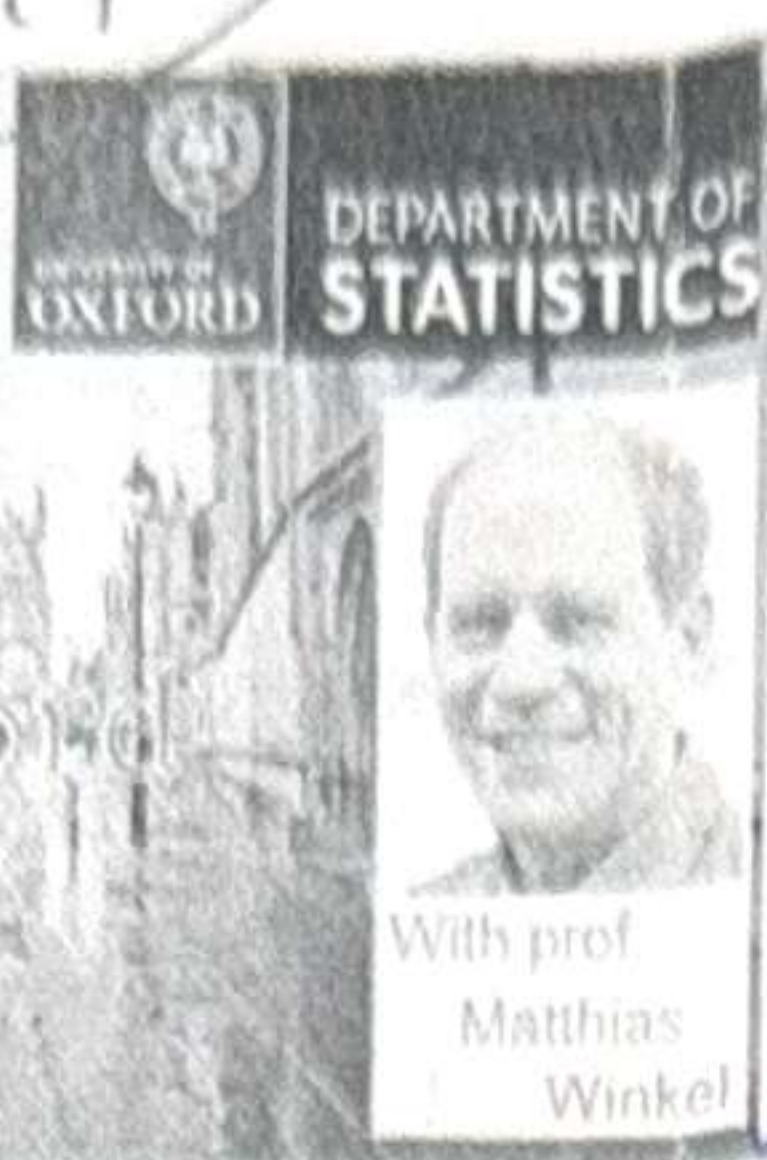


We start with real observation, not with formulas

1. It's raining
2. 80% chance of rain
3. Markov Weather model

Introduces the probabilistic nature of weather prediction



work with concrete things

School $\downarrow$ gravity $\downarrow$ **MOTION**

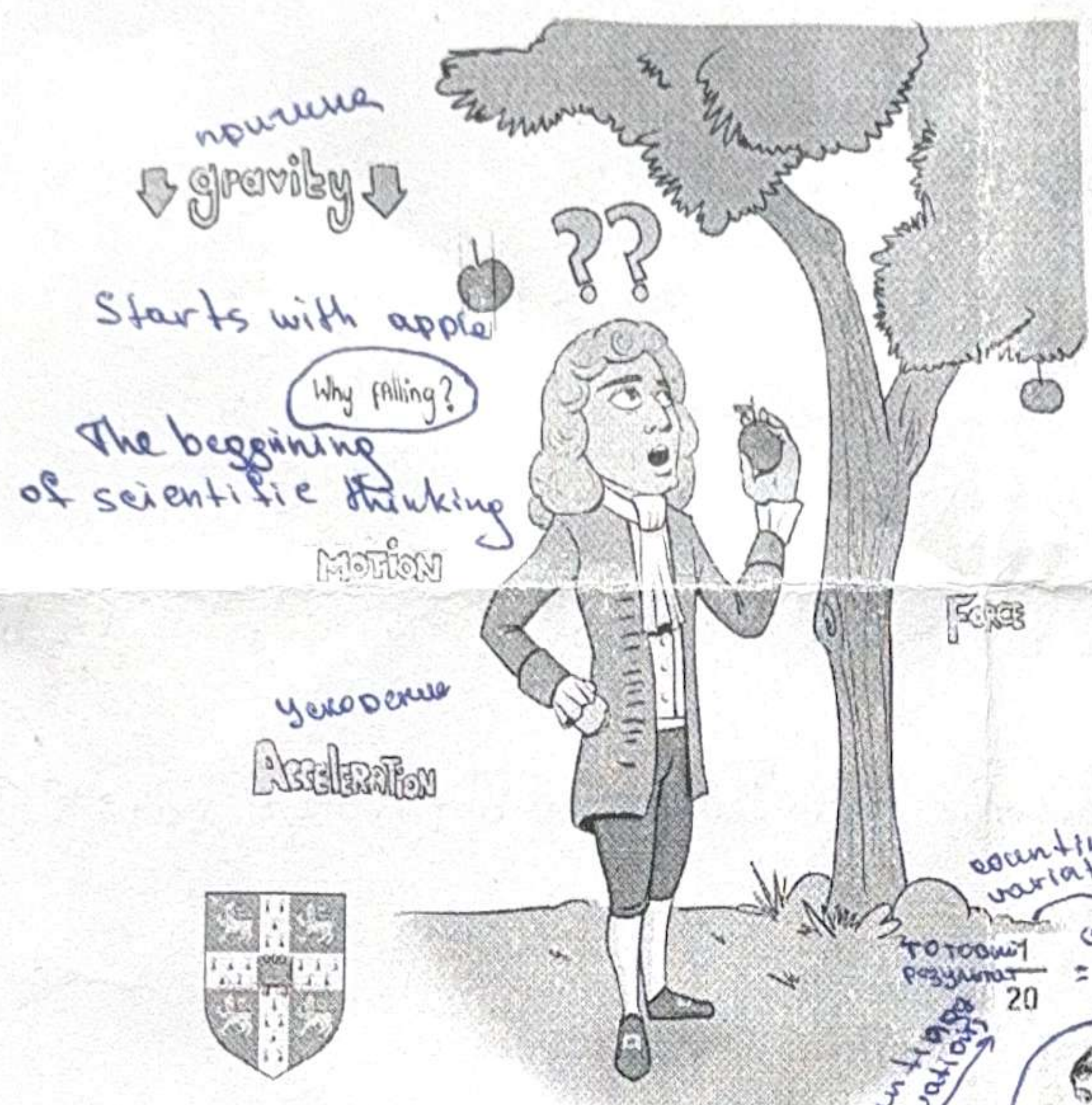
translating and idea into language of mathematics

==formalism==> University

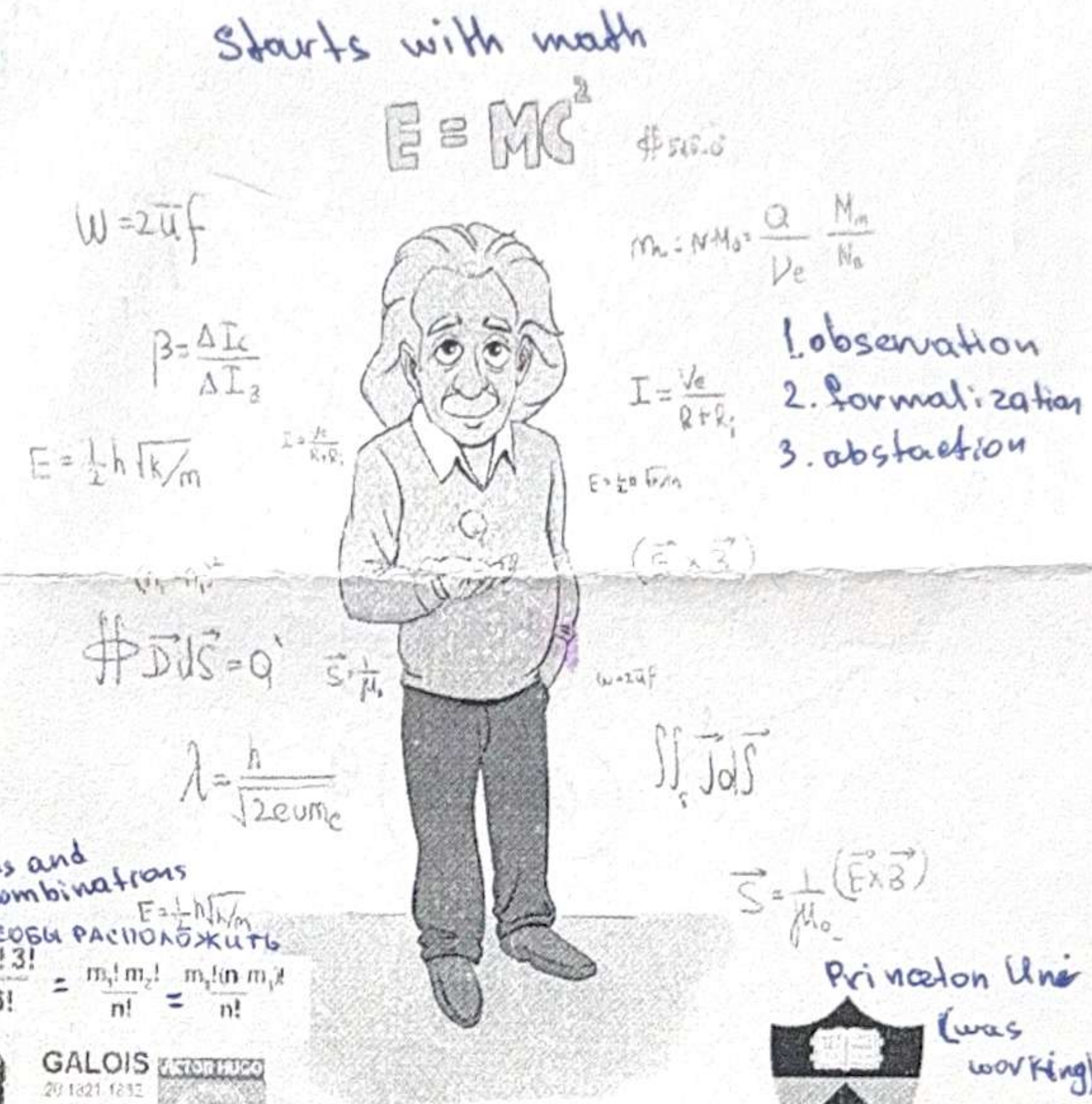
work with models $E=MC^2$

CONCRETE AND ABSTRACT THINKING

Consult



ISAAC NEWTON



ALBERT EINSTEIN

Motivation: 80% chance of rain

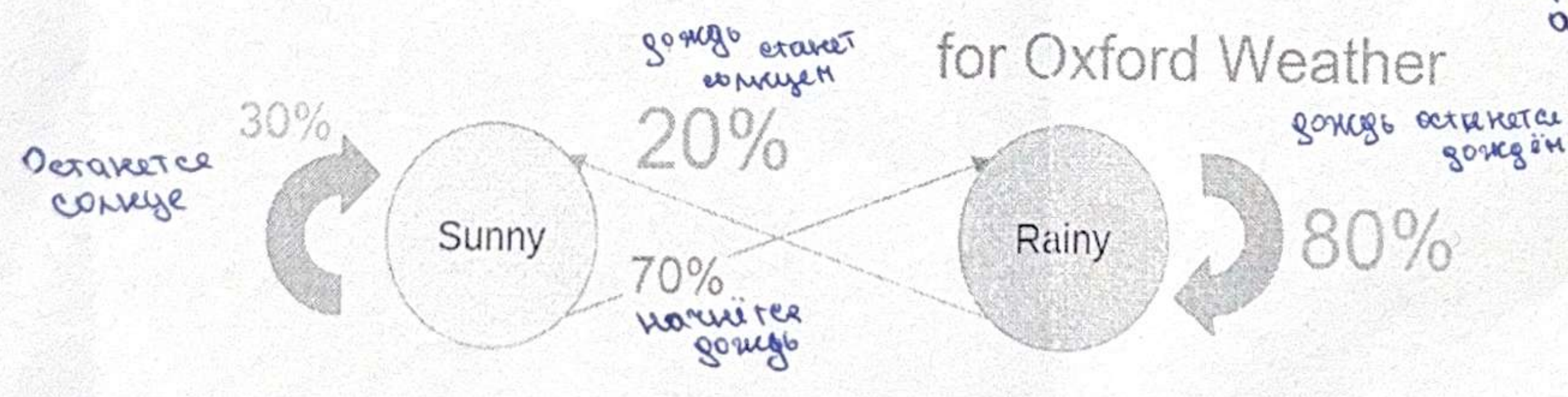
Let A_j be the event of rain on day j of this term, $1 \leq j \leq n$

