



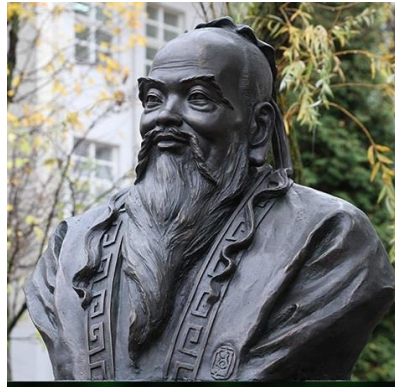
# Information Theory Introduction



**Sapere Aude**



No mind is visible  
to one,  
who has no mind



己所不欲，勿施於人  
yourself what you don't want  
don't do to others

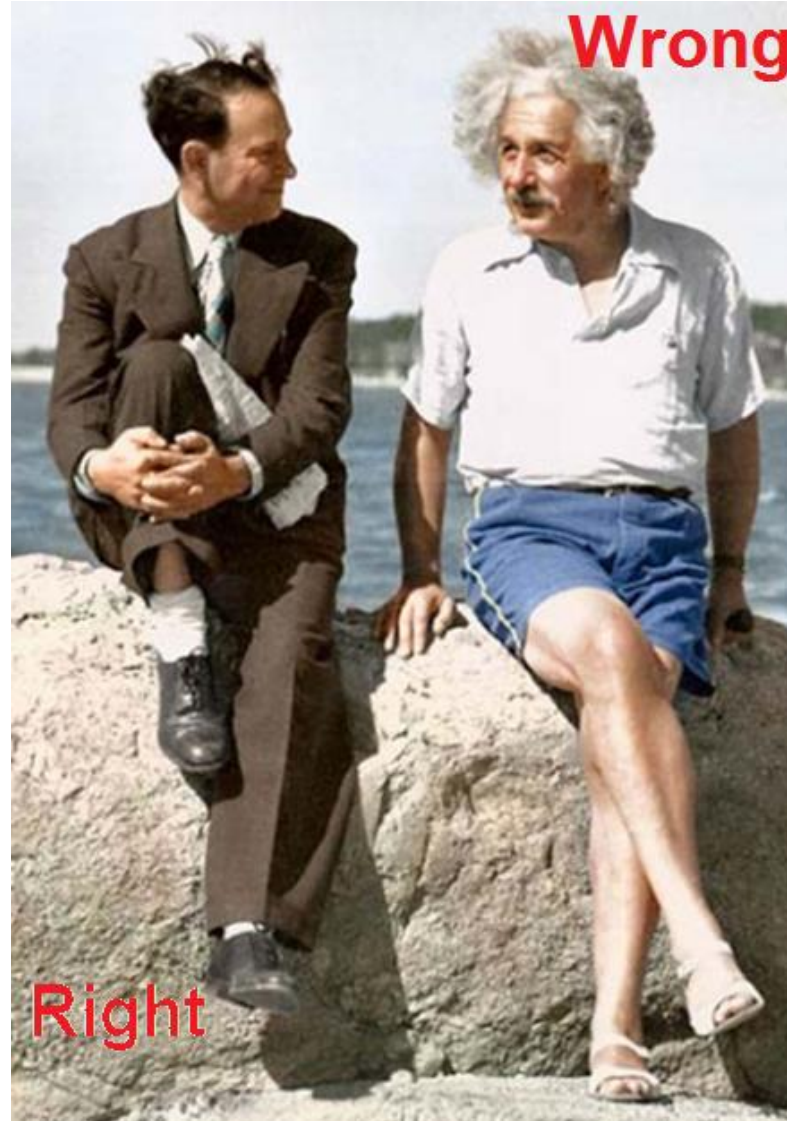
**YAROSHEVICH  
Andrey Olegovich**

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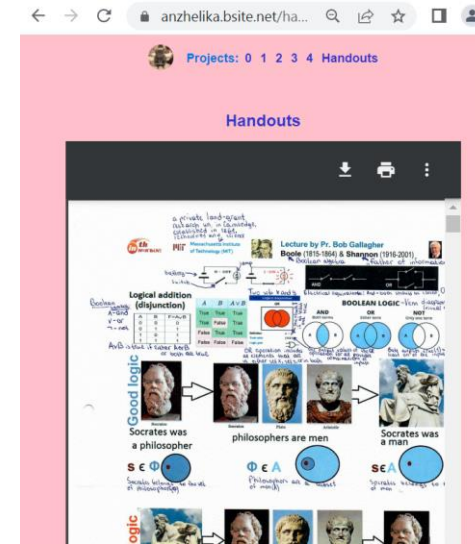
**+375 29 254-07-92**

# Business School Dress Code



# How to prepare for the exam:

1. **Paper Abstract**  
*(handout+your notes).*  
50%



2. **PDF-handout**  
*(handout+your notes).*  
+ premium  
12%

3. **1<sup>st</sup> copy of site**  
50%

4. **2<sup>nd</sup> copy of site**  
+ premium 12%

itcoursee.bsite.net,



Percentage of work completed

**Exam grade**

$$1.12 * 8 = 8.96$$

$$1.24 * 8 = 9.92$$

Final grade

**Massachusetts Institute of Technology**  
 • Located near to Harvard, in Cambridge, a suburb of Boston, Massachusetts  
 • I have not been to there, Harvard or MIT will not take me to work there, because you have to be a graduate of universities

Next, I present the beginning of a **lecture** by Professor Bob Gallagier, he is a member of the US National Academy of Sciences.

The lecture was delivered at the Massachusetts Institute of Technology.

He said what he wants to talk about both George Boole and Claude Shannon.

he'll be talking mostly about Claude Shannon

The general laws of nature are not, for the most part, immediate objects of perception

because old as he is he didn't quite catch up with George Boole



lecture

Handout is a summary of the lecture

The grade criterion is understanding of the material.

If you understand the material:  
 by 50% - you get 5,  
 by 90% - 9

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

**Logical addition (disjunction)**

	T	F
T	T	T
F	F	T
F	F	F

**BOOLEAN LOGIC**

AND OR NOT

**Good logic**

Socrates was a philosopher  $S \in \Phi$  philosophers are men  $\Phi \in A$  Socrates was a man  $S \in A$

**Bad logic**

Socrates was a man  $S \in A$  philosophers are men  $\Phi \in A$  Socrates was a philosopher  $S \in \Phi$

noise

message source → encoder → channel → decoder → message receiver

