

Physical basis of biophysics

1st Lecture

Mathematics Necessary for Understanding Physics Physical Quantities and Units

10th September 2019

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Information about the lectures:

Tuesday: 16:30-17:50 Hevesy György Hall

Friday: 17:00-18:20 Békésy György Hall



The screenshot shows the website of the Department of Biophysics and Radiation Biology at Semmelweis University. The page is titled 'Physical bases of biophysics' and includes a sidebar with navigation links. The main content area contains general information about the course, including its aims, objectives, and a list of recommended literature. A red circle highlights the 'Closing test of the course' section, which states that the test will be held on the 9th of October (Tuesday) and that the place and time will be announced later.

Information about the lectures:

Tuesday: 19:00-20:30 Háy lecture hall

Friday: 18:10-19:40 Háy lecture hall

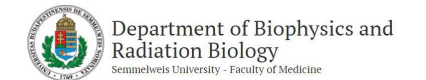
Sources for the course:

Notes made on the lectures

Tölgyesi: *Mathematical and Physical Basis of Medical Biophysics*)

Website of the department

(<http://biofiz.semmelweis.hu/>)



Home Education Research Services Staff Contact

Faculty of Pharmacy

Biophysics 1.

Biophysics 2

Physical bases of biophysics

Teaching assistant work

Number theory basics

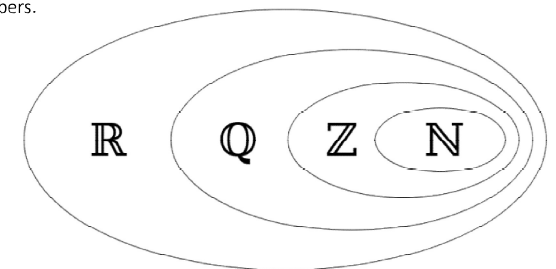
$\mathbb{N}=\{0,1,2,\dots,n,\dots\}$ not negative integers

$\mathbb{Z}=\{-3,-2,-1,0,1,2,3,\dots\}$ integer numbers

$\mathbb{Q}=\{p/q \mid p,q \in \mathbb{Z}, q \neq 0\}$

$\mathbb{Q}^* =$ all real numbers which are not rational numbers.

$\mathbb{R}=\{\mathbb{Q} \cup \mathbb{Q}^*\}$ real numbers



Normalized notation

$$M \times 10^n$$

M = mantissa $1 \leq M < 10$ $M \in \mathbb{R}$

n = an integer $n \in \mathbb{Z}$

n gives the order of magnitude of the number



Functions

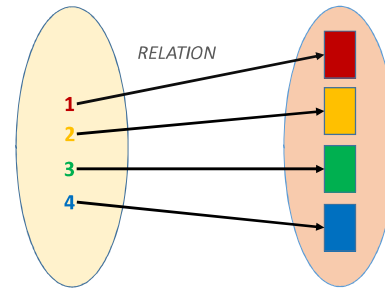
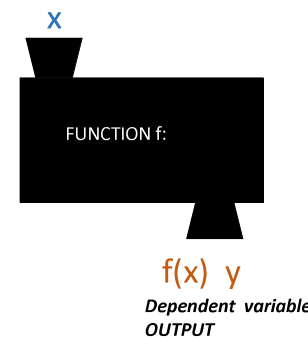
Domain of the function D_f

(the possible values for the independent variable)

Range of the function R_f

(the possible values that we can get with our function)

Independent variable
INPUT



x	f(x) or y
1	Red
2	Orange
3	Green
4	blue

Functions

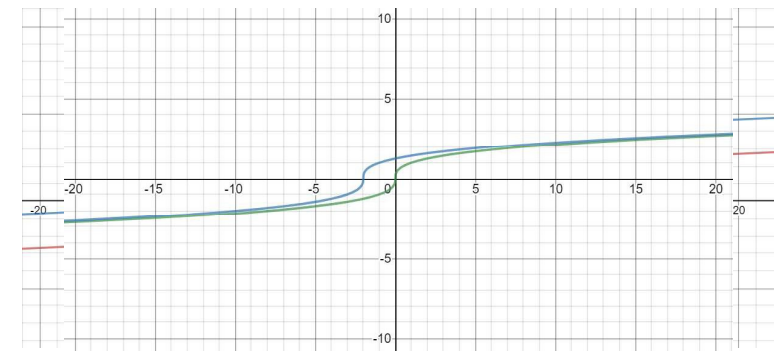
Function: A function is a relation that assigns a single value in the range to each value in the domain.