Suppose the events A_j are independent

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

Markoff Chain Probability Model — The future depends only on the present and doesn't depend on the past

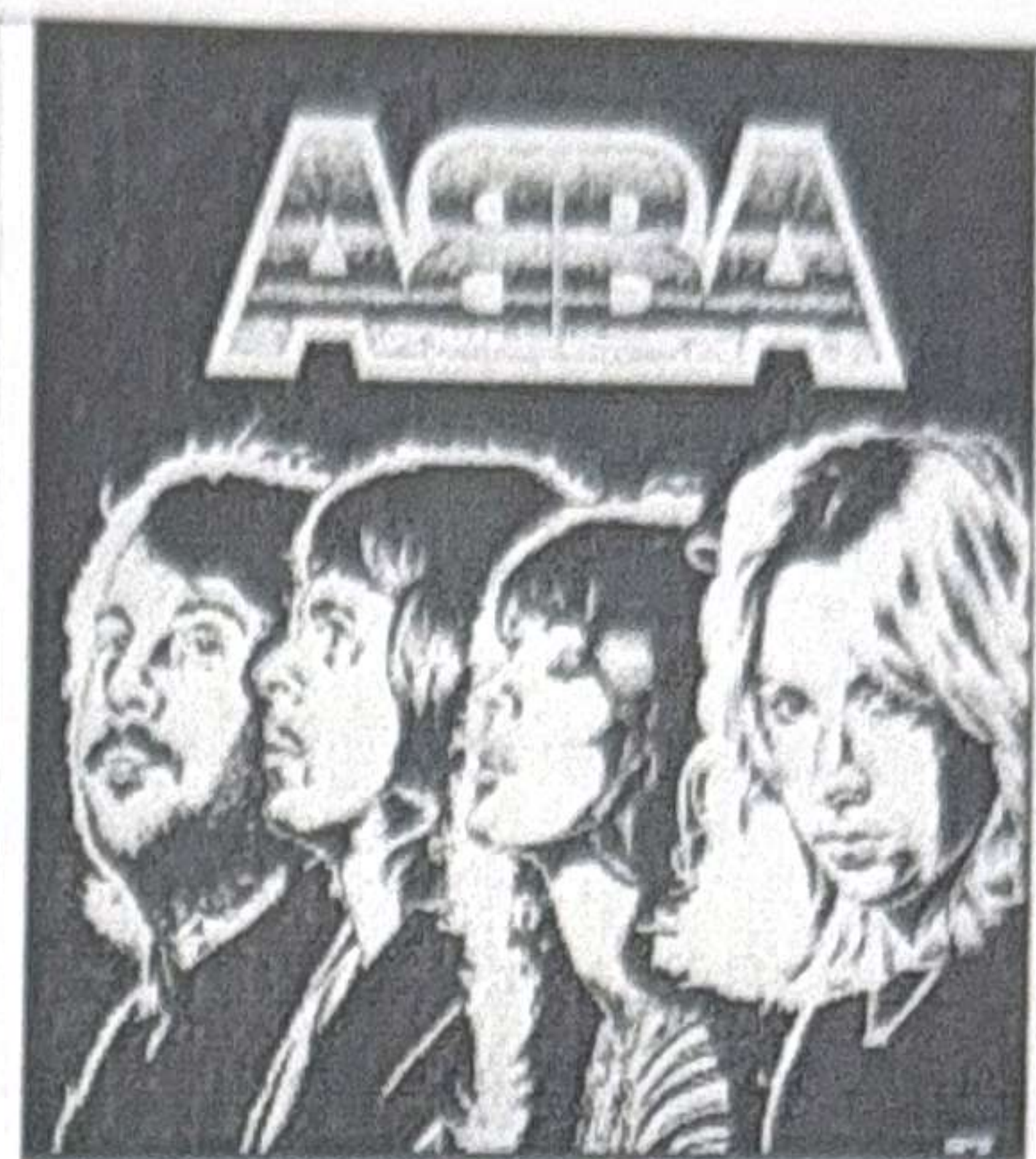
for Oxford Weather



This is the program we need to write today

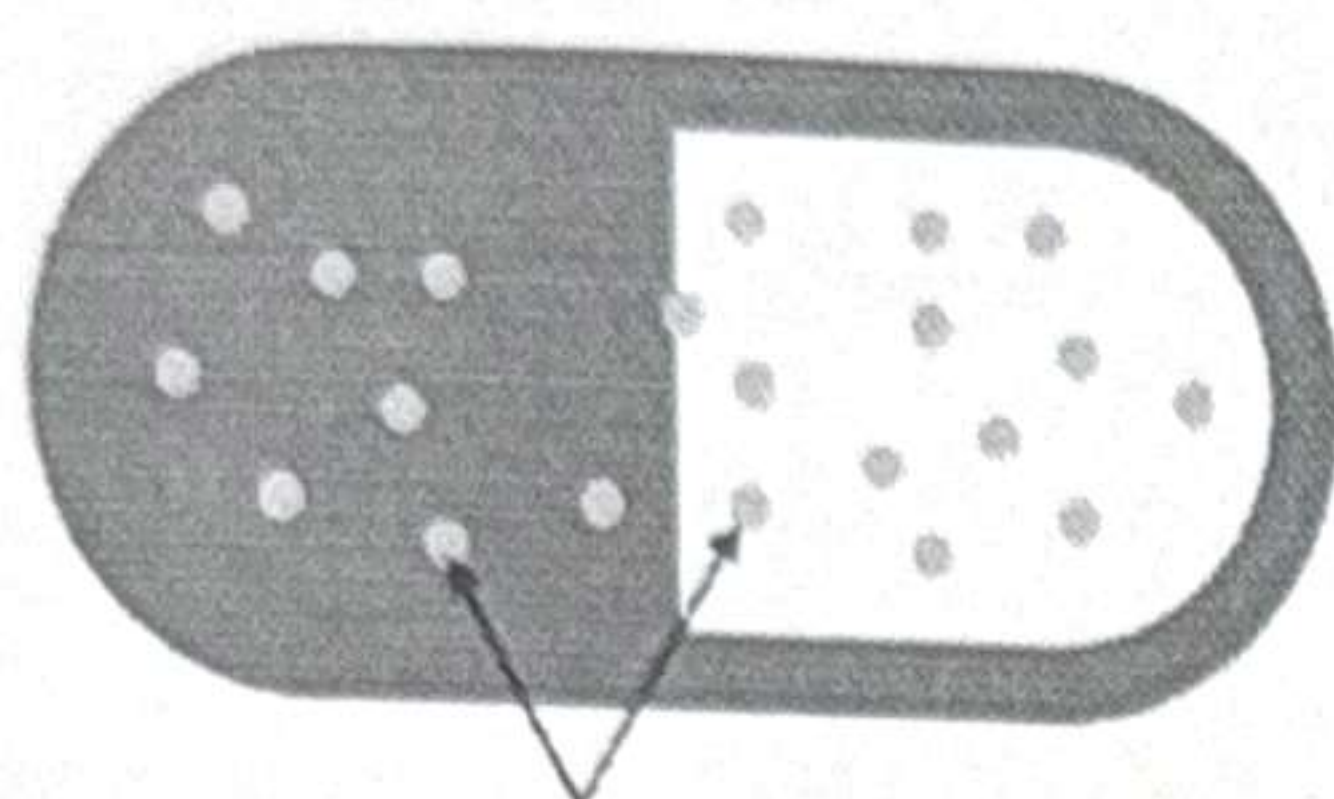
```
class ABBA
{
    static void Main(string[] args)
        // Here's a method called Main.
    {
        System.Console.WriteLine("ABBA!");
    }
}
```

В конце

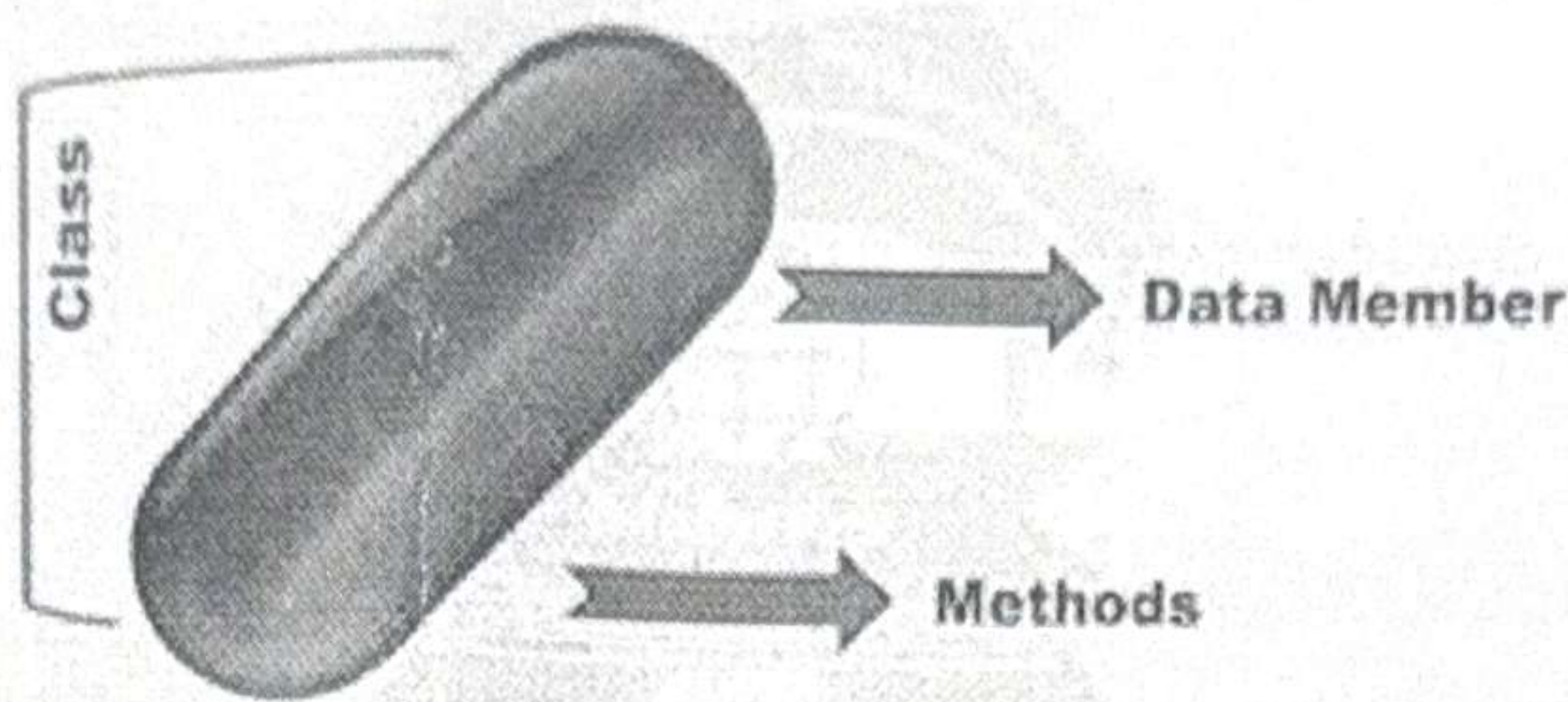


So there's the keyword class. Unlike C++, in C# all code must be placed in a class.