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George Boole (1815-1864) developed Boolean logic. The principles of logical thinking have been understood (and occasionally used) since the 1800s, but Boole's contribution was to show how to systematize 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 systematized 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 much non-scientific areas.

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

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

If you don't understand something about handout, ask the teacher or download the lecture and figure it out

# Abstract = *handout* + *your notes*

what is written there?

What does this picture mean?

What did Shannon do while developing Information Theory?

What Information Theory is about?

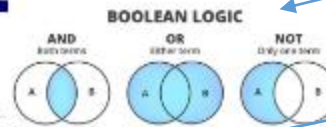
The collage features several elements:

- 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 construction systemized logical thinking for computer and communication systems, both for the design and programming of the systems and their applications.
- Logic abuse**: A red box highlights the text "Logic continues to be abused in politics, religion, and most non-scientific areas." A speech bubble above it says "Logic continues to be abused in politics, religion and most non-scientific areas." To the right, a portrait of a man is shown.
- Cartoon**: A sequence of drawings showing a progression from "Kant, Gauss, Goethe are great" to "Germany Great" to "Bad logic (abuse of logic)". A character says "I'm Great" and "I am German".
- Information Theory Diagram**: A flowchart showing "INFORMATION SOURCE" leading to "TRANSMITTER" (MESSAGE), then "SIGNAL" (MESSAGE), then "RECEIVER" (MESSAGE), and finally "DESTINATION". A "NOISE SOURCE" is shown interfering with the signal.
- Shannon's Contribution**: A portrait of Claude Shannon with the text "The Mathematical Theory of Communication" and "Creating a reliable connection over an unreliable (noisy) channel that's what IT is about". Below it, it says "and that's what Shannon did".
- Handwritten Notes**: Various notes in Cyrillic script are scattered throughout, including "C = B log2(1 + S/N)", "C = B log2(1 + S/N)", and "C = B log2(1 + S/N)".



