```
> restart;
  with(plots):
  with(StringTools):
  with(LinearAlgebra):
  with(DEtools):

  ##############################################################################################

  Region:=`Moscow`; url:="https://gogov.ru/covid-19/msk#data";

  #valp := [14.3017011620847, 174294.606596865, 0.112136011920555, 0.227305036587638,
  0.168356213163325, 0.132723499424831, #0.0924368623344482, 0.130118851494360, 0.163817974575960,
  0.162539645677865, 0.00976372140309013, 0.0198876861922680, #0.000969948445241616];

  valp:=readdata(cat(Region,`3c.txt`));

  ##############################################################################################

  fdisplay:=proc(f,p)
   print(cat(f,`.jpg`)); #print(cat(f,`.eps`));
   plotsetup(jpeg,plotoutput=cat(f,`.jpg`),plotoptions=`noborder`); print(display(p));
   plotsetup(ps,plotoutput=cat(f,`.eps`),plotoptions=`noborder`); print(display(p));
   plotsetup(default,plotoptions=`noborder`): print(display(p));
  end:

  pr:=proc(x) print(x); x; end:

  grad:=(F,V)->map(q->diff(F,q),V):

  linsplit:=(F,V)->subs(map(q->q=0,V),[op(grad(F,V)),F]):

  corr:=proc(x,y) local i; seq(x[i]=y[i],i=1..nops(x)): end:

  ssum:=(F,V)->convert([seq(F,V)],`+`):

  pprod:=(F,V)->convert([seq(F,V)],`*`):

  Lag:=proc(t,tx,kx) local i,j;
   ssum(kx[i]*pprod(piecewise(j=i,1,(t-tx[j])/(tx[i]-tx[j])),j=1..nops(tx)),i=1..nops(tx)):
  end:
```

```
Lag(t,[ta,tb],[a,b]); Lag(t,[ta,tb,tc],[a,b,c]);

pi:=evalf(Pi);


gM:=evalf(solve((1-x)^2=x,x)[2]):
goldMin:=proc(f,T,epsilon) local a,b,c,d,fa,fb,fc,fd,k;
 a:=op(1,T); b:=op(2,T); fa:=f(a); fb:=f(b); k:=0;
 c:=a+(b-a)*gM; fc:=f(c); d:=b-(b-a)*gM; fd:=f(d);
 while abs(a-b)>epsilon do: k:=k+1;
  if fc>fd then a:=c; fa:=fc; c:=d; fc:=fd; d:=b-(b-a)*gM; fd:=f(d);
  else b:=d; fb:=fd; d:=c; fd:=fc;+ c:=a+(b-a)*gM; fc:=f(c);
  fi;
 od: #print(k);
 (a+b)/2;
end:

findMin1:=proc(F,V) local f,df,f0,f1,f2,V0,V1,V2,ff,t,dt,i,j;
 ff:=V->F(op(evalf(map(exp,V)))); V1:=evalf(map(ln,V)); f1:=F(op(V));
 f:=[seq(F(seq(evalf(exp(V1[j]+piecewise(j=i,0.0001,0))),j=1..nops(V))),i=1..nops(V))];
 df:=[seq((f[j]-f1)/0.1,j=1..nops(V))];
 V0:=V1-0.001*df; f0:=ff(V0);  V2:=V1+0.001*df; f2:=ff(V2);
 dt:=0.0001; while f0<f1 do: V2:=V1; f2:=f1; V1:=V0; f1:=f0; V0:=V0-dt*df; f0:=ff(V0); dt:=dt*
1.1; od;
 dt:=0.0001; while f2<f1 do: V0:=V1; f0:=f1; V1:=V2; f1:=f2; V2:=V2+dt*df; f2:=ff(V2); dt:=dt*
1.1; od;
 t:=goldMin(t->ff(t*V0+(1-t)*V2),0..1,0.0001);
 map(exp,t*V0+(1-t)*V2);
end:

findMin:=proc(F,V) local V1,Z1,Z2;
 Z2:=pr(F(op(V))); V1:=findMin1(F,V); Z1:=pr(chi2(op(V1)));
 while abs(1-Z1/Z2)>0.0001 do; Z2:=Z1; V1:=findMin1(F,V1); Z1:=pr(chi2(op(V1))); end;
 V1;
end:
```

$$Region := Moscow$$

$url :=$ "https://gogov.ru/covid-19/msk#data"

$valp :=$ [14.27740482, 174749.1178, 0.1117266754, 0.2271766454, 0.1688488824, 0.1329698842, 0.09277648654, 0.1292567042, 0.1635178464, 0.1628294314, 0.009733504258, 0.01978215744, 0.00009706018508]

$$\frac{a\,(t-tb)}{ta-tb}+\frac{b\,(t-ta)}{tb-ta}$$

$$\frac{a\,(t-tb)\,(t-tc)}{(ta-tb)\,(ta-tc)}+\frac{b\,(t-ta)\,(t-tc)}{(tb-ta)\,(tb-tc)}+\frac{c\,(t-ta)\,(t-tb)}{(tc-ta)\,(tc-tb)}$$

$$\pi := 3.141592654 \quad (1$$

```
> `=====================================`;
`VERHULST FItAING`;
`=====================================`;
```

===

VERHULST FItAING

=== (2

```
> f_:=d->sum(a[j]*d^j,j=0..n); fe_:=d->sum(a[j]*d^j,j=0..ne);

M:='M':
ff:=x->M*(1-1/(exp(x)+1)); ff_:=unapply(solve(y=ff(x),x),y); diff(ff_(x),x); dff_:=unapply
(simplify(%,x),x);
ffe:=x->exp(x); ffe_:=unapply(solve(y=ffe(x),x),y); diff(ffe_(x),x); dffe_:=unapply(simplify(%,
x),x);

sigma:=x->simplify(sqrt(x));

chi2:=(T,f_)->simplify(sum(evalf(ff_(T[k])-f_(k))^2/dff_(T[k])^2/sigma(T[k])^2,k=1..nops(T)));
chi2e:=(T,f_)->simplify(sum(evalf(ffe_(T[k])-f_(k))^2/dffe_(T[k])^2/sigma(T[k])^2,k=1..nops(T)));

F:=proc(T,chi2,f_) chi2(T,f_);
 indets(%); grad(%%,%); subs(solve(%,%%),f_(i)); unapply(%,i);
end:
```

$$f\_ := d \mapsto \sum_{j=0}^{n} a_j \cdot d^j$$

$$fe\_ := d \mapsto \sum_{j=0}^{ne} a_j \cdot d^j$$

$$ff := x \mapsto M \cdot \left(1 - \frac{1}{e^x + 1}\right)$$

$$ff\_ := y \mapsto \ln\left(\frac{y}{M - y}\right)$$

$$\frac{\left(\frac{1}{M - x} + \frac{x}{(M - x)^2}\right)(M - x)}{x}$$

$$dff\_ := x \mapsto \frac{M}{(M - x) \cdot x}$$

$$ffe := x \mapsto e^x$$

$$ffe\_ := y \mapsto \ln(y)$$

$$\frac{1}{x}$$

$$dffe\_ := x \mapsto \frac{1}{x}$$

$$\sigma := x \mapsto simplify\left(\sqrt{x}\right)$$

$$\chi 2 := (T, f\_) \rightarrow simplify\left(\sum_{k=1}^{nops(T)} \frac{evalf\left(ff\_(T_k) - f\_(k)\right)^2}{dff\_(T_k)^2 \, \sigma(T_k)^2}\right)$$

$$chi2e := (T, f\_) \rightarrow simplify\left(\sum_{k=1}^{nops(T)} \frac{evalf\left(ffe\_(T_k) - f\_(k)\right)^2}{dffe\_(T_k)^2 \, \sigma(T_k)^2}\right) \quad (3$$

```
> dig:={"0","1","2","3","4","5","6","7","8","9","0"}: val:=proc() global data,i; local j,f; f:=0;
   while not(data[i] in dig) or f=1 and data[i] in {"+"} union dig do:
   if f=1 and not(data[i] in dig) then f:=0; else if data[i]="+" then f:=1; fi fi; i:=i+1: od:
   j:=i; while (data[i] in dig or data[i] in {"-","+"}) do i:=i+1: od: parse(data[j..i-1]);
  end:
  ` `; Region; status,data,headers:=HTTP:-Get(url): HTTP:-Code(status); i:=Search("<th>",data):

  iter:=proc() global i; local r;
   r:=val(); if data[i]<>"." then NULL else [r,val(),val(),val(),val(),val()],iter() fi;
```

```
end:

[iter()]: tA:=[seq(%[nops(%)+1-i],i=1..nops(%))];
dd:=tA[1][1]+piecewise(tA[1][2]=2,-29,tA[1][2]=4,31,0)-1;
T:=map(q->q[4],tA): #writedata(Region || `-i.txt`,%): #
T3:=map(q->q[5],tA): #writedata(Region || `-m.txt`,%): #
T1:=map(q->q[6],tA): #writedata(Region || `-r.txt`,%): #
T2:=[seq(T[i]-(T1[i]+T3[i]),i=1..nops(T))]: #writedata(Region || `-h.txt`,%): #
i:='i':
Region; 'T'=T; 'T1'=T1; 'T2'=T2; 'T3'=T3;

nops(T); [i+dd $ i=1..%];
```

``

Moscow

"OK"

tA := [[2, 3, 20, 1, 0, 0], [3, 3, 20, 1, 0, 0], [4, 3, 20, 1, 0, 0], [5, 3, 20, 1, 0, 0], [6, 3, 20, 6, 0, 0], [7, 3, 20, 6, 0, 1], [8, 3, 20, 6, 0, 1], [9, 3, 20, 9, 0, 1], [10, 3, 20, 9, 0, 1], [11, 3, 20, 15, 0, 1], [12, 3, 20, 19, 0, 1], [13, 3, 20, 24, 0, 1], [14, 3, 20, 33, 0, 1], [15, 3, 20, 33, 0, 1], [16, 3, 20, 53, 0, 1], [17, 3, 20, 56, 0, 1], [18, 3, 20, 86, 0, 1], [19, 3, 20, 98, 0, 5], [20, 3, 20, 131, 0, 5], [21, 3, 20, 137, 0, 8], [22, 3, 20, 191, 0, 8], [23, 3, 20, 262, 0, 9], [24, 3, 20, 290, 0, 9], [25, 3, 20, 410, 2, 15], [26, 3, 20, 546, 2, 15], [27, 3, 20, 703, 3, 18], [28, 3, 20, 817, 4, 18], [29, 3, 20, 1014, 6, 28], [30, 3, 20, 1226, 6, 28], [31, 3, 20, 1613, 11, 70], [1, 4, 20, 1880, 16, 115], [2, 4, 20, 2475, 19, 140], [3, 4, 20, 2923, 20, 168], [4, 4, 20, 3357, 27, 194], [5, 4, 20, 3893, 29, 198], [6, 4, 20, 4484, 29, 206], [7, 4, 20, 5181, 31, 222], [8, 4, 20, 5841, 31, 270], [9, 4, 20, 6698, 38, 313], [10, 4, 20, 7822, 50, 350], [11, 4, 20, 8852, 58, 499], [12, 4, 20, 10158, 72, 687], [13, 4, 20, 11513, 82, 837], [14, 4, 20, 13002, 95, 1016], [15, 4, 20, 14776, 106, 1205], [16, 4, 20, 16146, 113, 1394], [17, 4, 20, 18105, 127, 1517], [18, 4, 20, 20754, 148, 1679], [19, 4, 20, 24324, 176, 1763], [20, 4, 20, 26350, 204, 1838], [21, 4, 20, 29433, 233, 2057], [22, 4, 20, 31981, 261, 2267], [23, 4, 20, 33940, 288, 2448], [24, 4, 20, 36897, 325, 2735], [25, 4, 20, 39509, 366, 3047], [26, 4, 20, 42480, 404, 3175], [27, 4, 20, 45351, 435, 3524], [28, 4, 20, 48426, 479, 4130], [29, 4, 20, 50646, 546, 4610], [30, 4, 20, 53739, 611, 5135], [1, 5, 20, 57300, 658, 5766], [2, 5, 20, 62658, 695, 6374], [3, 5, 20, 68606, 729, 7029], [4, 5, 20, 74401, 764, 7573], [5, 5, 20, 80115, 816, 7870], [6, 5, 20, 85973, 866, 8458], [7, 5, 20, 92676, 905, 9227], [8, 5, 20, 98522, 956, 10259], [9, 5, 20, 104189, 1010, 12779], [10, 5, 20, 109740, 1068, 13790], [11, 5, 20, 115909, 1124, 17822], [12, 5, 20, 121301, 1179, 19642], [13, 5, 20, 126004, 1232, 21506], [14, 5, 20, 130716, 1290, 23327], [15, 5, 20, 135464, 1358, 24562], [16, 5, 20, 138969, 1432, 26032], [17, 5, 20, 142824, 1503, 27490], [18, 5, 20, 146062, 1580, 28913], [19, 5, 20, 149607, 1651, 31496]]

dd := 1

Moscow

T = [1, 1, 1, 1, 6, 6, 6, 9, 9, 15, 19, 24, 33, 33, 53, 56, 86, 98, 131, 137, 191, 262, 290, 410, 546, 703, 817, 1014, 1226, 1613, 1880, 2475, 2923, 3357, 3893, 4484, 5181, 5841, 6698, 7822, 8852, 10158, 11513, 13002, 14776, 16146, 18105, 20754, 24324, 26350, 29433, 31981, 33940, 36897, 39509, 42480, 45351, 48426, 50646, 53739, 57300, 62658, 68606, 74401, 80115, 85973, 92676, 98522, 104189, 109740, 115909, 121301, 126004, 130716, 135464, 138969, 142824, 146062, 149607]

