POZNAŃ UNIVERSITY OF MEDICAL SCIENCES

INTRODUCTION TO MEDICAL SCIENCES

Onsite course

September 15th – October 6th, 2023

REGULATIONS

1. The aim of the course Introduction to Medical Sciences is to revise students' knowledge of Physics, Chemistry, and Biology and to introduce new subject areas, which will contribute to the medical studies that the newcomers undertake.

2. The course is mandatory for all the students accepted to the 1st year of the MD Program, DDS Program, M. Sc. Physiotherapy Program, and Pharm. D. Program taught in English at Poznan University of Medical Sciences (PUMS).

3. The course comprises three parts:

- **INTRODUCTION TO BIOPHYSICS**
- **INTRODUCTION TO MEDICAL BIOLOGY**
- **INTRODUCTION TO MEDICAL CHEMISTRY**

4. The course consists of 17 classes (17 x 2h and 1 h for the test).

5. Classes will be held from **September 15th to October 6th, 2023**, according to the schedule available at: www.ump.edu.pl/en or VISUS (LMS platform).

6. The course is mandatory. Absence needs to be formally excused. To receive the credit, student must apply to the Dean's office for permission to take a supplementary class or classes and will be charged additionally for it. However, the number of absences cannot exceed 50% of the course's hours. A student who misses more than 50% of classes will not be allowed to take supplementary classes and will not get credit.

7. During each course, student is obliged to take partial tests, which will be held during class on **September 20th, September 27th, and October 4th**. The test will constitute 10 single-choice questions. The list of topics that cover each test will be available at VISUS (LMS platform). The cumulative score will be calculated for each course separately. Student may obtain a maximum of 30 points for each, Introduction to Medical Biology, Introduction to Medical Chemistry, and Introduction to Biophysics. Based on the results of the online Pre-Study Courses (Mastering Biophysics, Mastering Medical Biology, Mastering Medical Chemistry, *see Regulations of the Pre-Study Course, August 2023*), it will be possible to obtain a bonus (maximum 5 points), which will be added to the cumulative score for each course.

8. If the student fails to collect a cumulative score of 60% from three partial tests, a final test from all the material must be taken, which must be passed at 60%. **Student <u>is not</u> allowed to retake partial tests.**

9. Regulations of the final (Integrative) test in Introduction to Medical Sciences:

   - the test will be held in the form of a test comprising 90 questions – 30 from each area of study: Biophysics, Medical Biology, and Medical Chemistry,

   - based on the results of the online Pre-Study Courses (Mastering Biophysics, Mastering Medical Biology, Mastering Medical Chemistry, *see Regulations of the Pre-Study Course, August 2023*), it will be possible to obtain a bonus (maximum 5 points), which will be added to the final test results of Introduction to Biophysics, Introduction to Medical Biology and Introduction to Medical Chemistry, respectively. The bonus points are added to all attempts.

   - in order to pass the final test, it is necessary to score at least 60% on each examination part (Biophysics, Medical Biology, Medical Chemistry).

10. The final test will take place **at the Computer Examination Center, Poznan, 2 Parkowa Street, on October 6th, 2023.**

11. In case of failing the test or one of its parts, one retake is allowed. The retake will take place **at the Computer Examination Center, Poznan, 2 Parkowa Street, on October 13th, 2023.**

12. Passing the test from Introduction to Medical Sciences is mandatory to be admitted to the regular courses (e.g., Biophysics, Medical Chemistry, Biochemistry, Histology Embryology & Cell Biology).

13. During the course, students can take part in consultations in order to clarify doubts related to the material being presented. Consultations will be held during the office hours of the departments.

Reminder of an important point from the PreStudy course regulations (August)

At the end **each part** of the Pre-Study Course can be graded with a maximum of **5 bonus points**, which will be **included in the final score** for the relevant Introduction to Medical Sciences course to be held in September. The bonus points will be calculated according to the score obtained from assignments as follows:

60% - 67% - 1 point

68% - 75% - 2 points

76% - 83% - 3 points

84% - 91% - 4 points

92% - 100% - 5 points

The bonus points are added in every attempt of the final test.

The bonus points will be credited only to students taking the course on a regular basis.

