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

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

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

#valp := [12.0545284599666, 40487.7036090492, 0.0878540675828671, 0.119034763474605,
0.208571881538399, 0.163876229453231, #0.0804863589181470, 0.0940935501988715, 0.105057419991328,
0.104244846871936, 0.00441107479765352, 0.00987259141378349, #0.000931839501779284];

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:
```

$Region := Mosobl$

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

$valp :=$ [12.11547222, 40685.61891, 0.08860157496, 0.1194914102, 0.206504248, 0.1639018944, 0.08136304104, 0.09362917651, 0.1050655024, 0.104521194, 0.004380244938, 0.01024923215, 0.00009329616206]

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

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

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

```
> `====================================`;
`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:
```

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

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

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

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

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

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

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

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

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

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

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

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

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

```
> 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..%];
```

``

Mosobl

"OK"

tA := [[8, 3, 20, 1, 0, 0], [9, 3, 20, 1, 0, 0], [10, 3, 20, 1, 0, 0], [11, 3, 20, 3, 0, 0], [12, 3, 20, 3, 0, 0], [13, 3, 20, 4, 0, 0], [14, 3, 20, 5, 0, 0], [15, 3, 20, 8, 0, 0], [16, 3, 20, 9, 0, 0], [17, 3, 20, 11, 0, 0], [18, 3, 20, 12, 0, 0], [19, 3, 20, 17, 0, 0], [20, 3, 20, 18, 0, 1], [21, 3, 20, 35, 0, 1], [22, 3, 20, 35, 0, 1], [23, 3, 20, 35, 0, 1], [24, 3, 20, 35, 0, 2], [25, 3, 20, 41, 0, 7], [26, 3, 20, 41, 0, 7], [27, 3, 20, 49, 0, 8], [28, 3, 20, 85, 0, 8], [29, 3, 20, 112, 0, 10], [30, 3, 20, 119, 0, 10], [31, 3, 20, 119, 0, 14], [1, 4, 20, 134, 1, 17], [2, 4, 20, 177, 2, 17], [3, 4, 20, 211, 2, 17], [4, 4, 20, 260, 2, 30], [5, 4, 20, 305, 2, 33], [6, 4, 20, 387, 3, 34], [7, 4, 20, 454, 8, 47], [8, 4, 20, 549, 10, 50], [9, 4, 20, 748, 13, 52], [10, 4, 20, 930, 13, 66], [11, 4, 20, 1082, 14, 69], [12, 4, 20, 1360, 18, 75], [13, 4, 20, 1855, 19, 75], [14, 4, 20, 2315, 24, 75], [15, 4, 20, 2587, 26, 75], [16, 4, 20, 3054, 33, 91], [17, 4, 20, 3526, 40, 105], [18, 4, 20, 3954, 40, 126], [19, 4, 20, 4663, 49, 162], [20, 4, 20, 5241, 49, 176], [21, 4, 20, 5959, 49, 179], [22, 4, 20, 6590, 56, 186], [23, 4, 20, 7278, 56, 186], [24, 4, 20, 7889, 66, 235], [25, 4, 20, 8494, 69, 262], [26, 4, 20, 9070, 71, 272], [27, 4, 20, 9708, 71, 286], [28, 4, 20, 10231, 74, 311], [29, 4, 20, 10917, 90, 389], [30, 4, 20, 11710, 93, 430], [1, 5, 20, 12507, 109, 458], [2, 5, 20, 13314, 109, 503], [3, 5, 20, 14136, 111, 507], [4, 5, 20, 14939, 111, 526], [5, 5, 20, 15761, 127, 576], [6, 5, 20, 16590, 141, 611], [7, 5, 20, 17432, 156, 769], [8, 5, 20, 18350, 175, 813], [9, 5, 20, 19425, 186, 1030], [10, 5, 20, 20558, 195, 1236], [11, 5, 20, 21637, 209, 1389], [12, 5, 20, 22700, 219, 1582], [13, 5, 20, 23662, 226, 1745], [14, 5, 20, 24580, 240, 1987], [15, 5, 20, 25525, 253, 2468], [16, 5, 20, 26462, 262, 2724], [17, 5, 20, 27369, 268, 3088], [18, 5, 20, 28290, 268, 3361], [19, 5, 20, 29188, 271, 3614]]

dd := 7

Mosobl

T = [1, 1, 1, 3, 3, 4, 5, 8, 9, 11, 12, 17, 18, 35, 35, 35, 35, 41, 41, 49, 85, 112, 119, 119, 134, 177, 211, 260, 305, 387, 454, 549, 748, 930, 1082, 1360, 1855, 2315, 2587, 3054, 3526, 3954, 4663, 5241, 5959, 6590, 7278, 7889, 8494, 9070, 9708, 10231, 10917, 11710, 12507, 13314, 14136, 14939, 15761, 16590, 17432, 18350, 19425, 20558, 21637, 22700, 23662, 24580, 25525, 26462, 27369, 28290, 29188]