$T1$ = [0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 5, 5, 8, 8, 9, 9, 15, 15, 18, 18, 28, 28, 70, 115, 140, 168, 194, 198, 206, 222, 270, 313, 350, 499, 687, 837, 1016, 1205, 1394, 1517, 1679, 1763, 1838, 2057, 2267, 2448, 2735, 3047, 3175, 3524, 4130, 4610, 5135, 5766, 6374, 7029, 7573, 7870, 8458, 9227, 10259, 12779, 13790, 17822, 19642, 21506, 23327, 24562, 26032, 27490, 28913, 31496]

$T2$ = [1, 1, 1, 1, 6, 5, 5, 8, 8, 14, 18, 23, 32, 32, 52, 55, 85, 93, 126, 129, 183, 253, 281, 393, 529, 682, 795, 980, 1192, 1532, 1749, 2316, 2735, 3136, 3666, 4249, 4928, 5540, 6347, 7422, 8295, 9399, 10594, 11891, 13465, 14639, 16461, 18927, 22385, 24308, 27143, 29453, 31204, 33837, 36096, 38901, 41392, 43817, 45490, 47993, 50876, 55589, 60848, 66064, 71429, 76649, 82544, 87307, 90400, 94882, 96963, 100480, 103266, 106099, 109544, 111505, 113831, 115569, 116460]

$T3$ = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 2, 3, 4, 6, 6, 11, 16, 19, 20, 27, 29, 29, 31, 31, 38, 50, 58, 72, 82, 95, 106, 113, 127, 148, 176, 204, 233, 261, 288, 325, 366, 404, 435, 479, 546, 611, 658, 695, 729, 764, 816, 866, 905, 956, 1010, 1068, 1124, 1179, 1232, 1290, 1358, 1432, 1503, 1580, 1651]

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[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] **(4**

```
> h:=x->x;

  [seq(h(T[i])-h(T[i-1]),i=2..nops(T))]; [seq(%[i]-%[i-1],i=2..nops(%))]; [seq(%[i]-%[i-1],i=2..
  nops(%))];
  [seq([i+dd+1,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+2,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+3,%%%[i]
  ],i=1..nops(%%%))]:
  display(
   plot([%%%,%%,%],style=point),
   plot([%%%,%%,%],legend=[``,``,``]),
   title=`  N[i]`,titlefont=[roman,15]   ,gridlines=true
  );

  [seq((h(T[i])-h(T[i-5]))/5.,i=6..nops(T))]: [seq((%[i]-%[i-3])/3.,i=4..nops(%))]: [seq((%[i]-%
  [i-3])/3.,i=4..nops(%))]:
  [seq([i+dd+2,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+4,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+6,%%%[i]
```

```
],i=1..nops(%%%))]:
display(
 plot([%%%,%%,%],style=point),
 plot([%%%,%%,%],legend=[``,``,``]),
  title=`    N[i]              `,titlefont=[roman,15],gridlines=true
);
```

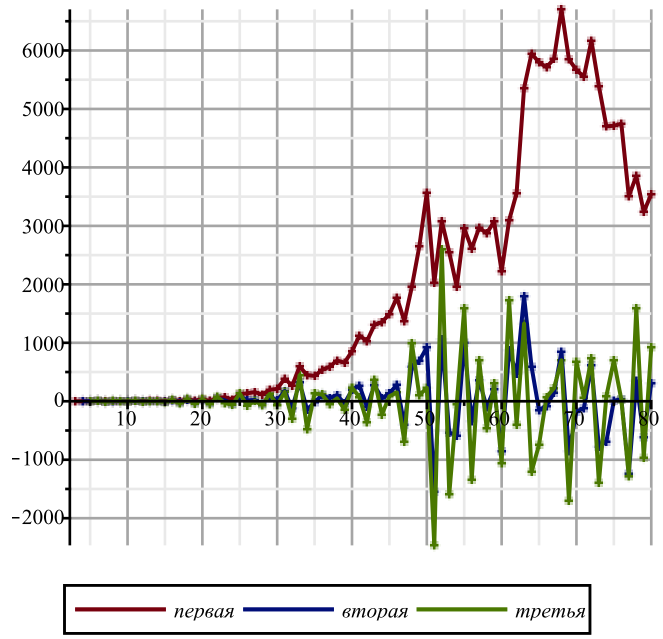
$$h := x \mapsto x$$

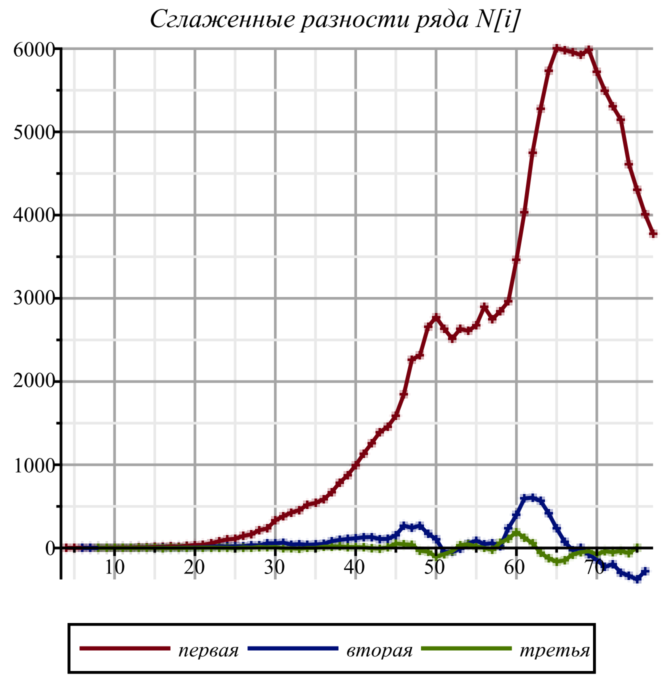
[0, 0, 0, 5, 0, 0, 3, 0, 6, 4, 5, 9, 0, 20, 3, 30, 12, 33, 6, 54, 71, 28, 120, 136, 157, 114, 197, 212, 387, 267, 595, 448, 434, 536, 591, 697, 660, 857, 1124, 1030, 1306, 1355, 1489, 1774, 1370, 1959, 2649, 3570, 2026, 3083, 2548, 1959, 2957, 2612, 2971, 2871, 3075, 2220, 3093, 3561, 5358, 5948, 5795, 5714, 5858, 6703, 5846, 5667, 5551, 6169, 5392, 4703, 4712, 4748, 3505, 3855, 3238, 3545]

[0, 0, 5, −5, 0, 3, −3, 6, −2, 1, 4, −9, 20, −17, 27, −18, 21, −27, 48, 17, −43, 92, 16, 21, −43, 83, 15, 175, −120, 328, −147, −14, 102, 55, 106, −37, 197, 267, −94, 276, 49, 134, 285, −404, 589, 690, 921, −1544, 1057, −535, −589, 998, −345, 359, −100, 204, −855, 873, 468, 1797, 590, −153, −81, 144, 845, −857, −179, −116, 618, −777, −689, 9, 36, −1243, 350, −617, 307]

[0, 5, −10, 5, 3, −6, 9, −8, 3, 3, −13, 29, −37, 44, −45, 39, −48, 75, −31, −60, 135, −76, 5, −64, 126, −68, 160, −295, 448, −475, 133, 116, −47, 51, −143, 234, 70, −361, 370, −227, 85, 151, −689, 993, 101, 231, −2465, 2601, −1592, −54, 1587, −1343, 704, −459, 304, −1059, 1728, −405, 1329, −1207, −743, 72, 225, 701, −1702, 678, 63, 734, −1395, 88, 698, 27, −1279, 1593, −967, 924]

Разности ряда N[i]






```
> h:=x->ln(x);

  [seq(h(T[i])-h(T[i-1]),i=2..nops(T))]; [seq(%[i]-%[i-1],i=2..nops(%))]; [seq(%[i]-%[i-1],i=2..
  nops(%))];
  [seq([i+dd+1,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+2,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+3,%%%[i]
  ],i=1..nops(%%%))]:
  display(
   plot([%%%,%%,%],style=point),
   plot([%%%,%%,%],legend=[``,``,``]),
   title=`  ln(N[i])`,titlefont=[roman,15]  ,gridlines=true
  );

  [seq((h(T[i])-h(T[i-5]))/5.,i=6..nops(T))]: [seq((%[i]-%[i-3])/3.,i=4..nops(%))]: [seq((%[i]-%
  [i-3])/3.,i=4..nops(%))]:
  [seq([i+dd+2,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+4,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+6,%%%[i]
  ],i=1..nops(%%%))]:
  display(
   plot([%%%,%%,%],style=point),
   plot([%%%,%%,%],legend=[``,``,``]),
```

```
title=`                    ln(N[i])`,titlefont=[roman,15],gridlines=true
);
```

$$h := x \mapsto \ln(x)$$

[0, 0, 0, ln(6), 0, 0, 2 ln(3) − ln(6), 0, ln(15) − 2 ln(3), ln(19) − ln(15), ln(24) − ln(19), ln(33) − ln(24), 0, ln(53) − ln(33), ln(56) − ln(53), ln(86) − ln(56), ln(98) − ln(86), ln(131) − ln(98), ln(137) − ln(131), ln(191) − ln(137), ln(262) − ln(191), ln(290) − ln(262), ln(410) − ln(290), ln(546) − ln(410), ln(703) − ln(546), ln(817) − ln(703), ln(1014) − ln(817), ln(1226) − ln(1014), ln(1613) − ln(1226), ln(1880) − ln(1613), ln(2475) − ln(1880), ln(2923) − ln(2475), ln(3357) − ln(2923), ln(3893) − ln(3357), ln(4484) − ln(3893), ln(5181) − ln(4484), ln(5841) − ln(5181), ln(6698) − ln(5841), ln(7822) − ln(6698), ln(8852) − ln(7822), ln(10158) − ln(8852), ln(11513) − ln(10158), ln(13002) − ln(11513), ln(14776) − ln(13002), ln(16146) − ln(14776), ln(18105) − ln(16146), ln(20754) − ln(18105), ln(24324) − ln(20754), ln(26350) − ln(24324), ln(29433) − ln(26350), ln(31981) − ln(29433), ln(33940) − ln(31981), ln(36897) − ln(33940), ln(39509) − ln(36897), ln(42480) − ln(39509), ln(45351) − ln(42480), ln(48426) − ln(45351), ln(50646) − ln(48426), ln(53739) − ln(50646), ln(57300) − ln(53739), ln(62658) − ln(57300), ln(68606) − ln(62658), ln(74401) − ln(68606), ln(80115) − ln(74401), ln(85973) − ln(80115), ln(92676) − ln(85973), ln(98522) − ln(92676), ln(104189) − ln(98522), ln(109740) − ln(104189), ln(115909) − ln(109740), ln(121301) − ln(115909), ln(126004) − ln(121301), ln(130716) − ln(126004), ln(135464) − ln(130716), ln(138969) − ln(135464), ln(142824) − ln(138969), ln(146062) − ln(142824), ln(149607) − ln(146062)]

