



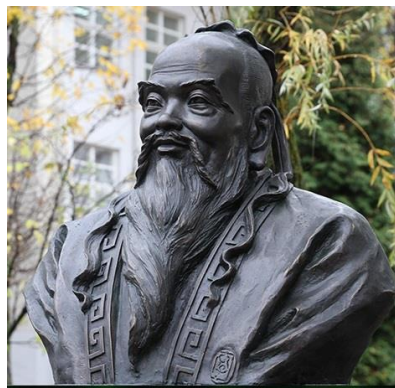
# Information Theory Introduction



**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

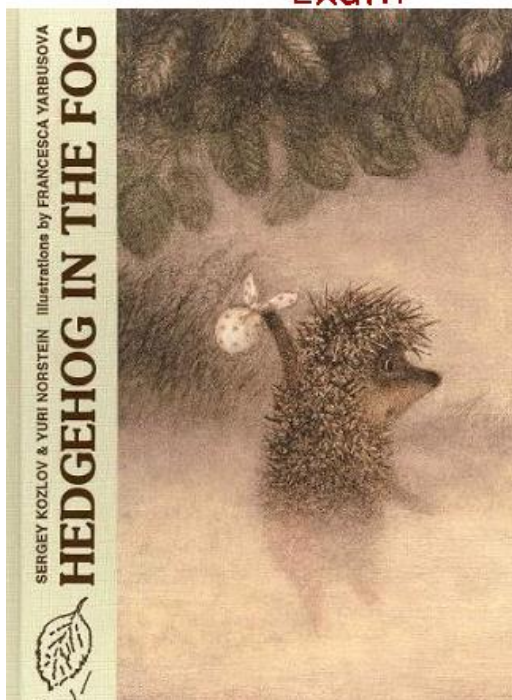
**YAROSHEVICH  
Andrey Olegovich**

**[www.YAROSHEVICH.com](http://www.YAROSHEVICH.com)  
ao@dot.net.by  
+375 29 254-07-92**

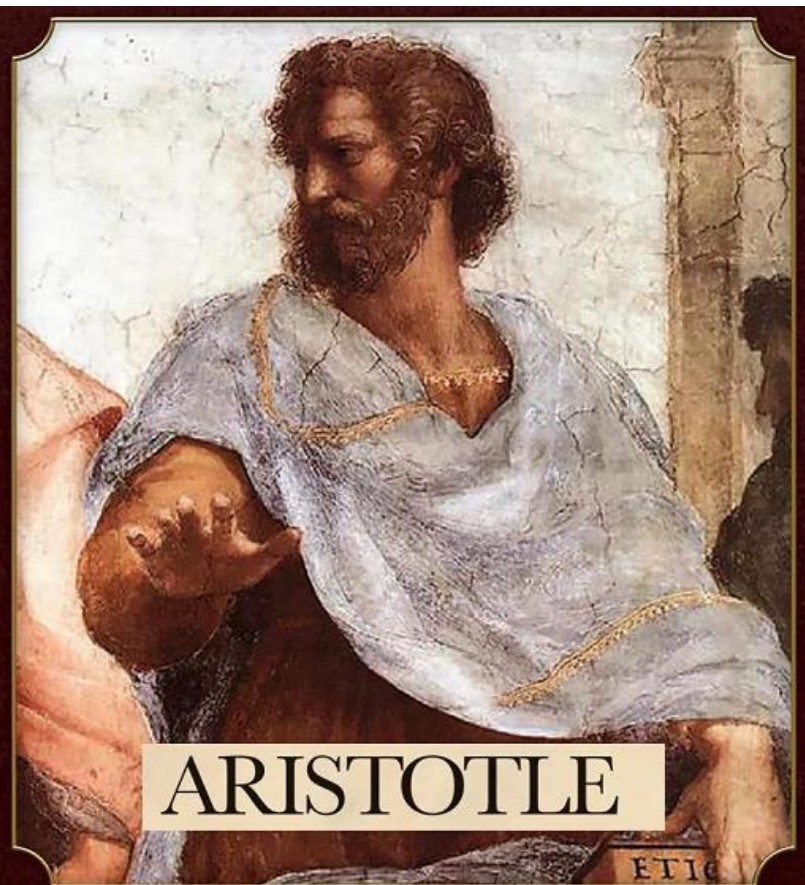
# Information Theory



Exam



$$\sum_x p(x) \cdot \log\left(\frac{1}{p(x)}\right)$$



My lectures are published and not published;  
they will be intelligible to those who heard them, and to none beside  
*[Letter to Alexander the Great].*