$T1$ = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 2, 7, 7, 8, 8, 10, 10, 14, 17, 17, 17, 30, 33, 34, 47, 50, 52, 66, 69, 75, 75, 75, 75, 91, 105, 126, 162, 176, 179, 186, 186, 235, 262, 272, 286, 311, 389, 430, 458, 503, 507, 526, 576, 611, 769, 813, 1030, 1236, 1389, 1582, 1745, 1987, 2468, 2724, 3088, 3361, 3614]

$T2$ = [1, 1, 1, 3, 3, 4, 5, 8, 9, 11, 12, 17, 17, 34, 34, 34, 33, 34, 34, 41, 77, 102, 109, 105, 116, 158, 192, 228, 270, 350, 399, 489, 683, 851, 999, 1267, 1761, 2216, 2486, 2930, 3381, 3788, 4452, 5016, 5731, 6348, 7036, 7588, 8163, 8727, 9351, 9846, 10438, 11187, 11940, 12702, 13518, 14302, 15058, 15838, 16507, 17362, 18209, 19127, 20039, 20899, 21691, 22353, 22804, 23476, 24013, 24661, 25303]

$T3$ = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 2, 2, 2, 2, 3, 8, 10, 13, 13, 14, 18, 19, 24, 26, 33, 40, 40, 49, 49, 49, 56, 56, 66, 69, 71, 71, 74, 90, 93, 109, 109, 111, 111, 127, 141, 156, 175, 186, 195, 209, 219, 226, 240, 253, 262, 268, 268, 271]

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[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

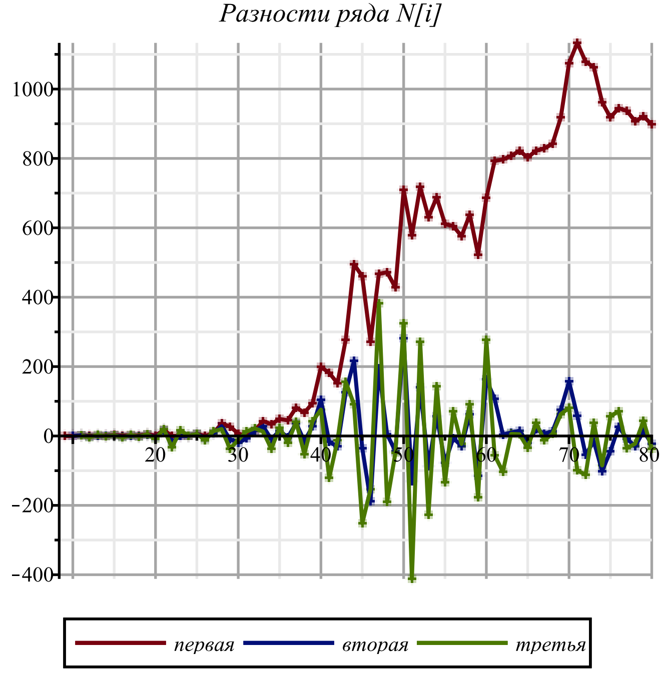
```
> h:=x->x;

[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
);
```

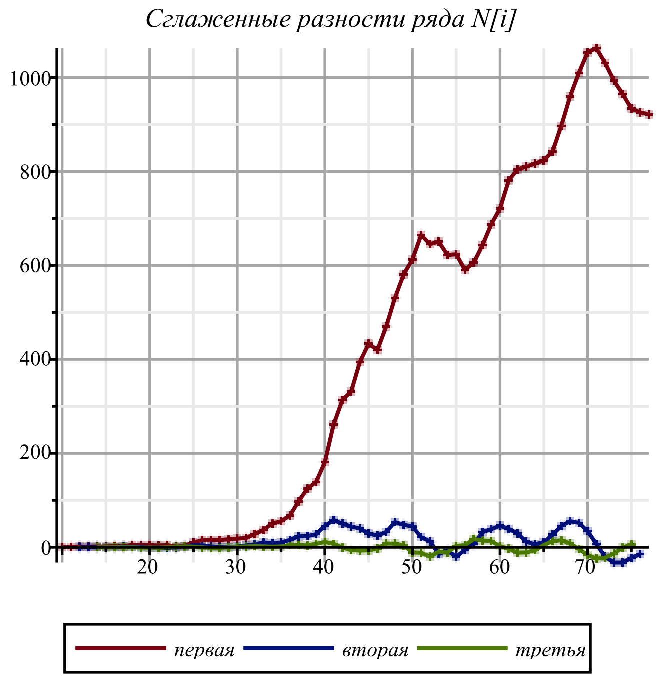
$$h := x \mapsto x$$

[0, 0, 2, 0, 1, 1, 3, 1, 2, 1, 5, 1, 17, 0, 0, 0, 6, 0, 8, 36, 27, 7, 0, 15, 43, 34, 49, 45, 82, 67, 95, 199, 182, 152, 278, 495, 460, 272, 467, 472, 428, 709, 578, 718, 631, 688, 611, 605, 576, 638, 523, 686, 793, 797, 807, 822, 803, 822, 829, 842, 918, 1075, 1133, 1079, 1063, 962, 918, 945, 937, 907, 921, 898]

[0, 2, −2, 1, 0, 2, −2, 1, −1, 4, −4, 16, −17, 0, 0, 6, −6, 8, 28, −9, −20, −7, 15, 28, −9, 15, −4, 37, −15, 28, 104, −17, −30, 126, 217, −35, −188, 195, 5, −44, 281, −131, 140, −87, 57, −77, −6, −29, 62, −115, 163, 107, 4, 10, 15, −19, 19, 7, 13, 76, 157, 58, −54, −16, −101, −44, 27, −8, −30, 14, −23]

[2, −4, 3, −1, 2, −4, 3, −2, 5, −8, 20, −33, 17, 0, 6, −12, 14, 20, −37, −11, 13, 22, 13, −37, 24, −19, 41, −52, 43, 76, −121, −13, 156, 91, −252, −153, 383, −190, −49, 325, −412, 271, −227, 144, −134, 71, −23, 91, −177, 278, −56, −103, 6, 5, −34, 38, −12, 6, 63, 81, −99, −112, 38, −85, 57, 71, −35, −22, 44, −37]