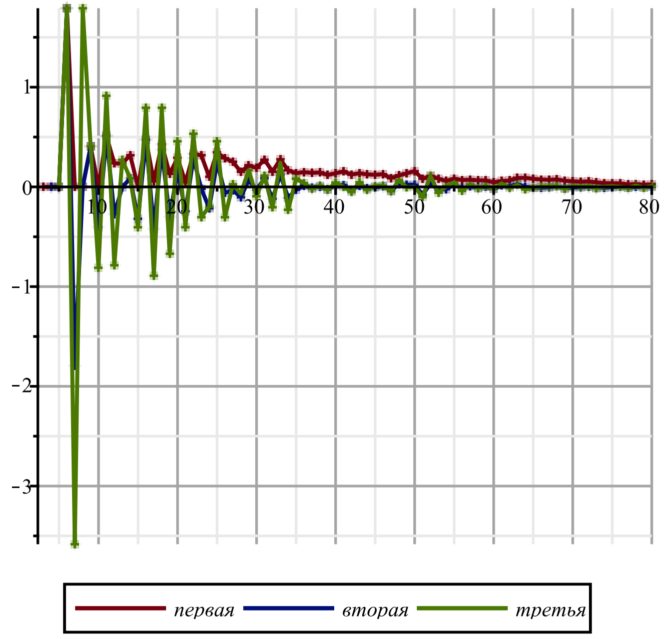
[0, 0, ln(6), -ln(6), 0, 2 ln(3) − ln(6), -2 ln(3) + ln(6), ln(15) − 2 ln(3), ln(19) − 2 ln(15) + 2 ln(3), ln(24) − 2 ln(19) + ln(15), ln(33) − 2 ln(24) + ln(19), -ln(33) + ln(24), ln(53) − ln(33), ln(56) − 2 ln(53) + ln(33), ln(86) − 2 ln(56) + ln(53), ln(98) − 2 ln(86) + ln(56), ln(131) − 2 ln(98) + ln(86), ln(137) − 2 ln(131) + ln(98), ln(191) − 2 ln(137) + ln(131), ln(262) − 2 ln(191) + ln(137), ln(290) − 2 ln(262) + ln(191), ln(410) − 2 ln(290) + ln(262), ln(546) − 2 ln(410) + ln(290), ln(703) − 2 ln(546) + ln(410), ln(817) − 2 ln(703) + ln(546), ln(1014) − 2 ln(817) + ln(703), ln(1226) − 2 ln(1014) + ln(817), ln(1613) − 2 ln(1226) + ln(1014), ln(1880) − 2 ln(1613) + ln(1226), ln(2475) − 2 ln(1880) + ln(1613), ln(2923) − 2 ln(2475) + ln(1880), ln(3357) − 2 ln(2923) + ln(2475), ln(3893) − 2 ln(3357) + ln(2923), ln(4484) − 2 ln(3893) + ln(3357), ln(5181) − 2 ln(4484) + ln(3893), ln(5841) − 2 ln(5181) + ln(4484), ln(6698) − 2 ln(5841) + ln(5181), ln(7822) − 2 ln(6698) + ln(5841), ln(8852) − 2 ln(7822) + ln(6698), ln(10158) − 2 ln(8852) + ln(7822), ln(11513) − 2 ln(10158) + ln(8852), ln(13002) − 2 ln(11513) + ln(10158), ln(14776) − 2 ln(13002) + ln(11513), ln(16146) − 2 ln(14776) + ln(13002), ln(18105) − 2 ln(16146) + ln(14776), ln(20754) − 2 ln(18105) + ln(16146), ln(24324) − 2 ln(20754) + ln(18105), ln(26350) − 2 ln(24324) + ln(20754), ln(29433) − 2 ln(26350) + ln(24324), ln(31981) − 2 ln(29433) + ln(26350), ln(33940) − 2 ln(31981) + ln(29433), ln(36897) − 2 ln(33940) + ln(31981), ln(39509) − 2 ln(36897) + ln(33940), ln(42480) − 2 ln(39509) + ln(36897), ln(45351) − 2 ln(42480) + ln(39509), ln(48426) − 2 ln(45351) + ln(42480), ln(50646) − 2 ln(48426) + ln(45351), ln(53739) − 2 ln(50646) + ln(48426),

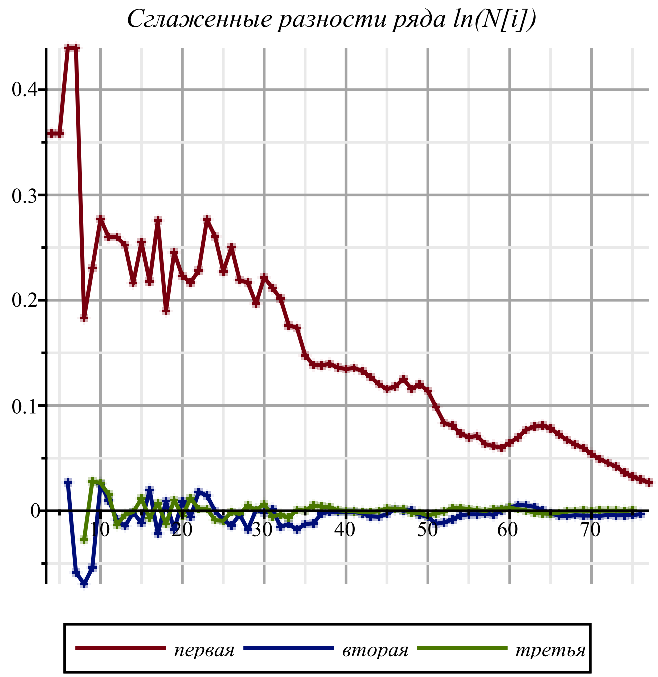
$\ln(57300) - 2\ln(53739) + \ln(50646), \ln(62658) - 2\ln(57300) + \ln(53739), \ln(68606) - 2\ln(62658) + \ln(57300), \ln(74401) - 2\ln(68606) + \ln(62658), \ln(80115) - 2\ln(74401) + \ln(68606), \ln(85973) - 2\ln(80115) + \ln(74401), \ln(92676) - 2\ln(85973) + \ln(80115), \ln(98522) - 2\ln(92676) + \ln(85973), \ln(104189) - 2\ln(98522) + \ln(92676), \ln(109740) - 2\ln(104189) + \ln(98522), \ln(115909) - 2\ln(109740) + \ln(104189), \ln(121301) - 2\ln(115909) + \ln(109740), \ln(126004) - 2\ln(121301) + \ln(115909), \ln(130716) - 2\ln(126004) + \ln(121301), \ln(135464) - 2\ln(130716) + \ln(126004), \ln(138969) - 2\ln(135464) + \ln(130716), \ln(142824) - 2\ln(138969) + \ln(135464), \ln(146062) - 2\ln(142824) + \ln(138969), \ln(149607) - 2\ln(146062) + \ln(142824)]$

$[0, \ln(6), -2\ln(6), \ln(6), 2\ln(3) - \ln(6), -4\ln(3) + 2\ln(6), \ln(15) - \ln(6), \ln(19) - 3\ln(15) + 4\ln(3), \ln(24) - 3\ln(19) + 3\ln(15) - 2\ln(3), \ln(33) - 3\ln(24) + 3\ln(19) - \ln(15), -2\ln(33) + 3\ln(24) - \ln(19), \ln(53) - \ln(24), \ln(56) - 3\ln(53) + 2\ln(33), \ln(86) - 3\ln(56) + 3\ln(53) - \ln(33), \ln(98) - 3\ln(86) + 3\ln(56) - \ln(53), \ln(131) - 3\ln(98) + 3\ln(86) - \ln(56), \ln(137) - 3\ln(131) + 3\ln(98) - \ln(86), \ln(191) - 3\ln(137) + 3\ln(131) - \ln(98), \ln(262) - 3\ln(191) + 3\ln(137) - \ln(131), \ln(290) - 3\ln(262) + 3\ln(191) - \ln(137), \ln(410) - 3\ln(290) + 3\ln(262) - \ln(191), \ln(546) - 3\ln(410) + 3\ln(290) - \ln(262), \ln(703) - 3\ln(546) + 3\ln(410) - \ln(290), \ln(817) - 3\ln(703) + 3\ln(546) - \ln(410), \ln(1014) - 3\ln(817) + 3\ln(703) - \ln(546), \ln(1226) - 3\ln(1014) + 3\ln(817) - \ln(703), \ln(1613) - 3\ln(1226) + 3\ln(1014) - \ln(817), \ln(1880) - 3\ln(1613) + 3\ln(1226) - \ln(1014), \ln(2475) - 3\ln(1880) + 3\ln(1613) - \ln(1226), \ln(2923) - 3\ln(2475) + 3\ln(1880) - \ln(1613), \ln(3357) - 3\ln(2923) + 3\ln(2475) - \ln(1880), \ln(3893) - 3\ln(3357) + 3\ln(2923) - \ln(2475), \ln(4484) - 3\ln(3893) + 3\ln(3357) - \ln(2923), \ln(5181) - 3\ln(4484) + 3\ln(3893) - \ln(3357), \ln(5841) - 3\ln(5181) + 3\ln(4484) - \ln(3893), \ln(6698) - 3\ln(5841) + 3\ln(5181) - \ln(4484), \ln(7822) - 3\ln(6698) + 3\ln(5841) - \ln(5181), \ln(8852) - 3\ln(7822) + 3\ln(6698) - \ln(5841), \ln(10158) - 3\ln(8852) + 3\ln(7822) - \ln(6698), \ln(11513) - 3\ln(10158) + 3\ln(8852) - \ln(7822), \ln(13002) - 3\ln(11513) + 3\ln(10158) - \ln(8852), \ln(14776) - 3\ln(13002) + 3\ln(11513) - \ln(10158), \ln(16146) - 3\ln(14776) + 3\ln(13002) - \ln(11513), \ln(18105) - 3\ln(16146) + 3\ln(14776) - \ln(13002), \ln(20754) - 3\ln(18105) + 3\ln(16146) - \ln(14776), \ln(24324) - 3\ln(20754) + 3\ln(18105) - \ln(16146), \ln(26350) - 3\ln(24324) + 3\ln(20754) - \ln(18105), \ln(29433) - 3\ln(26350) + 3\ln(24324) - \ln(20754), \ln(31981) - 3\ln(29433) + 3\ln(26350) - \ln(24324), \ln(33940) - 3\ln(31981) + 3\ln(29433) - \ln(26350), \ln(36897) - 3\ln(33940) + 3\ln(31981) - \ln(29433), \ln(39509) - 3\ln(36897) + 3\ln(33940) - \ln(31981), \ln(42480) - 3\ln(39509) + 3\ln(36897) - \ln(33940), \ln(45351) - 3\ln(42480) + 3\ln(39509) - \ln(36897), \ln(48426) - 3\ln(45351) + 3\ln(42480) - \ln(39509), \ln(50646) - 3\ln(48426) + 3\ln(45351) - \ln(42480), \ln(53739) - 3\ln(50646) + 3\ln(48426) - \ln(45351), \ln(57300) - 3\ln(53739) + 3\ln(50646) - \ln(48426), \ln(62658) - 3\ln(57300) + 3\ln(53739) - \ln(50646), \ln(68606) - 3\ln(62658) + 3\ln(57300) - \ln(53739), \ln(74401) - 3\ln(68606) + 3\ln(62658) - \ln(57300), \ln(80115) - 3\ln(74401) + 3\ln(68606) - \ln(62658), \ln(85973) - 3\ln(80115) + 3\ln(74401) - \ln(68606), \ln(92676) - 3\ln(85973) + 3\ln(80115) - \ln(74401), \ln(98522) - 3\ln(92676) + 3\ln(85973) - \ln(80115), \ln(104189) - 3\ln(98522) + 3\ln(92676)$