Encapsulated in a class.



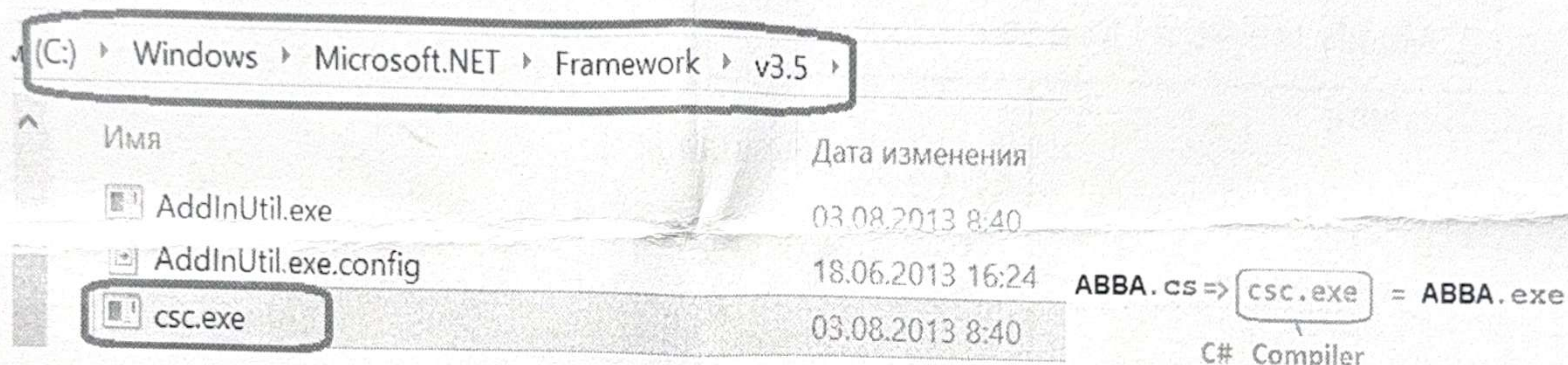
Medicines Inside Capsule



A ≠ a

C# is case sensitive

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

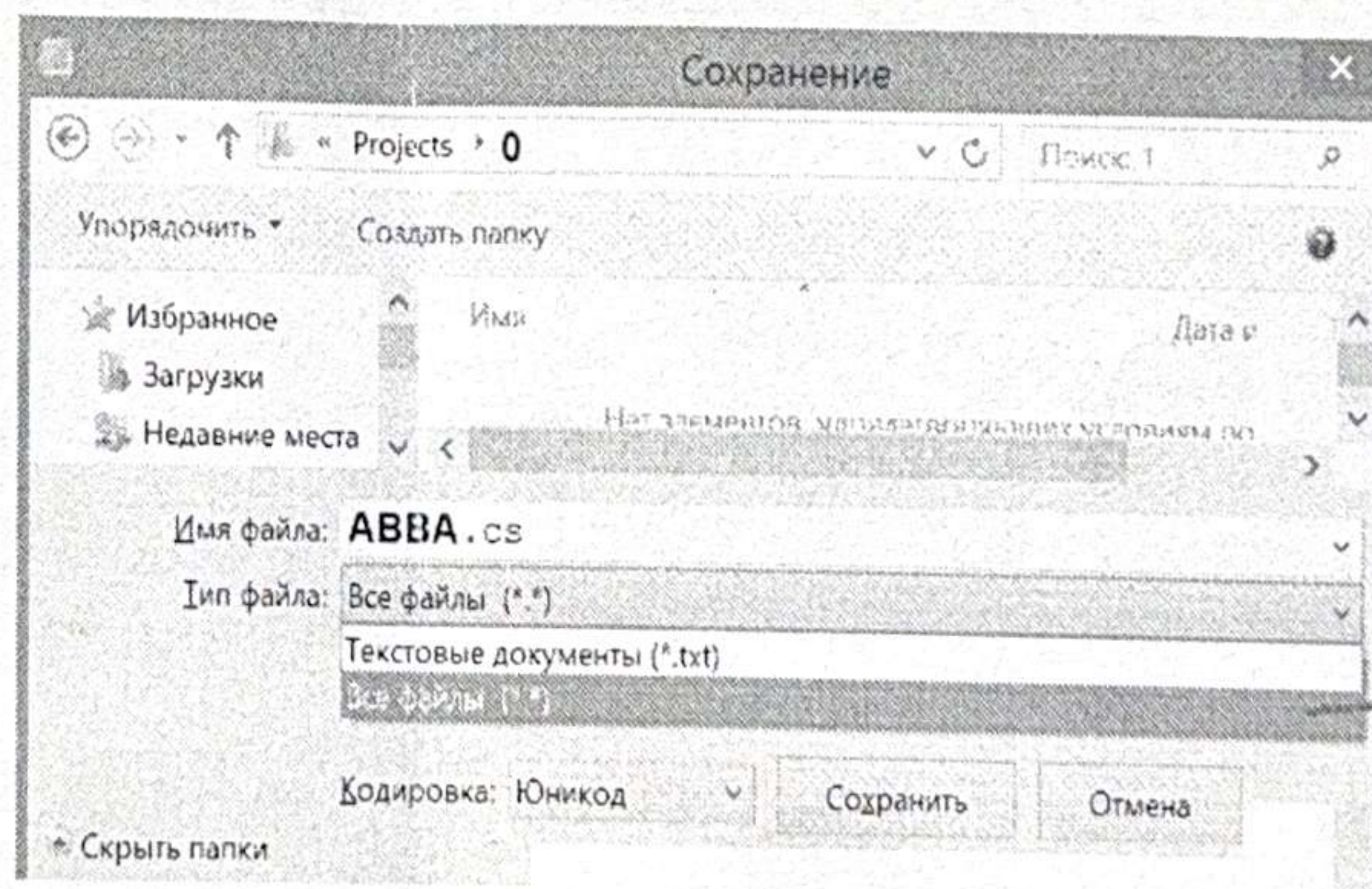


Step 1. And on my HDD, I also make a folder with the same name D:\ IT

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.