```
> 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
);
```

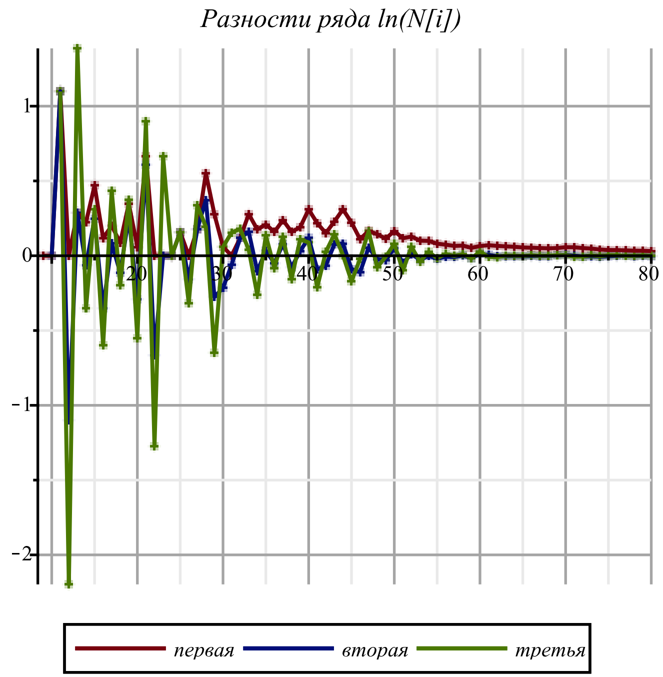
$$h := x \mapsto \ln(x)$$

[0, 0, ln(3), 0, 2 ln(2) − ln(3), ln(5) − 2 ln(2), 3 ln(2) − ln(5), 2 ln(3) − 3 ln(2), ln(11) − 2 ln(3), ln(12) − ln(11), ln(17) − ln(12), ln(18) − ln(17), ln(35) − ln(18), 0, 0, 0, ln(41) − ln(35), 0, 2 ln(7) − ln(41), ln(85) − 2 ln(7), ln(112) − ln(85), ln(119) − ln(112), 0, ln(134) − ln(119), ln(177) − ln(134), ln(211) − ln(177), ln(260) − ln(211), ln(305) − ln(260), ln(387) − ln(305), ln(454) − ln(387), ln(549) − ln(454), ln(748) − ln(549), ln(930) − ln(748), ln(1082) − ln(930), ln(1360) − ln(1082), ln(1855) − ln(1360), ln(2315) − ln(1855), ln(2587) − ln(2315), ln(3054) − ln(2587), ln(3526) − ln(3054), ln(3954) − ln(3526), ln(4663) − ln(3954), ln(5241) − ln(4663), ln(5959) − ln(5241), ln(6590) − ln(5959), ln(7278) − ln(6590), ln(7889) − ln(7278), ln(8494) − ln(7889), ln(9070) − ln(8494), ln(9708) − ln(9070), ln(10231) − ln(9708), ln(10917) − ln(10231), ln(11710) − ln(10917), ln(12507) − ln(11710), ln(13314) − ln(12507), ln(14136) − ln(13314), ln(14939) − ln(14136), ln(15761) − ln(14939), ln(16590) − ln(15761), ln(17432) − ln(16590), ln(18350) − ln(17432), ln(19425) − ln(18350), ln(20558) − ln(19425), ln(21637) − ln(20558), ln(22700) − ln(21637), ln(23662) − ln(22700), ln(24580) − ln(23662), ln(25525) − ln(24580), ln(26462) − ln(25525), ln(27369) − ln(26462), ln(28290) − ln(27369), ln(29188) − ln(28290)]

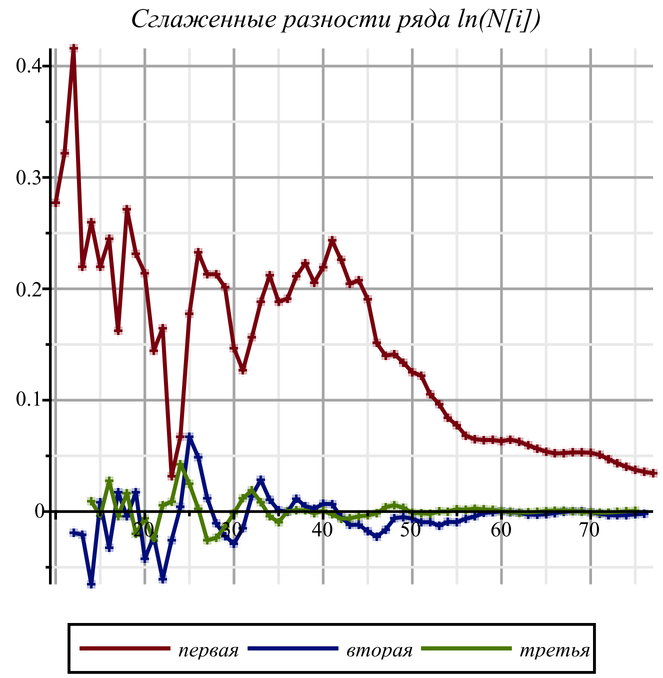
[0, ln(3), -ln(3), 2 ln(2) − ln(3), ln(5) − 4 ln(2) + ln(3), 5 ln(2) − 2 ln(5), 2 ln(3) − 6 ln(2) + ln(5), ln(11) − 4 ln(3) + 3 ln(2), ln(12) − 2 ln(11) + 2 ln(3), ln(17) − 2 ln(12) + ln(11), ln(18) − 2 ln(17) + ln(12), ln(35) − 2 ln(18) + ln(17), -ln(35) + ln(18), 0, 0, ln(41) − ln(35), -ln(41) + ln(35), 2 ln(7) − ln(41), ln(85) − 4 ln(7) + ln(41), ln(112) − 2 ln(85) + 2 ln(7), ln(119) − 2 ln(112) + ln(85), -ln(119) + ln(112), ln(134) − ln(119), ln(177) − 2 ln(134) + ln(119), ln(211) − 2 