Wykład 5

Funkcje Map, MapAt, Inner, Outer, etc.

In[1]:=
```
ClearAll["Global`*"]
```
wyczyść wszystko

Map, MapAt, MapThread, Outer, Inner ,Thread, Applay

Map, MapAll

In[2]:=
```
g =.
```

In[3]:=
```
? Map
```

Map[*f*, *expr*] or *f* /@ *expr* applies *f* to each element on the first level in *expr*.
Map[*f*, *expr*, *levelspec*] applies *f* to parts of *expr* specified by *levelspec*.
Map[*f*] represents an operator form of Map that can be applied to an expression. ≫

In[4]:=
```
Map[Funkcja, {K1, K2, {L1, L2}}]
```
zastosuj do

Out[4]= {Funkcja(K1), Funkcja(K2), Funkcja({L1, L2})}

In[5]:=
```
Funkcja /@ {K1, K2, {L1, L2}}
```

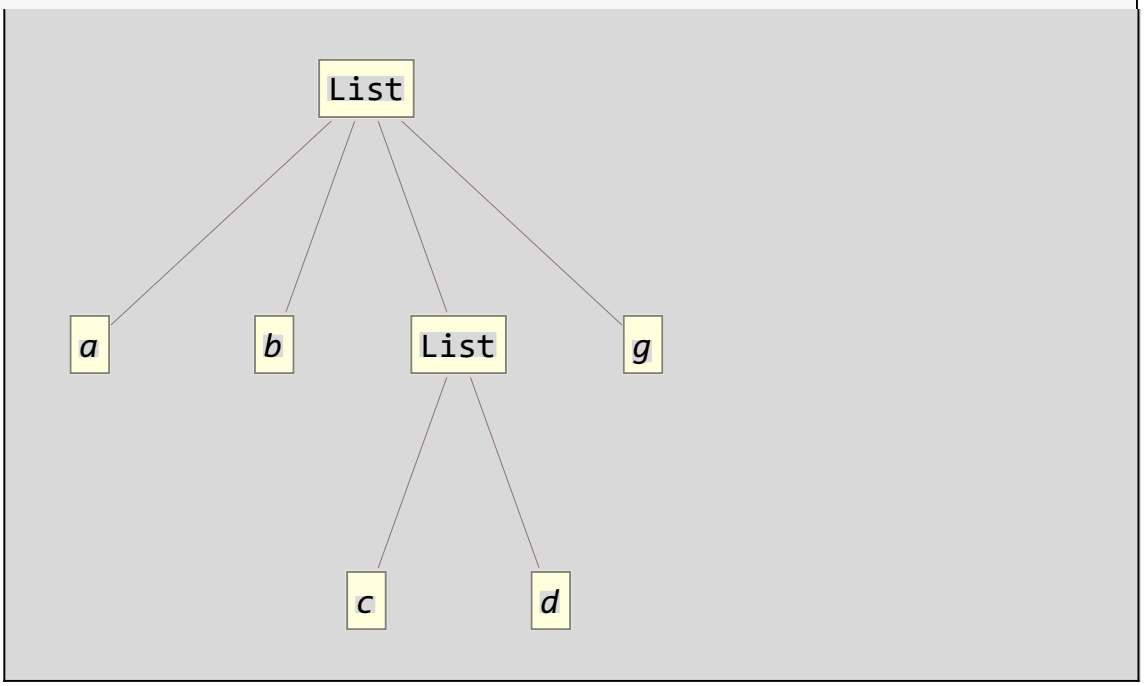
Out[5]= {Funkcja(K1), Funkcja(K2), Funkcja({L1, L2})}

In[6]:=
```
Map[ff, {a, b, {c, d}, g}]
```
zastosuj do

Out[6]= {ff(*a*), ff(*b*), ff({*c*, *d*}), ff(*g*)}

In[7]:=
```
{a, b, {c, d}, g} // TreeForm
```
w formie drzewka

Out[7]//TreeForm=



In[8]:=
```
Map[ff, {a, b, {c, d}, g}, 2]
```
zastosuj do

Out[8]= $\{\mathrm{ff}(a), \mathrm{ff}(b), \mathrm{ff}(\{\mathrm{ff}(c), \mathrm{ff}(d)\}), \mathrm{ff}(g)\}$

In[9]:=
```
Map[ff, {a, b, {c, d}, g}, {2}]
```
zastosuj do

Out[9]= $\{a, b, \{\mathrm{ff}(c), \mathrm{ff}(d)\}, g\}$

In[10]:=
```
f /@ {a, b, {c, d}, g}
```

Out[10]= $\{f(a), f(b), f(\{c, d\}), f(g)\}$

In[11]:=
```
Reverse /@ {{a, b}, {c, d}, {e, f}}
```
odwróć kolejność

Out[11]=
$$\begin{pmatrix} b & a \\ d & c \\ f & e \end{pmatrix}$$

In[12]:=
```
Lista = {a, b, {c, d}, g}
```

Out[12]= $\{a, b, \{c, d\}, g\}$

In[13]:=
```
Lista[[3, 1]]
```

Out[13]= c

In[14]:=
```
Array[LegendreP[#, x] + HermiteH[#, x] &, 10];
 tablic···  funkcja P Legendre'a  wielomian H Hermite'a
(Total@% // Simplify) // Expand
 oblicz sumę  uprość  rozszerz
GRA /@ %
Map[GRA, %%, {2}]
 zastosuj do
Map[GRA, %%%, {3}]
 zastosuj do
```

Out[15]=
$$\frac{308\,333\,x^{10}}{256}+\frac{77\,691\,x^9}{128}-\frac{5\,929\,229\,x^8}{256}-\frac{296\,393\,x^7}{32}+\frac{20\,228\,161\,x^6}{128}+\frac{3\,019\,349\,x^5}{64}-\frac{49\,958\,717\,x^4}{128}-\frac{2\,478\,549\,x^3}{32}+\frac{74\,148\,865\,x^2}{256}+\frac{3\,669\,971\,x}{128}-\frac{7\,339\,625}{256}$$

Out[16]=
$$\mathrm{GRA}\left(\frac{308\,333\,x^{10}}{256}\right)+\mathrm{GRA}\left(\frac{77\,691\,x^9}{128}\right)+\mathrm{GRA}\left(-\frac{5\,929\,229\,x^8}{256}\right)+\mathrm{GRA}\left(-\frac{296\,393\,x^7}{32}\right)+\mathrm{GRA}\left(\frac{20\,228\,161\,x^6}{128}\right)+\mathrm{GRA}\left(\frac{3\,019\,349\,x^5}{64}\right)+\mathrm{GRA}\left(-\frac{49\,958\,717\,x^4}{128}\right)+\mathrm{GRA}\left(-\frac{2\,478\,549\,x^3}{32}\right)+\mathrm{GRA}\left(\frac{74\,148\,865\,x^2}{256}\right)+\mathrm{GRA}\left(\frac{3\,669\,971\,x}{128}\right)+\mathrm{GRA}\left(-\frac{7\,339\,625}{256}\right)$$

Out[17]=
$$\mathrm{GRA}\left(\frac{308\,333}{256}\right)\mathrm{GRA}(x^{10})+\mathrm{GRA}\left(\frac{77\,691}{128}\right)\mathrm{GRA}(x^9)+\mathrm{GRA}\left(-\frac{5\,929\,229}{256}\right)\mathrm{GRA}(x^8)+\mathrm{GRA}\left(-\frac{296\,393}{32}\right)\mathrm{GRA}(x^7)+\mathrm{GRA}\left(\frac{20\,228\,161}{128}\right)\mathrm{GRA}(x^6)+\mathrm{GRA}\left(\frac{3\,019\,349}{64}\right)\mathrm{GRA}(x^5)+\mathrm{GRA}\left(-\frac{49\,958\,717}{128}\right)\mathrm{GRA}(x^4)+\mathrm{GRA}\left(-\frac{2\,478\,549}{32}\right)\mathrm{GRA}(x^3)+\mathrm{GRA}\left(\frac{74\,148\,865}{256}\right)\mathrm{GRA}(x^2)+\mathrm{GRA}\left(\frac{3\,669\,971}{128}\right)\mathrm{GRA}(x)-\frac{7\,339\,625}{256}$$

Out[18]=
$$\frac{74\,148\,865}{256}\mathrm{GRA}(x)^{\mathrm{GRA}(2)}-\frac{2\,478\,549}{32}\mathrm{GRA}(x)^{\mathrm{GRA}(3)}-\frac{49\,958\,717}{128}\mathrm{GRA}(x)^{\mathrm{GRA}(4)}+\frac{3\,019\,349}{64}\mathrm{GRA}(x)^{\mathrm{GRA}(5)}+\frac{20\,228\,161}{128}\mathrm{GRA}(x)^{\mathrm{GRA}(6)}-\frac{296\,393}{32}\mathrm{GRA}(x)^{\mathrm{GRA}(7)}-\frac{5\,929\,229}{256}\mathrm{GRA}(x)^{\mathrm{GRA}(8)}+\frac{77\,691}{128}\mathrm{GRA}(x)^{\mathrm{GRA}(9)}+\frac{308\,333}{256}\mathrm{GRA}(x)^{\mathrm{GRA}(10)}+\frac{3\,669\,971\,x}{128}-\frac{7\,339\,625}{256}$$

In[19]:=
```
Map[f, {a, {b, G}, c}]
 zastosuj do
```

Out[19]= $\{f(a), f(\{b, G\}), f(c)\}$

In[20]:=
```
f /@ {a, {b, G}, c}
```

Out[20]= $\{f(a), f(\{b, G\}), f(c)\}$

In[21]:=
```
? MapAll
```

MapAll[*f*, *expr*] or *f* //@ *expr* applies *f* to every subexpression in *expr*. ≫

In[22]:=
```
MapAll[f, {a, {b, G}, c}]
```
zastosuj do wszystkich

Out[22]= $f(\{f(a), f(\{f(b), f(G)\}), f(c)\})$

In[23]:=
```
f //@ {a, {b, G}, c}
```

Out[23]= $f(\{f(a), f(\{f(b), f(G)\}), f(c)\})$

In[24]:=
```
fff /@ h[p[a, b, c], d[g, f, h]]
```

Out[24]= $h(\text{fff}(p(a, b, c)), \text{fff}(d(g, f, h)))$

In[25]:=
```
Sin /@ h[p[a, b, c], d[g, f, h]]
```
sinus

Out[25]= $h(\sin(p(a, b, c)), \sin(d(g, f, h)))$

In[26]:=
```
Log //@ h[p[a, b, c], d[g, f, h]]
```
logarytm

Out[26]= $\log(h(\log(p(\log(a), \log(b), \log(c))), \log(d(\log(g), \log(f), \log(h)))))$

In[27]:=
```
10 x^20 - 2 x^3 + 4
Log //@ %
```
logarytm

Out[27]= $10\,x^{20} - 2\,x^3 + 4$

Out[28]= $\log\left(\log\left((\log(2) + i\,\pi)\,\log\left(\log^{\log(3)}(x)\right)\right) + \log\left(\log(10)\,\log\left(\log^{\log(20)}(x)\right)\right) + \log(4)\right)$

In[29]:=
```
Map[f, h[p[a, b, c], d[g, f, h]], {2}] (* na drugim poziomie *)
```
zastosuj do

Out[29]= $h(p(f(a), f(b), f(c)), d(f(g), f(f), f(h)))$

Jeśli ustawimy Heads -> True

In[30]:=
```
Map[FF, h[p[a, b, c], d[g, f, h]], {2}, Heads -> True]
```
zastosuj do głowy prawda

Out[30]= $h(\text{FF}(p)(\text{FF}(a), \text{FF}(b), \text{FF}(c)), \text{FF}(d)(\text{FF}(g), \text{FF}(f), \text{FF}(h)))$

In[31]:=
```
Map[FF, h[p[a, b, c], d[g, f, h]], {2}]
```
zastosuj do

Out[31]= $h(p(\text{FF}(a), \text{FF}(b), \text{FF}(c)), d(\text{FF}(g), \text{FF}(f), \text{FF}(h)))$

In[32]:=
```
2 (x - y) ^ 2 + A == CC
Plus[-A, #] & /@ %
```
suma
```
Times[1 / 2, #] & /@ %
```
mnożenie

Out[32]= $A + 2\,(x-y)^2 = \mathrm{CC}$

Out[33]= $2\,(x-y)^2 = \mathrm{CC} - A$

Out[34]= $(x-y)^2 = \dfrac{\mathrm{CC} - A}{2}$

MapAt

In[35]:=
```
? MapAt
```

MapAt[*f*, *expr*, *n*] applies *f* to the element at position *n* in *expr*. If *n* is negative, the position is counted from the end.
MapAt[*f*, *expr*, {*i*, *j*, …}] applies *f* to the part of *expr* at position {*i*, *j*, …}.
MapAt[*f*, *expr*, {{i_1, j_1, …}, {i_2, j_2, …}, …}] applies *f* to parts of *expr* at several positions.
MapAt[*f*, *pos*] represents an operator form of MapAt that can be applied to an expression. ≫

In[36]:=
```
? Lista
```

```
Global`Lista
```

```
Lista = {a, b, {c, d}, g}
```