Domain (D_f): Each value in the domain is also known as input value or INDEPENDENT VARIABLE and often labeled with the lowercase letter x

Range (R_f): each value in the range is also known as an output value, or DEPENDENT Variable and is often labeled lowercase letter y .

Function transformation

- **Vertical shifts**



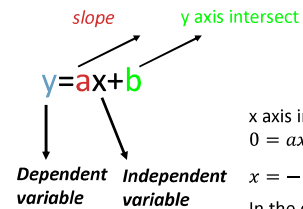
Linear equation

There is only one variable in the equation, the variable is at the first power

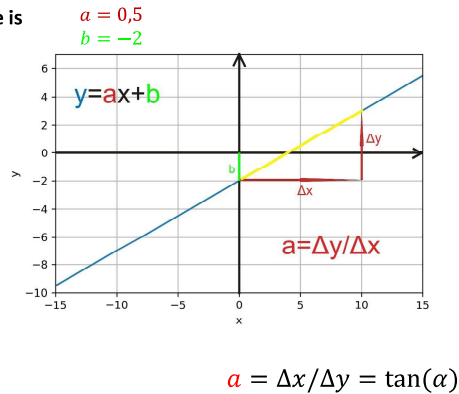
$R \rightarrow R \ x \rightarrow ax + b \ a, b \in R \ a \neq 0$

The graph of a linear function is a straight line

Rises the same rate everywhere

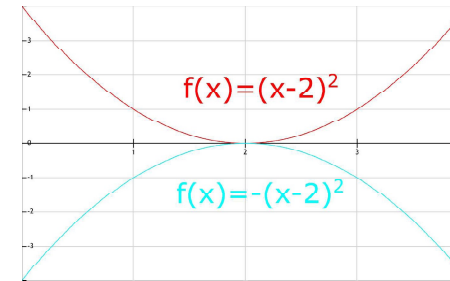


x axis intercept
 $0 = ax + b$
 $x = -\frac{b}{a}$
 In the case of the plotted function
 $0 = 0,5 * x + (-2)$
 $2 = 0,5x$
 $x = 4$

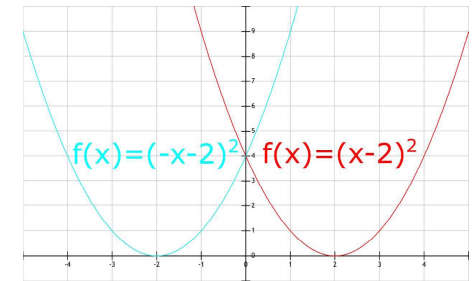


If $a = 0$ Then $y = b$
 If $b = 0$ Then $y = ax$

Transformation of functions

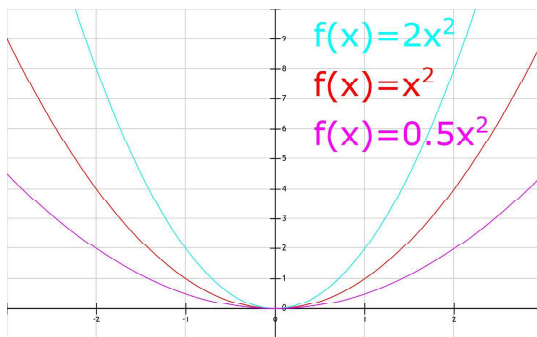


Reflection to the x-axis
 $g(x) = -f(x)$



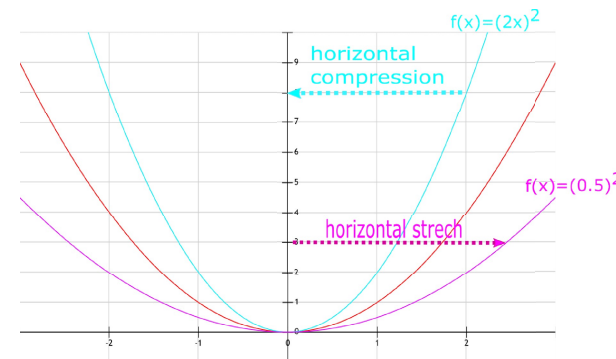
Reflection to the y-axis
 $g(x) = f(-x)$