ln(177) + ln(134), ln(260) − 2 ln(211) + ln(177), ln(305) − 2 ln(260) + ln(211), ln(387) − 2 ln(305) + ln(260), ln(454) − 2 ln(387) + ln(305), ln(549) − 2 ln(454) + ln(387), ln(748) − 2 ln(549) + ln(454), ln(930) − 2 ln(748) + ln(549), ln(1082) − 2 ln(930) + ln(748), ln(1360) − 2 ln(1082) + ln(930), ln(1855) − 2 ln(1360) + ln(1082), ln(2315) − 2 ln(1855) + ln(1360), ln(2587) − 2 ln(2315) + ln(1855), ln(3054) − 2 ln(2587) + ln(2315), ln(3526) − 2 ln(3054) + ln(2587), ln(3954) − 2 ln(3526) + ln(3054), ln(4663) − 2 ln(3954) + ln(3526), ln(5241) − 2 ln(4663) + ln(3954), ln(5959) − 2 ln(5241) + ln(4663), ln(6590) − 2 ln(5959) + ln(5241), ln(7278) − 2 ln(6590) + ln(5959), ln(7889) − 2 ln(7278) + ln(6590), ln(8494) − 2 ln(7889) + ln(7278), ln(9070) − 2 ln(8494) + ln(7889), ln(9708) − 2 ln(9070) + ln(8494), ln(10231) − 2 ln(9708) + ln(9070), ln(10917) − 2 ln(10231) + ln(9708), ln(11710) − 2 ln(10917) + ln(10231), ln(12507) − 2 ln(11710) + ln(10917), ln(13314) − 2 ln(12507) + ln(11710), ln(14136) − 2 ln(13314) + ln(12507), ln(14939) − 2 ln(14136) + ln(13314), ln(15761) − 2 ln(14939) + ln(14136), ln(16590) − 2 ln(15761) + ln(14939), ln(17432) − 2 ln(16590) + ln(15761), ln(18350) − 2 ln(17432) + ln(16590), ln(19425) − 2 ln(18350) + ln(17432), ln(20558) − 2 ln(19425) + ln(18350), ln(21637) − 2 ln(20558) + ln(19425), ln(22700) − 2 ln(21637) + ln(20558), ln(23662) − 2 ln(22700) + ln(21637), ln(24580) − 2 ln(23662) + ln(22700), ln(25525) − 2 ln(24580) + ln(23662), ln(26462)

$-2\ln(25525)+\ln(24580), \ln(27369)-2\ln(26462)+\ln(25525), \ln(28290)-2\ln(27369)+\ln(26462), \ln(29188)-2\ln(28290)+\ln(27369)]$

$[\ln(3), -2\ln(3), 2\ln(2), 2\ln(3)-6\ln(2)+\ln(5), 9\ln(2)-3\ln(5)-\ln(3), 2\ln(3)-11\ln(2)+3\ln(5), \ln(11)-6\ln(3)+9\ln(2)-\ln(5), \ln(12)-3\ln(11)+6\ln(3)-3\ln(2), \ln(17)-3\ln(12)+3\ln(11)-2\ln(3), \ln(18)-3\ln(17)+3\ln(12)-\ln(11), \ln(35)-3\ln(18)+3\ln(17)-\ln(12), -2\ln(35)+3\ln(18)-\ln(17), \ln(35)-\ln(18), 0, \ln(41)-\ln(35), -2\ln(41)+2\ln(35), 