$-\ln(85973), \ln(109740)-3\ln(104189)+3\ln(98522)-\ln(92676), \ln(115909)-3\ln(109740)+3\ln(104189)-\ln(98522),$
$\ln(121301)-3\ln(115909)+3\ln(109740)-\ln(104189), \ln(126004)-3\ln(121301)+3\ln(115909)-\ln(109740), \ln(130716)$
$-3\ln(126004)+3\ln(121301)-\ln(115909), \ln(135464)-3\ln(130716)+3\ln(126004)-\ln(121301), \ln(138969)-3\ln(135464)$
$+3\ln(130716)-\ln(126004), \ln(142824)-3\ln(138969)+3\ln(135464)-\ln(130716), \ln(146062)-3\ln(142824)+3\ln(138969)$
$-\ln(135464), \ln(149607)-3\ln(146062)+3\ln(142824)-\ln(138969)]$

Разности ряда ln(N[i])






```
> h:=x->ln(x);

  [seq(h(T[i])-h(T[i-1]),i=2..nops(T))]; [seq(%[i]-%[i-1],i=2..nops(%))]; [seq(%[i]-%[i-1],i=2..
  nops(%))];
  [seq([i+dd+1,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+1,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+1,%%%[i]
  ],i=1..nops(%%%))]:
  display(
   plot([%%%,%%,%],style=point),
   plot([%%%,%%,%],legend=[``,``,``]),
   title=`  ln(N[i])`,titlefont=[roman,15]   ,gridlines=true
  );
```

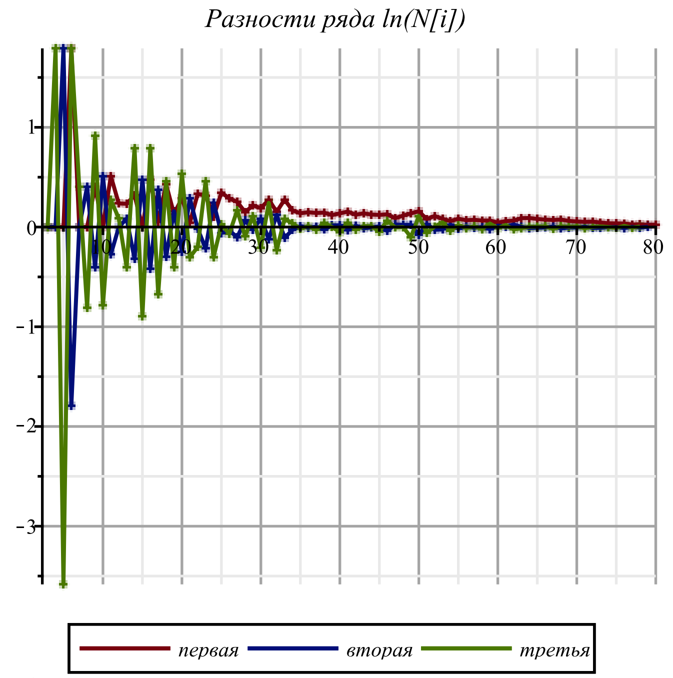
$$h := x \mapsto \ln(x)$$

$[0, 0, 0, \ln(6), 0, 0, 2\ln(3) - \ln(6), 0, \ln(15) - 2\ln(3), \ln(19) - \ln(15), \ln(24) - \ln(19), \ln(33) - \ln(24), 0, \ln(53) - \ln(33), \ln(56) - \ln(53), \ln(86) - \ln(56), \ln(98) - \ln(86), \ln(131) - \ln(98), \ln(137) - \ln(131), \ln(191) - \ln(137), \ln(262) - \ln(191), \ln(290) - \ln(262), \ln(410) - \ln(290), \ln(546) - \ln(410), \ln(703) - \ln(546), \ln(817) - \ln(703), \ln(1014) - \ln(817), \ln(1226) - \ln(1014), \ln(1613) - \ln(1226), \ln(1880) - \ln(1613), \ln(2475) - \ln(1880), \ln(2923) - \ln(2475), \ln(3357) - \ln(2923), \ln(3893) - \ln(3357),$

$\ln(4484) - \ln(3893), \ln(5181) - \ln(4484), \ln(5841) - \ln(5181), \ln(6698) - \ln(5841), \ln(7822) - \ln(6698), \ln(8852) - \ln(7822),$
$\ln(10158) - \ln(8852), \ln(11513) - \ln(10158), \ln(13002) - \ln(11513), \ln(14776) - \ln(13002), \ln(16146) - \ln(14776), \ln(18105)$
$- \ln(16146), \ln(20754) - \ln(18105), \ln(24324) - \ln(20754), \ln(26350) - \ln(24324), \ln(29433) - \ln(26350), \ln(31981)$
$- \ln(29433), \ln(33940) - \ln(31981), \ln(36897) - \ln(33940), \ln(39509) - \ln(36897), \ln(42480) - \ln(39509), \ln(45351)$
$- \ln(42480), \ln(48426) - \ln(45351), \ln(50646) - \ln(48426), \ln(53739) - \ln(50646), \ln(57300) - \ln(53739), \ln(62658)$
$- \ln(57300), \ln(68606) - \ln(62658), \ln(74401) - \ln(68606), \ln(80115) - \ln(74401), \ln(85973) - \ln(80115), \ln(92676)$
$- \ln(85973), \ln(98522) - \ln(92676), \ln(104189) - \ln(98522), \ln(109740) - \ln(104189), \ln(115909) - \ln(109740), \ln(121301)$
$- \ln(115909), \ln(126004) - \ln(121301), \ln(130716) - \ln(126004), \ln(135464) - \ln(130716), \ln(138969) - \ln(135464), \ln(142824)$
$- \ln(138969), \ln(146062) - \ln(142824), \ln(149607) - \ln(146062)]$

$[0, 0, \ln(6), -\ln(6), 0, 2\ln(3) - \ln(6), -2\ln(3) + \ln(6), \ln(15) - 2\ln(3), \ln(19) - 2\ln(15) + 2\ln(3), \ln(24) - 2\ln(19) + \ln(15),$
$\ln(33) - 2\ln(24) + \ln(19), -\ln(33) + \ln(24), \ln(53) - \ln(33), \ln(56) - 2\ln(53) + \ln(33), \ln(86) - 2\ln(56) + \ln(53), \ln(98)$
$- 2\ln(86) + \ln(56), \ln(131) - 2\ln(98) + \ln(86), \ln(137) - 2\ln(131) + \ln(98), \ln(191) - 2\ln(137) + \ln(131), \ln(262)$
$- 2\ln(191) + \ln(137), \ln(290) - 2\ln(262) + \ln(191), \ln(410) - 2\ln(290) + \ln(262), \ln(546) - 2\ln(410) + \ln(290), \ln(703)$
$- 2\ln(546) + \ln(410), \ln(817) - 2\ln(703) + \ln(546), \ln(1014) - 2\ln(817) + \ln(703), \ln(1226) - 2\ln(1014) + \ln(817), \ln(1613)$
$- 2\ln(1226) + \ln(1014), \ln(1880) - 2\ln(1613) + \ln(1226), \ln(2475) - 2\ln(1880) + \ln(1613), \ln(2923) - 2\ln(2475)$
$+ \ln(1880), \ln(3357) - 2\ln(2923) + \ln(2475), \ln(3893) - 2\ln(3357) + \ln(2923), \ln(4484) - 2\ln(3893) + \ln(3357), \ln(5181)$
$- 2\ln(4484) + \ln(3893), \ln(5841) - 2\ln(5181) + \ln(4484), \ln(6698) - 2\ln(5841) + \ln(5181), \ln(7822) - 2\ln(6698)$
$+ \ln(5841), \ln(8852) - 2\ln(7822) + \ln(6698), \ln(10158) - 2\ln(8852) + \ln(7822), \ln(11513) - 2\ln(10158) + \ln(8852), \ln(13002)$
$- 2\ln(11513) + \ln(10158), \ln(14776) - 2\ln(13002) + \ln(11513), \ln(16146) - 2\ln(14776) + \ln(13002), \ln(18105) - 2\ln(16146)$
$+ \ln(14776), \ln(20754) - 2\ln(18105) + \ln(16146), \ln(24324) - 2\ln(20754) + \ln(18105), \ln(26350) - 2\ln(24324) + \ln(20754),$
$\ln(29433) - 2\ln(26350) + \ln(24324), \ln(31981) - 2\ln(29433) + \ln(26350), \ln(33940) - 2\ln(31981) + \ln(29433), \ln(36897)$
$- 2\ln(33940) + \ln(31981), \ln(39509) - 2\ln(36897) + \ln(33940), \ln(42480) - 2\ln(39509) + \ln(36897), \ln(45351) - 2\ln(42480)$
$+ \ln(39509), \ln(48426) - 2\ln(45351) + \ln(42480), \ln(50646) - 2\ln(48426) + \ln(45351), \ln(53739) - 2\ln(50646) + \ln(48426),$
$\ln(57300) - 2\ln(53739) + \ln(50646), \ln(62658) - 2\ln(57300) + \ln(53739), \ln(68606) - 2\ln(62658) + \ln(57300), \ln(74401)$
$- 2\ln(68606) + \ln(62658), \ln(80115) - 2\ln(74401) + \ln(68606), \ln(85973) - 2\ln(80115) + \ln(74401), \ln(92676) - 2\ln(85973)$
$+ \ln(80115), \ln(98522) - 2\ln(92676) + \ln(85973), \ln(104189) - 2\ln(98522) + \ln(92676), \ln(109740) - 2\ln(104189)$
$+ \ln(98522), \ln(115909) - 2\ln(109740) + \ln(104189), \ln(121301) - 2\ln(115909) + \ln(109740), \ln(126004) - 2\ln(121301)$
$+ \ln(115909), \ln(130716) - 2\ln(126004) + \ln(121301), \ln(135464) - 2\ln(130716) + \ln(126004), \ln(138969) - 2\ln(135464)$
$+ \ln(130716), \ln(142824) - 2\ln(138969) + \ln(135464), \ln(146062) - 2\ln(142824) + \ln(138969), \ln(149607) - 2\ln(146062)$
$+ \ln(142824)]$