Logical addition (disjunction)

A	B	A ∨ B
0	0	0
0	1	1
1	0	1
1	1	1

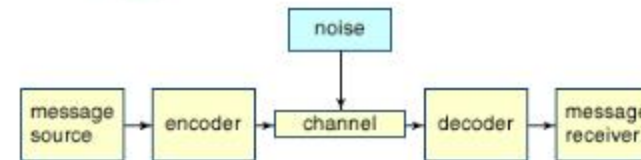
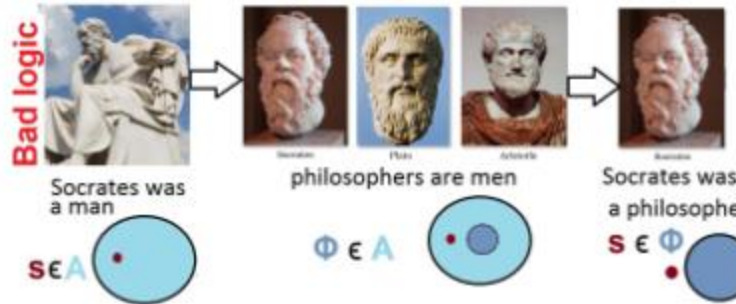


What is the difference between Boolean logic and Aristotelian logic?

Good logic



Bad logic





What is this?

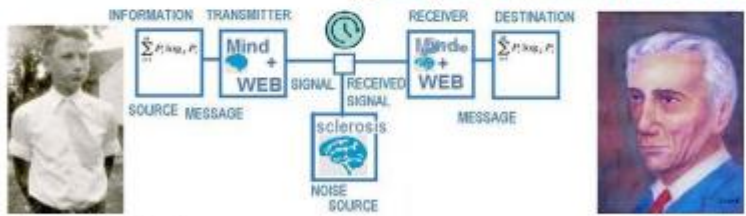


Bad way



Good way  
 ① listening  
 ② first way of processing  
 ③ Writing, incl. sth. you're not quite sure about

Is this girl good or bad?




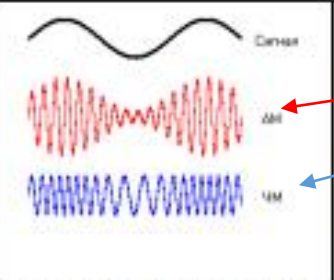
School  $\Rightarrow$  formalism  $\Rightarrow$  University

Motivation: 80% chance of rain  
 Let  $A_j$  be the event of rain at 3am on day  $j$  of this term,  $1 \leq j \leq n$   
 Suppose the events  $A_j$  are independent.


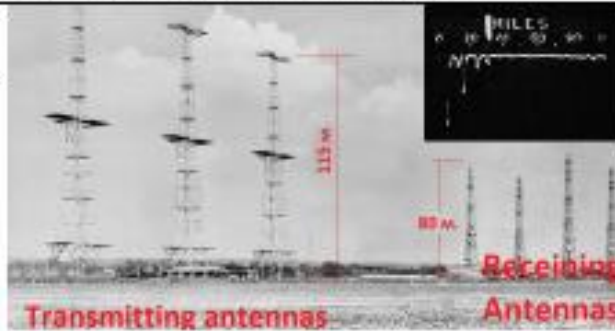
Oxford				
Tue 10th	Wed 11th	Thu 12th	Fri 13th	Sat 14th
10° 100%	5° 100%	13° 100%	10° 100%	5° 100%
100%	100%	100%	100%	100%

then take notes on the lecture yourself


What is this?