2\ln(7)-\ln(35), \ln(85)-6\ln(7)+2\ln(41), \ln(112)-3\ln(85)+6\ln(7)-\ln(41), \ln(119)-3\ln(112)+3\ln(85)-2\ln(7), -2\ln(119)+3\ln(112)-\ln(85), \ln(134)-\ln(112), \ln(177)-3\ln(134)+2\ln(119), \ln(211)-3\ln(177)+3\ln(134)-\ln(119), \ln(260)-3\ln(211)+3\ln(177)-\ln(134), \ln(305)-3\ln(260)+3\ln(211)-\ln(177), \ln(387)-3\ln(305)+3\ln(260)-\ln(211), \ln(454)-3\ln(387)+3\ln(305)-\ln(260), \ln(549)-3\ln(454)+3\ln(387)-\ln(305), \ln(748)-3\ln(549)+3\ln(454)-\ln(387), \ln(930)-3\ln(748)+3\ln(549)-\ln(454), \ln(1082)-3\ln(930)+3\ln(748)-\ln(549), \ln(1360)-3\ln(1082)+3\ln(930)-\ln(748), \ln(1855)-3\ln(1360)+3\ln(1082)-\ln(930), \ln(2315)-3\ln(1855)+3\ln(1360)-\ln(1082), \ln(2587)-3\ln(2315)+3\ln(1855)-\ln(1360), \ln(3054)-3\ln(2587)+3\ln(2315)-\ln(1855), \ln(3526)-3\ln(3054)+3\ln(2587)-\ln(2315), \ln(3954)-3\ln(3526)+3\ln(3054)-\ln(2587), \ln(4663)-3\ln(3954)+3\ln(3526)-\ln(3054), \ln(5241)-3\ln(4663)+3\ln(3954)-\ln(3526), \ln(5959)-3\ln(5241)+3\ln(4663)-\ln(3954), \ln(6590)-3\ln(5959)+3\ln(5241)-\ln(4663), \ln(7278)-3\ln(6590)+3\ln(5959)-\ln(5241), \ln(7889)-3\ln(7278)+3\ln(6590)-\ln(5959), \ln(8494)-3\ln(7889)+3\ln(7278)-\ln(6590), \ln(9070)-3\ln(8494)+3\ln(7889)-\ln(7278), \ln(9708)-3\ln(9070)+3\ln(8494)-\ln(7889), \ln(10231)-3\ln(9708)+3\ln(9070)-\ln(8494), \ln(10917)-3\ln(10231)+3\ln(9708)-\ln(9070), \ln(11710)-3\ln(10917)+3\ln(10231)-\ln(9708), \ln(12507)-3\ln(11710)+3\ln(10917)-\ln(10231), \ln(13314)-3\ln(12507)+3\ln(11710)-\ln(10917), \ln(14136)-3\ln(13314)+3\ln(12507)-\ln(11710), \ln(14939)-3\ln(14136)+3\ln(13314)-\ln(12507), \ln(15761)-3\ln(14939)+3\ln(14136)-\ln(13314), \ln(16590)-3\ln(15761)+3\ln(14939)-\ln(14136), \ln(17432)-3\ln(16590)+3\ln(15761)-\ln(14939), \ln(18350)-3\ln(17432)+3\ln(16590)-\ln(15761), \ln(19425)-3\ln(18350)+3\ln(17432)-\ln(16590), \ln(20558)-3\ln(19425)+3\ln(18350)-\ln(17432), \ln(21637)-3\ln(20558)+3\ln(19425)-\ln(18350), \ln(22700)-3\ln(21637)+3\ln(20558)-\ln(19425), \ln(23662)-3\ln(22700)+3\ln(21637)-\ln(20558), \ln(24580)-3\ln(23662)+3\ln(22700)-\ln(21637), \ln(25525)-3\ln(24580)+3\ln(23662)-\ln(22700), \ln(26462)-3\ln(25525)+3\ln(24580)-\ln(23662), \ln(27369)-3\ln(26462)+3\ln(25525)-\ln(24580), \ln(28290)-3\ln(27369)+3\ln(26462)-\ln(25525), \ln(29188)-3\ln(28290)+3\ln(27369)-\ln(26462)]$