$$
[0, \ln(6), -2 \ln(6), \ln(6), 2 \ln(3) - \ln(6), -4 \ln(3) + 2 \ln(6), \ln(15) - \ln(6), \ln(19) - 3 \ln(15) + 4 \ln(3), \ln(24) - 3 \ln(19) + 3 \ln(15)
- 2 \ln(3), \ln(33) - 3 \ln(24) + 3 \ln(19) - \ln(15), -2 \ln(33) + 3 \ln(24) - \ln(19), \ln(53) - \ln(24), \ln(56) - 3 \ln(53) + 2 \ln(33),
\ln(86) - 3 \ln(56) + 3 \ln(53) - \ln(33), \ln(98) - 3 \ln(86) + 3 \ln(56) - \ln(53), \ln(131) - 3 \ln(98) + 3 \ln(86) - \ln(56), \ln(137)
- 3 \ln(131) + 3 \ln(98) - \ln(86), \ln(191) - 3 \ln(137) + 3 \ln(131) - \ln(98), \ln(262) - 3 \ln(191) + 3 \ln(137) - \ln(131), \ln(290)
- 3 \ln(262) + 3 \ln(191) - \ln(137), \ln(410) - 3 \ln(290) + 3 \ln(262) - \ln(191), \ln(546) - 3 \ln(410) + 3 \ln(290) - \ln(262), \ln(703)
- 3 \ln(546) + 3 \ln(410) - \ln(290), \ln(817) - 3 \ln(703) + 3 \ln(546) - \ln(410), \ln(1014) - 3 \ln(817) + 3 \ln(703) - \ln(546),
\ln(1226) - 3 \ln(1014) + 3 \ln(817) - \ln(703), \ln(1613) - 3 \ln(1226) + 3 \ln(1014) - \ln(817), \ln(1880) - 3 \ln(1613) + 3 \ln(1226)
- \ln(1014), \ln(2475) - 3 \ln(1880) + 3 \ln(1613) - \ln(1226), \ln(2923) - 3 \ln(2475) + 3 \ln(1880) - \ln(1613), \ln(3357)
- 3 \ln(2923) + 3 \ln(2475) - \ln(1880), \ln(3893) - 3 \ln(3357) + 3 \ln(2923) - \ln(2475), \ln(4484) - 3 \ln(3893) + 3 \ln(3357)
- \ln(2923), \ln(5181) - 3 \ln(4484) + 3 \ln(3893) - \ln(3357), \ln(5841) - 3 \ln(5181) + 3 \ln(4484) - \ln(3893), \ln(6698)
- 3 \ln(5841) + 3 \ln(5181) - \ln(4484), \ln(7822) - 3 \ln(6698) + 3 \ln(5841) - \ln(5181), \ln(8852) - 3 \ln(7822) + 3 \ln(6698)
- \ln(5841), \ln(10158) - 3 \ln(8852) + 3 \ln(7822) - \ln(6698), \ln(11513) - 3 \ln(10158) + 3 \ln(8852) - \ln(7822), \ln(13002)
- 3 \ln(11513) + 3 \ln(10158) - \ln(8852), \ln(14776) - 3 \ln(13002) + 3 \ln(11513) - \ln(10158), \ln(16146) - 3 \ln(14776)
+ 3 \ln(13002) - \ln(11513), \ln(18105) - 3 \ln(16146) + 3 \ln(14776) - \ln(13002), \ln(20754) - 3 \ln(18105) + 3 \ln(16146)
- \ln(14776), \ln(24324) - 3 \ln(20754) + 3 \ln(18105) - \ln(16146), \ln(26350) - 3 \ln(24324) + 3 \ln(20754) - \ln(18105), \ln(29433)
- 3 \ln(26350) + 3 \ln(24324) - \ln(20754), \ln(31981) - 3 \ln(29433) + 3 \ln(26350) - \ln(24324), \ln(33940) - 3 \ln(31981)
+ 3 \ln(29433) - \ln(26350), \ln(36897) - 3 \ln(33940) + 3 \ln(31981) - \ln(29433), \ln(39509) - 3 \ln(36897) + 3 \ln(33940)
- \ln(31981), \ln(42480) - 3 \ln(39509) + 3 \ln(36897) - \ln(33940), \ln(45351) - 3 \ln(42480) + 3 \ln(39509) - \ln(36897), \ln(48426)
- 3 \ln(45351) + 3 \ln(42480) - \ln(39509), \ln(50646) - 3 \ln(48426) + 3 \ln(45351) - \ln(42480), \ln(53739) - 3 \ln(50646)
+ 3 \ln(48426) - \ln(45351), \ln(57300) - 3 \ln(53739) + 3 \ln(50646) - \ln(48426), \ln(62658) - 3 \ln(57300) + 3 \ln(53739)
- \ln(50646), \ln(68606) - 3 \ln(62658) + 3 \ln(57300) - \ln(53739), \ln(74401) - 3 \ln(68606) + 3 \ln(62658) - \ln(57300), \ln(80115)
- 3 \ln(74401) + 3 \ln(68606) - \ln(62658), \ln(85973) - 3 \ln(80115) + 3 \ln(74401) - \ln(68606), \ln(92676) - 3 \ln(85973)
+ 3 \ln(80115) - \ln(74401), \ln(98522) - 3 \ln(92676) + 3 \ln(85973) - \ln(80115), \ln(104189) - 3 \ln(98522) + 3 \ln(92676)
- \ln(85973), \ln(109740) - 3 \ln(104189) + 3 \ln(98522) - \ln(92676), \ln(115909) - 3 \ln(109740) + 3 \ln(104189) - \ln(98522),
\ln(121301) - 3 \ln(115909) + 3 \ln(109740) - \ln(104189), \ln(126004) - 3 \ln(121301) + 3 \ln(115909) - \ln(109740), \ln(130716)
- 3 \ln(126004) + 3 \ln(121301) - \ln(115909), \ln(135464) - 3 \ln(130716) + 3 \ln(126004) - \ln(121301), \ln(138969) - 3 \ln(135464)
+ 3 \ln(130716) - \ln(126004), \ln(142824) - 3 \ln(138969) + 3 \ln(135464) - \ln(130716), \ln(146062) - 3 \ln(142824) + 3 \ln(138969)
- \ln(135464), \ln(149607) - 3 \ln(146062) + 3 \ln(142824) - \ln(138969)]
$$




```
> n:=1: ne:=n: 'f(t)'=Sum(a[j]*t^j,j=0..n);

  fM:=proc(x) global M,chi2,F,T,f_; M:=x; chi2(T,F(T,chi2,f_)); end:

  ` `; `Approximation of the infection schedule by the solution of the Verhulst equation`; ` `;
  M:=goldMin(fM,max(T)+2..max(T)*2,1);
  nu:=F(T,chi2,f_): f:=unapply(ff(%(t)),t): N(t)=%(t); Chi2:=chi2(T,%%%);
  cat(`Next day forecast:    `,round(f(nops(T)+1)));
  cat(`The level of  0.5 M  is reached at    `,round(1+fsolve(f(d)=0.5*M,d=30)+dd-31),`  apr`);
  cat(`The level of  0.85 M  is reached at    `,round(1+fsolve(f(d)=0.85*M,d=30)+dd-31),`  apr`);
  ` `; `Approximation of the infection schedule by solving the Malthus equation`; ` `;
  nue:=F(T,chi2e,f_): fe:=unapply(ffe(%(t)),t): N(t)=%(t);

  simplify([diff(nu(d-dd),d),diff(nue(d-dd),d)]): [coeff(%[1],d,i) $ i=0..n-1];
  plot(%%,d=1+dd..nops(T)+dd,view=[0..nops(T)+dd,0..0.5],legend=[``,``],
  linestyle=[solid,dash],title=` `        ,titlefont=[roman,20],labels=[t,alpha(t)],
  gridlines=true);

  d1:=fsolve(f(d)=0.5*M,d=30)+dd; K_:=M; alpha_:=coeff(nu(t),t,1);
```

```
n:=4: ne:=n: 'f(t)'=Sum(a[j]*t^j,j=0..n);

fM:=proc(x) global M,chi2,F,T,f_; M:=x; chi2(T,F(T,chi2,f_)); end:

` `; `Approximation of the infection schedule by the solution of the Verhulst equation`; ` `;
M:=goldMin(fM,max(T)+2..max(T)*2,1);
nu:=F(T,chi2,f_): f:=unapply(ff(%(t)),t): N(t)=%(t); Chi2:=chi2(T,%%%);
cat(`Next day forecast:   `,round(f(nops(T)+1)));
cat(`The level of  0.5 M  is reached at   `,round(1+fsolve(f(d)=0.5*M,d=30)+dd-31),`  apr`);
cat(`The level of  0.85 M  is reached at   `,round(1+fsolve(f(d)=0.85*M,d=30)+dd-31),`  apr`);
` `; `Approximation of the infection schedule by solving the Malthus equation`; ` `;
nue:=F(T,chi2e,f_): fe:=unapply(ffe(%(t)),t): N(t)=%(t);

[seq([i,(
 (T[i-dd]-T[i-dd-1]) /(T2[i-dd]+T2[i-dd-1]) /((1-T[i-dd]/M)+(1-T[i-dd-1]/M))
)*4],i=1+dd+1..nops(T)+dd)]: [seq([%[i][1],(%[i-1][2]+%[i][2]+%[i+1][2])/3],i=2..nops(%)-1)]:
Palpha:=display(plot([%],color=blue),plot([%],style=point,symbolsize=8,symbol=solidcircle,color=
blue)):

simplify([diff(nu(d-dd),d),diff(nue(d-dd),d)]): [coeff(%[1],d,i) $ i=0..n-1];
plot(%%,d=1+dd..nops(T)+dd,view=[0..nops(T)+dd,0..0.5],legend=[``,``],
linestyle=[solid,dash],title=` `       ,titlefont=[roman,20],labels=[t,alpha(t)],
gridlines=true):

display(Palpha,%);
```

$$f(t) = \sum_{j=0}^{1} a_j t^j$$

\` \`

Approximation of the infection schedule by the solution of the Verhulst equation

\` \`

$$M := 177966.1497$$

$$N(t) = 177966.1497 - \frac{177966.1497}{e^{0.1198375427\,t - 7.905666459} + 1}$$

$$Chi2 := 13825.69994$$

Next day forecast: 150040

The level of 0.5 M is reached at 37 apr

The level of 0.85 M is reached at 51 apr

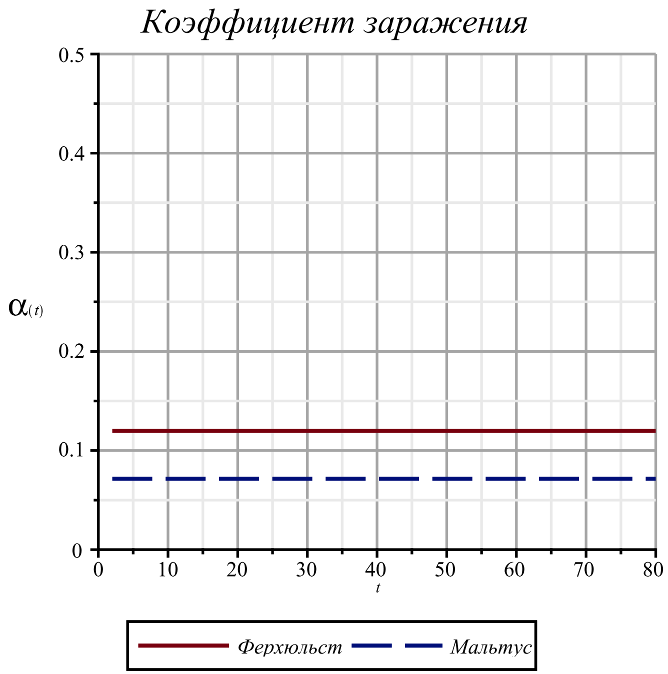
\` \`

Approximation of the infection schedule by solving the Malthus equation

\` \`

$$N(t) = e^{0.07161880470\,t + 6.502898293}$$

$$[0.1198375427]$$



$$d1 := 66.96986454$$

$$K\_ := 177966.1497$$

$$alpha\_ := 0.1198375427$$

$$f(t) = \sum_{j=0}^{4} a_j t^j$$

Approximation of the infection schedule by the solution of the Verhulst equation

$$M := 153036.3417$$

$$N(t) = 153036.3417 - \frac{153036.3417}{e^{1.359715571\,10^{-6}\,t^4 - 0.0001981555167\,t^3 + 0.008174655286\,t^2 + 0.09796917560\,t - 10.67689808} + 1}$$