 <p>Reginald A. Fessenden (October 6, 1866 – July 22, 1932)</p>	 <p>CW AM CW</p>	<p>(October 6, 1866 – July 22, 1932) first transmission of speech by radio (1906), and the first two-way radiotelegraphic communication across the Atlantic Ocean (1906)</p>
---	--	--

"Ни одна организация, занимающаяся какой-либо конкретной областью деятельности, никогда не изобретает какие-либо важные разработки в этой области или не внедряет какие-либо важные разработки в этой области до тех пор, пока она не будет вынуждена сделать это из-за внешней конкуренции." Oxford University Press. The Quarterly Journal of Economics, Feb., 1926, p. 262.


<p><b>Battle of Britain</b> (3 month 3 weeks) 10.07-31.10.1940</p>		 <p>Transmitting antennas Receiving Antennas</p>
<p>Radar played a major role in the Battle of England</p>		

**H. Nyquist**


$$W = K \log m$$

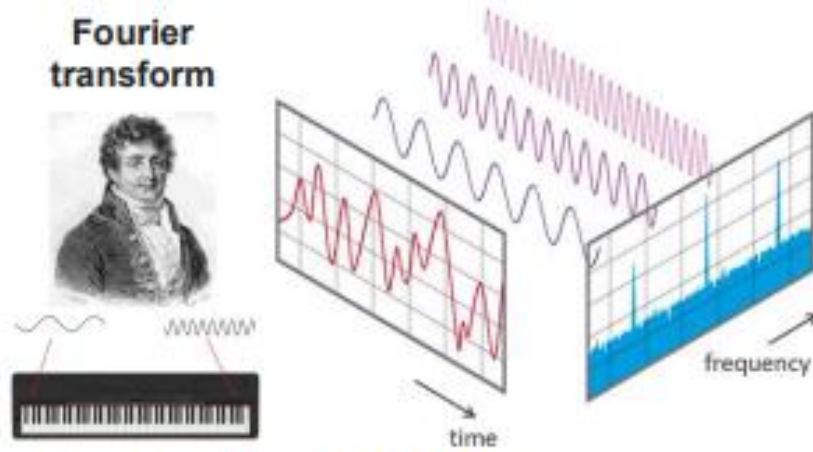
Where  $W$  is the speed of transmission of intelligence,  
 $m$  is the number of current values,  
and,  $K$  is a constant.

**Ralph Hartley**  
(81:1888-1970)


$$H = n \log s$$
$$= \log s^n.$$

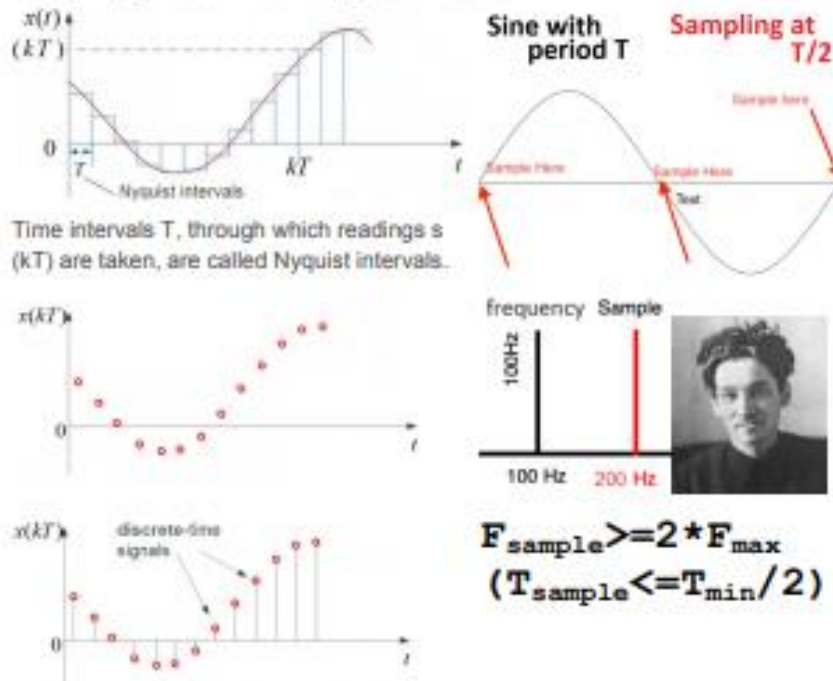
what is the entropy of a deck of cards for Bridge, preference (or Durak)?