>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 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) );
}
```

>ABBA

ABBA

Enter number of Vowels:2
Enter number of Consonants:2
4

>ABBA

ABBA

Enter number of Vowels:3
Enter number of Consonants:3
36



1

2

3

4



+0,1 +0.1

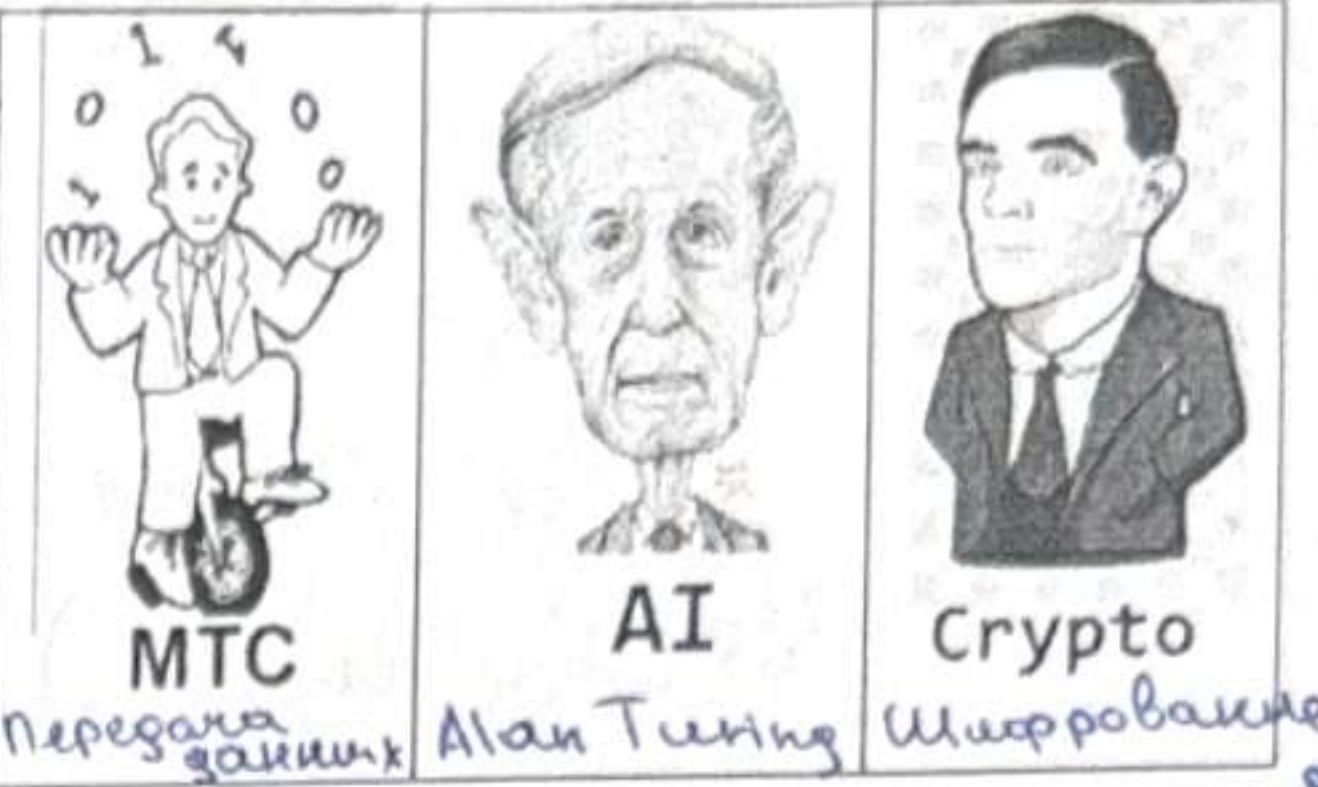
+0.1 Thorn

+0.1

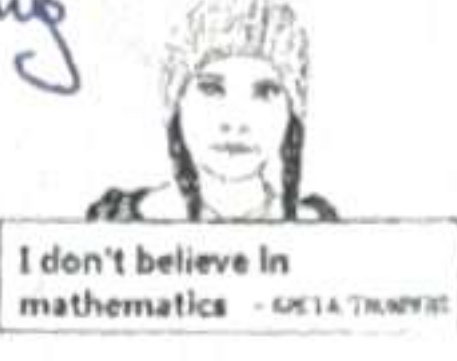
Do tip if I make error



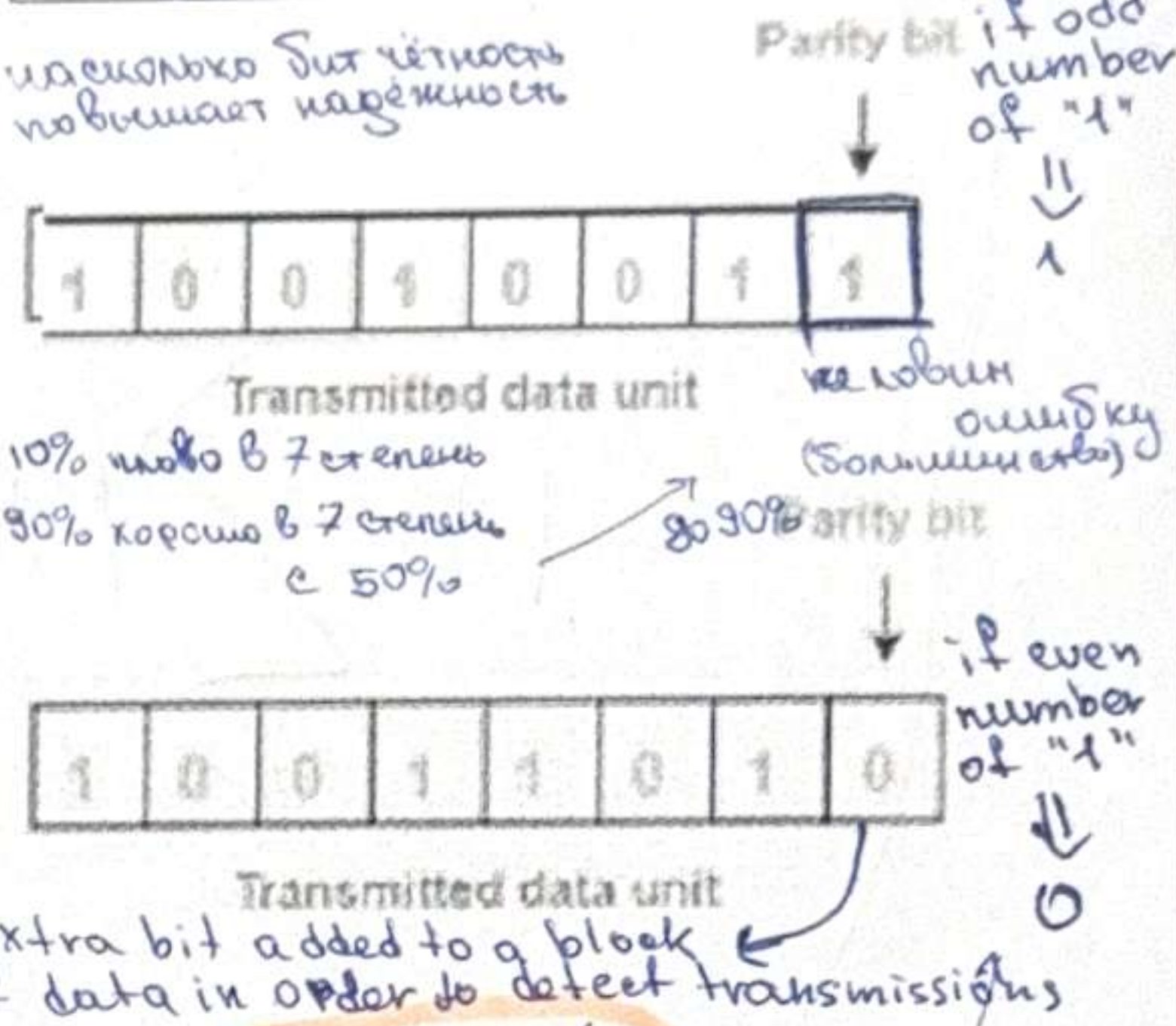
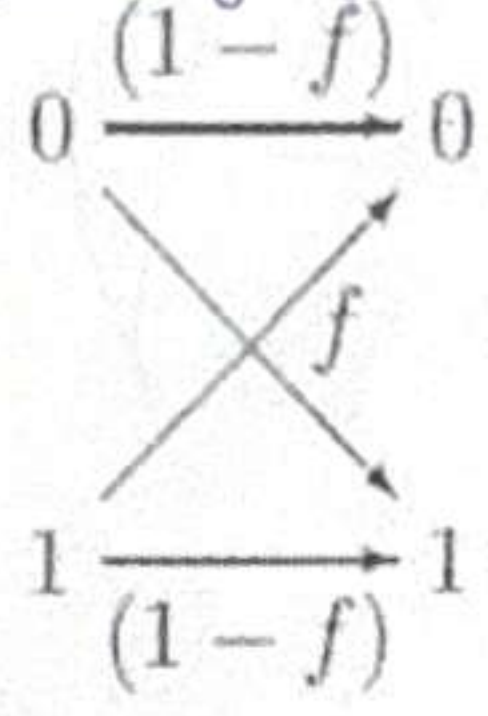
Sir Dr. D. MacKay,
University of Cambridge
(22 April 1967 – 14 April 2016)



Do not make decisions based on emotions alone
"I believe in clean energy,
but I also believe in mathematics"



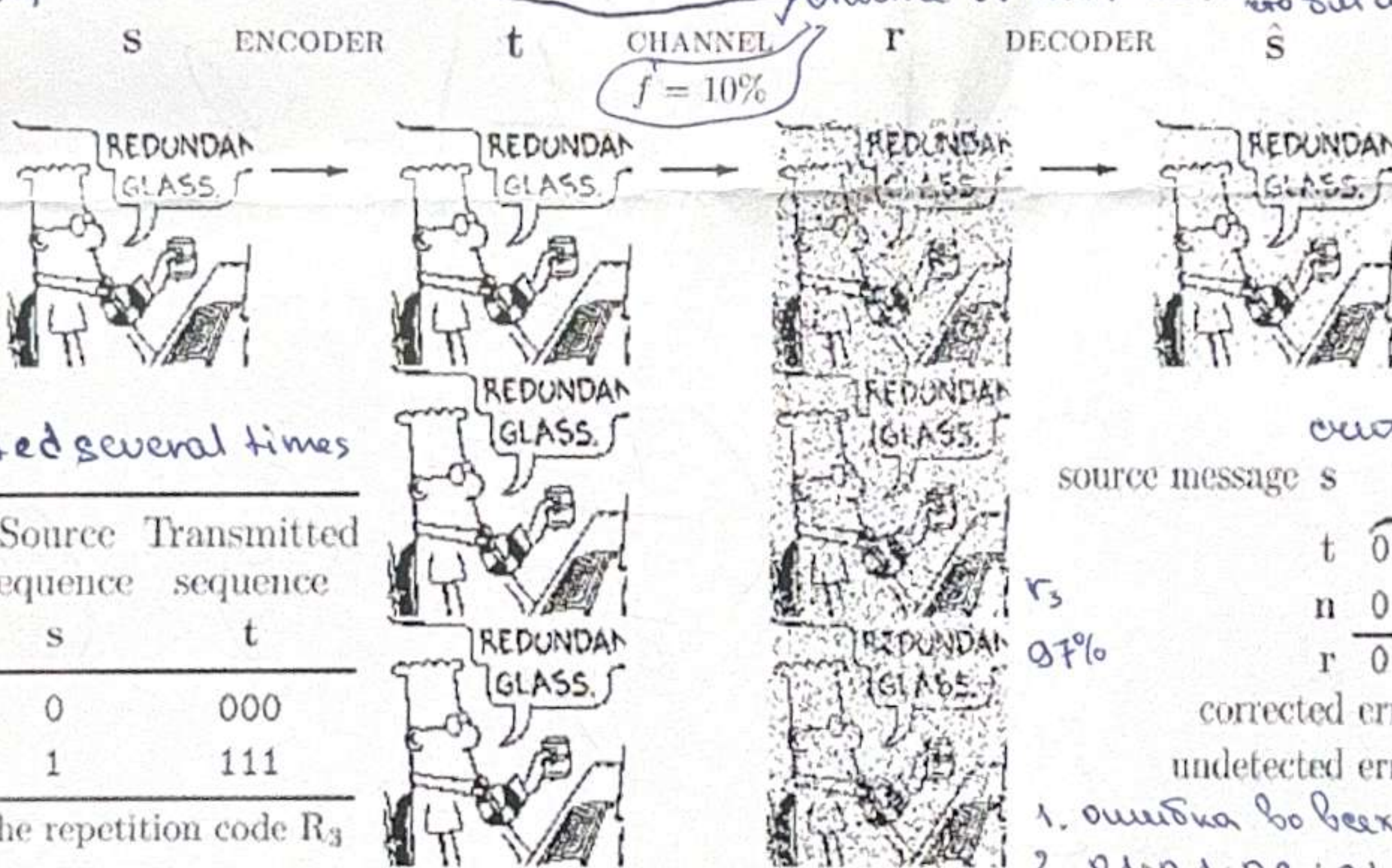
Binary Symmetric Channel



without noise
Example of transmitting a message through a noisy channel



representation of R-3 logic
(more copies)
less data loss



repetition code
each bit transmitted several times
to add redundancy