Vertical stretch and compressions



$g(x) = af(x)$
 $a > 1$ vertical stretch
 $0 < a < 1$ vertical compression

Horizontal stretch and compression

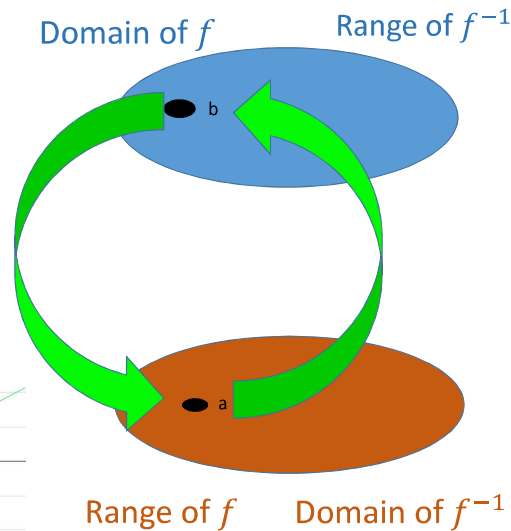
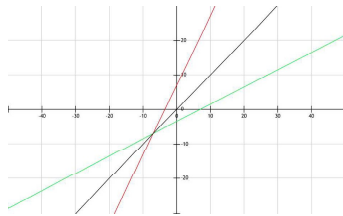


$g(x) = f(bx)$

- $b > 1$ graph compressed by $\frac{1}{b}$
- $0 < b < 1$ graph stretched by $\frac{1}{b}$
- $b < 0$ horizontal stretch or compression combined with horizontal reflection

Inverse function

- For any one-to-one function $f(x) = y$ a function is an inverse function of $f^{-1}(y) = x$
- The graph of $f^{-1}(x)$ is the graph of $f(x)$ reflected about the diagonal line $y = x$

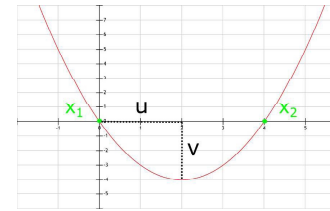


Quadratic equation

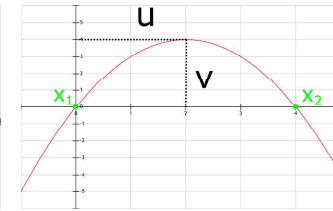
$R \rightarrow R, x \rightarrow ax^2 + bx + c$ $a, b, c \in R, a \neq 0$ if $a = 0$ the function is linear

The graph of a quadratic equation with one variable is a PARABOLA.

$ax^2 + bx + c = a(x - u)^2 + v$ u and v gives the coordinates for the vertex of the parabola this is where we find the axis of symmetry for the parabola

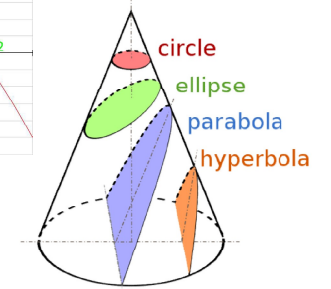


If $a > 0$

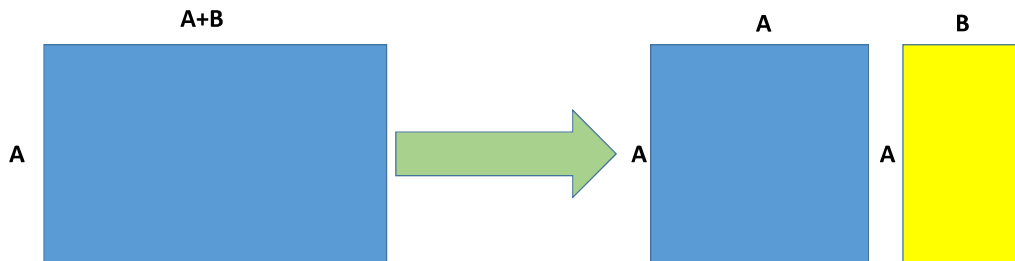


If $a < 0$

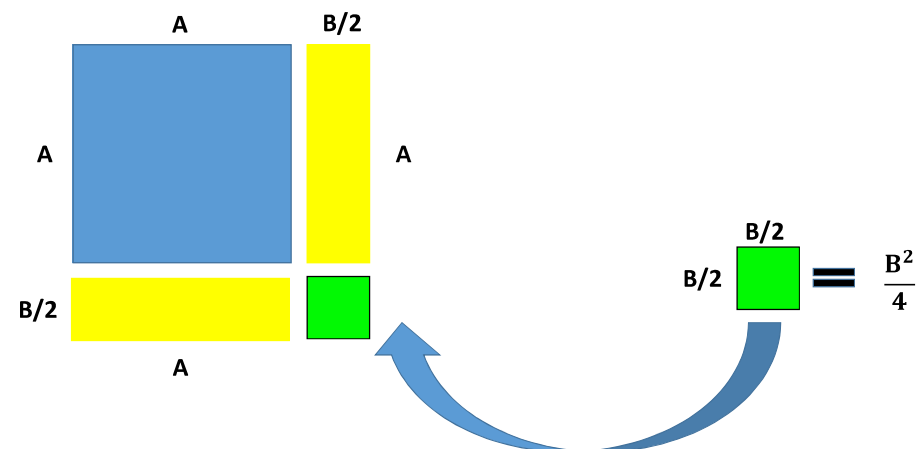
U and V are the coordinates for the vertex of the parabola