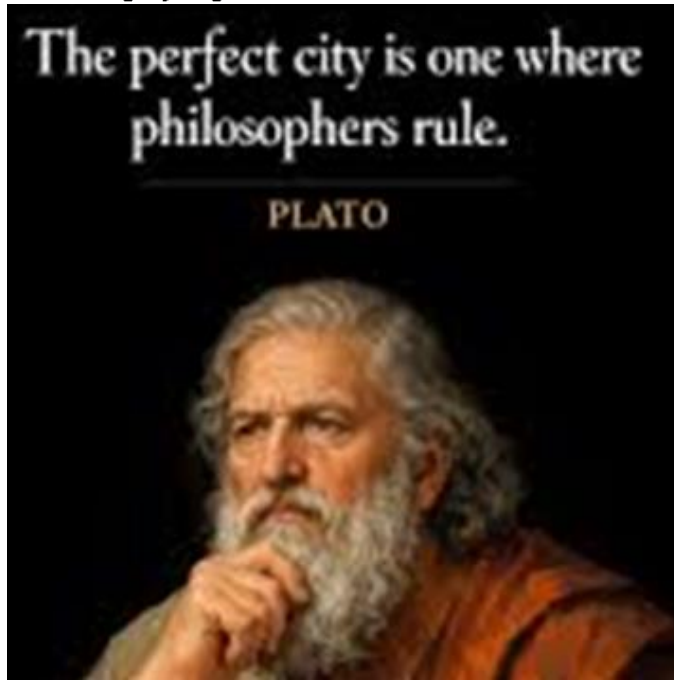
# Aristotle on the walls of the Kremlin's Annunciation Cathedral



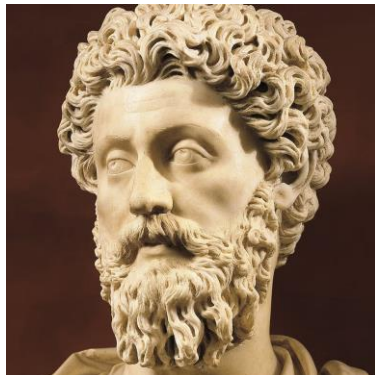


Aristotle was a student and friend of Plato

**Amicus Plato, sed magis amica  
veritas | Latim**

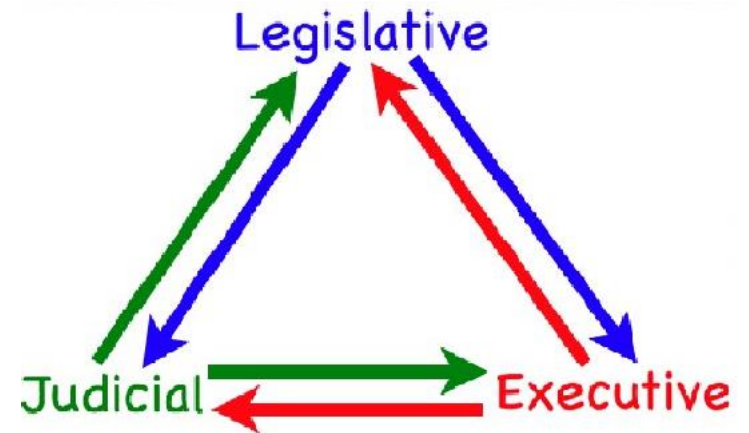


# Amicus Plato, sed magis amica veritas | Latim



*Marcus Aurelius*

Husband and wife in marriage control each other



Three (4 in In) branches of power control each other

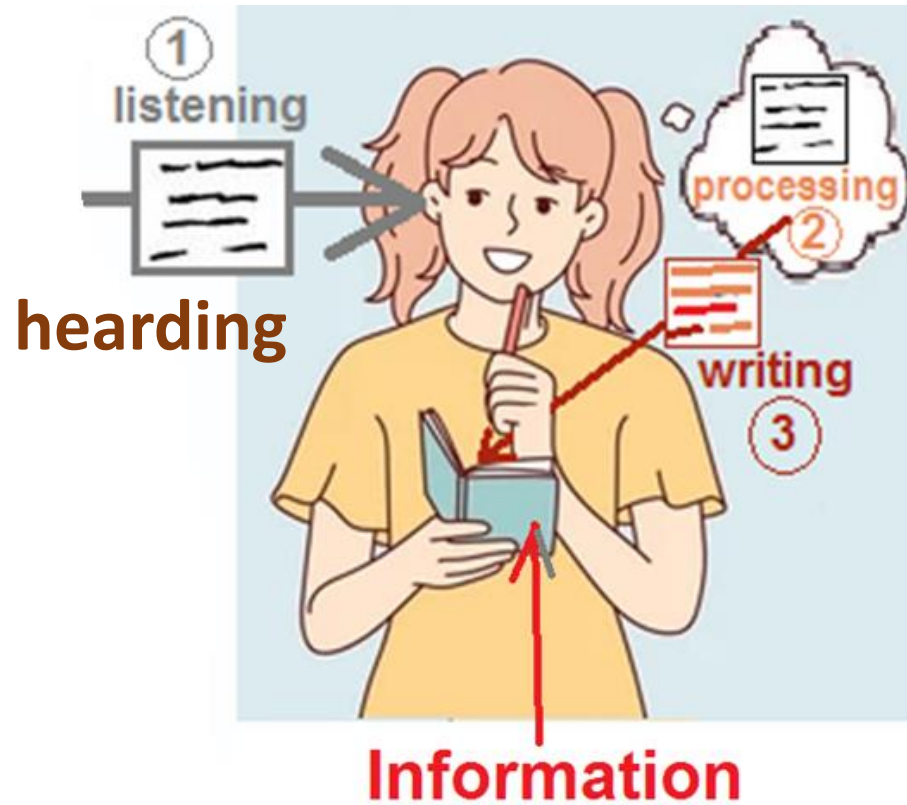
Why did you publish  
lectures and give  
social knowledge for  
the rabble