In[37]:=
```
MapAt[ff, Lista, {{1}, {3, 1}}]
```
zastosuj w danym miejscu

Out[37]= $\{\mathrm{ff}(a), b, \{\mathrm{ff}(c), d\}, g\}$

MapThread

In[38]:=
```
? MapThread
```

MapThread[*f*, {{a_1, a_2, …}, {b_1, b_2, …}, …}] gives {*f*[a_1, b_1, …], *f*[a_2, b_2, …], …}.
MapThread[*f*, {$expr_1$, $expr_2$, …}, *n*] applies *f* to the parts of the $expr_i$ at level *n*. ≫

In[39]:=
```
MapThread[f, {{a, b}, {x, y}}]
```
zastosuj w wątku

Out[39]= $\{f(a, x), f(b, y)\}$

Zobacz różnice

In[40]:=
```
Map[f, {{a, b}, {x, y}}]
```
zastosuj do

Out[40]=
$$\{f(\{a, b\}), f(\{x, y\})\}$$

In[41]:=
```
MapThread[#1 + #2 &, {{a, b}, {x, y}}]
```
zastosuj w wątku

Out[41]=
$$\{a + x, b + y\}$$

Outer

In[42]:=
```
? Outer
```

Outer[f, $list_1$, $list_2$, …] gives the generalized outer product of the $list_i$, forming all possible combinations of the lowest-level elements in each of them, and feeding them as arguments to f.
Outer[f, $list_1$, $list_2$, …, n] treats as separate elements only sublists at level n in the $list_i$.
Outer[f, $list_1$, $list_2$, …, n_1, n_2, …] treats as separate elements only sublists at level n_i in the corresponding $list_i$. ≫

In[43]:=
```
Outer[f, {a, b}, {x, y, z}]
```
zewnętrzny

Out[43]=
$$\begin{pmatrix} f(a, x) & f(a, y) & f(a, z) \\ f(b, x) & f(b, y) & f(b, z) \end{pmatrix}$$

In[44]:=
```
Outer[Times, {a, b, c}, {x, y, z}]
```
zewnę··· mnożenie

Out[44]=
$$\begin{pmatrix} a\,x & a\,y & a\,z \\ b\,x & b\,y & b\,z \\ c\,x & c\,y & c\,z \end{pmatrix}$$

In[45]:=
```
Outer[Times, Array[a, 4], Array[b, 4]] // MatrixForm
```
zewnę··· mnoże··· tablica wielow··· tablica wielowymia··· postać macierzy

Out[45]//MatrixForm=
$$\begin{pmatrix} a(1)\,b(1) & a(1)\,b(2) & a(1)\,b(3) & a(1)\,b(4) \\ a(2)\,b(1) & a(2)\,b(2) & a(2)\,b(3) & a(2)\,b(4) \\ a(3)\,b(1) & a(3)\,b(2) & a(3)\,b(3) & a(3)\,b(4) \\ a(4)\,b(1) & a(4)\,b(2) & a(4)\,b(3) & a(4)\,b(4) \end{pmatrix}$$

In[46]:=
```
Map[FFF, %]
```
zastosuj do

Out[46]=
$$\{\mathrm{FFF}(\{a(1)\,b(1), a(1)\,b(2), a(1)\,b(3), a(1)\,b(4)\}), \mathrm{FFF}(\{a(2)\,b(1), a(2)\,b(2), a(2)\,b(3), a(2)\,b(4)\}),$$
$$\mathrm{FFF}(\{a(3)\,b(1), a(3)\,b(2), a(3)\,b(3), a(3)\,b(4)\}), \mathrm{FFF}(\{a(4)\,b(1), a(4)\,b(2), a(4)\,b(3), a(4)\,b(4)\})\}$$

In[47]:=
```
Map[FFF, %%, {2}]
```
zastosuj do

Out[47]=
$$\begin{pmatrix} \text{FFF}(a(1)\,b(1)) & \text{FFF}(a(1)\,b(2)) & \text{FFF}(a(1)\,b(3)) & \text{FFF}(a(1)\,b(4)) \\ \text{FFF}(a(2)\,b(1)) & \text{FFF}(a(2)\,b(2)) & \text{FFF}(a(2)\,b(3)) & \text{FFF}(a(2)\,b(4)) \\ \text{FFF}(a(3)\,b(1)) & \text{FFF}(a(3)\,b(2)) & \text{FFF}(a(3)\,b(3)) & \text{FFF}(a(3)\,b(4)) \\ \text{FFF}(a(4)\,b(1)) & \text{FFF}(a(4)\,b(2)) & \text{FFF}(a(4)\,b(3)) & \text{FFF}(a(4)\,b(4)) \end{pmatrix}$$

Inner

In[48]:=
```
? Inner
```

Inner[f, $list_1$, $list_2$, g] is a generalization of Dot in which f plays the role of multiplication and g of addition. ≫

In[49]:=
```
Inner[f, {a1, a2, a3}, {b1, b2, b3}]
```
uogólniony iloczyn skalarny

Out[49]=
$$f(a_1, b_1) + f(a_2, b_2) + f(a_3, b_3)$$

In[50]:=
```
Inner[Times, {a1, a2, a3}, {b1, b2, b3}]
```
uogól··· mnożenie

Out[50]=
$$a_1\,b_1 + a_2\,b_2 + a_3\,b_3$$

In[51]:=
```
Inner[Plus, {a1, a2, a3}, {b1, b2, b3}]
```
uogól··· suma

Out[51]=
$$a_1 + a_2 + a_3 + b_1 + b_2 + b_3$$

In[52]:=
```
Inner[f, {a1, a2, a3}, {b1, b2, b3}, G]
```
uogólniony iloczyn skalarny

Out[52]=
$$G(f(a_1, b_1), f(a_2, b_2), f(a_3, b_3))$$

In[53]:=
```
Inner[Plus, {a1, a2, a3}, {b1, b2, b3}, Times]
```
uogól··· suma mnożenie

Out[53]=
$$(a_1 + b_1)\,(a_2 + b_2)\,(a_3 + b_3)$$

In[54]:=
```
Inner[Times, {a1, a2, a3}, {b1, b2, b3}, Plus]
```
uogól··· mnożenie suma

Out[54]=
$$a_1\,b_1 + a_2\,b_2 + a_3\,b_3$$

In[55]:=
```
Inner[Times, {a1, a2, a3}, {b1, b2, b3}, Power]
```
uogól··· mnożenie potęga

Out[55]=
$$(a_1\,b_1)^{(a_2\,b_2)^{a_3\,b_3}}$$

Thread

In[56]:=
```
? Thread
```

Thread[*f*[*args*]] "threads" *f* over any lists that appear in *args*.
Thread[*f*[*args*], *h*] threads *f* over any objects with head *h* that appear in *args*.
Thread[*f*[*args*], *h*, *n*] threads *f* over objects with head *h* that appear in the first *n* *args*. ≫

In[57]:=
```
Thread[f[a, b]]
```
nawlecz

Out[57]= $f(a, b)$

In[58]:=
```
Thread[f[{a, b}, {c, f}]]
```
nawlecz

Out[58]= $\{f(a, c), f(b, f)\}$

In[59]:=
```
a → b // FullForm
```
pełna forma

Out[59]//FullForm= Rule[*a*, *b*]

In[60]:=
```
Thread[Rule[{a, b}, {c, f}]]
```
nawlecz reguła

Out[60]= $\{a \to c, b \to f\}$

In[61]:=
```
Array[a# &, 100]
```
tablica wielowymiarowa
```
Array[b# &, 100];
```
tablica wielowymiarowa
```
Thread[Rule[%%, %]]
```
nawlecz reguła

Out[61]=
$$\{a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13}, a_{14}, a_{15}, a_{16}, a_{17}, a_{18}, a_{19}, a_{20},$$
$$a_{21}, a_{22}, a_{23}, a_{24}, a_{25}, a_{26}, a_{27}, a_{28}, a_{29}, a_{30}, a_{31}, a_{32}, a_{33}, a_{34}, a_{35}, a_{36}, a_{37}, a_{38}, a_{39}, a_{40},$$
$$a_{41}, a_{42}, a_{43}, a_{44}, a_{45}, a_{46}, a_{47}, a_{48}, a_{49}, a_{50}, a_{51}, a_{52}, a_{53}, a_{54}, a_{55}, a_{56}, a_{57}, a_{58}, a_{59}, a_{60},$$
$$a_{61}, a_{62}, a_{63}, a_{64}, a_{65}, a_{66}, a_{67}, a_{68}, a_{69}, a_{70}, a_{71}, a_{72}, a_{73}, a_{74}, a_{75}, a_{76}, a_{77}, a_{78}, a_{79}, a_{80},$$
$$a_{81}, a_{82}, a_{83}, a_{84}, a_{85}, a_{86}, a_{87}, a_{88}, a_{89}, a_{90}, a_{91}, a_{92}, a_{93}, a_{94}, a_{95}, a_{96}, a_{97}, a_{98}, a_{99}, a_{100}\}$$

Out[63]=
$$\{a_1 \to b_1, a_2 \to b_2, a_3 \to b_3, a_4 \to b_4, a_5 \to b_5, a_6 \to b_6, a_7 \to b_7, a_8 \to b_8, a_9 \to b_9, a_{10} \to b_{10},$$
$$a_{11} \to b_{11}, a_{12} \to b_{12}, a_{13} \to b_{13}, a_{14} \to b_{14}, a_{15} \to b_{15}, a_{16} \to b_{16}, a_{17} \to b_{17}, a_{18} \to b_{18}, a_{19} \to b_{19},$$
$$a_{20} \to b_{20}, a_{21} \to b_{21}, a_{22} \to b_{22}, a_{23} \to b_{23}, a_{24} \to b_{24}, a_{25} \to b_{25}, a_{26} \to b_{26}, a_{27} \to b_{27}, a_{28} \to b_{28},$$
$$a_{29} \to b_{29}, a_{30} \to b_{30}, a_{31} \to b_{31}, a_{32} \to b_{32}, a_{33} \to b_{33}, a_{34} \to b_{34}, a_{35} \to b_{35}, a_{36} \to b_{36}, a_{37} \to b_{37},$$
$$a_{38} \to b_{38}, a_{39} \to b_{39}, a_{40} \to b_{40}, a_{41} \to b_{41}, a_{42} \to b_{42}, a_{43} \to b_{43}, a_{44} \to b_{44}, a_{45} \to b_{45}, a_{46} \to b_{46},$$
$$a_{47} \to b_{47}, a_{48} \to b_{48}, a_{49} \to b_{49}, a_{50} \to b_{50}, a_{51} \to b_{51}, a_{52} \to b_{52}, a_{53} \to b_{53}, a_{54} \to b_{54}, a_{55} \to b_{55},$$
$$a_{56} \to b_{56}, a_{57} \to b_{57}, a_{58} \to b_{58}, a_{59} \to b_{59}, a_{60} \to b_{60}, a_{61} \to b_{61}, a_{62} \to b_{62}, a_{63} \to b_{63}, a_{64} \to b_{64},$$
$$a_{65} \to b_{65}, a_{66} \to b_{66}, a_{67} \to b_{67}, a_{68} \to b_{68}, a_{69} \to b_{69}, a_{70} \to b_{70}, a_{71} \to b_{71}, a_{72} \to b_{72}, a_{73} \to b_{73},$$
$$a_{74} \to b_{74}, a_{75} \to b_{75}, a_{76} \to b_{76}, a_{77} \to b_{77}, a_{78} \to b_{78}, a_{79} \to b_{79}, a_{80} \to b_{80}, a_{81} \to b_{81}, a_{82} \to b_{82},$$
$$a_{83} \to b_{83}, a_{84} \to b_{84}, a_{85} \to b_{85}, a_{86} \to b_{86}, a_{87} \to b_{87}, a_{88} \to b_{88}, a_{89} \to b_{89}, a_{90} \to b_{90}, a_{91} \to b_{91},$$
$$a_{92} \to b_{92}, a_{93} \to b_{93}, a_{94} \to b_{94}, a_{95} \to b_{95}, a_{96} \to b_{96}, a_{97} \to b_{97}, a_{98} \to b_{98}, a_{99} \to b_{99}, a_{100} \to b_{100}\}$$

In[64]:=
```
/. a_x_ → b_x_
```

In[64]:=
```
a == b // FullForm
```
pełna forma

Out[64]//FullForm=
```
Equal[a, b]
```

In[65]:=
```
v1 = {a, b, c}
v2 = {x, y, z}
```

Out[65]=
$$\{a, b, c\}$$

Out[66]=
$$\{x, y, z\}$$

In[67]:=
```
v1 == v2
```

Out[67]=
$$\{a, b, c\} = \{x, y, z\}$$

In[68]:=
```
Thread[Equal[v1, v2]]
```
nawlecz równe

Out[68]=
$$\{a = x, b = y, c = z\}$$

Apply

In[69]:=
```
? Apply
```

Apply[*f*, *expr*] or *f* @@ *expr* replaces the head of *expr* by *f*.
Apply[*f*, *expr*, {1}] or *f* @@@ *expr* replaces heads at level 1 of *expr* by *f*.
Apply[*f*, *expr*, *levelspec*] replaces heads in parts of *expr* specified by *levelspec*.
Apply[*f*] represents an operator form of Apply that can be applied to an expression. ≫