What is Fourier transform?



What is sampling?

Sampling. Kotelnikov-Nyquist Theorem

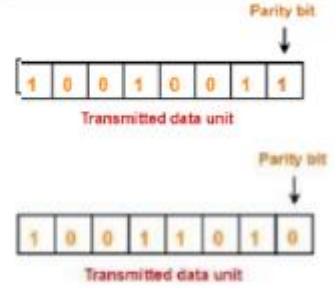
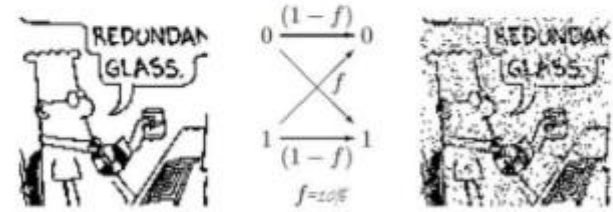


Who is this gentleman?

what good did he do for all of us



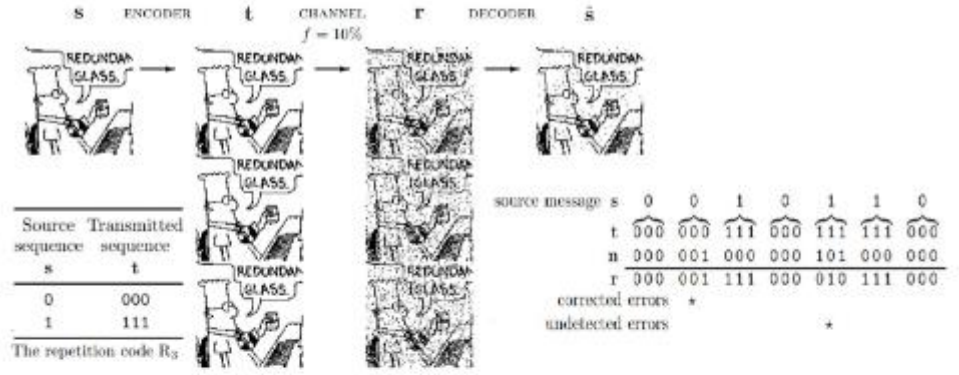
"I believe in clean energy,  
but I also believe in mathematics"



What is a parity bit?

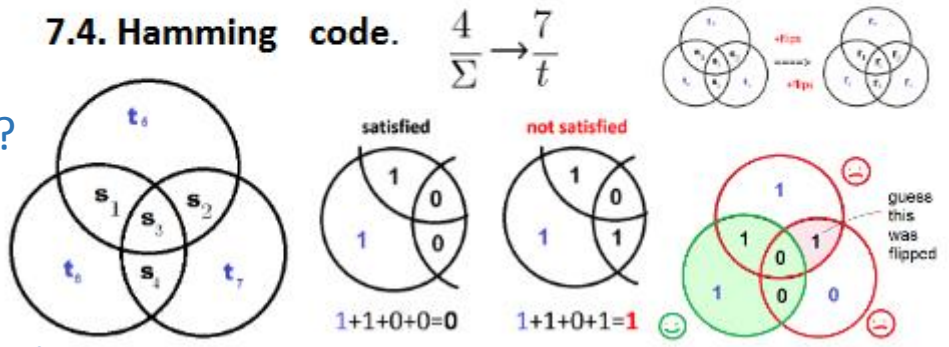
What it is?

What it is?