$$Chi2 := 1255.713413$$

Next day forecast: 149404

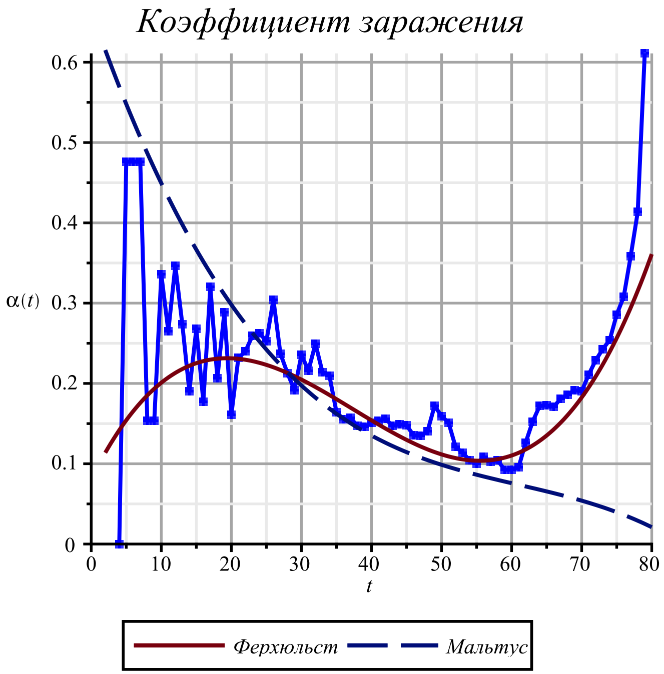
The level of 0.5 M is reached at 35 apr

The level of 0.85 M is reached at 45 apr

Approximation of the infection schedule by solving the Malthus equation

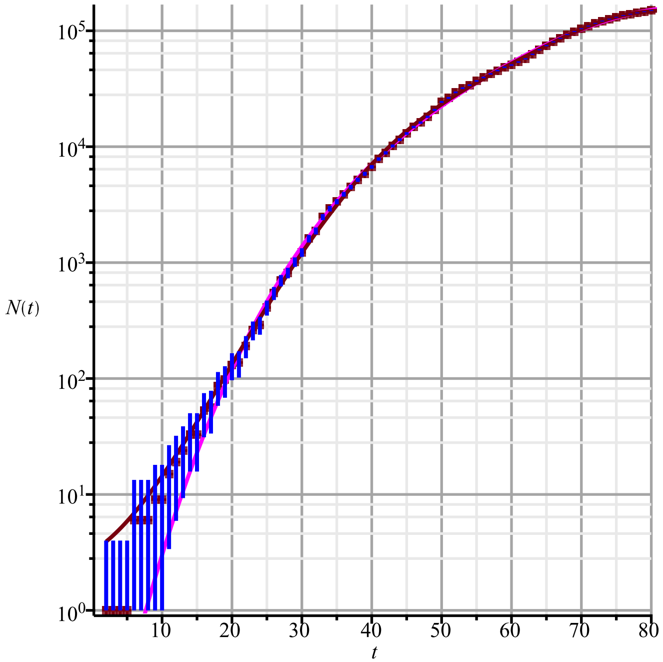
$$N(t) = e^{-5.161596503\,10^{-7}\,t^4 + 0.0001236878427\,t^3 - 0.01212608455\,t^2 + 0.6390536281\,t - 3.758369901}$$

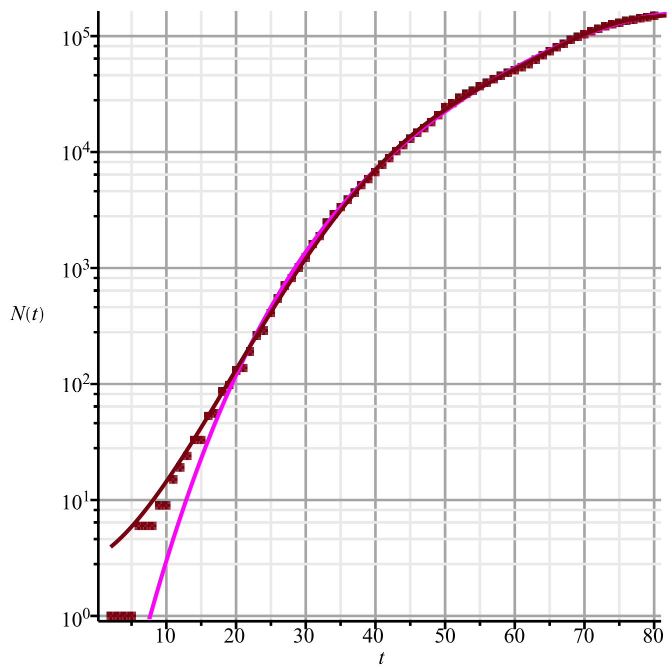
$$[0.0810199596200000,\ 0.0175545602600000,\ -0.000610783137000000,\ 5.438862284\,10^{-6}]$$



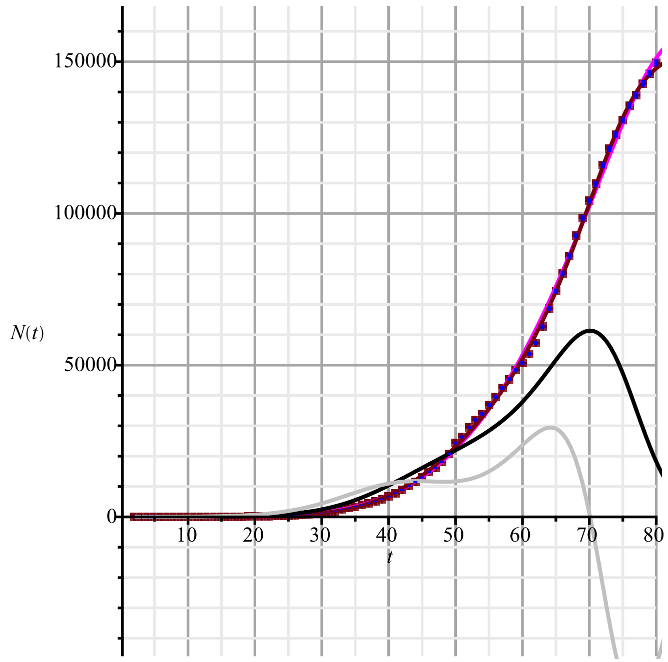

```
> df:=unapply(diff(f(i),i),i): ddf:=unapply(diff(f(i),i,i),i):

  display(
   plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=10,symbol=solidcircle),
   plot(fe(i-dd),i=1+dd..max(90,dd+nops(T)),color=magenta),
   plot(f(i-dd),i=1+dd..max(90,dd+nops(T))),
   seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
   axis[2]=[mode=log],
   view=[1..80,1..M*1.1],labels=[t,N(t)],gridlines=true
  );

  display(
   plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=8,symbol=solidcircle),
   plot(fe(i-dd),i=1+dd..max(120,dd+nops(T)),color=magenta),
   plot(f(i-dd),i=1+dd..max(120,dd+nops(T))),
  # seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
   axis[2]=[mode=log],
   view=[1..nops(T)+dd+1,1..T[nops(T)]*1.1],labels=[t,N(t)],gridlines=true
  );
```

```
display(
 plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=10,symbol=solidcircle),
 plot(fe(i-dd),i=1+dd..max(120,dd+nops(T)),color=magenta),
 plot(f(i-dd),i=1+dd..max(dd+nops(T),90)),
 plot(10*df(i-dd),i=1+dd..max(dd+nops(T),120),color=black),
 plot(100*ddf(i-dd),i=1+dd..max(dd+nops(T),120),color=gray),
 seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
 view=[1..80,-M*0.3..M*1.1],labels=[t,N(t)],gridlines=true
);

display(
 plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=8,symbol=solidcircle),
 plot(fe(i-dd),i=1+dd..max(120,dd+nops(T)),color=magenta),
 plot(f(i-dd),i=1+dd..max(dd+nops(T),120)),
# seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
 view=[1..nops(T)+dd+1,1..T[nops(T)]*1.1],labels=[t,N(t)],gridlines=true
);
```

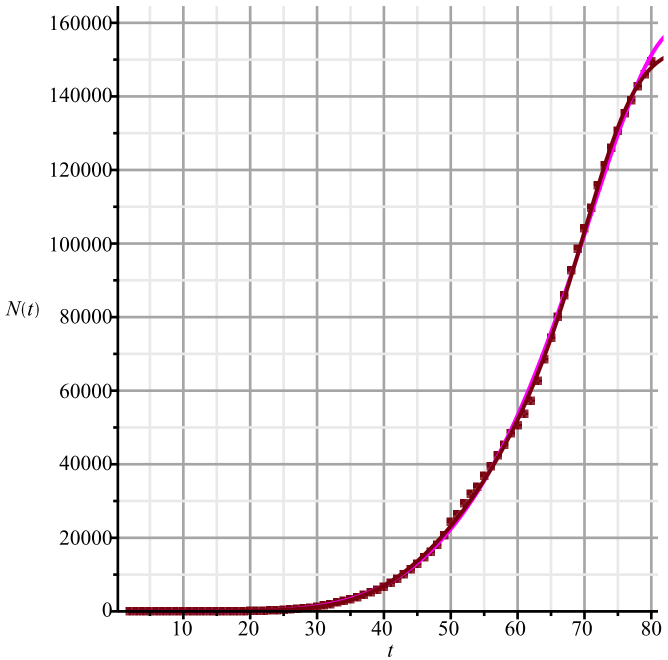




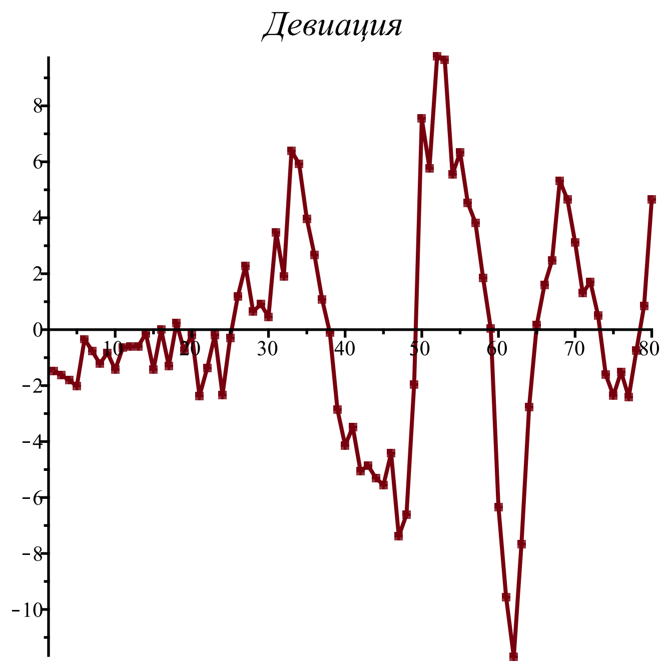
N(t)
10^5
10^4
10^3
10^2
10^1
10^0
10
20
30
40
50
60
70
80
t



150000
100000
50000
0
N(t)
10
20
30
40
50
60
70
80
t




```
> dT:=[[i,(T[i-dd]-f(i-dd))/sigma(f(i-dd))] $ i=1+dd..dd+nops(T)]:
  display( plot(%), plot(%,style=point,symbolsize=8,symbol=solidcircle),t i t l e = ` `    ,titlefont=
  [roman,20] );
```




```
> `=====================================`;
  `FORECAST`;
  `=====================================`;
```