In[70]:=
```
Apply[f, {A, B, Cc}]
```
zastosuj

Out[70]= $f(A, B, \mathrm{Cc})$

In[71]:=
```
f @@ {A, B, C}
```
sta

Out[71]= $f(A, B, C)$

In[72]:=
```
f @@ {A, {B, C}, {x, {G, {y, {z}}}}}
```
stała

Out[72]= $f(A, \{B, C\}, \{x, \{G, \{y, \{z\}\}\}\})$

In[73]:=
```
f @@ H[A, {B, C}, {x, {G, {y, {z}}}}]
```
stała

Out[73]= $f(A, \{B, C\}, \{x, \{G, \{y, \{z\}\}\}\})$

In[74]:=
```
H[A, {B, C}, {x, {G, {y, {z}}}}] /. H → F
```
stała

Out[74]= $F(A, \{B, C\}, \{x, \{G, \{y, \{z\}\}\}\})$

In[75]:=
```
Sin[x^2 + y Sin[(c + d)^3]]
```
sinus sinus

```
f @@ %
%% /. Sin → f
```
sinus

Out[75]= $\sin\left(y \sin\left((c+d)^3\right)+x^2\right)$

Out[76]= $f\left(y \sin\left((c+d)^3\right)+x^2\right)$

Out[77]= $f\left(y f\left((c+d)^3\right)+x^2\right)$

In[78]:=
```
Plus @@ {A, B, C, DD, g, h}
```
suma stała

Out[78]= $A + B + C + \mathrm{DD} + g + h$

Ale

In[79]:=
```
Plus @@ {A, B, {C, DD}, {g, {h}}}
```
suma stała

Out[79]= $\{A + B + C + g, \{A + B + \mathrm{DD} + h\}\}$

In[80]:=
```
{A, B, {C, DD}, {g, {h}}} // FullForm
```
stała pełna forma

Out[80]//FullForm= $\mathrm{List}[A, B, \mathrm{List}[C, \mathrm{DD}], \mathrm{List}[g, \mathrm{List}[h]]]$

In[81]:=
```
List @@ F[x, y, z]
```
lista

Out[81]= $\{x, y, z\}$

In[82]:=
```
f @@ {A, B, {C, DD}, {g, {h}}}
```
stała

Out[82]= $f(A, B, \{C, \mathrm{DD}\}, \{g, \{h\}\})$

Zatem w przypadku Plus@@{A,B,{C,DD},{g,{h}}}, zastąpił Head List przez Plus, ale potem dodał do siebie dwie listy?

In[83]:=
```
A + B + {C, DD} + {g, {h}}
```
stała

Out[83]= $\{A + B + C + g, \{A + B + \mathrm{DD} + h\}\}$

In[84]:=
```
{C, DD} + {g, {h}}
```
stała
```
A + B
% + %%
```

Out[84]= $\{C + g, \{\mathrm{DD} + h\}\}$

Out[85]= $A + B$

Out[86]= $\{A + B + C + g, \{A + B + \mathrm{DD} + h\}\}$

In[87]:=
```
A + B + {C, DD}
```
stała
```
{g, {h}}
% + %%
```

Out[87]= $\{A + B + C, A + B + \mathrm{DD}\}$

Out[88]= $\{g, \{h\}\}$

Out[89]= $\{A + B + C + g, \{A + B + \mathrm{DD} + h\}\}$

UWAGA
Plus@@ działa jak Total

In[90]:=
```
Array[# &, 100]
tablica wielowymiarov
Total@%
oblicz sumę
```

Out[90]=
```
{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28,
  29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52,
  53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76,
  77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100}
```

Out[91]=
```
5050
```

In[92]:=
```
Total[{{A, b, {c, d}}, e, {f, {g}}}]
oblicz sumę
```

Total: Lists of unequal length in {{A, b, {c, d}}, e, {f, {g}}} cannot be added.

Out[92]=
```
Total[{{A, b, {c, d}}, e, {f, {g}}}]
```

Zastosowania

Niech będzie dana lista:
L={{a[1],b[1],c[1]},{a[2],b[2],c[2]},...,{a[100],b[100],c[100]}}

a) Napisz dwie funkcje/procedury, które generują listę L.
b) Niech będzie dana funkcja F[x1,...,x100], napisz trzy różne funkcje/procedury, które działając na listę L zwracają
{F[a[1],...,a[100]],F[b[1],...,b[100]],F[c[1],...,c[100]]}.
c) Zmodyfikuj funkcję F, tak aby gdy liczba jej argumentów wynosi jeden zwracała Sin.
d) Napisz funkcję/procedurę, która działając na L zwraca:
L={{a[1],Sin[b[1]],c[1]},{a[2],Sin[b[2]],c[2]},...,{a[100],Sin[b[100]],c[100]}}
UWAGA nie używaj funkcji For, Table, Array, Do, While....
e) Napisz trzy różne funkcje, które zamieniają w każdej trójce symboli listy L element pierwszy z drugim.
f) Wygeneruj listę
{a[1],...,a[100]}
i napisz prostą procedurę zwracającą
F[a[1],...,a[100]].

Rozwiązanie a)

Napisz dwie funkcje/procedury, które generują listę L.

In[93]:=
```
Table[{a[k], b[k], c[k]}, {k, 1, 100}];
tabela
```

In[94]:=
```
Table[{a[k], b[k], c[k]}, {k, 1, #}] &[100];
```
tabela

In[95]:=
```
Transpose@{Array[a, 100], Array[b, 100], Array[c, 100]};
```
transpozycja | tablica wielowymi··· | tablica wielowymi··· | tablica wielowymiarow

In[96]:=
```
Transpose@(Array[#, 100] & /@ {a, b, c});
```
transpozycja | tablica wielowymiarowa

In[97]:=
```
Clear[i]
```
wyczyść
```
Lista = {};
For[i = 1, i < 101, i++, AppendTo[Lista, {a[i], b[i], c[i]}]]
```
dla | dołącz na końcu do wartości zmiennej
```
Lista;
```

Dygresja

In[101]:=
```
a[x_] := ToExpression@("a" <> ToString[x])
```
zamień na wyrażenie | przemień na ciąg

In[102]:=
```
b[x_] := ToExpression@StringJoin["b", ToString[x]]
```
zamień na wyra··· | połącz ciągi znaków | przemień na ciąg

In[103]:=
```
c[x_] := ToExpression@StringJoin["c", ToString[x]]
```
zamień na wyra··· | połącz ciągi znaków | przemień na ciąg

In[104]:=
```
a[100]
```
Out[104]=
a100

In[105]:=
```
Array[a# &, 100]
```
tablica wielowymiarowa

Out[105]=
$$\{a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13}, a_{14}, a_{15}, a_{16}, a_{17}, a_{18}, a_{19}, a_{20},$$
$$a_{21}, a_{22}, a_{23}, a_{24}, a_{25}, a_{26}, a_{27}, a_{28}, a_{29}, a_{30}, a_{31}, a_{32}, a_{33}, a_{34}, a_{35}, a_{36}, a_{37}, a_{38}, a_{39}, a_{40},$$
$$a_{41}, a_{42}, a_{43}, a_{44}, a_{45}, a_{46}, a_{47}, a_{48}, a_{49}, a_{50}, a_{51}, a_{52}, a_{53}, a_{54}, a_{55}, a_{56}, a_{57}, a_{58}, a_{59}, a_{60},$$
$$a_{61}, a_{62}, a_{63}, a_{64}, a_{65}, a_{66}, a_{67}, a_{68}, a_{69}, a_{70}, a_{71}, a_{72}, a_{73}, a_{74}, a_{75}, a_{76}, a_{77}, a_{78}, a_{79}, a_{80},$$
$$a_{81}, a_{82}, a_{83}, a_{84}, a_{85}, a_{86}, a_{87}, a_{88}, a_{89}, a_{90}, a_{91}, a_{92}, a_{93}, a_{94}, a_{95}, a_{96}, a_{97}, a_{98}, a_{99}, a_{100}\}$$

In[106]:=
```
a[xxx] == axxx
```
Out[106]=
True

In[107]:=
```
Clear[a]
```
wyczyść

Rozwiązanie b)

Niech będzie dana funkcja F[x1,...,x100], napisz trzy różne funkcje/procedury, które działając na

listę L zwracają

{F[a[1],...,a[100]],F[b[1],...,b[100]],F[c[1],...,c[100]]}.

In[108]:=
```
MapThread[F, Lista]
```
zastosuj w wątku

Out[108]=
```
{F(a(1), a(2), a(3), a(4), a(5), a(6), a(7), a(8), a(9), a(10), a(11), a(12), a(13), a(14), a(15), a(16),
    a(17), a(18), a(19), a(20), a(21), a(22), a(23), a(24), a(25), a(26), a(27), a(28), a(29), a(30),
    a(31), a(32), a(33), a(34), a(35), a(36), a(37), a(38), a(39), a(40), a(41), a(42), a(43), a(44),
    a(45), a(46), a(47), a(48), a(49), a(50), a(51), a(52), a(53), a(54), a(55), a(56), a(57), a(58),
    a(59), a(60), a(61), a(62), a(63), a(64), a(65), a(66), a(67), a(68), a(69), a(70), a(71), a(72),
    a(73), a(74), a(75), a(76), a(77), a(78), a(79), a(80), a(81), a(82), a(83), a(84), a(85), a(86),
    a(87), a(88), a(89), a(90), a(91), a(92), a(93), a(94), a(95), a(96), a(97), a(98), a(99), a(100)),
  F(b1, b2, b3, b4, b5, b6, b7, b8, b9, b10, b11, b12, b13, b14, b15, b16, b17, b18, b19, b20, b21,
    b22, b23, b24, b25, b26, b27, b28, b29, b30, b31, b32, b33, b34, b35, b36, b37, b38, b39, b40, b41,
    b42, b43, b44, b45, b46, b47, b48, b49, b50, b51, b52, b53, b54, b55, b56, b57, b58, b59, b60, b61,
    b62, b63, b64, b65, b66, b67, b68, b69, b70, b71, b72, b73, b74, b75, b76, b77, b78, b79, b80, b81,
    b82, b83, b84, b85, b86, b87, b88, b89, b90, b91, b92, b93, b94, b95, b96, b97, b98, b99, b100),
  F(c1, c2, c3, c4, c5, c6, c7, c8, c9, c10, c11, c12, c13, c14, c15, c16, c17, c18, c19, c20, c21,
    c22, c23, c24, c25, c26, c27, c28, c29, c30, c31, c32, c33, c34, c35, c36, c37, c38, c39, c40, c41,
    c42, c43, c44, c45, c46, c47, c48, c49, c50, c51, c52, c53, c54, c55, c56, c57, c58, c59, c60, c61,
    c62, c63, c64, c65, c66, c67, c68, c69, c70, c71, c72, c73, c74, c75, c76, c77, c78, c79, c80, c81,
    c82, c83, c84, c85, c86, c87, c88, c89, c90, c91, c92, c93, c94, c95, c96, c97, c98, c99, c100)}
```

In[109]:=
```
F @@ # & /@ Transpose[Lista]
```
transpozycja

Out[109]=
```
{F(a(1), a(2), a(3), a(4), a(5), a(6), a(7), a(8), a(9), a(10), a(11), a(12), a(13), a(14), a(15), a(16),
    a(17), a(18), a(19), a(20), a(21), a(22), a(23), a(24), a(25), a(26), a(27), a(28), a(29), a(30),
    a(31), a(32), a(33), a(34), a(35), a(36), a(37), a(38), a(39), a(40), a(41), a(42), a(43), a(44),
    a(45), a(46), a(47), a(48), a(49), a(50), a(51), a(52), a(53), a(54), a(55), a(56), a(57), a(58),
    a(59), a(60), a(61), a(62), a(63), a(64), a(65), a(66), a(67), a(68), a(69), a(70), a(71), a(72),
    a(73), a(74), a(75), a(76), a(77), a(78), a(79), a(80), a(81), a(82), a(83), a(84), a(85), a(86),
    a(87), a(88), a(89), a(90), a(91), a(92), a(93), a(94), a(95), a(96), a(97), a(98), a(99), a(100)),
  F(b1, b2, b3, b4, b5, b6, b7, b8, b9, b10, b11, b12, b13, b14, b15, b16, b17, b18, b19, b20, b21,
    b22, b23, b24, b25, b26, b27, b28, b29, b30, b31, b32, b33, b34, b35, b36, b37, b38, b39, b40, b41,
    b42, b43, b44, b45, b46, b47, b48, b49, b50, b51, b52, b53, b54, b55, b56, b57, b58, b59, b60, b61,
    b62, b63, b64, b65, b66, b67, b68, b69, b70, b71, b72, b73, b74, b75, b76, b77, b78, b79, b80, b81,
    b82, b83, b84, b85, b86, b87, b88, b89, b90, b91, b92, b93, b94, b95, b96, b97, b98, b99, b100),
  F(c1, c2, c3, c4, c5, c6, c7, c8, c9, c10, c11, c12, c13, c14, c15, c16, c17, c18, c19, c20, c21,
    c22, c23, c24, c25, c26, c27, c28, c29, c30, c31, c32, c33, c34, c35, c36, c37, c38, c39, c40, c41,
    c42, c43, c44, c45, c46, c47, c48, c49, c50, c51, c52, c53, c54, c55, c56, c57, c58, c59, c60, c61,
    c62, c63, c64, c65, c66, c67, c68, c69, c70, c71, c72, c73, c74, c75, c76, c77, c78, c79, c80, c81,
    c82, c83, c84, c85, c86, c87, c88, c89, c90, c91, c92, c93, c94, c95, c96, c97, c98, c99, c100)}
```