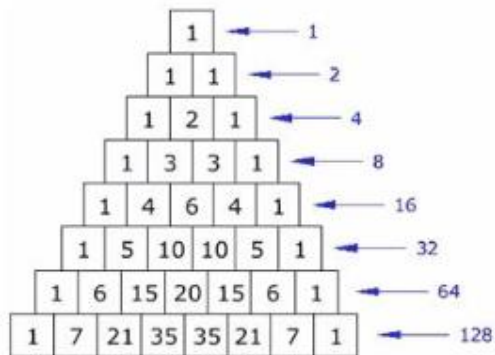


### 7.4. Hamming code. $\frac{4}{\Sigma} \rightarrow \frac{7}{t}$

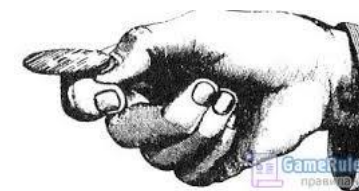
Why is the Hamming code number 7.4?



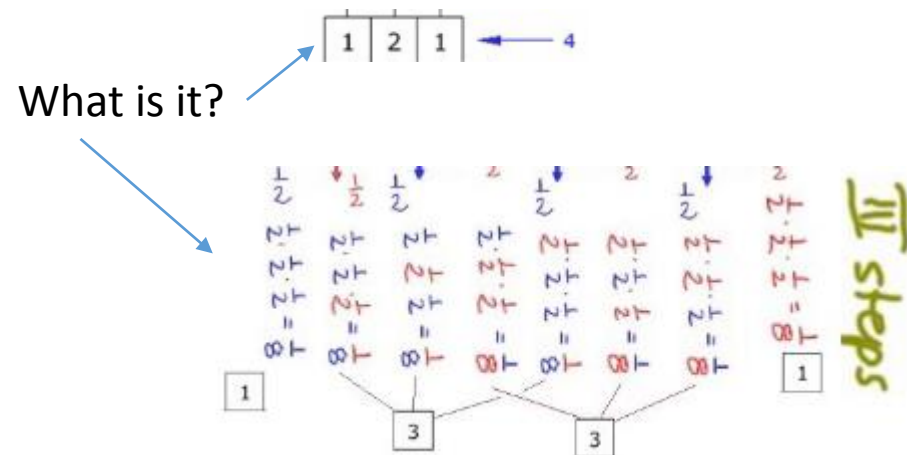
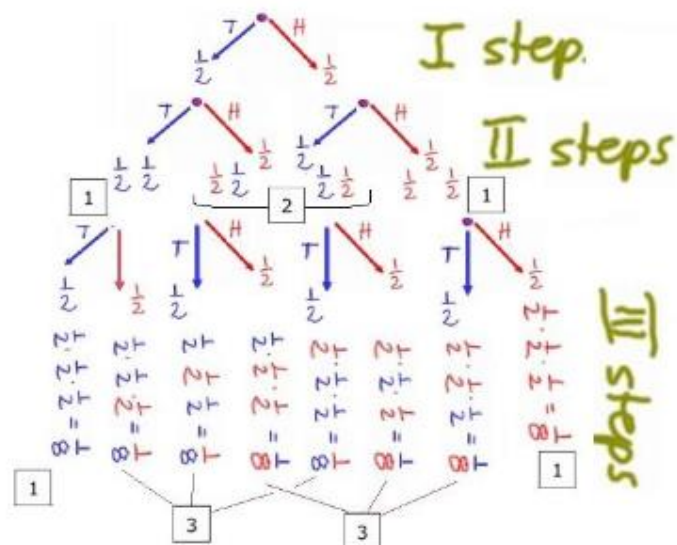
Encode the number 7 with Hamming code