The course coordinator is Anna Marcinkowska-Gapińska Ph.D.
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All necessary information is available at:
http://biofizyka.ump.edu.pl/ International Students / Introduction to Biophysics

INTRODUCTION TO BIOPHYSICS

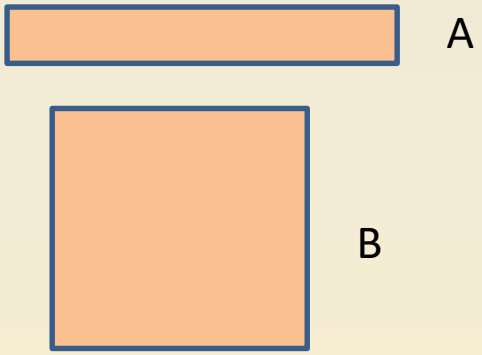
09/15/2023

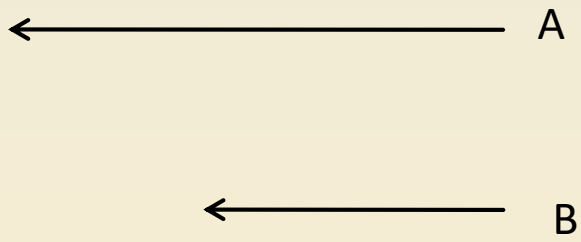
Introduction

A physical quantity – any property of object, substance or phenomenon which can be measured.

For example: *time, length, mass, density, force, volume, velocity, temperature...*

A qualitative analysis – *longer, bigger, faster…*





A quantitative analysis – *how many times (much)….longer, greater, faster…*
we have to know the value and unit of quantity

for example: from measurements (A_A=2 cm^2) (A_B=6 cm^2)

So we can say:

The area of B is 3 times greater than the area of A

SI - the International Systemt of Units

The SI is the modern metric system of measurement: a set of units which can be used to specify anything which can be measured.
The universal language of science.

The SI is founded on seven *SI base units* for seven *base quantities*.

Base quantity	**Unit name**	**Symbol**
1. length	meter	m
2. mass	kilogram	kg
3. time	second	s
4. electric current	ampere	A
5. thermodynamic temperature	kelvin	K
6. amount of substance	mole	mol
7. luminous intensity	candela	cd

Definitions of the SI base units

meter	The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second.
kilogram	The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram
second	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.
ampere	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length.
kelvin	The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.
mole	The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12; its symbol is "mol." When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

SI derived units

Other quantities, called *derived quantities*, are defined in terms of the seven base quantities via a system of quantity equations.

The *SI derived units* for these derived quantities are obtained from these equations and the seven SI base units. Examples of such SI derived units are given in the table below.

Examples of SI derived units

Derived quantity	Unit name	Symbol
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s^2
mass density	kilogram per cubic meter	kg/m^3
current density	ampere per square meter	A/m^2
magnetic field	ampere per meter	A/m

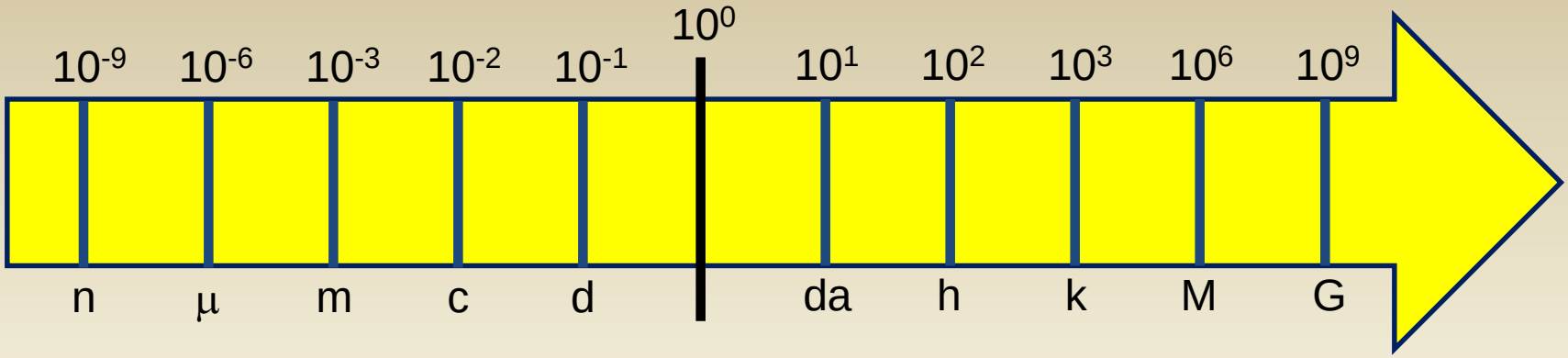
SI derived units with special names and symbols

frequency	hertz	Hz	s^{-1}
force	newton	N	$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work,	joule	J	$m^{2} \cdot kg \cdot s^{-2}$
power	watt	W	$m^{2} \cdot kg \cdot s^{-3}$
electric charge	coulomb	C	$s \cdot A$

Prefixes

The standard SI prefixes for indicating powers of 10.