In[110]:=
```
% - %%
```

Out[110]=
```
{0, 0, 0}
```

In[111]:=
```
Thread[F[Transpose[Lista]]]
```
nawlecz transpozycja

Out[111]=
```
{F({a(1), a(2), a(3), a(4), a(5), a(6), a(7), a(8), a(9), a(10), a(11), a(12), a(13), a(14), a(15), a(16), a(17),
    a(18), a(19), a(20), a(21), a(22), a(23), a(24), a(25), a(26), a(27), a(28), a(29), a(30), a(31),
    a(32), a(33), a(34), a(35), a(36), a(37), a(38), a(39), a(40), a(41), a(42), a(43), a(44), a(45),
    a(46), a(47), a(48), a(49), a(50), a(51), a(52), a(53), a(54), a(55), a(56), a(57), a(58), a(59),
    a(60), a(61), a(62), a(63), a(64), a(65), a(66), a(67), a(68), a(69), a(70), a(71), a(72), a(73),
    a(74), a(75), a(76), a(77), a(78), a(79), a(80), a(81), a(82), a(83), a(84), a(85), a(86), a(87),
    a(88), a(89), a(90), a(91), a(92), a(93), a(94), a(95), a(96), a(97), a(98), a(99), a(100)}),
 F({b1, b2, b3, b4, b5, b6, b7, b8, b9, b10, b11, b12, b13, b14, b15, b16, b17, b18, b19, b20, b21,
    b22, b23, b24, b25, b26, b27, b28, b29, b30, b31, b32, b33, b34, b35, b36, b37, b38, b39, b40, b41,
    b42, b43, b44, b45, b46, b47, b48, b49, b50, b51, b52, b53, b54, b55, b56, b57, b58, b59, b60, b61,
    b62, b63, b64, b65, b66, b67, b68, b69, b70, b71, b72, b73, b74, b75, b76, b77, b78, b79, b80, b81,
    b82, b83, b84, b85, b86, b87, b88, b89, b90, b91, b92, b93, b94, b95, b96, b97, b98, b99, b100}),
 F({c1, c2, c3, c4, c5, c6, c7, c8, c9, c10, c11, c12, c13, c14, c15, c16, c17, c18, c19, c20, c21,
    c22, c23, c24, c25, c26, c27, c28, c29, c30, c31, c32, c33, c34, c35, c36, c37, c38, c39, c40, c41,
    c42, c43, c44, c45, c46, c47, c48, c49, c50, c51, c52, c53, c54, c55, c56, c57, c58, c59, c60, c61,
    c62, c63, c64, c65, c66, c67, c68, c69, c70, c71, c72, c73, c74, c75, c76, c77, c78, c79, c80, c81,
    c82, c83, c84, c85, c86, c87, c88, c89, c90, c91, c92, c93, c94, c95, c96, c97, c98, c99, c100})}
```

Rozwiązanie c)

Zmodyfikuj funkcję F, tak aby gdy liczba jej argumentów wynosiła jeden zwracała Sin.

In[112]:=
```
F[x_] := Sin[x]
```
sinus

Rozwiązanie d)

Napisz funkcję/procedurę, która działając na L zwraca:
L={{a[1],Sin[b[1]],c[1]},{a[2],Sin[b[2]],c[2]},...,{a[100],Sin[b[100]],c[100]}}

UWAGA nie używaj funkcji For, Table, Array, Do, While....

In[113]:=
```
MapAt[Sin, #, 2] & /@ Lista
```
zasto··· sinus

$$\begin{pmatrix} a(1) & \sin(b1) & c1 \\ a(2) & \sin(b2) & c2 \\ a(3) & \sin(b3) & c3 \\ a(4) & \sin(b4) & c4 \\ a(5) & \sin(b5) & c5 \\ a(6) & \sin(b6) & c6 \\ a(7) & \sin(b7) & c7 \\ a(8) & \sin(b8) & c8 \\ a(9) & \sin(b9) & c9 \\ a(10) & \sin(b10) & c10 \end{pmatrix}$$

Out[113]=

a(11)	sin(b11)	c11
a(12)	sin(b12)	c12
a(13)	sin(b13)	c13
a(14)	sin(b14)	c14
a(15)	sin(b15)	c15
a(16)	sin(b16)	c16
a(17)	sin(b17)	c17
a(18)	sin(b18)	c18
a(19)	sin(b19)	c19
a(20)	sin(b20)	c20
a(21)	sin(b21)	c21
a(22)	sin(b22)	c22
a(23)	sin(b23)	c23
a(24)	sin(b24)	c24
a(25)	sin(b25)	c25
a(26)	sin(b26)	c26
a(27)	sin(b27)	c27
a(28)	sin(b28)	c28
a(29)	sin(b29)	c29
a(30)	sin(b30)	c30
a(31)	sin(b31)	c31
a(32)	sin(b32)	c32
a(33)	sin(b33)	c33
a(34)	sin(b34)	c34
a(35)	sin(b35)	c35
a(36)	sin(b36)	c36
a(37)	sin(b37)	c37
a(38)	sin(b38)	c38
a(39)	sin(b39)	c39
a(40)	sin(b40)	c40
a(41)	sin(b41)	c41
a(42)	sin(b42)	c42
a(43)	sin(b43)	c43
a(44)	sin(b44)	c44
a(45)	sin(b45)	c45
a(46)	sin(b46)	c46
a(47)	sin(b47)	c47
a(48)	sin(b48)	c48
a(49)	sin(b49)	c49
a(50)	sin(b50)	c50
a(51)	sin(b51)	c51
a(52)	sin(b52)	c52
a(53)	sin(b53)	c53
a(54)	sin(b54)	c54
a(55)	sin(b55)	c55
a(56)	sin(b56)	c56
a(57)	sin(b57)	c57
a(58)	sin(b58)	c58
a(59)	sin(b59)	c59
a(60)	sin(b60)	c60
a(61)	sin(b61)	c61
a(62)	sin(b62)	c62
a(63)	sin(b63)	c63
a(64)	sin(b64)	c64
a(65)	sin(b65)	c65
a(66)	sin(b66)	c66
a(67)	sin(b67)	c67
a(68)	sin(b68)	c68
a(69)	sin(b69)	c69
a(70)	sin(b70)	c70

a(71)	sin(b71)	c71
a(72)	sin(b72)	c72
a(73)	sin(b73)	c73
a(74)	sin(b74)	c74
a(75)	sin(b75)	c75
a(76)	sin(b76)	c76
a(77)	sin(b77)	c77
a(78)	sin(b78)	c78
a(79)	sin(b79)	c79
a(80)	sin(b80)	c80
a(81)	sin(b81)	c81
a(82)	sin(b82)	c82
a(83)	sin(b83)	c83
a(84)	sin(b84)	c84
a(85)	sin(b85)	c85
a(86)	sin(b86)	c86
a(87)	sin(b87)	c87
a(88)	sin(b88)	c88
a(89)	sin(b89)	c89
a(90)	sin(b90)	c90
a(91)	sin(b91)	c91
a(92)	sin(b92)	c92
a(93)	sin(b93)	c93
a(94)	sin(b94)	c94
a(95)	sin(b95)	c95
a(96)	sin(b96)	c96
a(97)	sin(b97)	c97
a(98)	sin(b98)	c98
a(99)	sin(b99)	c99
a(100)	sin(b100)	c100

Rozwiązanie e)

Napisz trzy różne funkcje, które zamieniają w każdej trójce symboli listy L element pierwszy z drugim.

In[114]:=
```
{#[[2]], #[[1]], #[[3]]} & /@ Lista
```

b1	a(1)	c1
b2	a(2)	c2
b3	a(3)	c3
b4	a(4)	c4
b5	a(5)	c5
b6	a(6)	c6
b7	a(7)	c7
b8	a(8)	c8
b9	a(9)	c9
b10	a(10)	c10
b11	a(11)	c11
b12	a(12)	c12
b13	a(13)	c13
b14	a(14)	c14
b15	a(15)	c15
b16	a(16)	c16
b17	a(17)	c17
b18	a(18)	c18
b19	a(19)	c19
b20	a(20)	c20

Out[114]=

b21	$a(21)$	c21
b22	$a(22)$	c22
b23	$a(23)$	c23
b24	$a(24)$	c24
b25	$a(25)$	c25
b26	$a(26)$	c26
b27	$a(27)$	c27
b28	$a(28)$	c28
b29	$a(29)$	c29
b30	$a(30)$	c30
b31	$a(31)$	c31
b32	$a(32)$	c32
b33	$a(33)$	c33
b34	$a(34)$	c34
b35	$a(35)$	c35
b36	$a(36)$	c36
b37	$a(37)$	c37
b38	$a(38)$	c38
b39	$a(39)$	c39
b40	$a(40)$	c40
b41	$a(41)$	c41
b42	$a(42)$	c42
b43	$a(43)$	c43
b44	$a(44)$	c44
b45	$a(45)$	c45
b46	$a(46)$	c46
b47	$a(47)$	c47
b48	$a(48)$	c48
b49	$a(49)$	c49
b50	$a(50)$	c50
b51	$a(51)$	c51
b52	$a(52)$	c52
b53	$a(53)$	c53
b54	$a(54)$	c54
b55	$a(55)$	c55
b56	$a(56)$	c56
b57	$a(57)$	c57
b58	$a(58)$	c58
b59	$a(59)$	c59
b60	$a(60)$	c60
b61	$a(61)$	c61
b62	$a(62)$	c62
b63	$a(63)$	c63
b64	$a(64)$	c64
b65	$a(65)$	c65
b66	$a(66)$	c66
b67	$a(67)$	c67
b68	$a(68)$	c68
b69	$a(69)$	c69
b70	$a(70)$	c70
b71	$a(71)$	c71
b72	$a(72)$	c72
b73	$a(73)$	c73
b74	$a(74)$	c74
b75	$a(75)$	c75
b76	$a(76)$	c76
b77	$a(77)$	c77
b78	$a(78)$	c78
b79	$a(79)$	c79

b80	$a(80)$	c80
b81	$a(81)$	c81
b82	$a(82)$	c82
b83	$a(83)$	c83
b84	$a(84)$	c84
b85	$a(85)$	c85
b86	$a(86)$	c86
b87	$a(87)$	c87
b88	$a(88)$	c88
b89	$a(89)$	c89
b90	$a(90)$	c90
b91	$a(91)$	c91
b92	$a(92)$	c92
b93	$a(93)$	c93
b94	$a(94)$	c94
b95	$a(95)$	c95
b96	$a(96)$	c96
b97	$a(97)$	c97
b98	$a(98)$	c98
b99	$a(99)$	c99
b100	$a(100)$	c100

In[115]:=
```
Lista /. a → temp /. b → a /. temp → b
```

b1	b1	c1
b2	b2	c2
b3	b3	c3
b4	b4	c4
b5	b5	c5
b6	b6	c6
b7	b7	c7
b8	b8	c8
b9	b9	c9
b10	b10	c10
b11	b11	c11
b12	b12	c12
b13	b13	c13
b14	b14	c14
b15	b15	c15
b16	b16	c16
b17	b17	c17
b18	b18	c18
b19	b19	c19
b20	b20	c20
b21	b21	c21
b22	b22	c22
b23	b23	c23
b24	b24	c24
b25	b25	c25
b26	b26	c26
b27	b27	c27
b28	b28	c28
b29	b29	c29
b30	b30	c30
b31	b31	c31
b32	b32	c32
b33	b33	c33
b34	b34	c34
b35	b35	c35