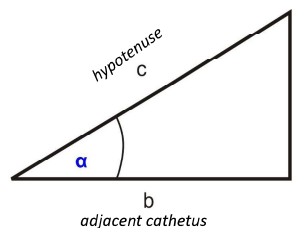
Completing the square



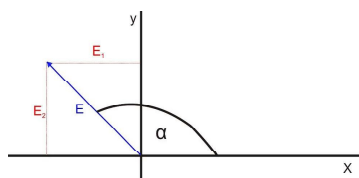
Completing the square



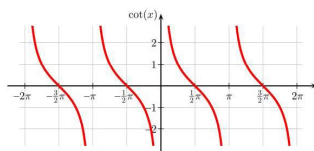
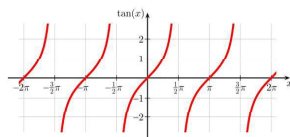
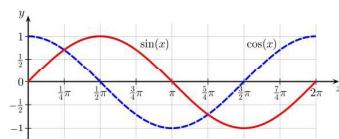
Trigonometric functions



$$\begin{aligned}\sin(\alpha) &= a/c \\ \cos(\alpha) &= b/c \\ \operatorname{tg}(\alpha) &= \tan(\alpha) = a/b \\ \operatorname{ctg}(\alpha) &= b/a\end{aligned}$$



$$\begin{aligned}E &\text{ is a unit vector} \\ &\text{rotated with } \alpha \text{ angle} \\ \sin(\alpha) &= E_2 \\ \cos(\alpha) &= E_1 \\ \operatorname{tg}(\alpha) &= E_2/E_1\end{aligned}$$

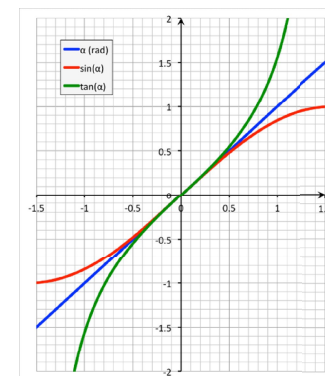


Trigonometric functions

In case of small angles ($< 10 \approx 0.2$ rad)

$$\sin(\alpha) \approx \alpha [\text{rad}] \approx \tan(\alpha)$$

szög(°)	radián(rad)	sin(α)	tan(α)
1	0,01745	0,01745	0,01745
2	0,03491	0,03490	0,03492
3	0,05236	0,05233	0,05241
4	0,06981	0,06976	0,06993
5	0,08727	0,08716	0,08749
10	0,1745	0,1736	0,1763

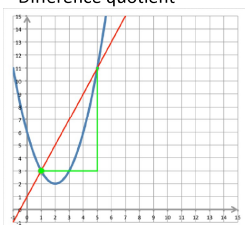


Mathematical Dance Moves

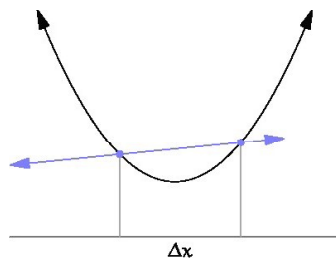


Differentiation and Integration

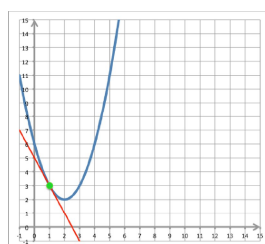
Difference quotient



$$\frac{f(x) - f(x_0)}{x - x_0}$$



Derivative when the difference quotient is calculated for $\delta x \rightarrow 0$



$$\lim_{x \rightarrow x_0} \frac{f(x) - f(x_0)}{x - x_0}$$

Derivation in the case of simple mechanic problems

Rectilinear Motions $v = \text{const.}$

$$\text{example: } v = 100 \frac{\text{m}}{\text{s}}$$

t(s)	s(m)	$v = (\frac{\text{m}}{\text{s}})$	$a = (\frac{\text{m}}{\text{s}^2})$
0	0		
1	100	100	
2	200	100	0
3	300	100	0
4	400	100	0
5	500	100	0
6	600	100	0
7	700	100	0
8	800	100	0
9	900	100	0