===

FORECAST

=== (5

```
> proc3:=proc(E)
   E[1]*convert(map(X->X^coeff(E[2],X,1),M),`*`);
  end:

  proc2:=proc(X,E)
   proc3(E)*(coeff(E[3],X,1)-coeff(E[2],X,1));
  end:

  proc1:=proc(X)
   convert(map(E->proc2(X,E),L),`+`);
  end:
```

```
> A:='A': B:='B': C:='C': M:=[A,B,C];

  L:=[
   [P[`01`],0,A],
   [(B/K)*P[`12`],A,B],
   [P[`23`],B,C],
   [P[`10`],A,0], [P[`20`],B,0], [P[`30`],C,0]
  ]: Matrix(%);

  eqs:=map(X->Diff(X,t)=proc1(X),M); Vector(%);
```

$$M := [A, B, C]$$

$$\begin{bmatrix} P_{01} & 0 & A \\ \frac{B\,P_{12}}{K} & A & B \\ P_{23} & B & C \\ P_{10} & A & 0 \\ P_{20} & B & 0 \\ P_{30} & C & 0 \end{bmatrix}$$

$$eqs := \left[\frac{\partial}{\partial t} A = P_{01} - \frac{B\,P_{12}\,A}{K} - P_{10}\,A,\ \frac{\partial}{\partial t} B = \frac{B\,P_{12}\,A}{K} - P_{23}\,B - P_{20}\,B,\ \frac{\partial}{\partial t} C = P_{23}\,B - P_{30}\,C \right]$$

$$\begin{bmatrix} \frac{\partial}{\partial t} A = P_{01} - \frac{B\,P_{12}\,A}{K} - P_{10}\,A \\ \frac{\partial}{\partial t} B = \frac{B\,P_{12}\,A}{K} - P_{23}\,B - P_{20}\,B \\ \frac{\partial}{\partial t} C = P_{23}\,B - P_{30}\,C \end{bmatrix} \tag{6}$$

```
> v:=M; alpha:='alpha': K:=k0; tA:=[1,15,35,50,58,62,73,nops(T)+dd]; kA:=['k1x||i' $ i=1..nops(tA)]
  ;

  par:=[d0,k0,op(kA),k2a,k2b,k3];

  param:=[
    P[`01`]=0,  P[`12`]=alpha(t,op(kA)), P[`23`]=beta(t,k2a,k2b),
    P[`10`]=0, P[`20`]=k3
  ];

  init:=[   A(-d0)=K,   B(-d0)=1,   C(-d0)=0  ];
```

$$v := [A, B, C]$$

$$K := k0$$

$$tA := [1, 15, 35, 50, 58, 62, 73, 80]$$

$$kA := [k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8]$$

$$par := [d0, k0, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8, k2a, k2b, k3]$$

$$param := \left[P_{01} = 0, P_{12} = \alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8), P_{23} = \beta(t, k2a, k2b), P_{10} = 0, P_{20} = k3\right]$$

$$init := [A(-d0) = k0, B(-d0) = 1, C(-d0) = 0] \quad (7$$

```
> res:=solve(map(rhs,eqs[1..2]),v[1..2]); res:=res[2]: subs(P[`30`]=P[`10`],param,res);

  J:=Matrix(subs(res,map(q->grad(rhs(q),v[1..2]),eqs[1..2]))); evalm(%-lambda): collect(Determinant
  (%),lambda);

  subs(P[`30`]=P[`10`],pr(param),%); solve(%,{lambda});
```

$$res := \left[\left[A = \frac{P_{01}}{P_{10}}, B = 0\right], \left[A = \frac{k0\,(P_{23} + P_{20})}{P_{12}}, B = -\frac{k0\,P_{10}\,P_{20} + k0\,P_{10}\,P_{23} - P_{01}\,P_{12}}{P_{12}\,(P_{23} + P_{20})}\right]\right]$$

$$\left[A = \frac{k0\,(\beta(t, k2a, k2b) + k3)}{\alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8)}, B = 0\right]$$

$$J := \begin{bmatrix} \frac{k0\,P_{10}\,P_{20} + k0\,P_{10}\,P_{23} - P_{01}\,P_{12}}{(P_{23} + P_{20})\,k0} - P_{10} & -P_{23} - P_{20} \\ -\frac{k0\,P_{10}\,P_{20} + k0\,P_{10}\,P_{23} - P_{01}\,P_{12}}{(P_{23} + P_{20})\,k0} & 0 \end{bmatrix}$$

$$\frac{(k0\,P_{20} + k0\,P_{23})\,\lambda^2}{(P_{23} + P_{20})\,k0} + \frac{P_{01}\,P_{12}\,\lambda}{(P_{23} + P_{20})\,k0} + \frac{-k0\,P_{10}\,P_{20}^2 - 2\,k0\,P_{10}\,P_{20}\,P_{23} - k0\,P_{10}\,P_{23}^2 + P_{01}\,P_{12}\,P_{20} + P_{01}\,P_{12}\,P_{23}}{(P_{23} + P_{20})\,k0}$$

$$[P_{01} = 0, P_{12} = \alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8), P_{23} = \beta(t, k2a, k2b), P_{10} = 0, P_{20} = k3]$$

$$\frac{(k0\,k3 + k0\,\beta(t, k2a, k2b))\,\lambda^2}{(\beta(t, k2a, k2b) + k3)\,k0}$$

$$\{\lambda = 0\}, \{\lambda = 0\} \qquad (8$$

```
> Eqs:=subs(map(q->q=q(t),v),Diff=diff,P[`30`]=P[`10`],param,eqs); #dsolve(%);
```

$$Eqs := \left[\frac{d}{dt}\,A(t) = -\frac{B(t)\,\alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8)\,A(t)}{k0}, \frac{d}{dt}\,B(t) = \frac{B(t)\,\alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8)\,A(t)}{k0} - \beta(t, k2a, k2b)\,B(t) - k3\,B(t), \frac{d}{dt}\,C(t) = \beta(t, k2a, k2b)\,B(t)\right] \qquad (9$$

```
> N:='N': A:='A': B:='B': C:='C': val:=valp:

  #alpha:=unapply(simplify(evalf(piecewise(t<tA[1],kA[1],t<tA[2],Lag(t,tA[1..3],kA[1..3]),
  # seq(op([t<tA[i+1],(Lag(t,tA[i-1..i+1],kA[i-1..i+1])+Lag(t,tA[i..i+2],kA[i..i+2]))/2]),i=2..nops
  (kA)-2),
  #t<tA[nops(tA)],Lag(t,tA[nops(tA)-2..nops(tA)],kA[nops(kA)-2..nops(kA)]),
  #kA[nops(kA)]))),t,op(kA));

  alpha:=unapply(simplify(evalf(piecewise(t<tA[1],kA[1],t<tA[3],Lag(t,tA[1..4],kA[1..4]),
   seq(op([t<tA[i+1],Lag(t,tA[i-1..i+2],kA[i-1..i+2])]),i=3..nops(kA)-3),
  t<tA[nops(tA)],Lag(t,tA[nops(tA)-3..nops(tA)],kA[nops(kA)-3..nops(kA)]),
  kA[nops(kA)]))),t,op(kA));

  beta:=(t,k2a,k2b)->piecewise(t<69,k2a,k2b);
```

```
EQS:=[op(Eqs),op(init)]:

res:=dsolve(EQS,numeric,map(q->q(t),v),output=listprocedure,parameters=par); assign('v[i]=subs
(res,v[i](t))' $ i=1..nops(v)):

chi2a:='chi2a': chi2:=unapply(chi2a(x0,xx,kA,x2a,x2b,x3),x0,xx,op(kA),x2a,x2b,x3):

chi2a:=proc(x0,xx,x1,x2a,x2b,x3) local i; global K_; K_:=xx;
  res(parameters=[corr(par,[x0,xx,op(x1),x2a,x2b,x3])]):
  sum((T[i]-(K_-A(i+dd)))^2/(K_-A(i+dd)),i=1..nops(T))+
  sum((T2[i]-B(i+dd))^2/B(i+dd),i=1..nops(T2))+
  sum((T1[i]-C(i+dd))^2/C(i+dd),i=1..nops(T1));
end:

chi2(op(pr(val))); val:=findMin(chi2,val); chi2(op(%));

#plot(map(q->q(t),v),t=0..3.0e4,legend=[``,``,``],
#linestyle=[solid,dash,dashdot],gridlines=true);

writedata(cat(Region,`3c.txt`),val);

display(
 plot(map(q->q(t),v),t=0..300,legend=[``,``,``],
  linestyle=[solid,dash,dashdot],gridlines=true),
 plot([[seq([i+dd,K_-T[i]],i=1..nops(T))]],style=point,symbolsize=7,symbol=asterisk),
 plot([[seq([i+dd,T1[i]],i=1..nops(T1))]],style=point,symbolsize=7,symbol=circle),
 plot([[seq([i+dd,T2[i]],i=1..nops(T2))]],style=point,symbolsize=7,symbol=diamond,color=black),
 size=[1000,400],legendstyle=[font=[roman,15]]
): fdisplay(cat(Region,`3c`),%);
```

$$\alpha := (t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8) \mapsto \begin{cases} (-0.00004287429258 \cdot k1x1 + 0.0001020408163 \cdot k1x2 - 0.00009803921574 \cdot k1x3 + 0.0 \\ (-0.00003322259134 \cdot k1x2 + 0.0001449275363 \cdot k1x3 - 0.0002380952381 \cdot k1x \\ (-0.0001073537306 \cdot k1x3 + 0.0006944444445 \cdot k1x4 - 0.001358695652 \cdot \\ (-0.0004528985509 \cdot k1x4 + 0.002083333333 \cdot k1x5 - 0.001893939394 \cdot k \\ (-0.0007575757577 \cdot k1x5 + 0.001262626263 \cdot k1x6 - 0.0008658008661 \cdot \end{cases}$$

$$\beta := (t, k2a, k2b) \mapsto \begin{cases} k2a & t < 69 \\ k2b & otherwise \end{cases}$$

$res := [t = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, A(t) = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, B(t) = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, C(t) = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}]$

[14.27740482, 174749.1178, 0.1117266754, 0.2271766454, 0.1688488824, 0.1329698842, 0.09277648654, 0.1292567042, 0.1635178464, 0.1628294314, 0.009733504258, 0.01978215744, 0.00009706018508]