Out[115]=

b36	b36	c36
b37	b37	c37
b38	b38	c38
b39	b39	c39
b40	b40	c40
b41	b41	c41
b42	b42	c42
b43	b43	c43
b44	b44	c44
b45	b45	c45
b46	b46	c46
b47	b47	c47
b48	b48	c48
b49	b49	c49
b50	b50	c50
b51	b51	c51
b52	b52	c52
b53	b53	c53
b54	b54	c54
b55	b55	c55
b56	b56	c56
b57	b57	c57
b58	b58	c58
b59	b59	c59
b60	b60	c60
b61	b61	c61
b62	b62	c62
b63	b63	c63
b64	b64	c64
b65	b65	c65
b66	b66	c66
b67	b67	c67
b68	b68	c68
b69	b69	c69
b70	b70	c70
b71	b71	c71
b72	b72	c72
b73	b73	c73
b74	b74	c74
b75	b75	c75
b76	b76	c76
b77	b77	c77
b78	b78	c78
b79	b79	c79
b80	b80	c80
b81	b81	c81
b82	b82	c82
b83	b83	c83
b84	b84	c84
b85	b85	c85
b86	b86	c86
b87	b87	c87
b88	b88	c88
b89	b89	c89
b90	b90	c90
b91	b91	c91
b92	b92	c92
b93	b93	c93
b94	b94	c94
b95	b95	c95

b95	b95	c95
b96	b96	c96
b97	b97	c97
b98	b98	c98
b99	b99	c99
b100	b100	c100

In[116]:=
```
Lista /. {aa_, bb_, cc_} → {bb, aa, cc}
```

Out[116]=

b1	$a(1)$	c1
b2	$a(2)$	c2
b3	$a(3)$	c3
b4	$a(4)$	c4
b5	$a(5)$	c5
b6	$a(6)$	c6
b7	$a(7)$	c7
b8	$a(8)$	c8
b9	$a(9)$	c9
b10	$a(10)$	c10
b11	$a(11)$	c11
b12	$a(12)$	c12
b13	$a(13)$	c13
b14	$a(14)$	c14
b15	$a(15)$	c15
b16	$a(16)$	c16
b17	$a(17)$	c17
b18	$a(18)$	c18
b19	$a(19)$	c19
b20	$a(20)$	c20
b21	$a(21)$	c21
b22	$a(22)$	c22
b23	$a(23)$	c23
b24	$a(24)$	c24
b25	$a(25)$	c25
b26	$a(26)$	c26
b27	$a(27)$	c27
b28	$a(28)$	c28
b29	$a(29)$	c29
b30	$a(30)$	c30
b31	$a(31)$	c31
b32	$a(32)$	c32
b33	$a(33)$	c33
b34	$a(34)$	c34
b35	$a(35)$	c35
b36	$a(36)$	c36
b37	$a(37)$	c37
b38	$a(38)$	c38
b39	$a(39)$	c39
b40	$a(40)$	c40
b41	$a(41)$	c41
b42	$a(42)$	c42
b43	$a(43)$	c43
b44	$a(44)$	c44
b45	$a(45)$	c45
b46	$a(46)$	c46
b47	$a(47)$	c47
b48	$a(48)$	c48
b49	$a(49)$	c49
b50	$a(50)$	c50

b51	$a(51)$	c51
b52	$a(52)$	c52
b53	$a(53)$	c53
b54	$a(54)$	c54
b55	$a(55)$	c55
b56	$a(56)$	c56
b57	$a(57)$	c57
b58	$a(58)$	c58
b59	$a(59)$	c59
b60	$a(60)$	c60
b61	$a(61)$	c61
b62	$a(62)$	c62
b63	$a(63)$	c63
b64	$a(64)$	c64
b65	$a(65)$	c65
b66	$a(66)$	c66
b67	$a(67)$	c67
b68	$a(68)$	c68
b69	$a(69)$	c69
b70	$a(70)$	c70
b71	$a(71)$	c71
b72	$a(72)$	c72
b73	$a(73)$	c73
b74	$a(74)$	c74
b75	$a(75)$	c75
b76	$a(76)$	c76
b77	$a(77)$	c77
b78	$a(78)$	c78
b79	$a(79)$	c79
b80	$a(80)$	c80
b81	$a(81)$	c81
b82	$a(82)$	c82
b83	$a(83)$	c83
b84	$a(84)$	c84
b85	$a(85)$	c85
b86	$a(86)$	c86
b87	$a(87)$	c87
b88	$a(88)$	c88
b89	$a(89)$	c89
b90	$a(90)$	c90
b91	$a(91)$	c91
b92	$a(92)$	c92
b93	$a(93)$	c93
b94	$a(94)$	c94
b95	$a(95)$	c95
b96	$a(96)$	c96
b97	$a(97)$	c97
b98	$a(98)$	c98
b99	$a(99)$	c99
b100	$a(100)$	c100

In[117]:=
```
Table[{#[[j, 2]], #[[j, 1]], #[[j, 3]]}, {j, 1, Length[#]}] &@Lista
```
tabela — długość

b1	$a(1)$	c1
b2	$a(2)$	c2
b3	$a(3)$	c3
b4	$a(4)$	c4
b5	$a(5)$	c5

Out[117]=

b6	$a(6)$	c6
b7	$a(7)$	c7
b8	$a(8)$	c8
b9	$a(9)$	c9
b10	$a(10)$	c10
b11	$a(11)$	c11
b12	$a(12)$	c12
b13	$a(13)$	c13
b14	$a(14)$	c14
b15	$a(15)$	c15
b16	$a(16)$	c16
b17	$a(17)$	c17
b18	$a(18)$	c18
b19	$a(19)$	c19
b20	$a(20)$	c20
b21	$a(21)$	c21
b22	$a(22)$	c22
b23	$a(23)$	c23
b24	$a(24)$	c24
b25	$a(25)$	c25
b26	$a(26)$	c26
b27	$a(27)$	c27
b28	$a(28)$	c28
b29	$a(29)$	c29
b30	$a(30)$	c30
b31	$a(31)$	c31
b32	$a(32)$	c32
b33	$a(33)$	c33
b34	$a(34)$	c34
b35	$a(35)$	c35
b36	$a(36)$	c36
b37	$a(37)$	c37
b38	$a(38)$	c38
b39	$a(39)$	c39
b40	$a(40)$	c40
b41	$a(41)$	c41
b42	$a(42)$	c42
b43	$a(43)$	c43
b44	$a(44)$	c44
b45	$a(45)$	c45
b46	$a(46)$	c46
b47	$a(47)$	c47
b48	$a(48)$	c48
b49	$a(49)$	c49
b50	$a(50)$	c50
b51	$a(51)$	c51
b52	$a(52)$	c52
b53	$a(53)$	c53
b54	$a(54)$	c54
b55	$a(55)$	c55
b56	$a(56)$	c56
b57	$a(57)$	c57
b58	$a(58)$	c58
b59	$a(59)$	c59
b60	$a(60)$	c60
b61	$a(61)$	c61
b62	$a(62)$	c62
b63	$a(63)$	c63
b64	$a(64)$	c64
b65	$a(65)$	c65

b65	$a(65)$	c65
b66	$a(66)$	c66
b67	$a(67)$	c67
b68	$a(68)$	c68
b69	$a(69)$	c69
b70	$a(70)$	c70
b71	$a(71)$	c71
b72	$a(72)$	c72
b73	$a(73)$	c73
b74	$a(74)$	c74
b75	$a(75)$	c75
b76	$a(76)$	c76
b77	$a(77)$	c77
b78	$a(78)$	c78
b79	$a(79)$	c79
b80	$a(80)$	c80
b81	$a(81)$	c81
b82	$a(82)$	c82
b83	$a(83)$	c83
b84	$a(84)$	c84
b85	$a(85)$	c85
b86	$a(86)$	c86
b87	$a(87)$	c87
b88	$a(88)$	c88
b89	$a(89)$	c89
b90	$a(90)$	c90
b91	$a(91)$	c91
b92	$a(92)$	c92
b93	$a(93)$	c93
b94	$a(94)$	c94
b95	$a(95)$	c95
b96	$a(96)$	c96
b97	$a(97)$	c97
b98	$a(98)$	c98
b99	$a(99)$	c99
b100	$a(100)$	c100

Rozwiązanie f)

Podpunkt f) Wygeneruj listę

{a[1],...,a[100]}

i napisz prostą procedurę zwracającą

F[a[1],...,a[100]].

In[118]:=
```
Array[a, 100]
```
tablica wielowymiar
```
F @@ %
```

Out[118]=
$$\{a(1), a(2), a(3), a(4), a(5), a(6), a(7), a(8), a(9), a(10), a(11), a(12), a(13), a(14), a(15), a(16), a(17), a(18), a(19), a(20), a(21), a(22), a(23), a(24), a(25), a(26), a(27), a(28), a(29), a(30), a(31), a(32), a(33), a(34), a(35), a(36), a(37), a(38), a(39), a(40), a(41), a(42), a(43), a(44), a(45), a(46), a(47), a(48), a(49), a(50), a(51), a(52), a(53), a(54), a(55), a(56), a(57), a(58), a(59), a(60), a(61), a(62), a(63), a(64), a(65), a(66), a(67), a(68), a(69), a(70), a(71), a(72), a(73), a(74), a(75), a(76), a(77), a(78), a(79), a(80), a(81), a(82), a(83), a(84), a(85), a(86), a(87), a(88), a(89), a(90), a(91), a(92), a(93), a(94), a(95), a(96), a(97), a(98), a(99), a(100)\}$$

Out[119]=
$$F(a(1), a(2), a(3), a(4), a(5), a(6), a(7), a(8), a(9), a(10), a(11), a(12), a(13), a(14), a(15), a(16), a(17), a(18), a(19), a(20), a(21), a(22), a(23), a(24), a(25), a(26), a(27), a(28), a(29), a(30), a(31), a(32), a(33), a(34), a(35), a(36), a(37), a(38), a(39), a(40), a(41), a(42), a(43), a(44), a(45), a(46), a(47), a(48), a(49), a(50), a(51), a(52), a(53), a(54), a(55), a(56), a(57), a(58), a(59), a(60), a(61), a(62), a(63), a(64), a(65), a(66), a(67), a(68), a(69), a(70), a(71), a(72), a(73), a(74), a(75), a(76), a(77), a(78), a(79), a(80), a(81), a(82), a(83), a(84), a(85), a(86), a(87), a(88), a(89), a(90), a(91), a(92), a(93), a(94), a(95), a(96), a(97), a(98), a(99), a(100))$$

Generator liczb losowych

Liczby losowe a raczej pseudolosowe

In[120]:=
```
? RandomReal
```

RandomReal[] gives a pseudorandom real number in the range 0 to 1.
RandomReal[{x_{min}, x_{max}}] gives a pseudorandom real number in the range x_{min} to x_{max}.
RandomReal[x_{max}] gives a pseudorandom real number in the range 0 to x_{max}.
RandomReal[*range*, n] gives a list of n pseudorandom reals.
RandomReal[*range*, {n_1, n_2, …}] gives an $n_1 \times n_2 \times \ldots$ array of pseudorandom reals. ≫

In[121]:=
```
? RandomInteger
```

RandomInteger[{i_{min}, i_{max}}] gives a pseudorandom integer in the range {i_{min}, i_{max}}.
RandomInteger[i_{max}] gives a pseudorandom integer in the range {0, …, i_{max}}.
RandomInteger[] pseudorandomly gives 0 or 1.
RandomInteger[*range*, n] gives a list of n pseudorandom integers.
RandomInteger[*range*, {n_1, n_2, …}] gives an $n_1 \times n_2 \times \ldots$ array of pseudorandom integers. ≫

In[122]:=
```
? RandomComplex
```

RandomComplex[] gives a pseudorandom complex number with real and imaginary parts in the range 0 to 1.
RandomComplex[{z_{min}, z_{max}}] gives a pseudorandom complex
number in the rectangle with corners given by the complex numbers z_{min} and z_{max}.
RandomComplex[z_{max}] gives a pseudorandom complex number in the rectangle whose corners are the origin and z_{max}.
RandomComplex[*range*, n] gives a list of n pseudorandom complex numbers.
RandomComplex[*range*, {n_1, n_2, …}] gives an $n_1 \times n_2 \times \ldots$ array of pseudorandom complex numbers. ≫

In[123]:=
```
RandomInteger[10]
losowa liczba całkowita
RandomInteger[10]
losowa liczba całkowita
RandomInteger[10]
losowa liczba całkowita
RandomInteger[10]
losowa liczba całkowita
```

Out[123]= 5

Out[124]= 4

Out[125]= 1

Out[126]= 2

In[127]:=
```
SeedRandom[5]
ziarno generatora liczb lo
RandomInteger[10]
losowa liczba całkowita
SeedRandom[5]
ziarno generatora liczb lo
RandomInteger[10]
losowa liczba całkowita
SeedRandom[5]
ziarno generatora liczb lo
RandomInteger[10]
losowa liczba całkowita
SeedRandom[5]
ziarno generatora liczb lo
RandomInteger[10]
losowa liczba całkowita
```

Out[128]= 0

Out[130]= 0

Out[132]= 0

Out[134]= 0

In[135]:=
```
RandomReal[{0, 1}, 12]
```
losowa liczba rzeczywista

Out[135]=
```
{0.0126493, 0.040307, 0.832874, 0.500286, 0.213854,
  0.112341, 0.436214, 0.531221, 0.678557, 0.800048, 0.549056, 0.781682}
```

Przykład

In[136]:=
```
? Line
```

Line[{p_1, p_2, …}] represents the line segments joining a sequence for points p_i.
Line[{{p_{11}, p_{12}, …}, {p_{21}, …}, …}] represents a collection of lines. ≫