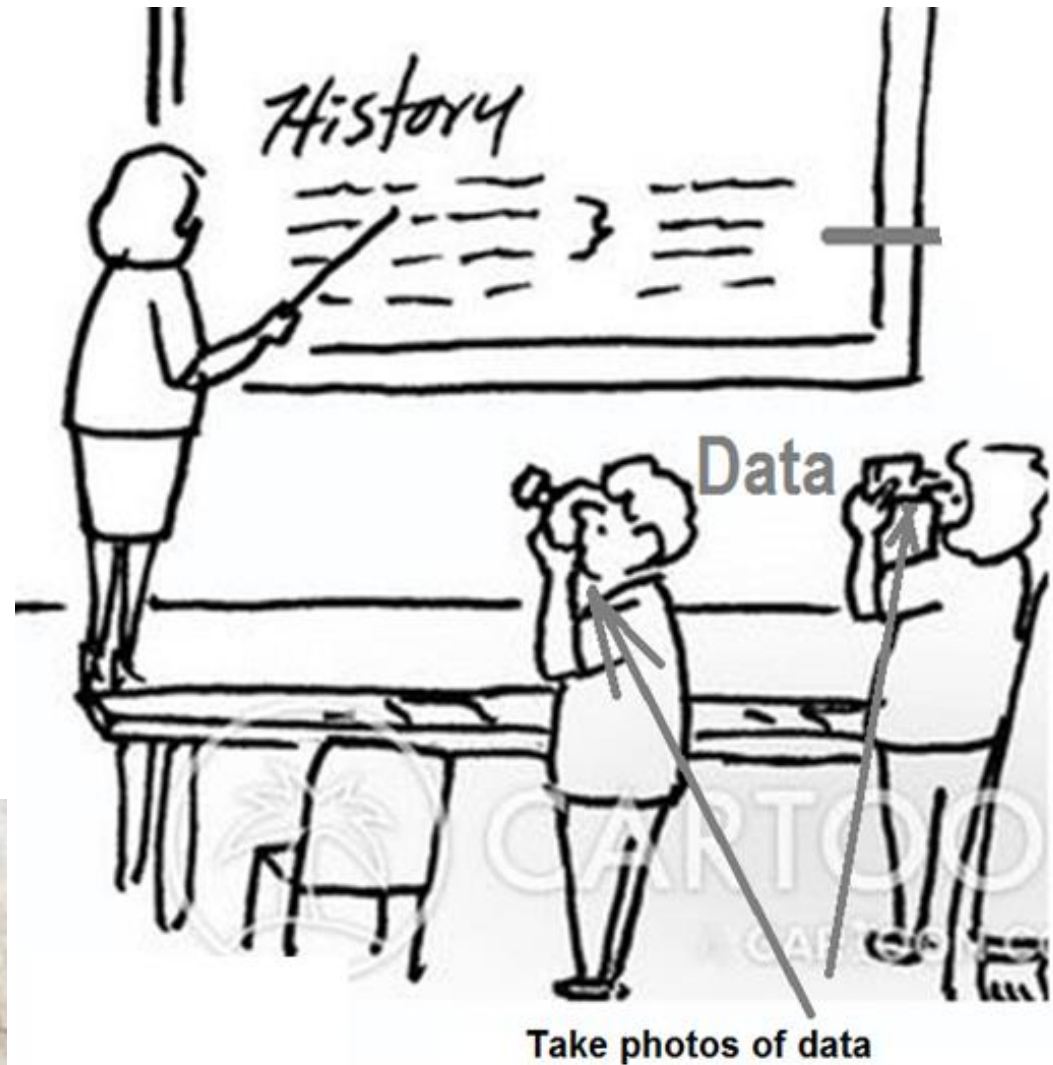
Alexander of Macedon was a student  
and friend of Aristotle

"My lectures are published and  
not published; they will be  
intelligible to those who heard  
them, and to none beside."





they will be  
intelligible to  
those who heard  
them



and to none beside

## Second-order approximation

(digram structure as in English).

ON IE ANTSOUTINYS ARE T INCTORE ST BE S  
DEAMY ACHIN D ILONASIVE TUCOOWE AT  
TEASONARE FUSO TIZIN ANDY TOBE SEACE  
CTISBE.