If one is corrupted
the original value
can be recovered
through majority voting

Source sequence	Transmitted sequence
s	t
0	000
1	111

The repetition code R_3

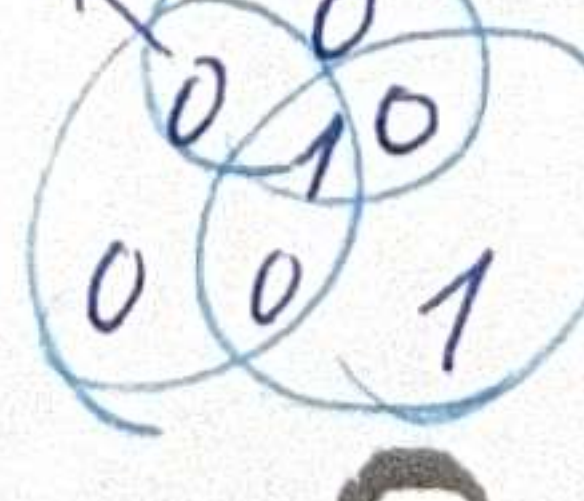
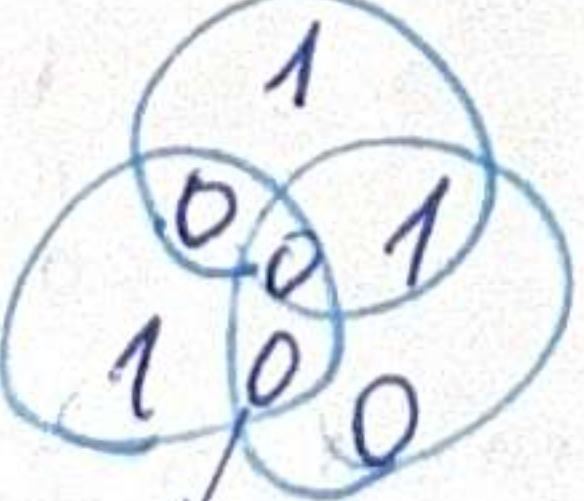
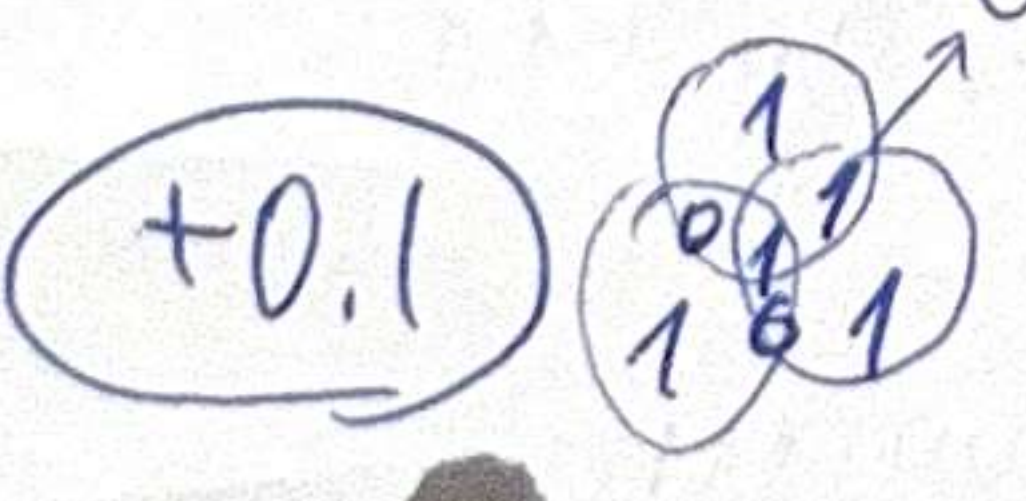
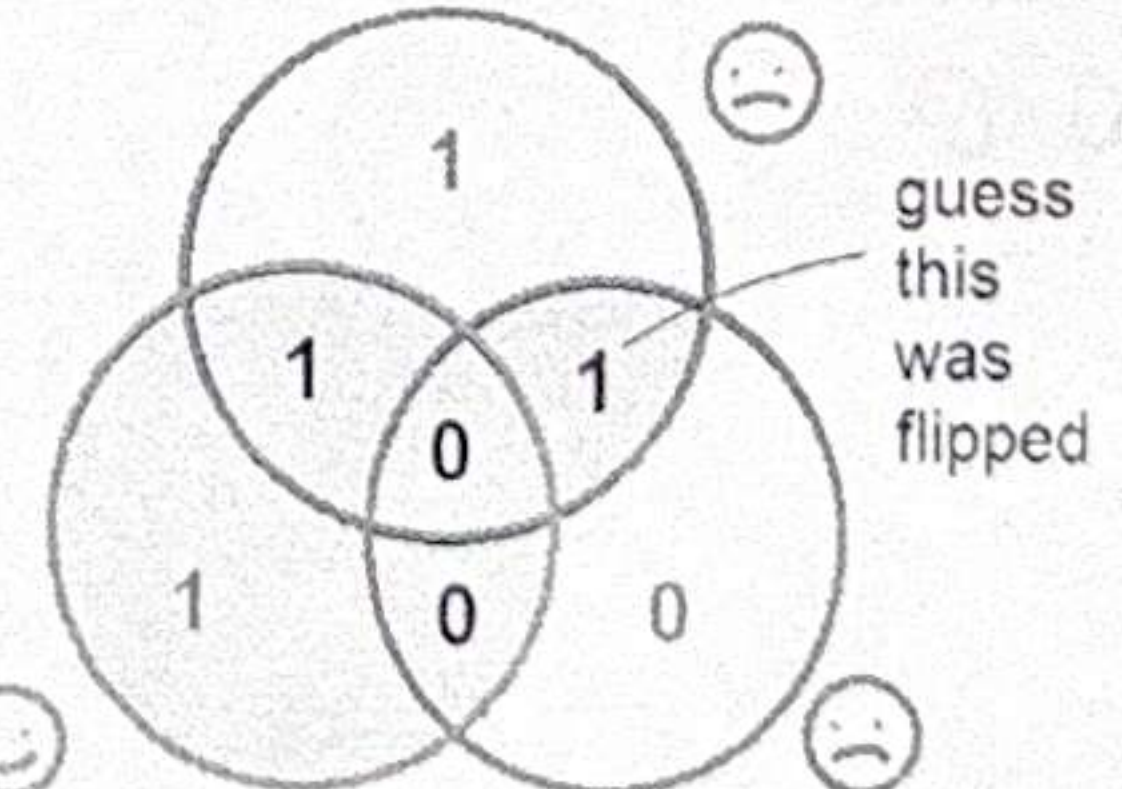
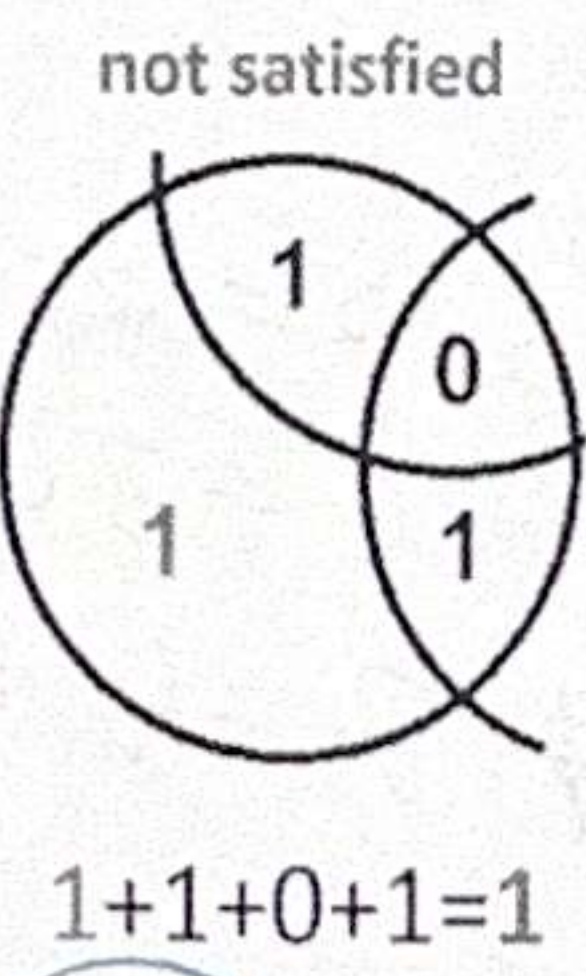
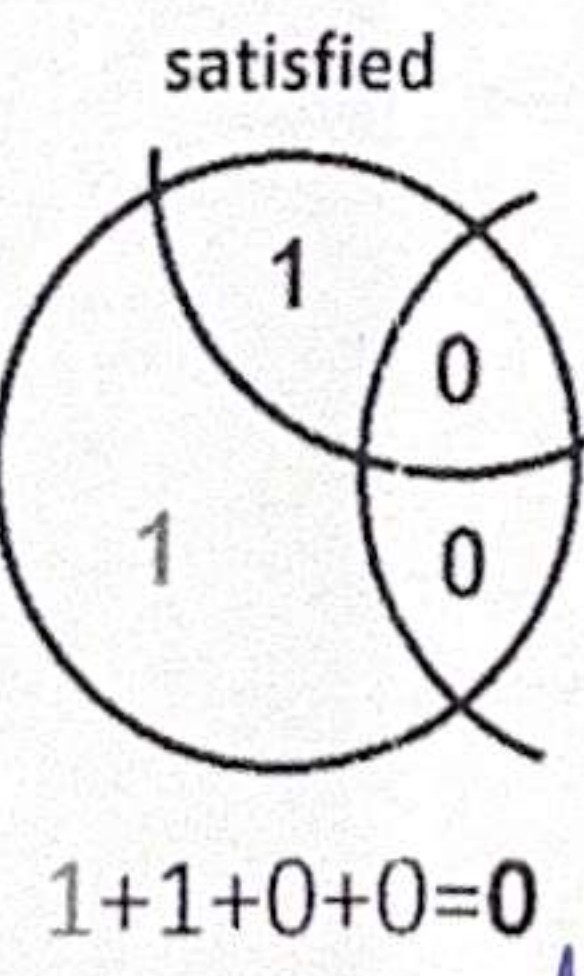
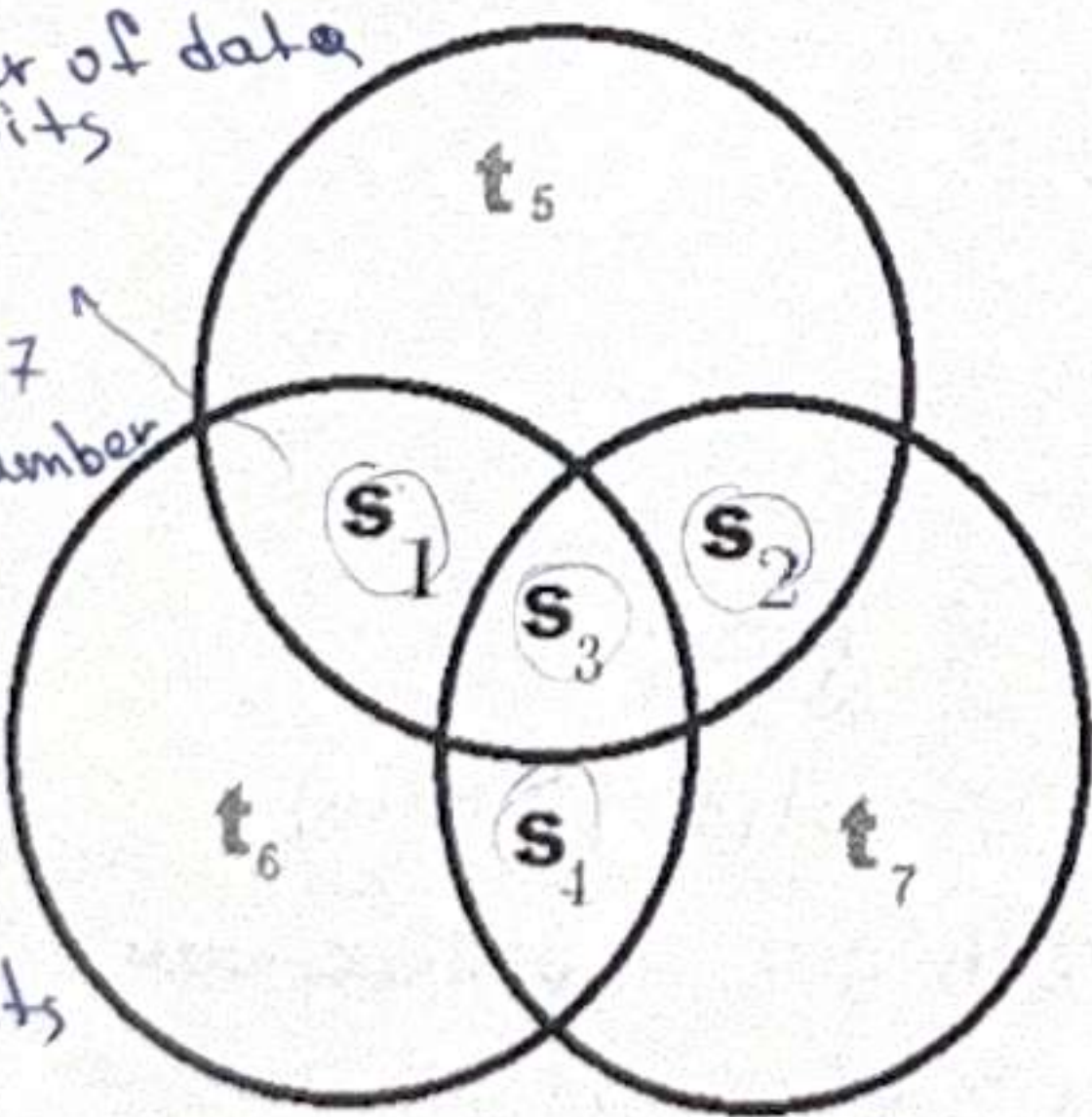
source message	s	0	0	1	0	1	1	0
t	000	000	111	000	111	111	000	
n	000	001	000	000	101	000	000	
r	000	001	111	000	010	111	000	

corrected errors *
undetected errors
1. 0.001
2. 0.1-0.1-0.9; 0.1-0.9-0.1; 0.9-0.1-0.1
0.009 0.009 0.009
0.1-0.1-0.1 = 0.001
= 0.028
→ 0.97 = 97%

7.4. Hamming code.

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

Makey
number of data bits
4
total number of bits
7
7-4=3
parity bits



+0.1

Handout 3

$0000 = \frac{4}{8} = 0,5$ **1**
 $00 = \frac{2}{8} = 0,25$ **концы**