3469.30581140466

3469.30581140466

3443.18750903512

3429.92692785211

3429.34469590459

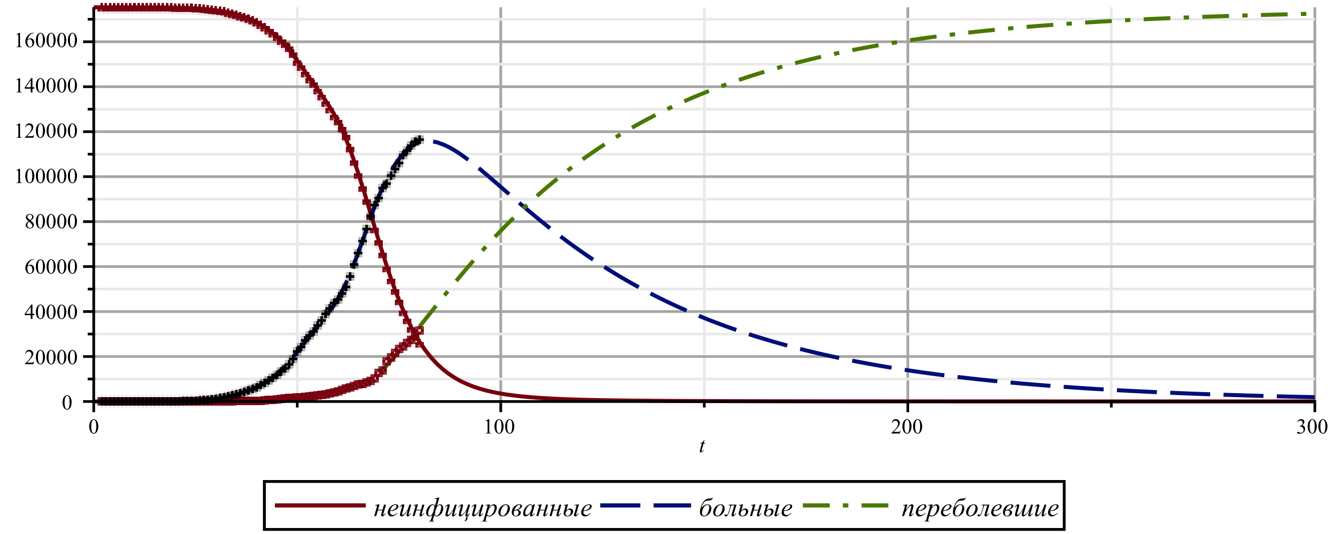
3428.32418597274

3428.29829986885

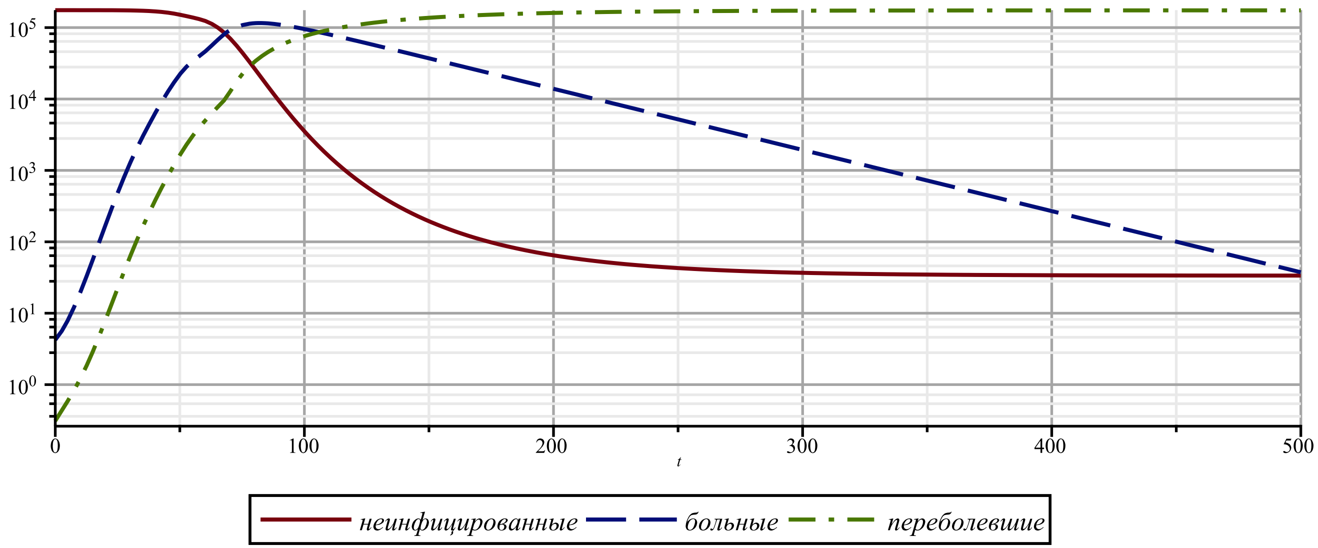
val ≔ [14.2387162629638, 175334.877789389, 0.111218824689690, 0.227491840059972, 0.169305909414144, 0.132863412188621, 0.0930754930998156, 0.128330467069723, 0.163065115204793, 0.163040075451214, 0.00973039757451593, 0.0196595639715861, 0.0000969856731488592]

3428.29829986885

Moscow3c.jpg

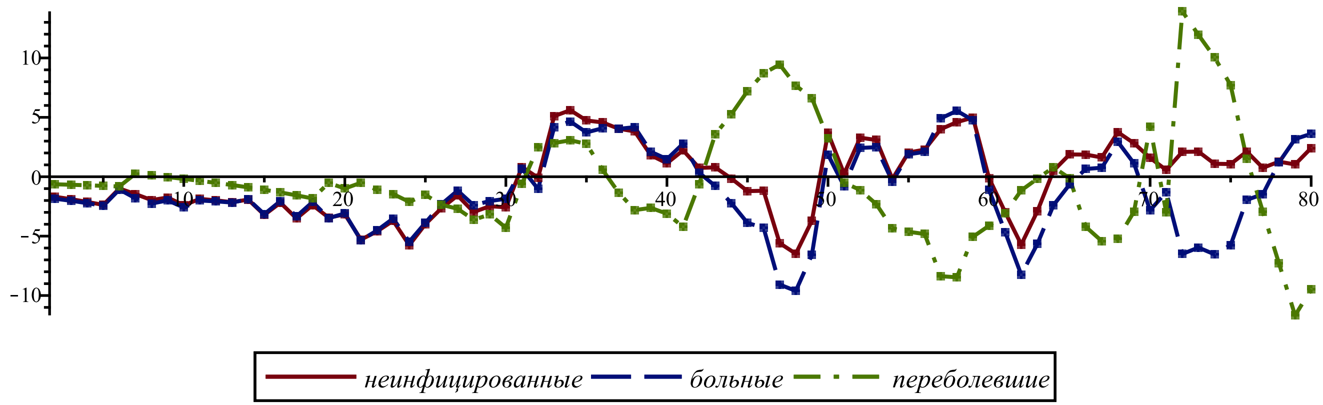



```
> logplot(map(q->q(t),v), t=0..500, legend=[``,``,``],
  linestyle=[solid,dash,dashdot],gridlines=true,size=[1000,400],legendstyle=[font=[roman,15]]);
```

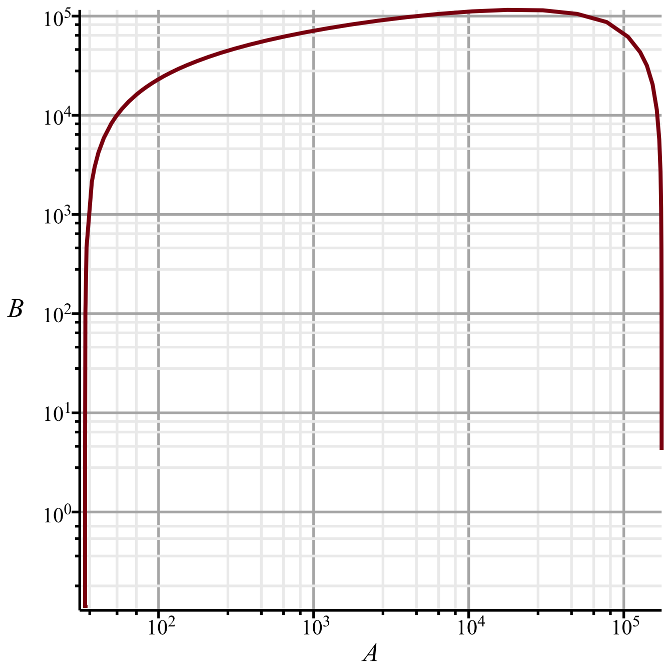



```
> display(
   plot([
    [[i,(T[i-dd]-(K_-A(i)))/sigma(K_-A(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T2[i-dd]-(B(i)))/sigma(B(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T1[i-dd]-(C(i)))/sigma(C(i))] $ i=1+dd..dd+nops(T)]
   ],linestyle=[solid,dash,dashdot],legend=[` `,` `,` `]                        ),
   plot([
    [[i,(T[i-dd]-(K_-A(i)))/sigma(K_-A(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T2[i-dd]-(B(i)))/sigma(B(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T1[i-dd]-(C(i)))/sigma(C(i))] $ i=1+dd..dd+nops(T)]
   ],style=point,symbolsize=8,symbol=solidcircle),
   size=[1000,300],legendstyle=[font=[roman,15]]
  ): fdisplay(cat(Region,`3c-dev`),%);
```

Moscow3c-dev.jpg




```
> plot([v[1](t),v[2](t),t=0..3.0e4],axis[1]=[mode=log],axis[2]=[mode=log],labels=[v[1],v[2]],
  labelfont=[roman,15],gridlines=true);
```

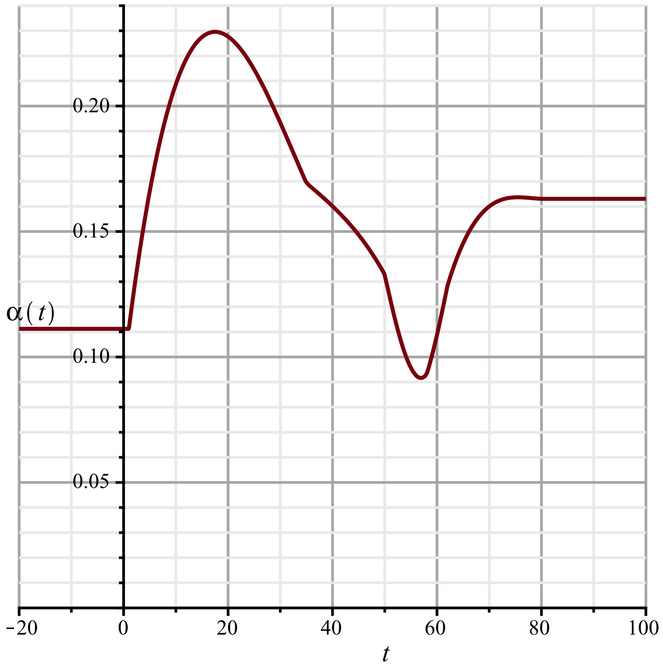



```
> [seq([i,(
   (T[i-dd]-T[i-dd-1]) /(T2[i-dd]+T2[i-dd-1]) /((1-T[i-dd]/K_)+(1-T[i-dd-1]/K_))
  )*4],i=1+dd+1..nops(T)+dd)]: [seq([%[i][1],(%[i-1][2]+%[i][2]+%[i+1][2])/3],i=2..nops(%)-1)]:
```

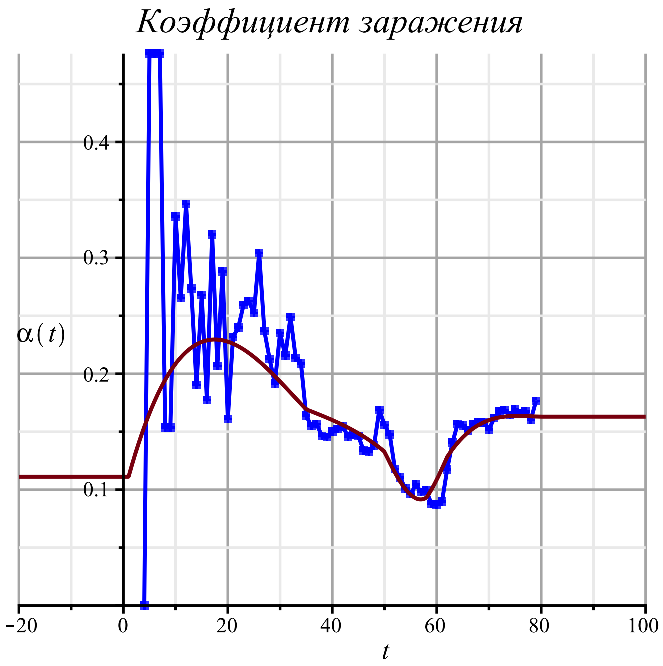
```
Palpha:=display(plot([%],color=blue),plot([%],style=point,symbolsize=8,symbol=solidcircle,color=
blue)):
#display(%,gridlines=true,labels=['t','alpha(t)'],labelfont=[roman,15],view=[0..nops(T)+dd,0.
.0.9]);

subs(corr(par,val),alpha(t, op(kA)));
plot(%,t=-20..100,gridlines=true,labels=['t',''alpha(t)''],labelfont=[roman,15],view=[-20..100,0.
.0.24]):
fdisplay(cat(Region,`3c-zar`),%); display([Palpha,%],t i t l e = `   `                ,titlefont=
[roman,20]);
```

$$\begin{cases} 0.111218824689690 & t < 1. \\ 7.01116454415445\ 10^{-6}\ t^3 - 0.000687407978747371\ t^2 + 0.0176140524118115\ t + 0.0942851689989880 & t < 35. \\ -2.89108700028207\ 10^{-6}\ t^3 + 0.000302817179386333\ t^2 - 0.0123402586403920\ t + 0.354219273245842 & t < 50. \\ 0.0000466497918135028\ t^3 - 0.00678152850443779\ t^2 + 0.318592812315531\ t - 4.67417992964219 & t < 58. \\ -0.0000663480868064319\ t^3 + 0.0124281108586837\ t^2 - 0.765734830962850\ t + 15.6428386398418 & t < 62. \\ 9.15652892577350\ 10^{-6}\ t^3 - 0.00214427995619127\ t^2 + 0.167200200020820\ t - 4.17772699899413 & t < 80. \\ 0.163040075451214 & 80. \le t \end{cases}$$

Moscow3c-zar.jpg



α(t)
0.20
0.15
0.10
0.05
-20
0
20
40
60
80
100
t


Коэффициент заражения
α(t)
0.4
0.3
0.2
0.1
-20
0
20
40
60
80
100
t