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

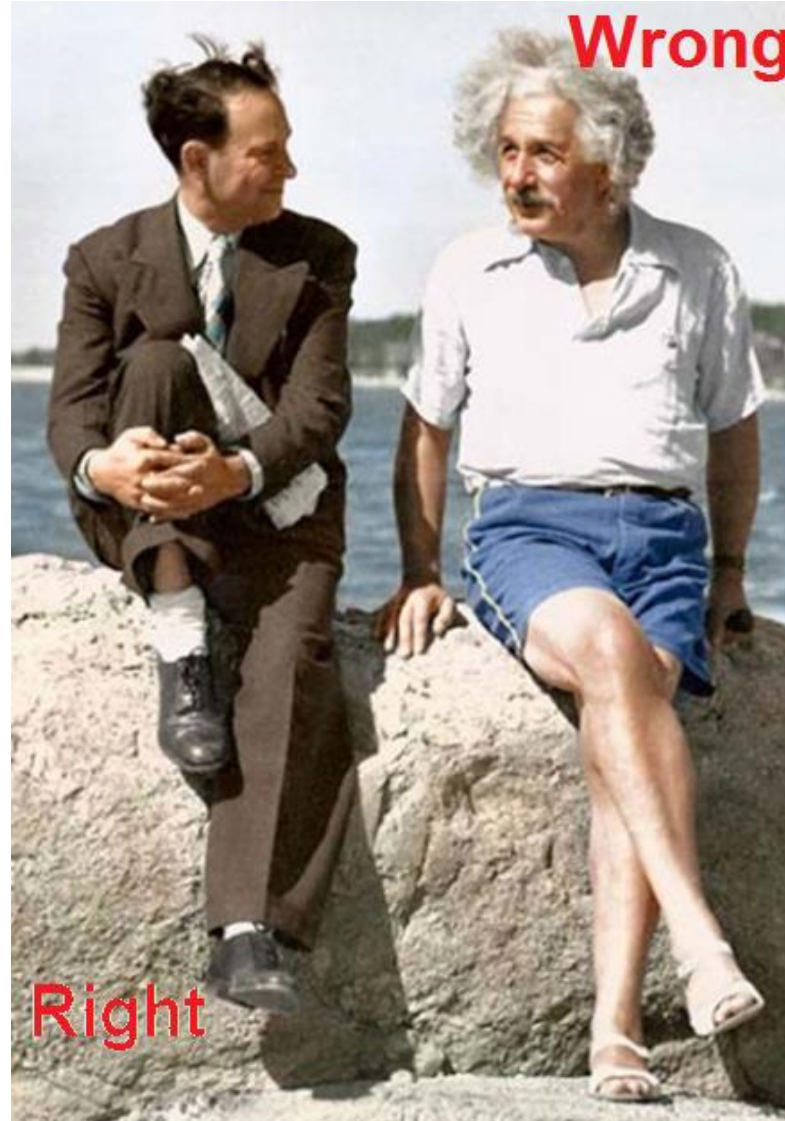
9

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

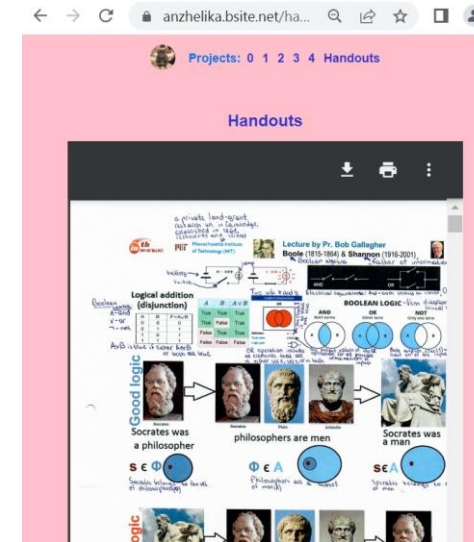
<https://youtu.be/5RhWJ3vcGq0?t=34> –  
“Heart of a dog” by Bulgakov. Sharikov  
learns to speak.

# 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**

$$1.12 * 8 = 8.96 \quad \text{Final}$$

$$1.24 * 8 = 9.92 \quad \text{grade}$$



# Abstract = *handout* + *your notes*

what is written there?

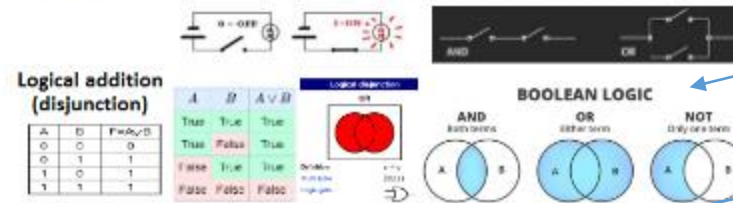
What does this picture mean?

What did Shannon do while developing Information Theory?

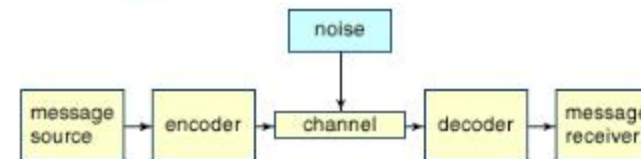
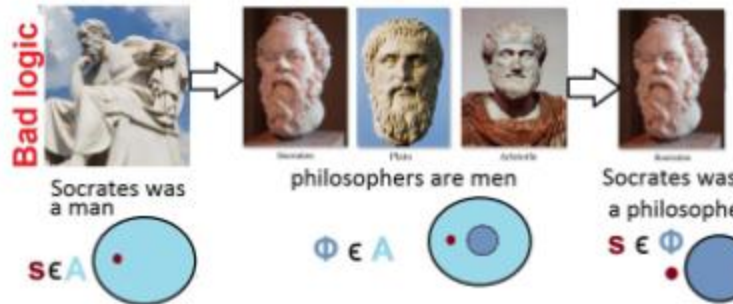
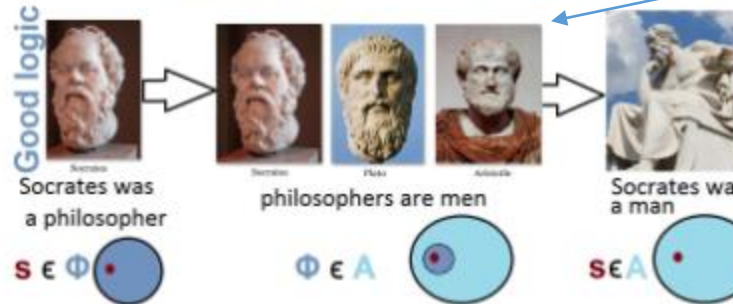
What Information Theory is about?