In[137]:=
```
? Point
```

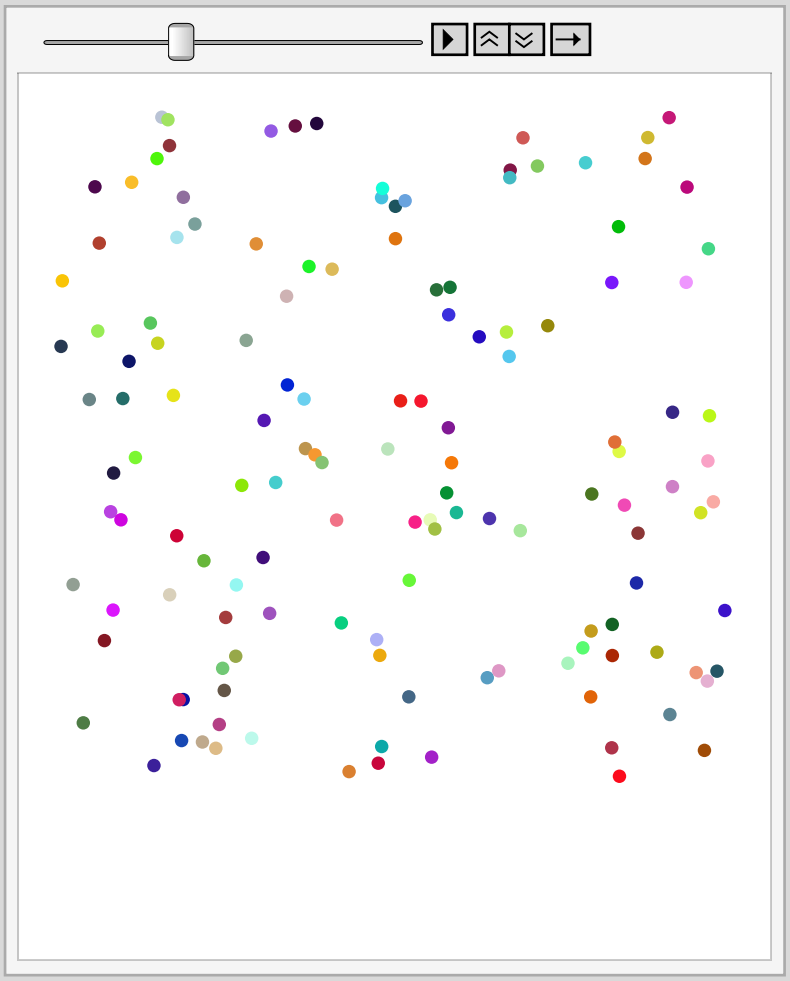
Point[p] is a graphics and geometry primitive that represents a point at p.
Point[{p_1, p_2, …}] represents a collection of points. ≫

In[138]:=
```
RandomReal[{-1, 1}, 2]
```
losowa liczba rzeczywista

Out[138]=
```
{−0.758469, 0.434636}
```

In[139]:=
```
L =.
L = {};
Array[
 tablica wielowymiarowa
   AppendTo[L, {RGBColor[RandomReal[{0, 1}, 3]], RandomReal[{-1, 1}, 2]}] &, 400];
   dołącz na końc··· kolor RGB losowa liczba rzeczywista losowa liczba rzeczywista
Map[{PointSize[Large], First@#, Point[#[[2]]]} &, %, {2}];
 zast··· rozmiar kro··· duży pierwszy punkt
Graphics /@ %;
 grafika
ListAnimate[%]
 animuj liste
```

Out[144]=



Funkcja dopasowująca: Fit

Fit

In[145]:=
```
? Fit
```

Fit[*data*, *funs*, *vars*] finds a least-squares fit to a list of data as a linear combination of the functions *funs* of variables *vars*. ≫

In[146]:=
```
czas = Table[i, {i, 0, 9}]
       tabela
```

Out[146]=
```
{0, 1, 2, 3, 4, 5, 6, 7, 8, 9}
```

In[147]:=
```
odleglosc = {0, 1.5, 6.0, 13.5, 24.0, 37.5, 54.0, 73.5, 96.0, 121.5}
```

Out[147]=
```
{0, 1.5, 6., 13.5, 24., 37.5, 54., 73.5, 96., 121.5}
```

In[148]:=
```
Options[TableForm]
opcje    w formie tabeli
```

Out[148]=
```
{TableAlignments → Automatic, TableDepth → ∞,
  TableDirections → Column, TableHeadings → None, TableSpacing → Automatic}
```

In[149]:=
```
vwdata = Transpose[{czas, odleglosc}]
         transpozycja
TableForm[%, , TableHeadings → {None, { "Czas", "Odległość"}}]
w formie tabeli    nagłówki tabeli    żaden
```

Out[149]=

$$\begin{pmatrix} 0 & 0 \\ 1 & 1.5 \\ 2 & 6. \\ 3 & 13.5 \\ 4 & 24. \\ 5 & 37.5 \\ 6 & 54. \\ 7 & 73.5 \\ 8 & 96. \\ 9 & 121.5 \end{pmatrix}$$

Out[150]//TableForm=

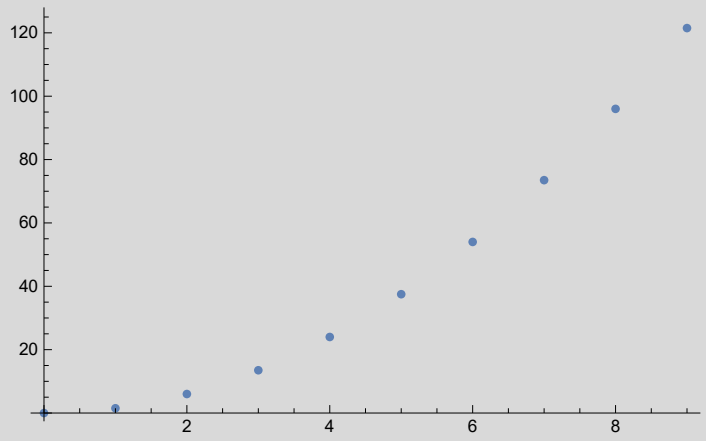
Czas	Odległość
0	0
1	1.5
2	6.
3	13.5
4	24.
5	37.5
6	54.
7	73.5
8	96.
9	121.5

In[151]:=
```
TeXForm[%]
```
zapis w TeX–u

Out[151]//TeXForm=
```
\left(
\begin{array}{cc}
 0 & 0 \\
 1 & 1.5 \\
 2 & 6. \\
 3 & 13.5 \\
 4 & 24. \\
 5 & 37.5 \\
 6 & 54. \\
 7 & 73.5 \\
 8 & 96. \\
 9 & 121.5 \\
\end{array}
\right)
```

In[152]:=
```
ListPlot[vwdata]
```
wykres danych z listy

Out[152]=



Chop

In[153]:=
```
wynik = Fit[vwdata, {1, t, t^2, t^3}, t]
```
dopasuj

Out[153]=
$$1.29301\times10^{-16}\,t^3 + 1.5\,t^2 + 1.68356\times10^{-15}\,t + 3.31414\times10^{-14}$$

In[154]:=
```
? Chop
```

Chop[*expr*] replaces approximate real numbers in *expr* that are close to zero by the exact integer 0. ≫

In[155]:=
```
Chop[10^(-10) // N]
```
zamiana bardzo małej ·· przybliże

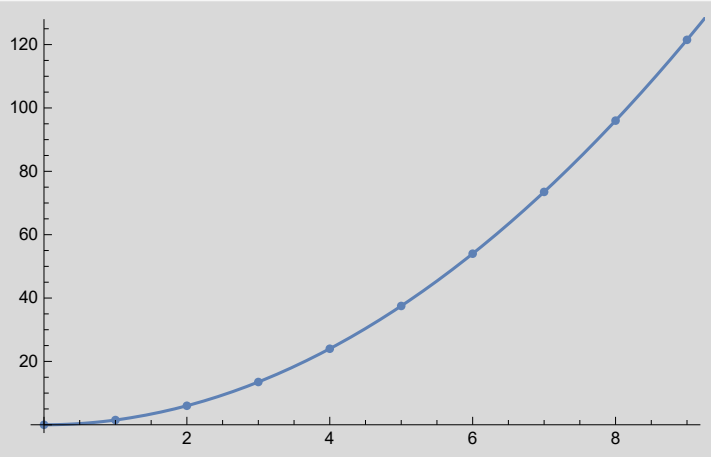
Out[155]=
$$1.\times10^{-10}$$

In[156]:=
```
Chop[wynik]
```
zamiana bardzo małej liczby na zero

Out[156]=
$$1.5\,t^2$$

In[157]:=
```
Show[ListPlot[vwdata], Plot[Chop[wynik], {t, 0, 10}]]
```
pokaż | wykres danych z listy | wyk··· | zamiana bardzo małej liczby na zerc

Out[157]=

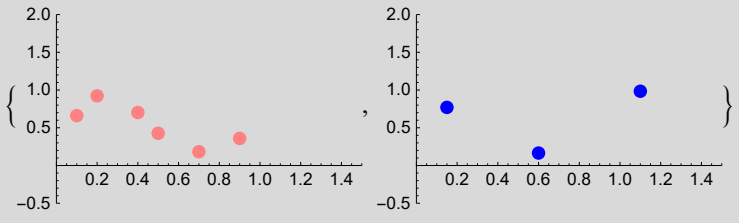


Dopasowanie do punktów

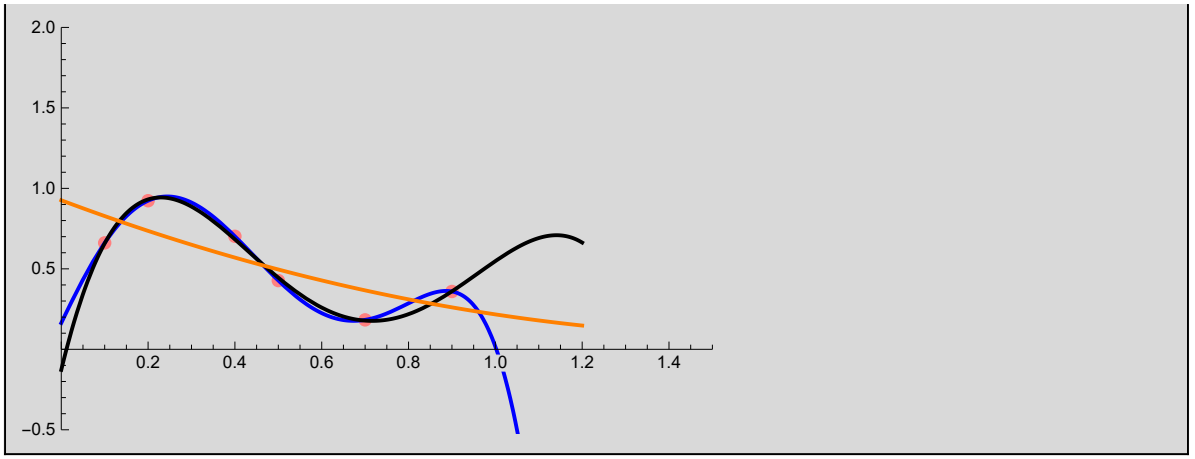
In[158]:=

```
hnew[x_] := (0.5 + 0.4 Sin[2 π x]) (1 + RandomVariate[NormalDistribution[0, 0.5]]);
                    sinus                 próba losowa      rozkład normalny

{#, hnew[#]} & /@ {0.1, 0.2, 0.4, 0.5, 0.7, 0.9};
{#, hnew[#]} & /@ {0.15, 0.6, 1.1};

MapThread[Function[ListPlot[#1, PlotStyle → {#2, PointSize[Large]}],
 zastosuj w…  funkcja   wykres danych …  styl grafiki      rozmiar kro…  duży
    PlotRange → {{0, 1.5}, {-0.5, 2}}]], {{%%, %}, {Pink, Blue}}]
    zakres wykresu                                  różowy  niebieski

line[n_] := Fit[%%%%, Array[x^(# - 1) &, n], x];
             dopasuj   tablica wielowymiarowa
{line[6], line[5], line[3]};

obraz1 = Show[First[%%%], Plot[%, {x, 0, 1.2},
          pokaż  pierwszy          wykres
    PlotStyle → {{Blue, Thick}, {Black, Thick}, {Orange, Thick}}]]
    styl grafiki      niebi…  gruby    czarny  gruby    pomara…  gruby
Export["obraz1.eps", %];
 eksportuj

Show[%%, Last[%%%%%]]
 pokaż    ostatni
Export["obraz2.eps", %];
 eksportuj

obraz3 = Show[%%, Plot[0.5 + 0.4 Sin[2 π x], {x, 0, 1.5}, PlotStyle → {Pink, Thick}]]
          pokaż  wykres          sinus                 styl grafiki      różowy  gruby
Export["obraz3.eps", %];
 eksportuj
```