Value	Name	Symbol	Value	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deca	da	10^{-24}	yocto	y



(directly)

1 **m**m = $1 \cdot 10^{3}$ μm *because* $\frac{\textbf{m}}{\mu}$ $\frac{10^{-3}}{10^{-6}} = 10^{-3-(-6)} = 10^{-3+6} = 10^{3}$

1 μm = $1 \cdot 10^{-3}$ mm

1 km = $1 \cdot 10^{5}$ cm *because* $\frac{\textbf{k}}{\textbf{c}}$ $\frac{10^{3}}{10^{-2}} = 10^{3-(-2)} = 10^{5}$

(indirectly)

1 km = $1 \cdot 10^{3}$ m=$1 \cdot 10^{3} \cdot 10^{2}$ cm=$1 \cdot 10^{5}$ cm

<u>Convert 20 nm to mm</u>

#1. (directly) 20 nm = $20 \cdot 10^{\textbf{-9+3}}$ mm=$20 \cdot 10^{-6}$ mm

#2. (indirectly) 20 nm = $20 \cdot 10^{-9}$ m= $20 \cdot 10^{-9} \cdot 10^{3}$ mm=$20 \cdot 10^{-6}$ mm

25 cm = $25 \cdot 10^{-2}$ m

10^{-2}

10^{-2} means - *move decimal point* ***to the left by two***

10^{-2}

25 cm = 0.25 m

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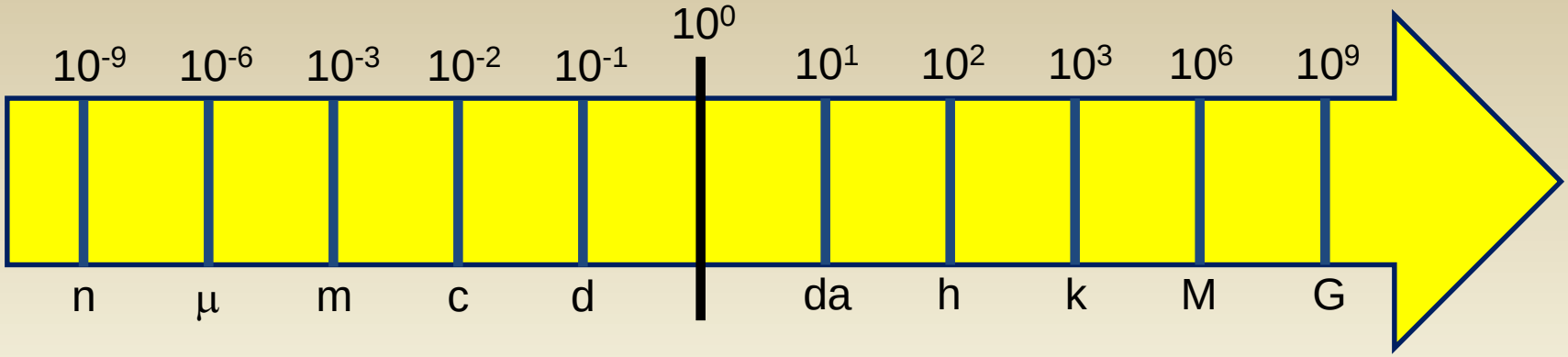
25 km = $25 \cdot 10^{3}$ m

10^{3}

10^{3} means - *move decimal point* ***to the right by three***

10^{+3}

25. km= 25 000 m



Convert

a) 250 μm = m

b) 8 mm^2 = m^2

c) 0.3 m^3 = cm^3

d) 40 ml = m^3

e) 15 l = dm^3

f) 6 dm^3 = cm^3

Exercise 1:
Convert 240 km/h to m/s

Exercise 2:
Convert 15 m/s to km/h

Exercise 3:
Convert the meatbolic rate of an animal 48 kJ/day to J/s

Exercise 4:
The period of electromagnetic wave equals 4 μs. Calculate its frequency.