The handout is divided into three main sections with handwritten notes and diagrams:

- Top Section: Boolean Logic**
  - Text: "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."
  - Diagram: A flowchart showing "Kant, Gauss, Goethe are great" leading to "Kant, Gauss, Goethe - Germans" leading to "Germany Great".
  - Diagram: A flowchart showing "German Great" leading to "I am German" leading to "I'm Great".
  - Text: "Logic continues to be abused in politics, religion, and most non-scientific areas." (circled in red)
  - Text: "Logic continues to be abused in politics, religion, and most non-scientific areas." (circled in red)
  - Text: "Bad logic (abuse of logic)"
  - Text: "C. Shannon 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."
- Bottom Section: Information Theory**
  - Text: "The Mathematical Theory of Communication"
  - Diagram: A block diagram of a communication system. It shows "INFORMATION SOURCE" connected to "TRANSMITTER", which is connected to "MESSAGE". "MESSAGE" is connected to "SIGNAL", which is connected to "RECEIVER". "RECEIVER" is connected to "DESTINATION". A "NOISE SOURCE" is connected to the "SIGNAL" line.
  - Text: "Creating a reliable connection over an unreliable (noisy) channel that's what IT is about"
  - Text: "and that's what Shannon did"
  - Text: "C = B log<sub>2</sub>(1 + S/N)"
  - Text: "Technique: Shannon's theory of communication is based on the idea of a reliable connection over an unreliable (noisy) channel. This is what IT is about. Shannon's theory of communication is based on the idea of a reliable connection over an unreliable (noisy) channel. This is what IT is about. Shannon's theory of communication is based on the idea of a reliable connection over an unreliable (noisy) channel. This is what IT is about."

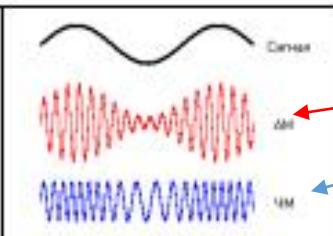


What is the difference between Boolean logic and Aristotelian logic?

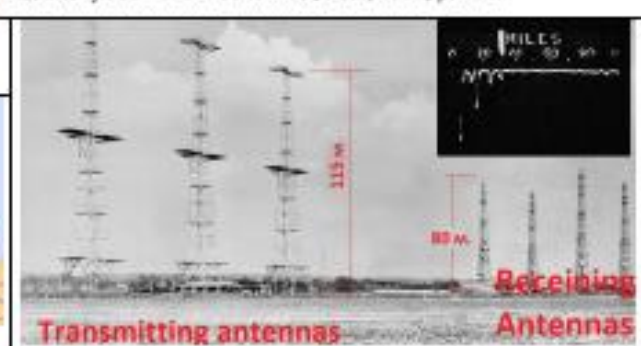




What is this?

|                                                                                                                                                            |                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><b>Reginald A. Fessenden</b><br/>(October 6, 1866 – July 22, 1932)</p> |  <p>Carrier<br/>AM<br/>FM</p> <p>(October 6, 1866 – July 22, 1932)<br/>first transmission of speech by radio (1900), 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.

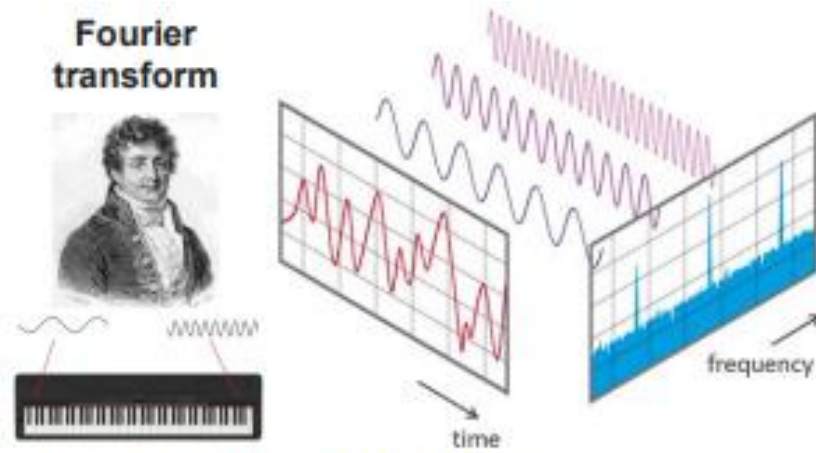
|                                                                                                                                                              |                                                                                                                                            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

|                                                                                                             |                                                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>H. Nyquist</b></p>  | $W = K \log m$ <p>Where <math>W</math> is the speed of transmission of intelligence,<br/><math>m</math> is the number of current values,<br/>and, <math>K</math> is a constant.</p> |
|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                     |                                                                             |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
|  | <p><b>Ralph Hartley</b><br/>(81:1888-1970)</p> $H = n \log s$ $= \log s^n.$ |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|