 $0 = \frac{1}{8} = 0,125$ **среднее**
 $0 = \frac{1}{8} = 0,125$ **к-во?**
 нужно задать
 чтобы угадать шарик.

кол-во вопросов		
3	1	0,5
4	2	0,5
5	3	0,375
6	3	0,375

1,75

$$H = \sum_{i=1}^n p(x) \cdot \log_2 \left(\frac{1}{p(x)} \right)$$

$$\log_2 \left(\frac{1}{\frac{1}{2}} \right) = \log_2(2) = 1$$

$$\log_2 \left(\frac{1}{\frac{1}{4}} \right) = \log_2(4) = 2$$

3.14

$$\log_2 \left(\frac{1}{\frac{1}{8}} \right) = \log_2(8) = 3$$

0000000

00

00

$$5.5 = 25$$

$$6.6 = 36$$

$$7.7 = 49 \text{ 5\%}$$

в двоичной:

$$7 = 0111 \text{ (4 бита)}$$

3 5 6 7 - ~~проверочные~~ ^{информационные}

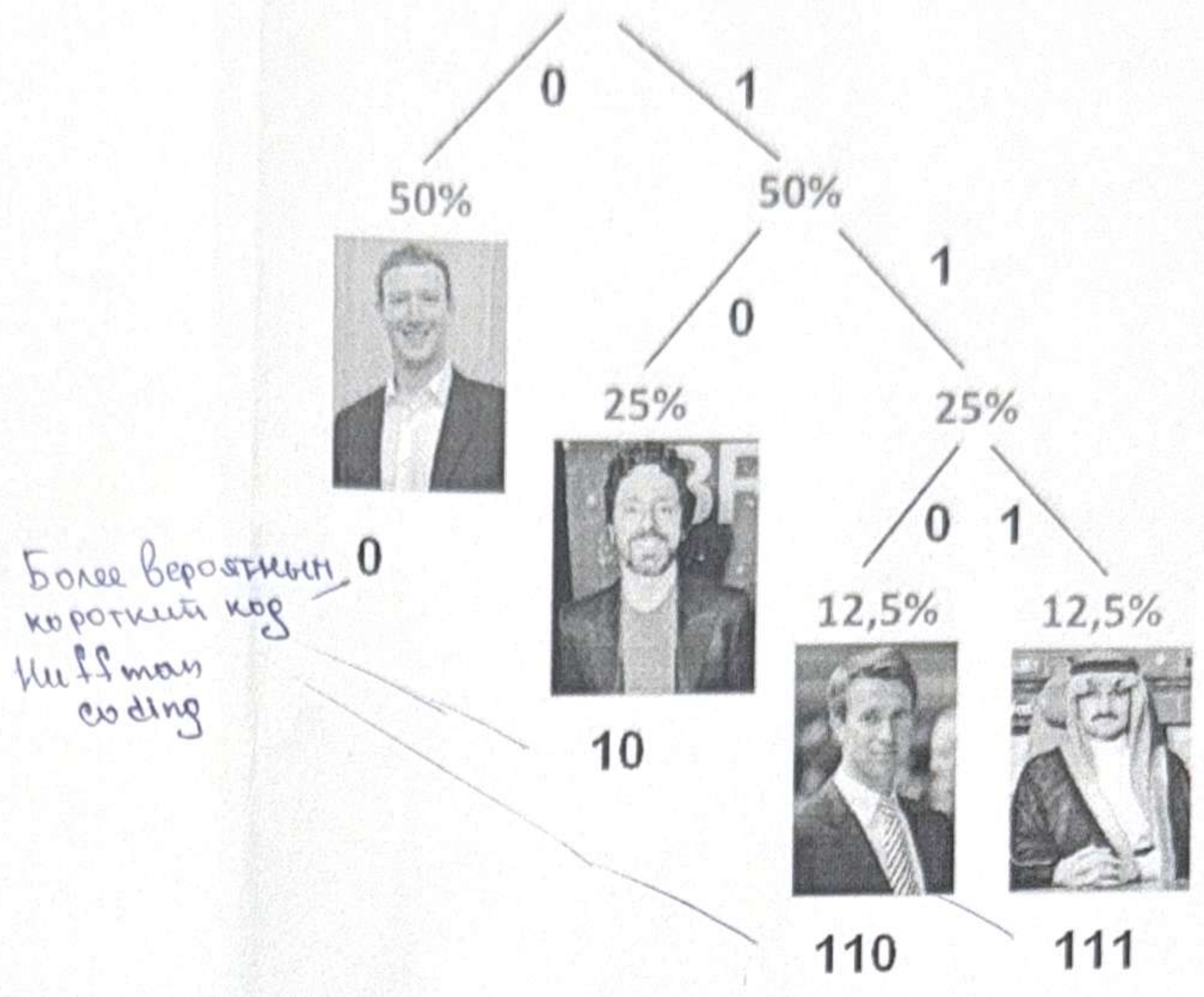
1 2 4 - проверочные биты

$P_1 P_2 O P_4 1 1 1$

" " "

0 0 1

Encoded word 0001111



Более вероятный короткий код Huffman coding

апроксимация первого уровня

апроксимация 2 уровня

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	мамма 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 (diagram (2-symbols) structure as in Belarusian)