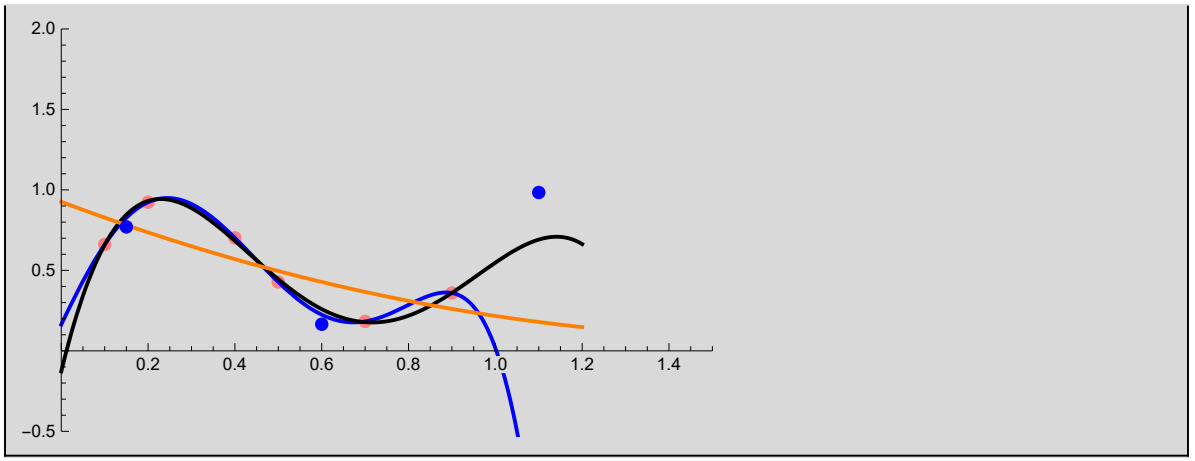
Out[161]=



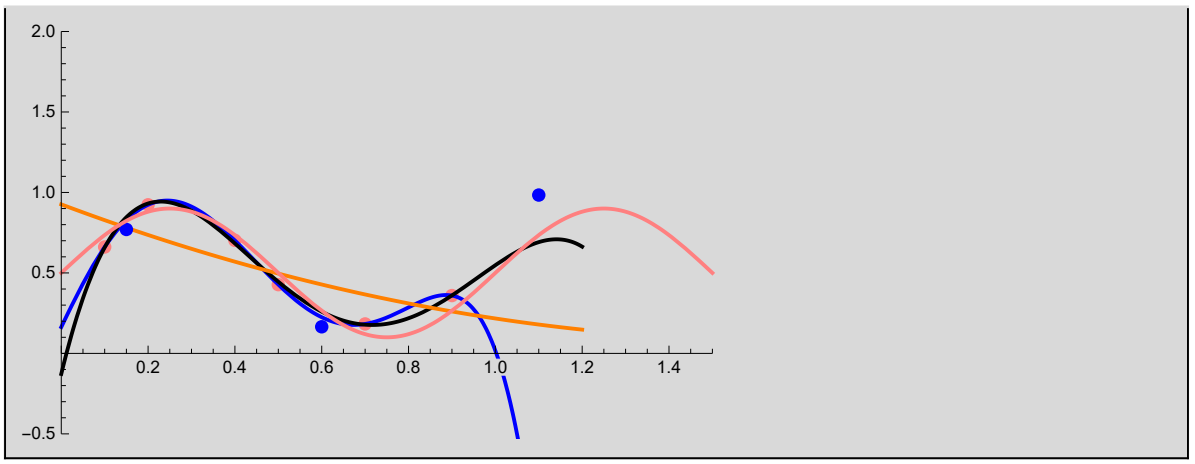
Out[164]=



Out[166]=



Out[168]=



In[170]:=

```
Clear[data, datanew]
```

wyczyść

Użyte funkcje

In[171]:=

```
? Export
```

Export["*file.ext*", *expr*] exports data to a file, converting it to the format corresponding to the file extension *ext*.
Export[*file*, *expr*, "*format*"] exports data in the specified format.
Export[*file*, *exprs*, *elems*] exports data by treating *exprs* as elements specified by *elems*. ≫

In[172]:=
```
? Show
```

Show[*graphics*, *options*] shows graphics with the specified options added.
Show[g_1, g_2, …] shows several graphics combined. ≫

In[173]:=
```
?? RandomVariate
```

RandomVariate[*dist*] gives a pseudorandom variate from the symbolic distribution *dist*.
RandomVariate[*dist*, *n*] gives a list of *n* pseudorandom variates from the symbolic distribution *dist*.
RandomVariate[*dist*, {n_1, n_2, …}] gives an
$n_1 \times n_2 \times \ldots$ array of pseudorandom variates from the symbolic distribution *dist*. ≫

```
Attributes[RandomVariate] = {Protected}
```

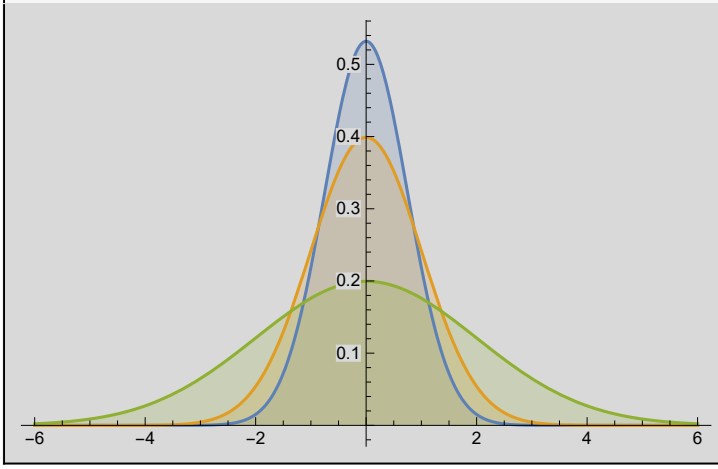
```
Options[RandomVariate] = {Method → Automatic, WorkingPrecision → Automatic}
```

In[174]:=
```
? NormalDistribution
```

NormalDistribution[μ, σ] represents a normal (Gaussian) distribution with mean μ and standard deviation σ.
NormalDistribution[] represents a normal distribution with zero mean and unit standard deviation. ≫

In[175]:=
```
Plot[Table[PDF[NormalDistribution[0, σ], x], {σ, {.75, 1, 2}}] // Evaluate,
 {x, -6, 6}, Filling → Axis]
```
wyk… tabela fu… rozkład normalny oblicz
wypełnienie oś

Out[175]=



Obwody Elektryczne

In[176]:=
```
WolframAlpha["Gustav Kirchhoff"]
```
zapytaj WolframAlpha

Input interpretation:

Gustav Kirchhoff (physicist)

Basic information:

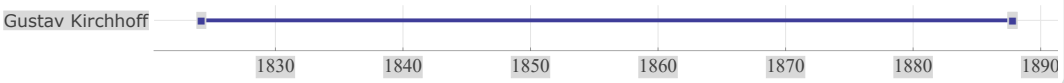
Out[176]=

full name	Gustav Robert Kirchhoff
date of birth	Friday, March 12, 1824 (193 years ago)
place of birth	Konigsberg, Bavaria, Germany
date of death	Monday, October 17, 1887 (age: 63 years) (130 years ago)
place of death	Berlin, Berlin, Germany

Image:

Timeline:

Include today



Scientific contributions:

Physics:

Kirchhoff's current law | Kirchhoff's voltage law | Ohm's law

Wikipedia summary:

> Gustav Robert Kirchhoff (12 March 1824 – 17 October 1887) was a German physicist who contributed to the fundamental understanding of electrical circuits, spectroscopy, and the emission o black–body radiation by heated objects.

Full entry »

Wikipedia page hits history:

Log scale

(in hits per day)

(based on weekly averages of daily hits to English-language "Gustav Kirchhoff" page)

WolframAlpha

Pierwsze Prawo Kirchhoffa

In[177]:=
```
WolframAlpha["Kirchhoff's current law"]
```
zapytaj WolframAlpha

Out[177]=

Input interpretation:

Kirchhoff's current law (physical principle)

Description:

At any node in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node.

Alternate names:

- KCL
- Kirchhoff's first rule
- Kirchhoff's junction rule
- Kirchhoff's nodal rule
- Kirchhoff's point rule

History:

formulation date	1845 (172 years ago)
formulator	Gustav Kirchhoff

Associated equation:

$$\sum_{k=1}^{n} I_k = 0$$

Classes:

Kirchhoff's rules | laws of physics

WolframAlpha

Drugie Prawo Kirchhoffa

In[178]:=
```
WolframAlpha["Kirchhoff's voltage law"]
```
zapytaj WolframAlpha

Out[178]=

Input interpretation:

Kirchhoff's voltage law (physical principle)

Description:

The signed sum of the voltages around any closed circuit must be zero.

Alternate names:

- Kirchhoff's loop rule
- Kirchhoff's mesh rule
- Kirchhoff's second rule
- KVL

History:

formulation date	1845 (172 years ago)
formulator	Gustav Kirchhoff

Associated equation:

$$\sum_{k=1}^{n} V_k = 0$$

Classes:

Kirchhoff's rules | laws of physics

WolframAlpha

Prawo Ohma

In[179]:=
```
WolframAlpha["Georg Ohm"]
```
zapytaj WolframAlpha

Input interpretation:

Georg Ohm (physicist)

Out[179]=

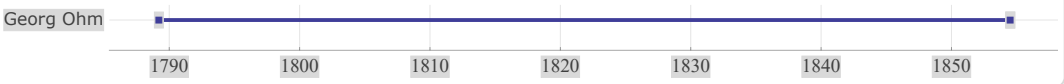
Basic information:

full name	Georg Simon Ohm
date of birth	Monday, March 16, 1789 (228 years ago)
place of birth	Erlangen, Bavaria, Germany
date of death	Thursday, July 6, 1854 (age: 65 years) (163 years ago)
place of death	Munich, Bavaria, Germany

Image:

Timeline:

Include today



Familial relationships:

Parents:

Johann Wolfgang Ohm | Maria Elizabeth Beck

Siblings:

Martin Ohm | Elizabeth Barbara Ohm

Scientific contributions:

Physics:

Ohm's law | Watt's law for electrical power

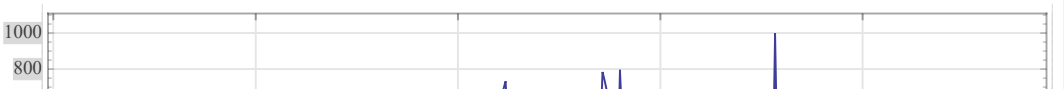
Wikipedia summary:

> Georg Simon Ohm (16 March 1789 – 6 July 1854) was a German physicist and mathematician. As a school teacher, Ohm began his research with the new electrochemical cell, invented by Italian scientist Alessandro Volta. Using equipment of his own creation, Ohm found that there is a direct proportionality between the potential difference (voltage) applied across a conductor and the resultar electric current. This relationship is known as Ohm's law.

Full entry »

Wikipedia page hits history:

Log scale



(in hits per day)

(based on weekly averages of daily hits to English-language "Georg Ohm" page)

WolframAlpha

In[180]:=

```
WolframAlpha["Ohm's law"]
```

zapytaj WolframAlpha

Out[180]=

Assuming "Ohm's law" is referring to a physical principle | Use as a formula instead

Input interpretation:

Ohm's law (physical principle)

Description:

The current through a conductor is directly proportional to the voltage across the conductor and inversely proportional to its resistance.

Alternate description:

A generalization also sometimes known as Ohm's law (but actually due to Kirchhoff) states the the current density is proportional to the product of conductivity and electric field strength.

History: More

formulation date	1827 (190 years ago)
formulator	Georg Ohm
additional people involved	Henry Cavendish | Gustav Kirchhoff

Associated equations:

$I = V/R$ | $\mathbf{J} = \sigma \mathbf{E}$

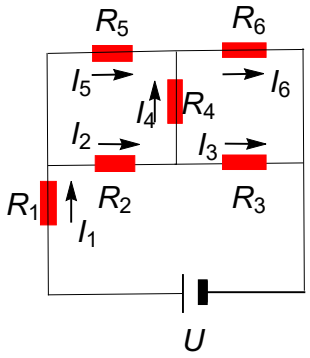
Class:

laws of physics

WolframAlpha

Rozwiązanie obwodu z prądem

Wyznacz natężenia prądu na opornikach R_1, R_2, R_3, R_4, R_5, R_6, znając napięcie U.



$$i_1 - i_2 - i_5 = 0$$
$$i_6 - i_4 - i_5 = 0$$
$$i_2 - i_3 - i_4 = 0$$
$$-i_5 R_5 + i_4 R_4 + i_2 R_5 = 0$$
$$-i_4 R_4 - i_6 R_6 + i_3 R_3 = 0$$
$$-i_2 R_2 - i_3 R_3 + U - i_1 R_1 = 0$$

In[181]:=
```
? Solve
```

Solve[*expr*, *vars*] attempts to solve the system *expr* of equations or inequalities for the variables *vars*.
Solve[*expr*, *vars*, *dom*] solves over the domain *dom*. Common choices of *dom* are Reals, Integers, and Complexes. ≫

In[182]:=
```
rownania =.
rownania = {i1 - i2 - i5 == 0,
        i6 - i4 - i5 == 0,
        i2 - i3 - i4 == 0,
       -i5 R5 + i4 R4 + i2 R5 == 0,
       -i4 R4 - i6 R6 + i3 R3 == 0,
       -i2 R2 + i3 R3 + U - i1 R1 == 0}
```

Out[183]=
$$\{i1 - i2 - i5 = 0,\ -i4 - i5 + i6 = 0,\ i2 - i3 - i4 = 0,$$
$$i2\,R5 + i4\,R4 - i5\,R5 = 0,\ i3\,R3 - i4\,R4 - i6\,R6 = 0,\ -i1\,R1 - i2\,R2 + i3\,R3 + U = 0\}$$

In[184]:=
```
Clear[i1, i2, i3, i4, i5, i6, R1, R2, R3, R4, R5, R6, rozwiazanie]
wyczyść
Solve[rownania,
rozwiąż równanie
        {i1, i2, i3, i4, i5, i6}
 ] // Simplify
      uprość
rozwiazanie = Flatten@%
              spłaszcz
```

Out[185]=
$$\{\{i1 \to -((U\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6))),$$
$$i2 \to -((U\,(R3\,R5+R4\,(R5+R6)+R5\,R6))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6))),$$
$$i3 \to (U\,(R4\,(R5+R6)+2\,R5\,R6))/(R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)+R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)-R3\,(R4\,(R5+R6)+2\,R5\,R6)),$$
$$i4 \to (R5\,U\,(R6-R3))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6)),$$
$$i5 \to -((U\,(R3\,(R4+R5)+R5\,(R4+R6)))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6))),$$
$$i6 \to -((U\,(R3\,(R4+2\,R5)+R4\,R5))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6)))\}\}$$