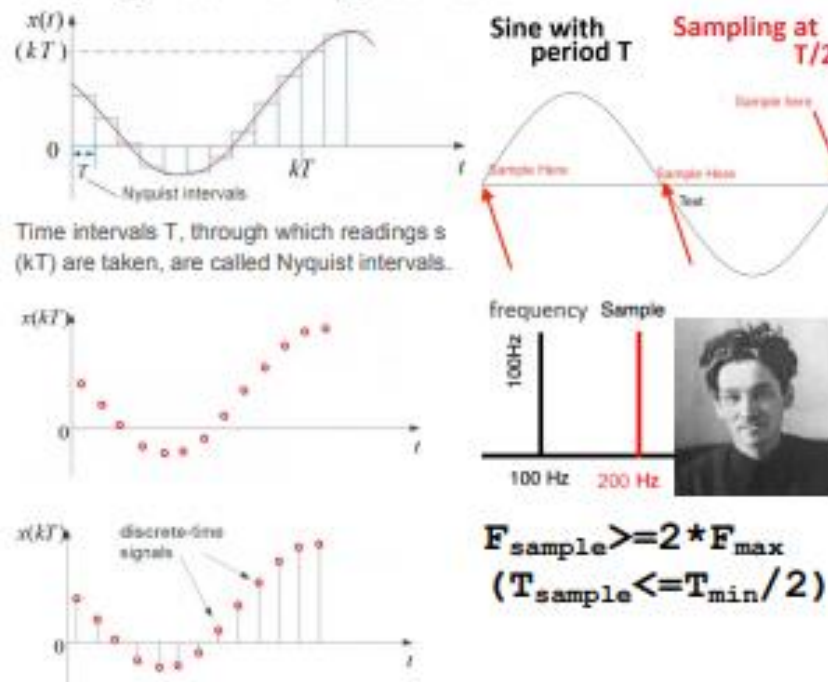
what is the entropy of a deck of cards for Bridge, preference (or Durak)?

What is Fourier transform?



What is sampling?

**Sampling. Kotelnikov-Nyquist Theorem**

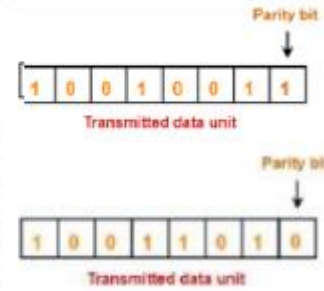
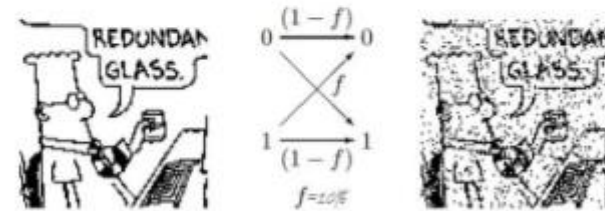


Who is this gentleman?

what good did he do for all of us



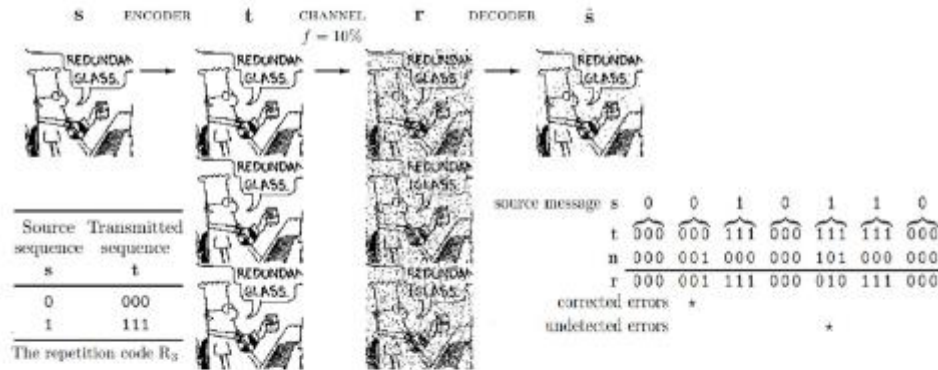
"I believe in clean energy,  
but I also believe in mathematics"



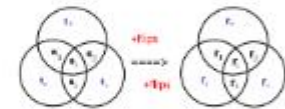
What is a parity bit?

What it is?

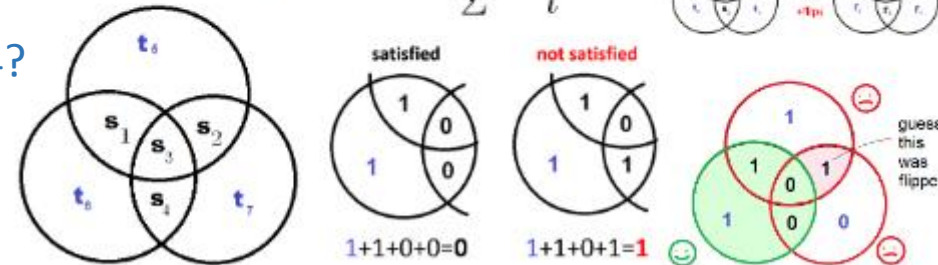
What it is?