+0.1

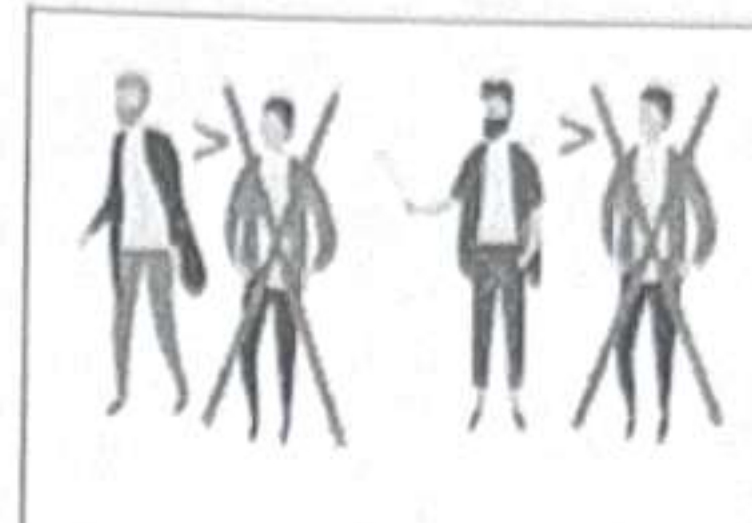
Logic of choosing a partner according to IT



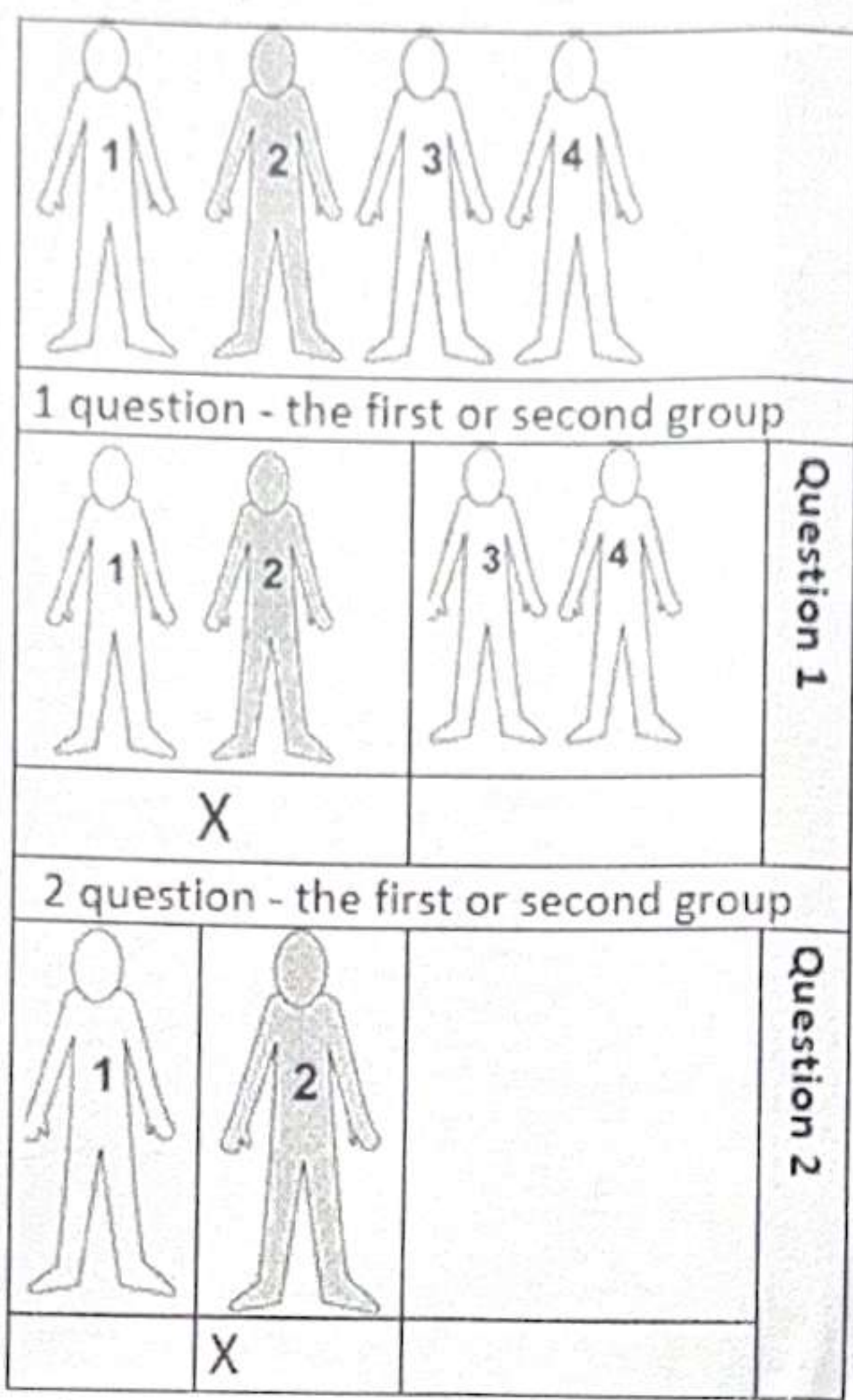
Say NO to the first



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



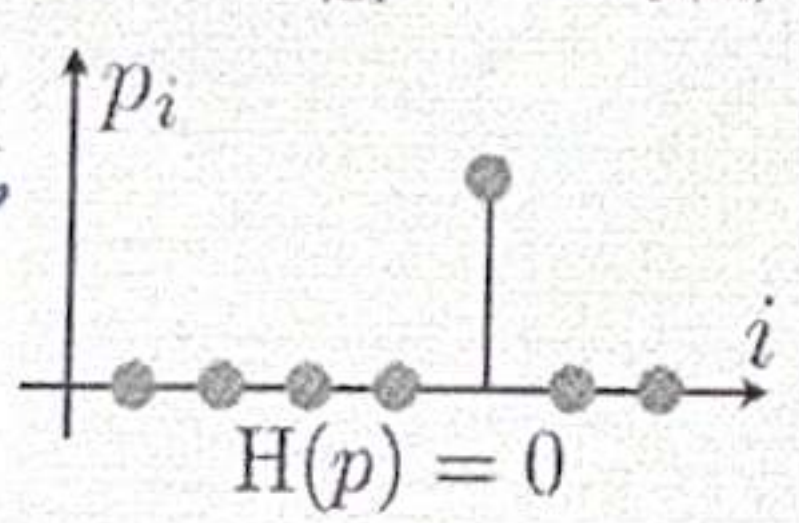
Average number of questions = $2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 = 2$

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		

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

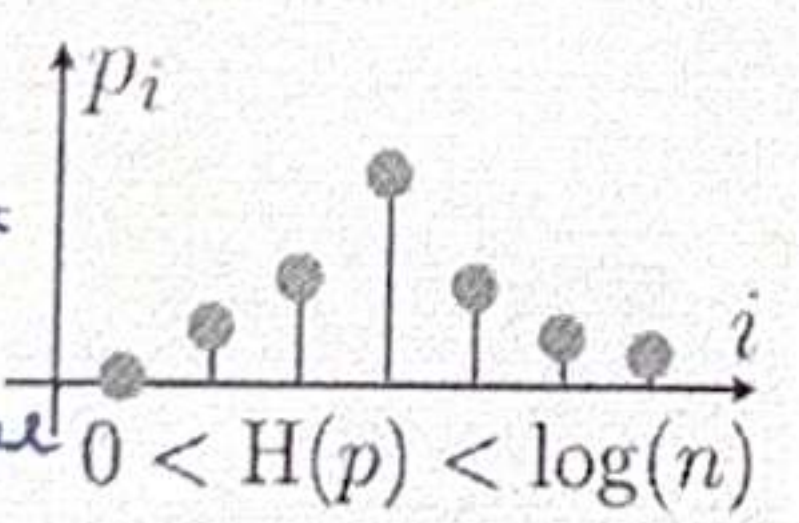


P=100%
H=0

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

Quantifying information

Некоторые варианты вероятностей

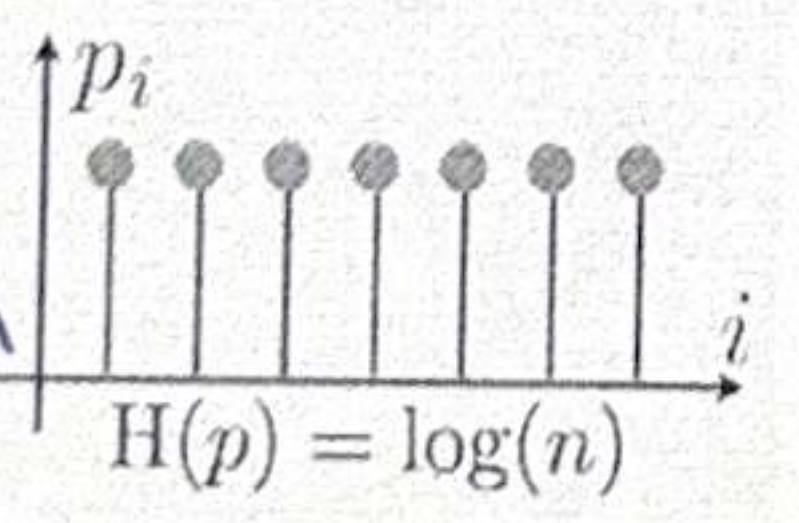


H=среднее

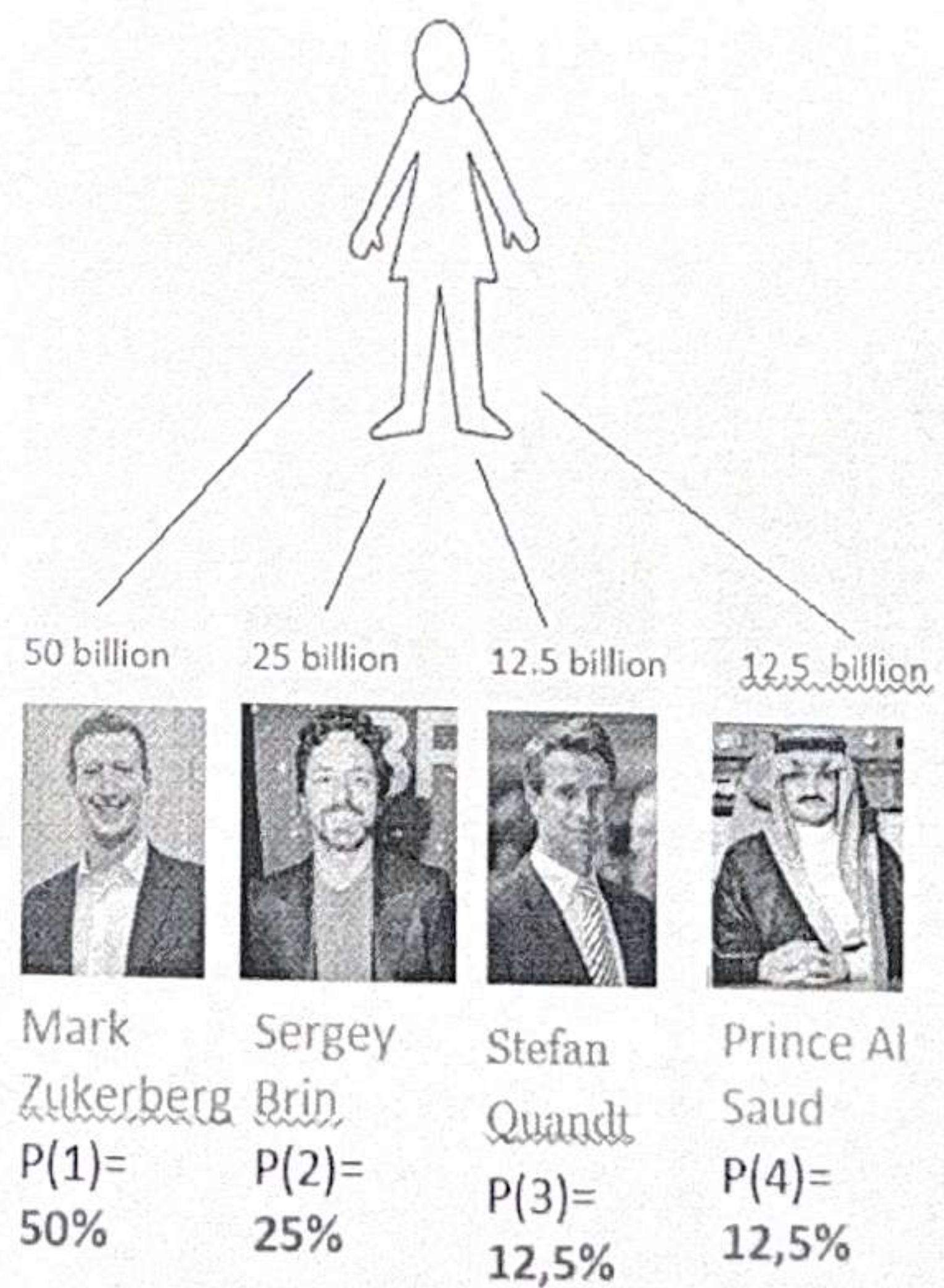
$$I(x_i) = \log_2 \left(\frac{1}{p_i} \right)$$

number of bits required to encode choice

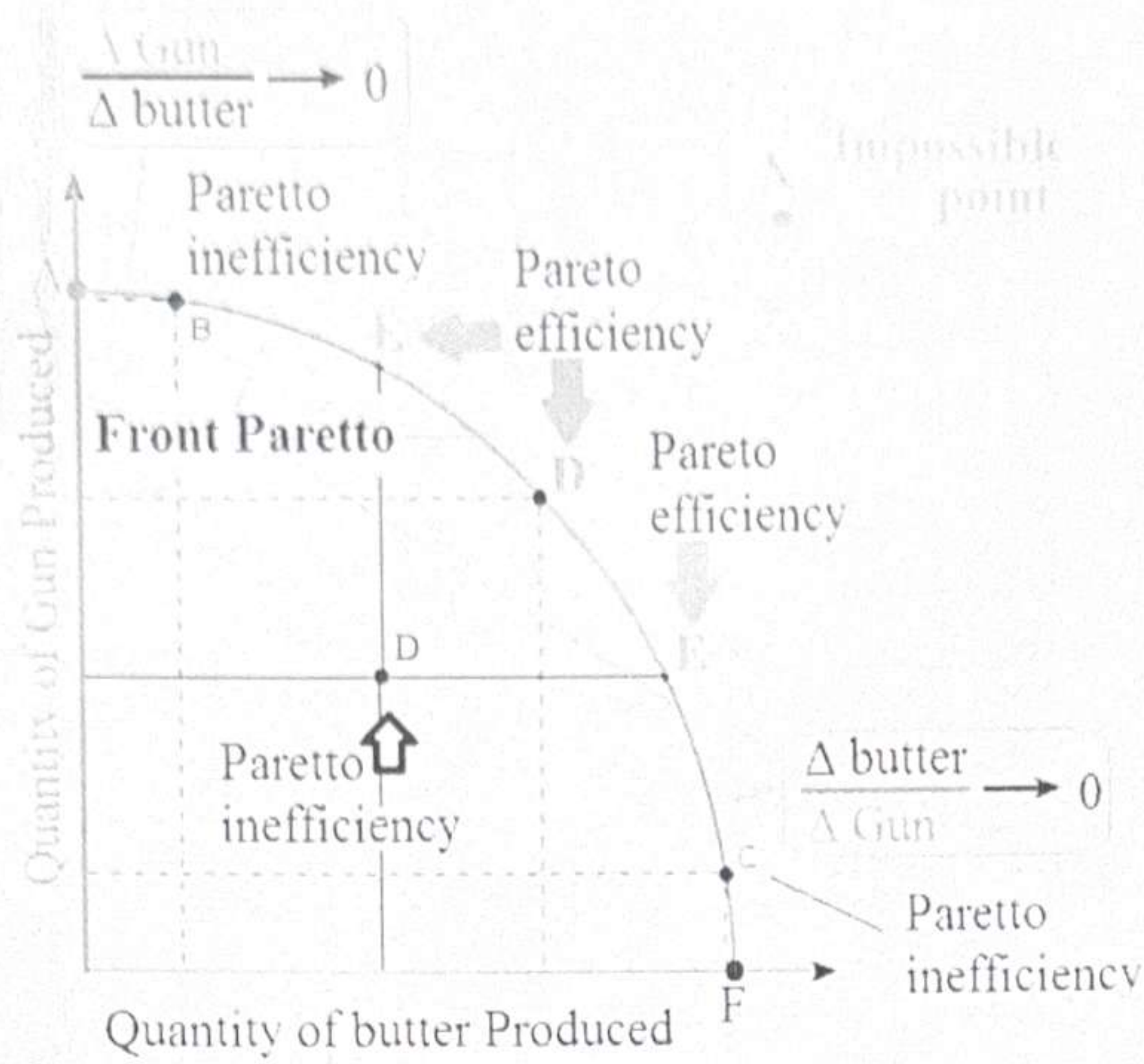
Варианты значений вероятностей



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