Out[186]=
$$\{i1 \to -((U\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6))),$$
$$i2 \to -((U\,(R3\,R5+R4\,(R5+R6)+R5\,R6))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6))),$$
$$i3 \to (U\,(R4\,(R5+R6)+2\,R5\,R6))/(R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)+R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)-R3\,(R4\,(R5+R6)+2\,R5\,R6)),$$
$$i4 \to (R5\,U\,(R6-R3))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6)),$$
$$i5 \to -((U\,(R3\,(R4+R5)+R5\,(R4+R6)))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6))),$$
$$i6 \to -((U\,(R3\,(R4+2\,R5)+R4\,R5))/(-R1\,(R3\,(R4+2\,R5)+R4\,(2\,R5+R6)+2\,R5\,R6)-R2\,(R3\,R5+R4\,(R5+R6)+R5\,R6)+R3\,(R4\,(R5+R6)+2\,R5\,R6)))\}$$

Programy obliczeniowe (symboliczne) często mają błędy, sprawdźmy wynik

In[187]:=
```
rownania /. rozwiazanie // Simplify
                           uprość
```

Out[187]=
```
{True, True, True, True, True, True}
```

Załóżmy, że wszystkie oporniki charakteryzują sie tą samą impedancją

In[188]:=
```
rozwiazanie /. {R1 → R, R2 → R, R3 → R, R4 → R, R5 → R, R6 → R}
```

Out[188]=
$$\left\{i1 \to \frac{U}{R},\ i2 \to \frac{U}{2\,R},\ i3 \to \frac{U}{2\,R},\ i4 \to 0,\ i5 \to \frac{U}{2\,R},\ i6 \to \frac{U}{2\,R}\right\}$$

Rysujemy wartości natężeń

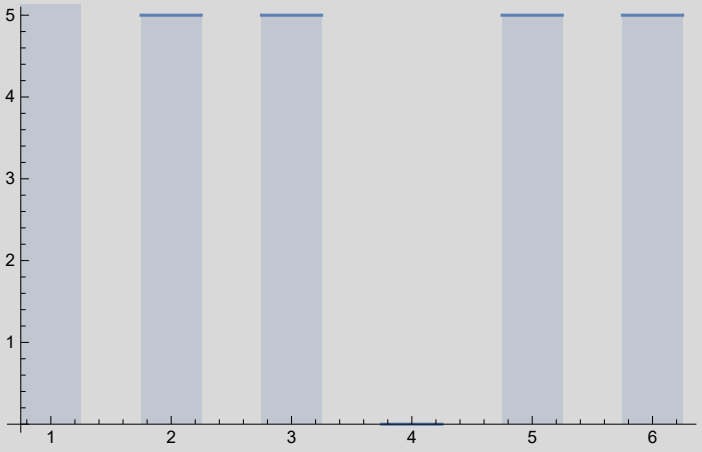
In[189]:=
```
Prady[U_, {R1_, R2_, R3_, R4_, R5_, R6_}] :=
 Evaluate[{i1, i2, i3, i4, i5, i6} /. rozwiazanie]
```
oblicz

In[190]:=
```
Prady[10, {1, 1, 1, 1, 1, 1}]
```

Out[190]=
{10, 5, 5, 0, 5, 5}

In[191]:=
```
DiscretePlot[Prady[10, {1, 1, 1, 1, 1, 1}][[i]], {i, Array[# &, 6]}, ExtentSize → 0.5]
```
wykres dyskretny tablica wielowymia··· wielkość zakresu

Out[191]=



In[192]:=
```
Array[{StringJoin["i", ToString[#]], #} &, 6]
```
tablica ··· połącz ciągi znaków przemień na ciąg znaków

Out[192]=

$$\begin{pmatrix} i1 & 1 \\ i2 & 2 \\ i3 & 3 \\ i4 & 4 \\ i5 & 5 \\ i6 & 6 \end{pmatrix}$$

In[193]:=
```
Array[{"i" <> ToString[#], #} &, 6]
```
tablica wielowy··· przemień na ciąg znaków

Out[193]=

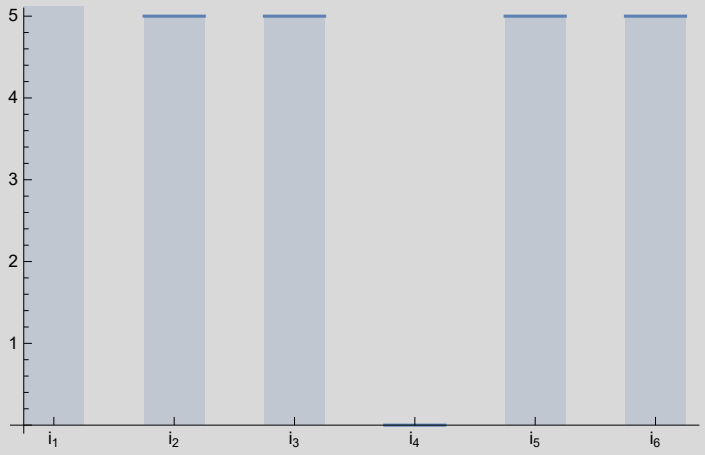
$$\begin{pmatrix} i1 & 1 \\ i2 & 2 \\ i3 & 3 \\ i4 & 4 \\ i5 & 5 \\ i6 & 6 \end{pmatrix}$$

In[194]:=
```
5₄ // FullForm
```
pełna forma

Out[194]//FullForm=
```
Subscript[5, 4]
```

In[195]:=
```
DiscretePlot[Prady[10, {1, 1, 1, 1, 1, 1}][[i]], {i, Array[# &, 6]},
 ExtentSize → 0.5, Ticks → {Array[{#, Subscript["i", #]} &, 6], Automatic}]
```
wykres dyskretny | tablica wielowymiarowa | wielkość zakresu | znaczki n··· | tablica wie··· | indeks dolny | automatyczny

Out[195]=



In[196]:=
```
({i1, i2, i3, i4, i5, i6} /. rozwiazanie) /.
 ({R1 → #, R2 -> #, R3 → # , R4 → #, R5 → #, R6 → #} &@10)
```

Out[196]=

$$\left\{\frac{U}{10}, \frac{U}{20}, \frac{U}{20}, 0, \frac{U}{20}, \frac{U}{20}\right\}$$

In[197]:=
```
({i1, i2, i3, i4, i5, i6} /. rozwiazanie) /. ({R1, R2, R3 , R4, R5, R6} &@10)
```

ReplaceAll: {R1, R2, R3, R4, R5, R6} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

Out[197]=

$$\{-((U\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6}))/(-\mathrm{R1}\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})-\mathrm{R2}\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6})+\mathrm{R3}\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6}))),$$
$$-((U\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6}))/(-\mathrm{R1}\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})-\mathrm{R2}\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6})+\mathrm{R3}\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6}))),$$
$$(U\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6}))/(\mathrm{R1}\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})+\mathrm{R2}\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6})-\mathrm{R3}\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})),$$
$$(\mathrm{R5}\,U\,(\mathrm{R6}-\mathrm{R3}))/(-\mathrm{R1}\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})-\mathrm{R2}\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6})+\mathrm{R3}\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})),$$
$$-((U\,(\mathrm{R3}\,(\mathrm{R4}+\mathrm{R5})+\mathrm{R5}\,(\mathrm{R4}+\mathrm{R6})))/(-\mathrm{R1}\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})-\mathrm{R2}\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6})+\mathrm{R3}\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6}))),$$
$$-((U\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,\mathrm{R5}))/(-\mathrm{R1}\,(\mathrm{R3}\,(\mathrm{R4}+2\,\mathrm{R5})+\mathrm{R4}\,(2\,\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})-\mathrm{R2}\,(\mathrm{R3}\,\mathrm{R5}+\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+\mathrm{R5}\,\mathrm{R6})+\mathrm{R3}\,(\mathrm{R4}\,(\mathrm{R5}+\mathrm{R6})+2\,\mathrm{R5}\,\mathrm{R6})))\}\,/.\,\{\mathrm{R1},\mathrm{R2},\mathrm{R3},\mathrm{R4},\mathrm{R5},\mathrm{R6}\}$$

In[198]:=
```
Outer[Rule, {R1, R2, R3 , R4, R5, R6}, {10}]
```
zewnę·· | reguła

Out[198]=

$$\{\{\mathrm{R1}\to 10\},\{\mathrm{R2}\to 10\},\{\mathrm{R3}\to 10\},\{\mathrm{R4}\to 10\},\{\mathrm{R5}\to 10\},\{\mathrm{R6}\to 10\}\}$$

In[199]:=
```
Flatten@Outer[Rule, {R1, R2, R3 , R4, R5, R6}, {10}]
```
spłaszcz zewnę· reguła

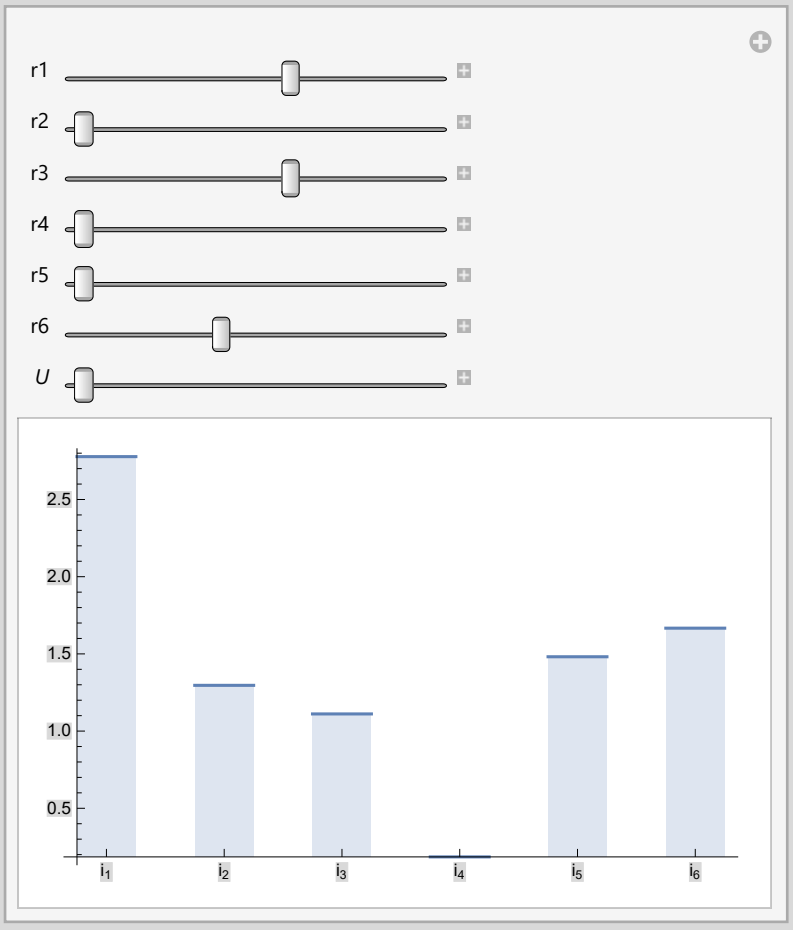
Out[199]=
$$\{R1 \to 10,\ R2 \to 10,\ R3 \to 10,\ R4 \to 10,\ R5 \to 10,\ R6 \to 10\}$$

In[200]:=
```
({i1, i2, i3, i4, i5, i6} /. rozwiazanie) /.
 Flatten@Outer[Rule, {R1, R2, R3 , R4, R5, R6}, {10}]
```
spłaszcz zewnę· reguła

Out[200]=
$$\left\{\frac{U}{10}, \frac{U}{20}, \frac{U}{20}, 0, \frac{U}{20}, \frac{U}{20}\right\}$$

In[201]:=
```
Manipulate[
```
zmieniaj
```
 DiscretePlot[Prady[10, {r1, r2, r3, r4, r5, r6}][[i]],
```
wykres dyskretny
```
  {i, Array[# &, 6]}, ExtentSize → 0.5, PlotRange → All,
```
tablica wielowymia··· wielkość zakresu zakres wykresu wszystko
```
  Ticks → {Array[{#, Subscript["i", #]} &, 6], Automatic}],
```
znaczki n··· tablica wie··· indeks dolny automatyczny
```
 {r1, 0.0001, 10, 1}, {r2, 0.0001, 10, 1}, {r3, 0.0001, 10, 1},
 {r4, 0.0001, 10, 1}, {r5, 0.0001, 10, 1}, {r6, 0.0001, 10, 1}, {U, 0, 10}]
```

Out[201]=



In[202]:=

```
Manipulate[
 zmieniaj
 DiscretePlot[Prady[10, {r1, r2, r3, r4, r5, r6}][[i]],
  wykres dyskretny
  {i, Array[# &, 6]}, ExtentSize → 0.5], {r1, 0.0001, 10}, {r2, 0.0001, 10},
      tablica wielowymia··· wielkość zakresu
 {r3, 0.0001, 10}, {r4, 0.0001, 10}, {r5, 0.0001, 10}, {r6, 0.0001, 10}]
```

Out[202]=