Exercise 5:
The frequency of mechanical wave equals 250 kHz. Calculate its period.

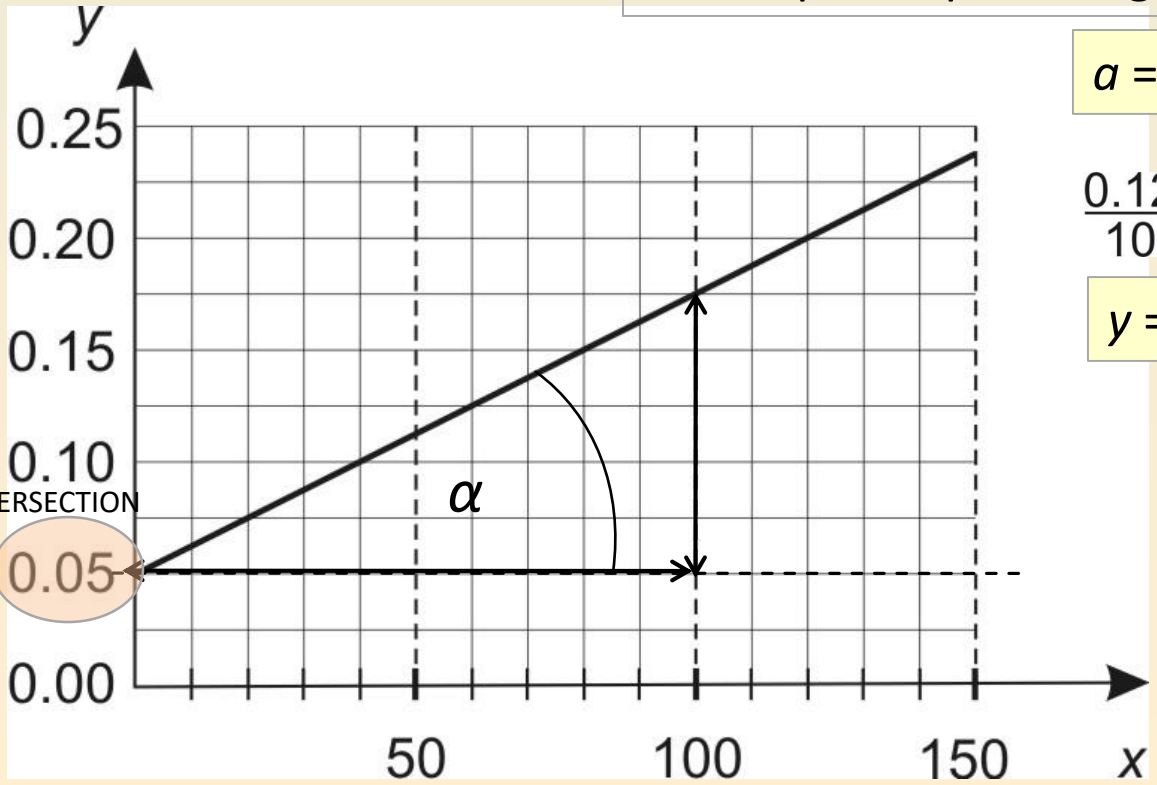
Functions and graphs

1. Linear function: $y(x) = a \cdot x + b$

$b = 0.05$

The slope a equals tangent of the angle α:

$a = \tan\alpha$

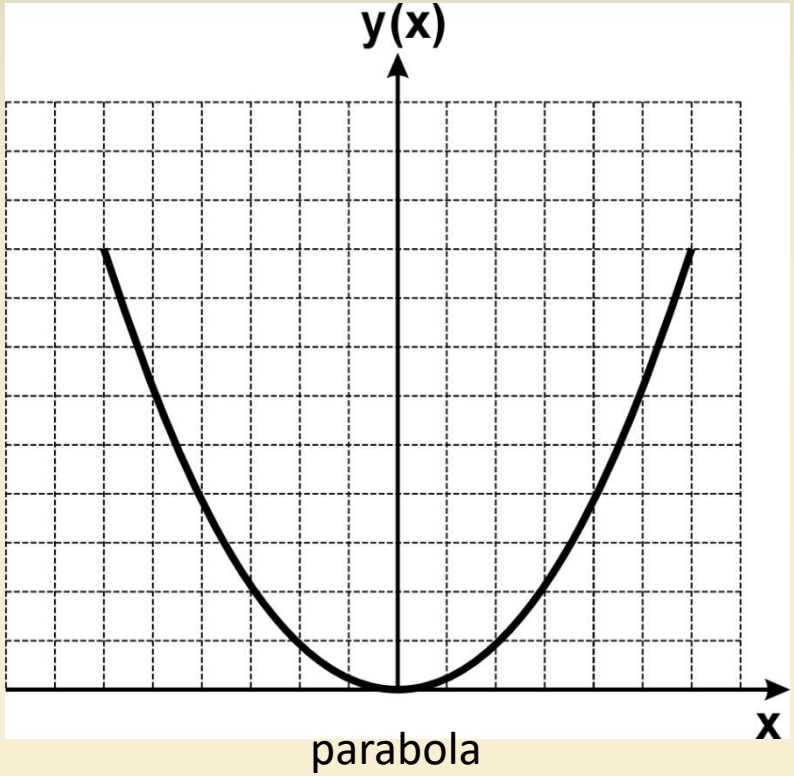


y INTERSECTION

$\frac{0.125}{100} = 0.125 \times 10^{-2} = 125 \times 10^{-5}$

$y = 125 \times 10^{-5} \cdot x + 0.05$

2. Quadratic function: $y(x) = ax^2 + bx + c$



parabola

$$F = mr\omega^2$$

$$E = \tfrac{1}{2} mv^2$$

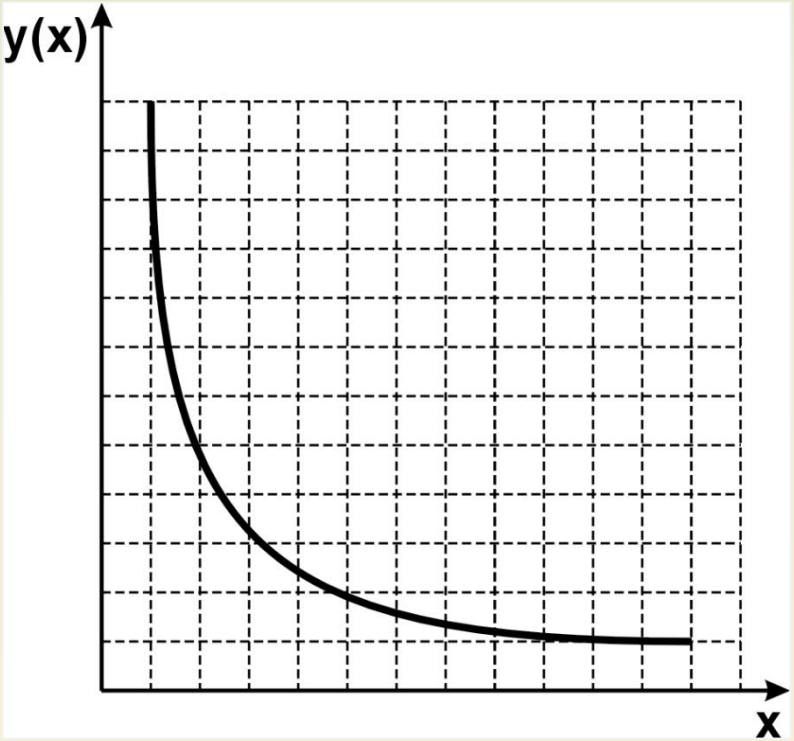
3. Inversely proportional relation – hyperbolic function:

$$y = \frac{a}{x}$$

$$y \cdot x = \text{const.}$$

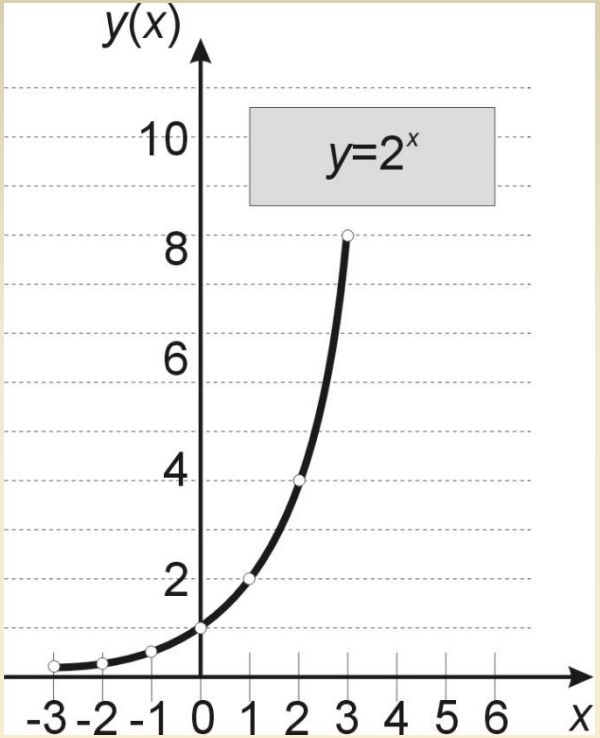
$$V = \frac{kQ}{r}$$

$$F = \frac{mv^2}{r}$$



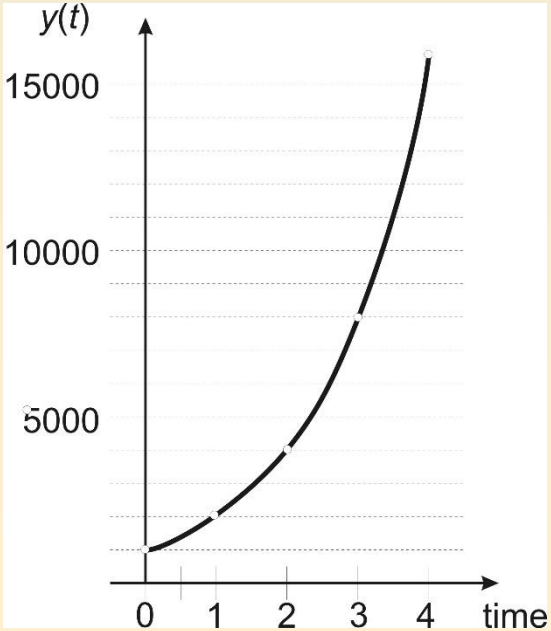
hyperbola

4. Exponential function: $y(x) = a^x$



Exponential functions occur, for instance, in the study of the growth of certain populations of bacteria. As an illustration it might be observed experimentally that the number of bacteria in a culture doubles every hour.

If 1000 bacteria are present at the start of the experiment, than the experimenter would obtain the readings presented below, where t is the time in hours and $y(t)$ is the bacteria count at time t.



$$y(t) = 1000 \cdot 2^x$$

Y doubles every X

Find the function if:

a) Y triples every X
b) Y halves every X

5. Natural exponential function

$$y(x) = y_0 e^{a \cdot x}$$

The number "*e*" is a limit of a certain arithmetic expression. It appears naturally in the investigation of many physical phenomena and equals approximately: 2.718... .

$$\left(1 + \frac{1}{n}\right)^n$$

e=2.72

The factor "*a*" in the exponent is usually negative (*-a*).

$$y(x) = y_0 e^{-a \cdot x}$$

Examples:

- Attenuation of electromagnetic ionising radiation: $I = I_0 e^{-\mu x}$

  μ – linear attenuation coefficient

- Transmittance vs. solution concentration: $T = e^{-\varepsilon \lambda dc}$

  ε_λ stands for the *absorptivity*

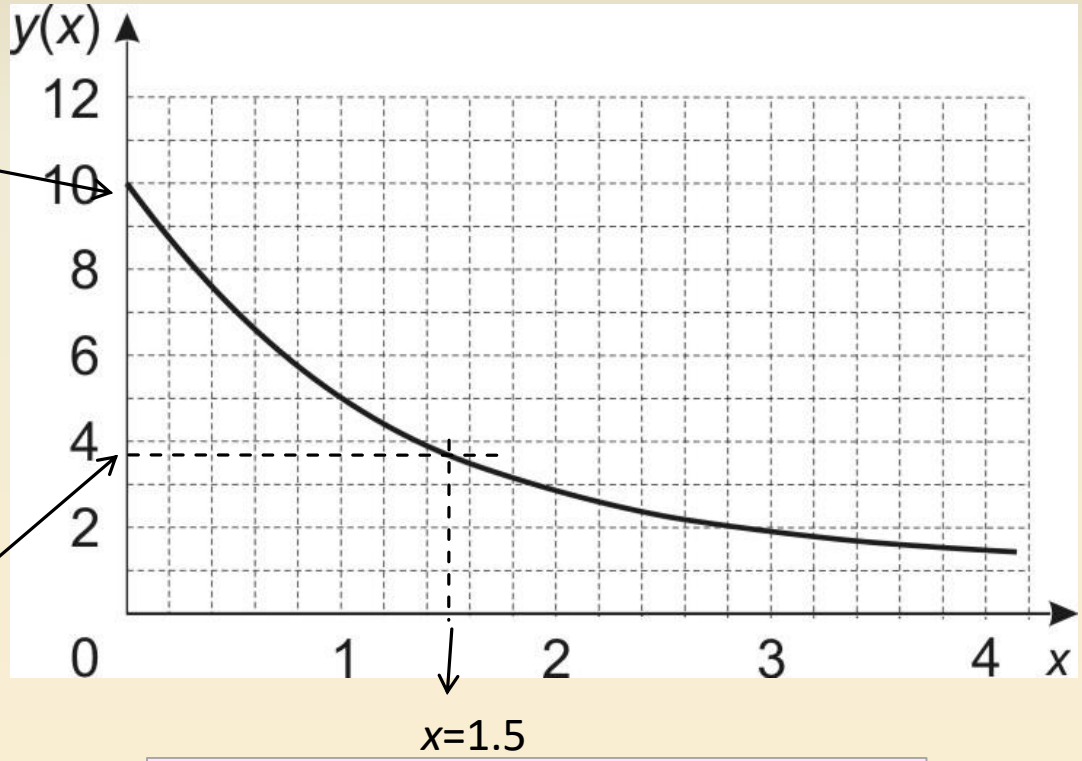
- Stress relaxation : $\sigma = \sigma_0 e^{-t/\tau}$

  τ – stress relaxation time

How to determine y_0 and a?

$$y(x) = y_0 e^{-a \cdot x}$$

y_0=? and a=?



if $a \cdot x = 1$
then $y(x) = y_0/e$

$a \cdot x = 1, \quad a = 1/x = 1/1.5 \approx 0.7$

$$y(x) = 10 \cdot e^{-0.7 \cdot x}$$

Laws of exponents:

$$a^{-n} = \frac{1}{a^n}$$

$$10^{-5} = \frac{1}{10^5} = 0.00001$$

$$a^0 = 1$$

$$a^1 = a$$

$$a^m \times a^n = a^{m+n}$$

$$10^2 \times 10^4 = 10^6$$

$$\frac{a^m}{a^n} = a^{m-n}$$

$$\frac{8^2}{8^4} = 8^{2-4} = 8^{-2} = \frac{1}{8^2} = \frac{1}{64}$$

$$(a^m)^n \times a^n = a^{m \times n}$$

$$(2^3)^2 = 2^6 = 64$$

Exercises. Simplify expressions:

1. $\frac{\left(2x^2\right)^3}{4x^8} =$

2. $\frac{2x^3 3x^2}{\left(x^2\right)^3} =$

3. $\frac{\left(10^4 \times 10^{-2}\right)^3}{10^8} \times 10^{\frac{1}{2}} =$

4. $\frac{\left(6x^3\right)^2}{\left(2x^2\right)^3} =$

5. $\frac{1}{6} a^5 \left(-3a^2\right)\left(4a^7\right) =$

6. $\frac{\left(4x^{-4}\right)^4}{\left(2x^2\right)^{-8}} =$

$$a^{-n} = \frac{1}{a^n}$$

$$a^m \times a^n = a^{m+n}$$

$$\frac{a^m}{a^n} = a^{m-n}$$

$$\left(a^m\right)^n = a^{m \times n}$$

5. Logarithmic function

It is the inverse function to the exponential function ($y = a^x$):

$$\log_a y = x \quad \text{only if} \quad a^x = y$$

(*the logarithm of* ***y*** *with base* ***a***)

Properties of *log function:*

$$\log_a (u \cdot w) = \log_a u + \log_b w$$

$$\log_a \left(\frac{u}{w} \right) = \log_a u - \log_b w$$

$$\log_a (u^c) = c \cdot \log_a u$$

$$\log_e Y = \ln Y$$

natural logarithm

(*the base* ***a*** *= e =2.72*)

$$\log_{10} Y = \log Y$$

decimal logarithm

(*the base* ***a*** *= 10*)

EXERCISES:

Change the following equations to the logarithmic form:

a) $4^3 = 64$ ($\log_4 64=3$),

b) $2^7 = 128$,

c) $10^{-3}=0.001$,

d) $m = t^{e}$.