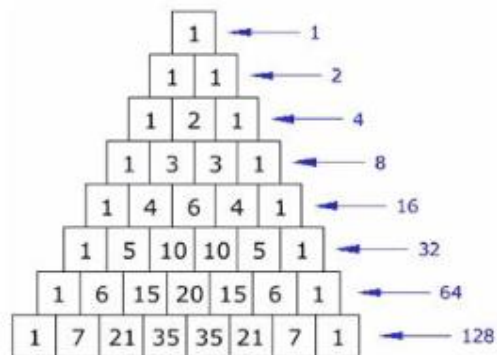
7.4. Hamming code.  $\frac{4}{\Sigma} \rightarrow \frac{7}{t}$



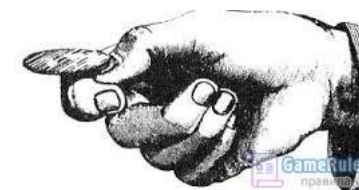
Why is the Hamming code number 7.4?



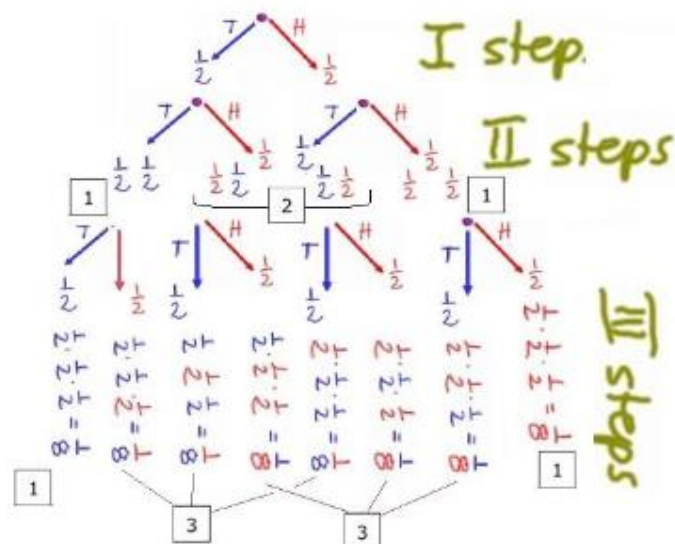
Encode the number 7 with Hamming code



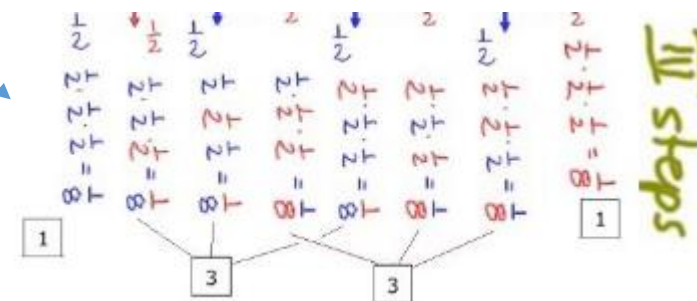
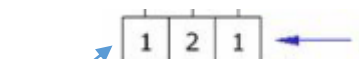
Pascal's triangle



Why did Pascal create his triangle?

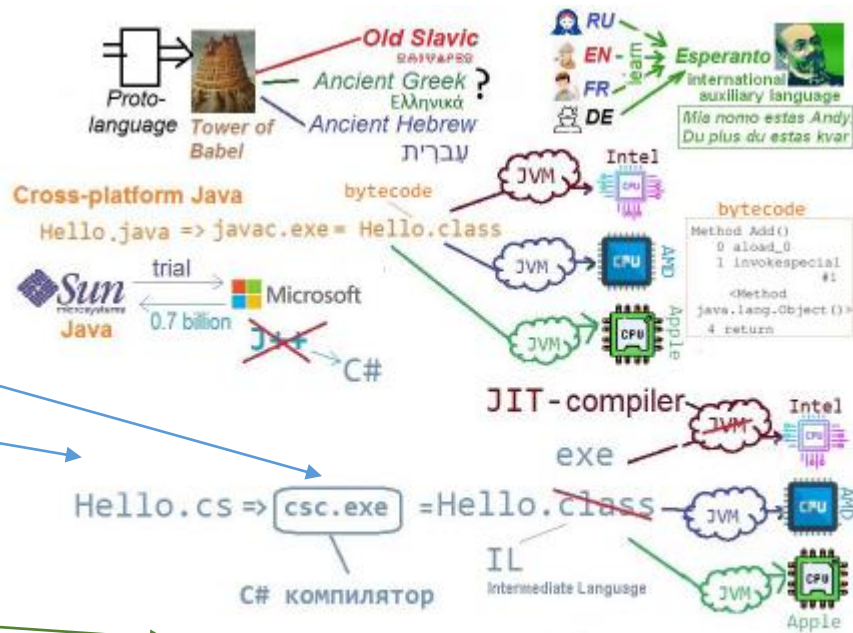


What is it?