Σ

2.Example

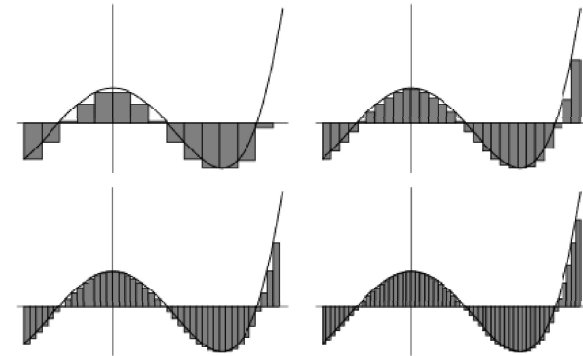
Rectilinear Motion with Uniform Acceleration $a = \text{const.}$

$$a = 2 \frac{\text{m}}{\text{s}^2} \quad v_o = 100 \frac{\text{m}}{\text{s}}$$

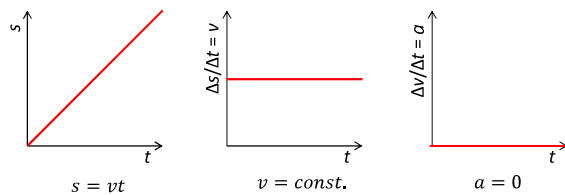
t	s	$v \left(\frac{\text{m}}{\text{s}} \right) \delta t = 1\text{s}$	$v \left(\frac{\text{m}}{\text{s}} \right) \delta t = 0.01\text{s}$	$a \left(\frac{\text{m}}{\text{s}^2} \right)$
0	0	100	100	
1	101	102	102,02	2
2	204	104	104,04	2
3	309	106	106,06	2
4	416	108	108,08	2
5	525	110	110,1	2
6	636	112	112,12	2
7	749	113	114,14	2
8	864	116	116,16	2

How to calculate an Integral

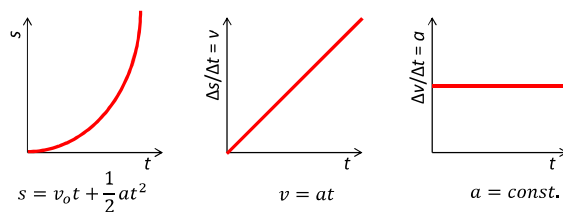
$$\Sigma \rightarrow \int$$



Uniform Rectilinear Motion:



Rectilinear Motion with Uniform Acceleration:



Physical quantities SI units

$$\text{physical quantity} = \text{numerical number} * \text{unit}$$

Types of physical units:

Scalar quantities: a quantity without spatial direction (mass, temperature)

Vektor quantities: represent physical quantities that have both magnitude and direction (velocity)

c-can stand for depending on the context for a lot of physical quantities or constants

- Speed of light in vacuum ($3 \times 10^8 \frac{\text{m}}{\text{s}}$)
- Velocity of wave [$\frac{\text{m}}{\text{s}}$]
- concentration [$\frac{\text{mol}}{\text{m}^3}$]
- Specific heat capacity [$\frac{\text{J}}{\text{kg}}$]

Α α	Β β	Γ γ	Δ δ	Ε ε	Ζ ζ	Η η	Θ θ
ἄλφα	βήτα	γάμμα	δέλτα	ἐπσίλον	ζήτα	ήτα	θήτα
alpha	beta	gamma	delta	epsilon	zeta	eta	theta
α	β	γ	δ	ε	ζ	η	θ
[a/ɑ]	[b]	[ɣ]	[d]	[e]	[z/dz]	[e]	[θ]
Ι ι	Κ κ	Λ λ	Μ μ	Ν ν	Ξ ξ	Ο ο	Π π
ἰότα	κάππα	λάμβδα	μῦ	νῦ	ξί	ὀμικρόν	πί
iota	kappa	lambda	mu	nu	xi	omikron	pi
ι	κ	λ	μ	ν	ξ	ο	π
[i/ɪ]	[k]	[l]	[m]	[n]	[ks]	[o]	[p]
Ρ ρ	Σ σ/ς	Τ τ	Υ υ	Φ φ	Χ χ	Ψ ψ	Ω ω
ῥο	στίγμα	ταῦ	ὑψίλον	φεῖ	χί	ψί	ὀμέγα
rho	sigma	tau	upsilon	phi	chi	psi	omega
ρ	σ	τ	υ	φ	χ	ψ	ω
[r]	[s/z]	[t]	[y/y:]	[pʰ]	[kʰ]	[ps]	[ɔ]