Change the following equations to exponential form:

a) $\log_5 1=0$,

b) $\log_3 27=3$,

c) $\log_a k=n$,

d) $\log_{10} 0.01=-2$.

Find value of the logarithms:

a) $\log_{10}1000 =$

b) $\log_2 16 =$

c) $\log_5 5^3 =$

d) $\log_{10}0.001 =$

e) $\log_e e^{-2} =$

f) $\log_{10}10 =$

Determine the value of x:

a) $\log_3 81=x$,

b) $\log_5 x=-2$,

c) $\log_x 8=3$,

Solve equation

$\log x+\log 5=\log 30$

Find the value of A:

a) $A=\log 10^3+\log 10^{-3}$

b) $A=\left(\log x^4+4\cdot\log x^{-1}\right)^{4/3}$

EXAMPLES

1. *Acoustics* - the sound intensity level (**SIL**), the sound pressure level (**SPL**)

$$SIL = 10 \cdot \log_{10} \frac{I}{I_0} \quad [\text{dB}]$$

$$SPL = 10 \cdot \log_{10} \frac{p^2}{p_0^2} \rightarrow SPL = 20 \cdot \log_{10} \frac{p}{p_0}$$

where I_0 is the intensity of threshold of hearing at 1000 Hz (i.e.10^{-12} W/m^2)

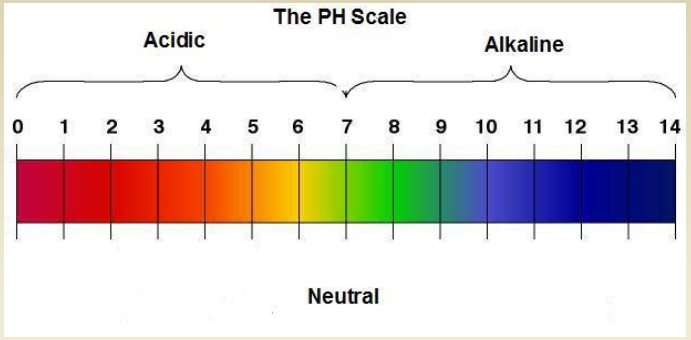
where p_0 is the acoustic pressure amplitude of hearing threshold at 1000 Hz (i.e.$2 \cdot 10^{-5}$ Pa)

Find *SIL* if:

a) I is 2 times as great as I_0
b) *I* is 100 times as great as I_0
c) *I* is 1000 times as great as I_0
d) *I* is 100 000 times as great as I_0

2. Chemists use a number denoted by **pH** to describe quantitatively the acidicity or basicity of solutions.
By definition:

$$pH = -\log_{10}[H^+]$$



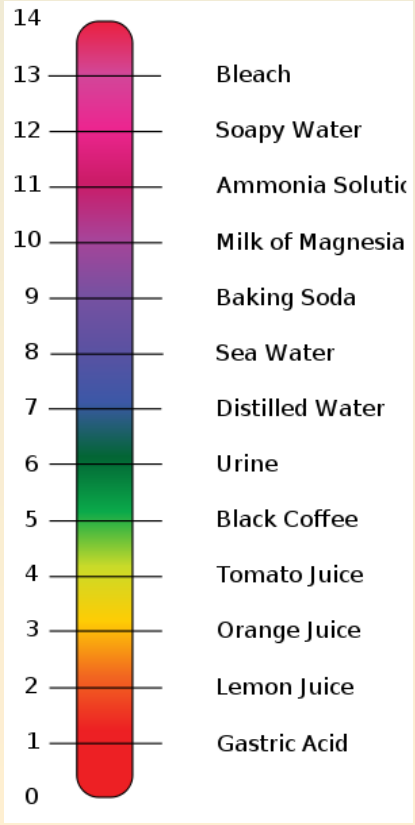
Approximate the pH of each substance:

a) sea water, $[H^+] \approx 5.0 \times 10^{-9}$

b) carrots, $[H^+] \approx 1.0 \times 10^{-5}$

c) vinegar, $[H^+] \approx 6 \times 10^{-3}$

$\log_{10}5 \sim 0.7$
$\log_{10}6 \sim 0.78$



3. Magnitude of an earthquake - the **Richter scale**:

$$R = \log_{10} \frac{I}{I_0}$$

Find the magnitude of an earthquake that has intensity:

a) 100 times that of I_0:
b) 10,000 times that of I_0,
c) 100,000 times that of I_0.