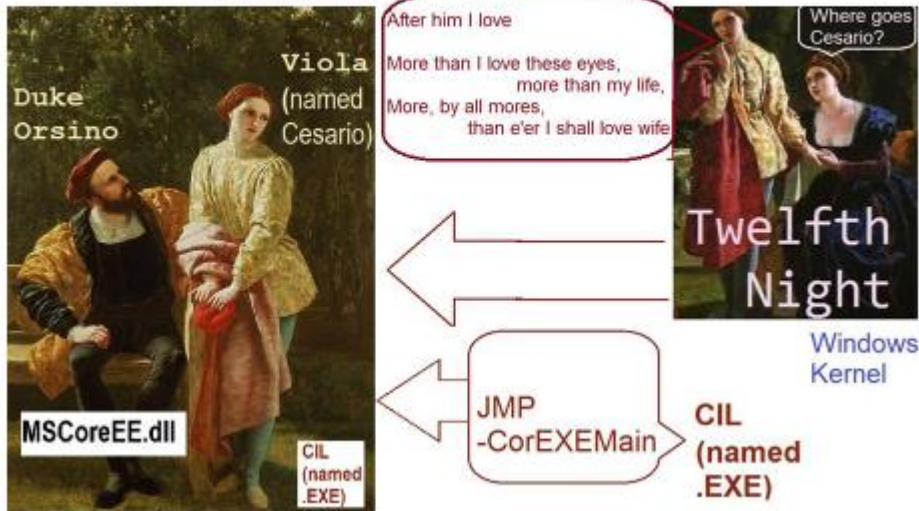
What is this thing called?

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



What is this?

What is this?



Who wrote 12th. night

What is that?

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;

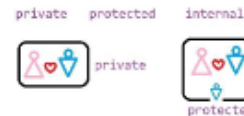
    dori.name = "Dori";
    dori.breed = "Mongrel";
    dori.Bark();
}
```

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

What is this?

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

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?

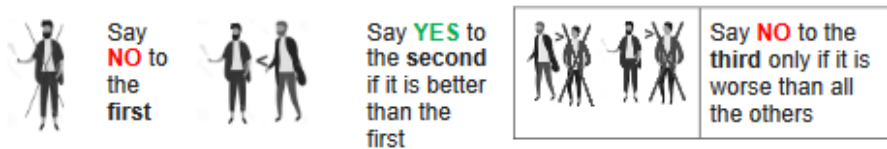


```
class AFather
{
    protected string name;
    internal int age;
}
class Program
{
    static void Main(string[] args)
    {
        AFather af = new AFather();
        af.age = 33;
        ASon andy = new ASon("Olaf");
    }
}
```

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

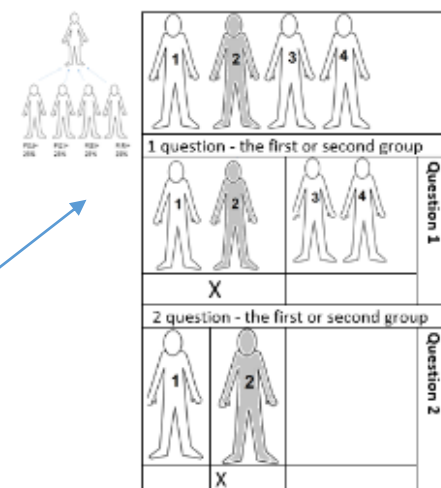
```
class Program
{
    static void Main(string[] args)
    {
        AFather af = new AFather();
        ASon andy = new ASon("Olaf");
    }
}
```

What is this?



What is this?

What is this?



Average number of questions =

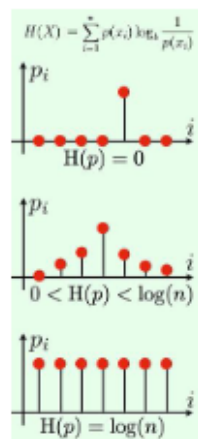
$$2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 + 2 \cdot 0.25 = 2$$

Average number of questions =

$$1 \cdot 0.5 + 2 \cdot 0.25 + 3 \cdot 0.125 + 3 \cdot 0.125$$



|                                         |                                                                                           |         |
|-----------------------------------------|-------------------------------------------------------------------------------------------|---------|
| Question 1.<br>Is this Zuckerberg?      |  50%   | 1*0.5   |
| Question 2.<br>Is this Sergey Brin?     |  25%   | 2*0.25  |
| Question 3.<br>Is this Stefan from BMW? |  12.5% | 3*0.125 |
| So Prince Saud                          |  12.5% | 3*0.125 |
| Average number of questions = 1.75      |                                                                                           |         |



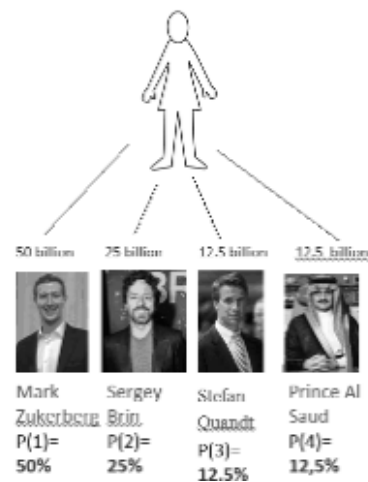
$$\sum_{i=1}^n p(i) \log_2 \frac{1}{p(i)}$$

Quantifying information

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

number of bits required to encode choice

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



What is this?

# 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 =  $\frac{5!}{2!}$

To: vanojefferson@g

Date: Thu, 1 May 2025

Subject: +0.5: QUEST 1 35

ANSWER: 1929

+ 0.5

+ 1.53

+ 0.5

= 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 Exain  
+ 0.5 to Exain  
+ 0.5 to Exain  
+ 0.5 to Exain  
+ 0.5 to Exain

0.5  
0.5  
0.5  
0.5  
0.5

+

1.53

0.5

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

= 4.53



3.03