Энтропия - мера хаоса, неопределенности или степени неупорядоченности системы. Показывает сколько информации содержится в сообщении.



Vilfredo Pareto

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
confess	5 years, 5 years	0 year, 20 years
remain silent	20 years, 0 year	1 year, 1 year

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Game Theory

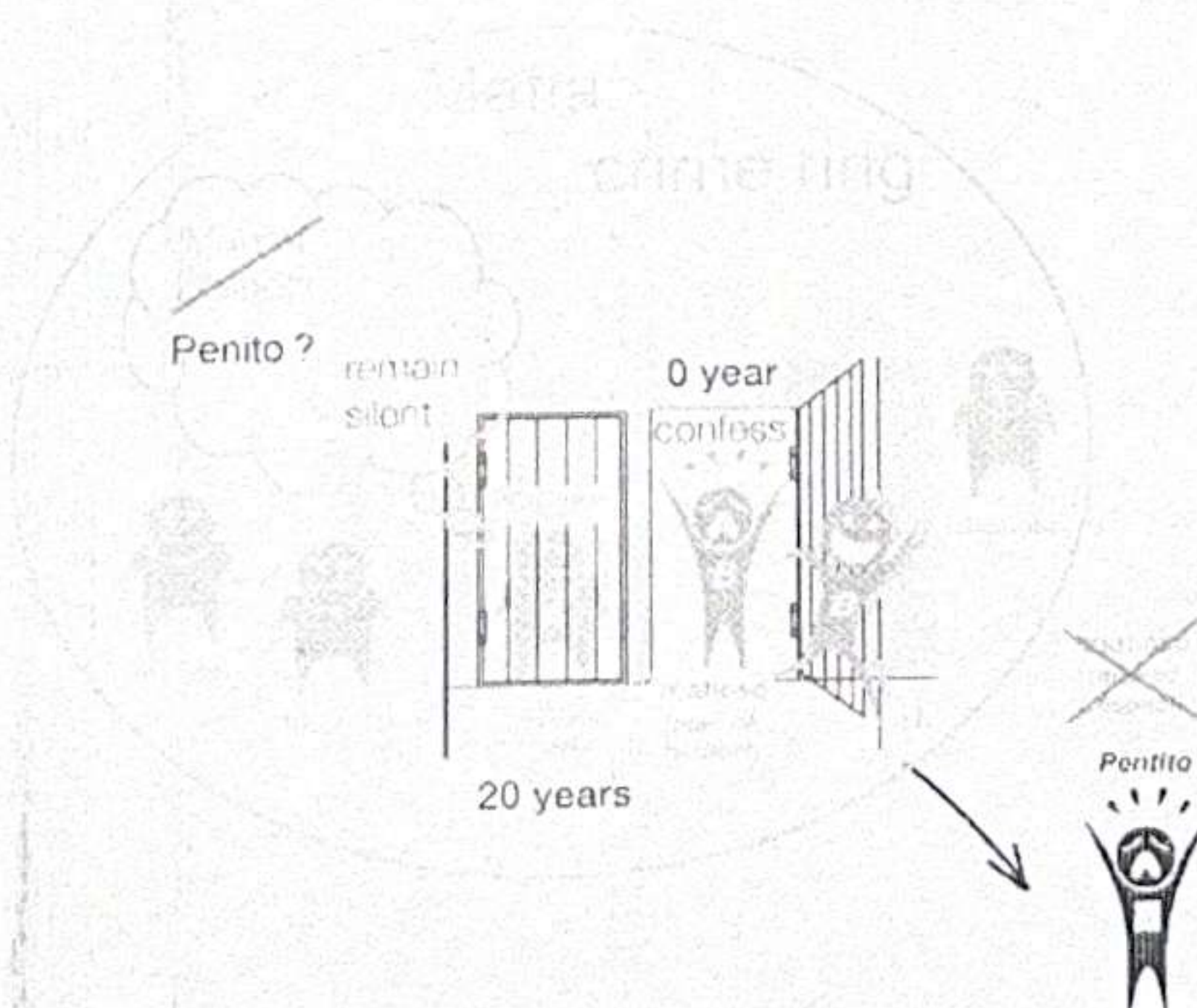
Nash Equilibrium



** => Nash equilibrium

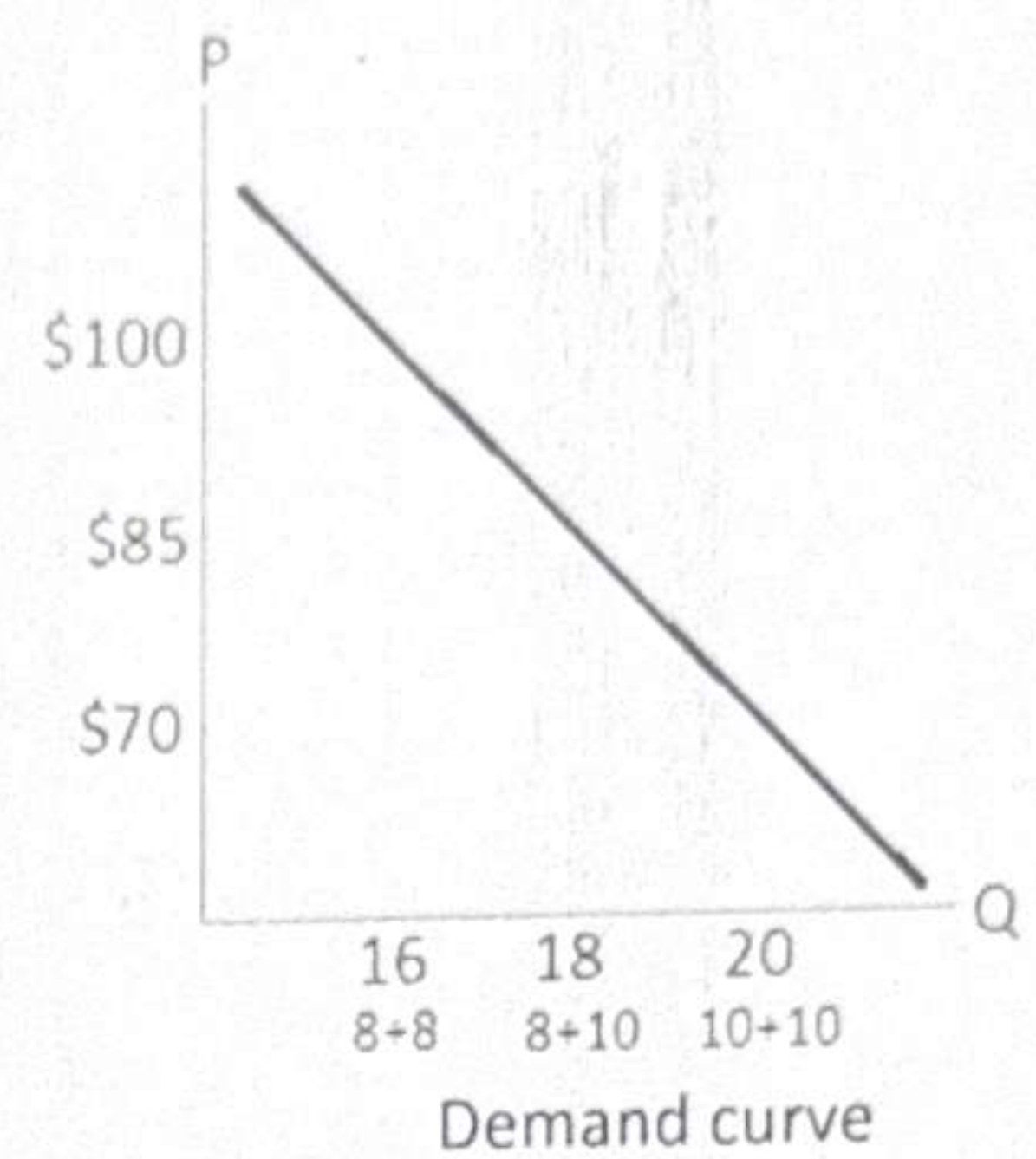
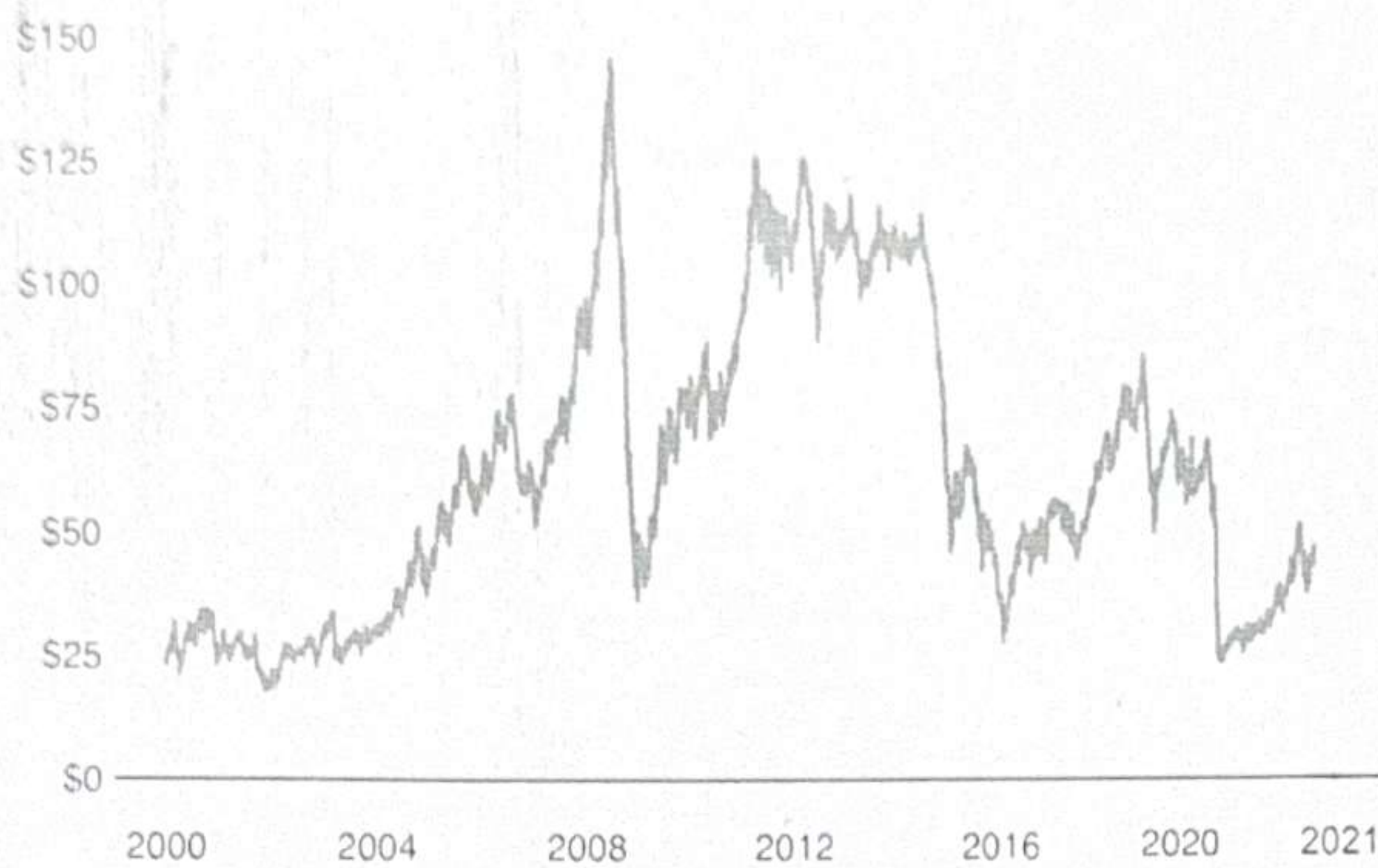
H ₁ (x)	H ₂ (x)	Player 2	
		Recognition	Non-recognition
Player 1	1	-5, -5*	-20, 0
	2	-20, -5*	0, -1

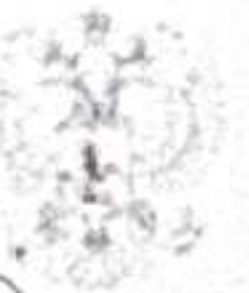
Pareto Optimality



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
-	$8 \cdot 10^6$ 	 \$800 millions per day \$100  \$800 millions per day	 \$850 millions per day \$85  \$680
	$10 \cdot 10^6$ 	 \$680 millions per day \$85  \$850 millions per day	 \$700 millions per day \$70  \$700 millions per day