Pascal's triangle

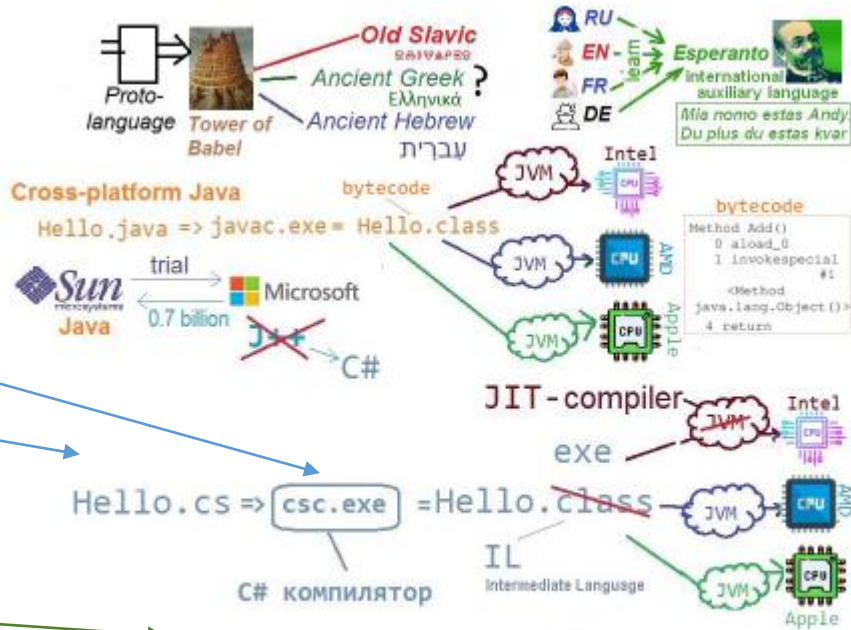


Why did Pascal create his triangle?



$$\begin{aligned}
 (a + b)^0 &= 1 \\
 (a + b)^1 &= a + b \\
 (a + b)^2 &= a^2 + 2ab + b^2 \\
 (a + b)^3 &= a^3 + 3a^2b + 3ab^2 + b^3 \\
 (a + b)^4 &= a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4 \\
 (a + b)^5 &= a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5
 \end{aligned}$$

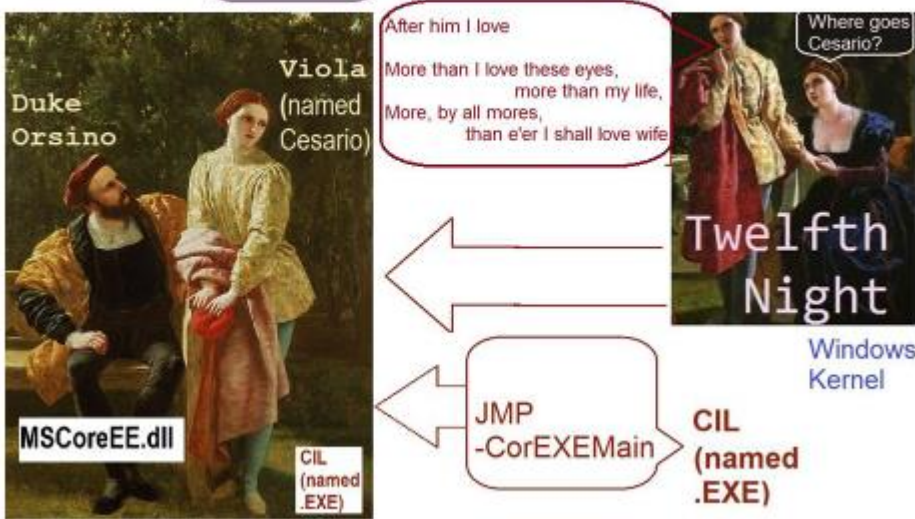
What is this thing called?



What is this?



What is this?



What is that?



Who wrote 12th. night

What is this?

```

class Dog
{
    public string name;
    public string breed;
    public int age;

```



```

    public void Bark()
    {
        Console.WriteLine("Woof woof!");
    }

```

What is this?

```

static void Main(string[] args)
{
    Dog dori = new Dog(); //Constructor works
    dori.age = 3;

    dori.name = "Dori";
    dori.breed = "Mongrel";
    dori.Bark();
}

```

```

public Dog()
{
}
public Dog(string name)
{
    this.name = name;
}
public Dog(string name, string breed)
{
    this.name = name;
    this.breed = breed;
}

```

- 1 - constructor no returns value
2. The name of the constructor is the same name is the class.
3. more than one constructor

What is this?

What is this?

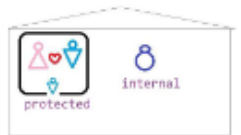


```

class AFather
{
    protected string name;
    int age;
}
class ASon:AFather
{
    public ASon(string name)
    {
        base.age = 33;
        base.name = name;
    }
}

```

What is this?



What is this?

```

class AFather
{
    protected string name;
    internal int age;
}
class Program
{
    static void Main(string[] args)
    {
        AFather af = new AFather();
        af.age = 33;
        ASon andy = new ASon("OlaF");
    }
}

```

```

class ASon:AFather
{
    public ASon(string name)
    {
        base.name = name;
        base.age = 33;
    }
}

```

```

class Program
{
    static void Main(string[] args)
    {
        AFather af = new AFather();
        ASon andy = new ASon("OlaF");
    }
}

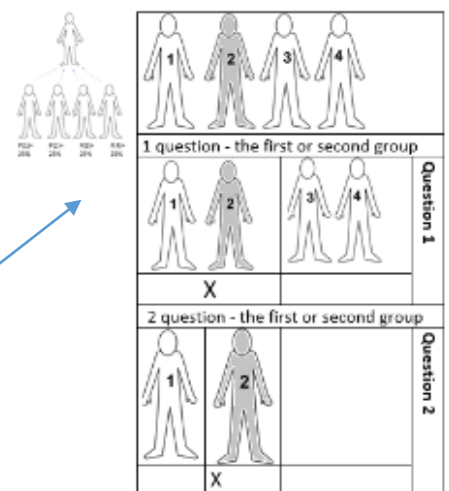
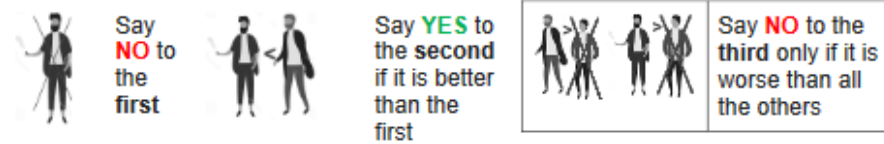
```



What is this?

What is this?

What is this?



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			

Quantifying information

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

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

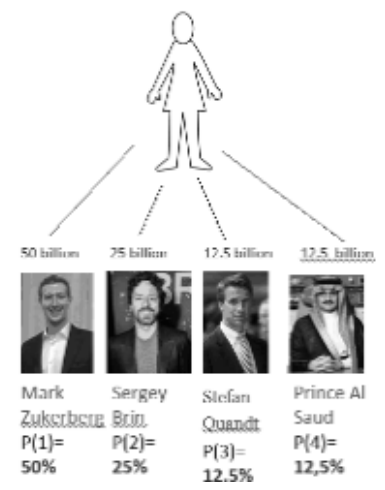
$H(p) = 0$

$0 < H(p) < \log(n)$

$H(p) = \log(n)$

number of bits required to encode choice

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

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


# Calculate your bonuses for the exam – before the exam starts



Amount

DKK

Converted to

USD



data.bls.gov/cgi-bin/c...

### CPI Inflation Calculator

\$

in

has the same buying power as

in

+ 0.5 to Exam 27. 3. 23

KATYA =  $\frac{5!}{2!}$   ← 1

To: vanojefferson@g

Date: Thu, 1 May 2025

Subject: +0.5: QUEST 1 35

+ 0.5

+

+ 0.5

ANSWER: 1929

= 2.53

Не очко обычно губит,  
а к 11 туз

[песня «Владимирский централ»]



For it is when you overplay your hand

That you will probably lose.

[ It is not the lack that ruins, but the excess ]



+0.5 to Exam  
+0.5 to Exam  
+0.5 to Exam  
+0.5 to Exam  
+0.5 to Exam

0.5  
0.5  
0.5  
0.5  
0.5

+	1.53	To:	vanojefferson@g
	0.5	Date:	Thu, 1 May 2025
		Subject:	+0.5: QUEST 1 35
		ANSWER: 1929	

= 4.53



3.03