Разности ряда ln(N[i])
1
0
−1
−2
20
30
40
50
60
70
80
первая
вторая
третья




```
> 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
  );
```

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

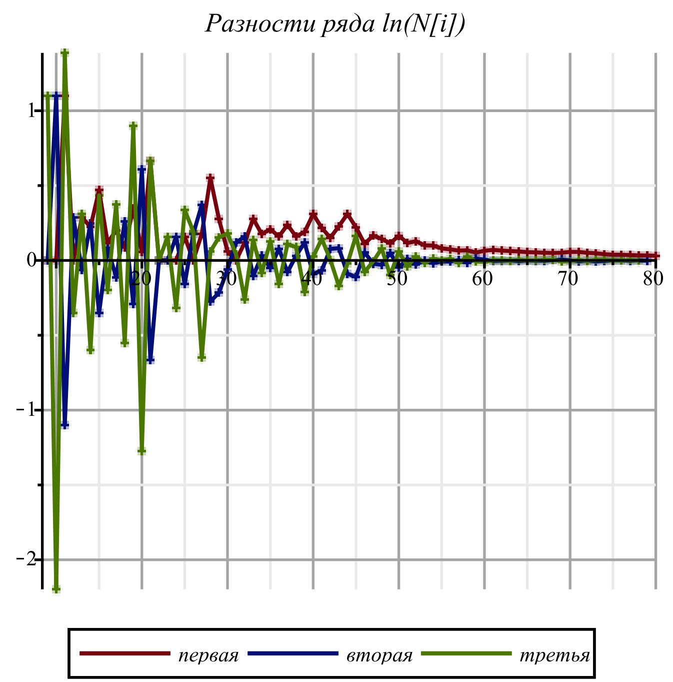
$[0, 0, \ln(3), 0, 2\ln(2) - \ln(3), \ln(5) - 2\ln(2), 3\ln(2) - \ln(5), 2\ln(3) - 3\ln(2), \ln(11) - 2\ln(3), \ln(12) - \ln(11), \ln(17) - \ln(12),$
$\ln(18) - \ln(17), \ln(35) - \ln(18), 0, 0, 0, \ln(41) - \ln(35), 0, 2\ln(7) - \ln(41), \ln(85) - 2\ln(7), \ln(112) - \ln(85), \ln(119)$
$- \ln(112), 0, \ln(134) - \ln(119), \ln(177) - \ln(134), \ln(211) - \ln(177), \ln(260) - \ln(211), \ln(305) - \ln(260), \ln(387) - \ln(305),$
$\ln(454) - \ln(387), \ln(549) - \ln(454), \ln(748) - \ln(549), \ln(930) - \ln(748), \ln(1082) - \ln(930), \ln(1360) - \ln(1082), \ln(1855)$

$-\ln(1360), \ln(2315)-\ln(1855), \ln(2587)-\ln(2315), \ln(3054)-\ln(2587), \ln(3526)-\ln(3054), \ln(3954)-\ln(3526), \ln(4663)$
$-\ln(3954), \ln(5241)-\ln(4663), \ln(5959)-\ln(5241), \ln(6590)-\ln(5959), \ln(7278)-\ln(6590), \ln(7889)-\ln(7278), \ln(8494)$
$-\ln(7889), \ln(9070)-\ln(8494), \ln(9708)-\ln(9070), \ln(10231)-\ln(9708), \ln(10917)-\ln(10231), \ln(11710)-\ln(10917),$
$\ln(12507)-\ln(11710), \ln(13314)-\ln(12507), \ln(14136)-\ln(13314), \ln(14939)-\ln(14136), \ln(15761)-\ln(14939), \ln(16590)$
$-\ln(15761), \ln(17432)-\ln(16590), \ln(18350)-\ln(17432), \ln(19425)-\ln(18350), \ln(20558)-\ln(19425), \ln(21637)$
$-\ln(20558), \ln(22700)-\ln(21637), \ln(23662)-\ln(22700), \ln(24580)-\ln(23662), \ln(25525)-\ln(24580), \ln(26462)$
$-\ln(25525), \ln(27369)-\ln(26462), \ln(28290)-\ln(27369), \ln(29188)-\ln(28290)]$

$[0, \ln(3), -\ln(3), 2\ln(2)-\ln(3), \ln(5)-4\ln(2)+\ln(3), 5\ln(2)-2\ln(5), 2\ln(3)-6\ln(2)+\ln(5), \ln(11)-4\ln(3)+3\ln(2),$
$\ln(12)-2\ln(11)+2\ln(3), \ln(17)-2\ln(12)+\ln(11), \ln(18)-2\ln(17)+\ln(12), \ln(35)-2\ln(18)+\ln(17), -\ln(35)+\ln(18),$
$0, 0, \ln(41)-\ln(35), -\ln(41)+\ln(35), 2\ln(7)-\ln(41), \ln(85)-4\ln(7)+\ln(41), \ln(112)-2\ln(85)+2\ln(7), \ln(119)$
$-2\ln(112)+\ln(85), -\ln(119)+\ln(112), \ln(134)-\ln(119), \ln(177)-2\ln(134)+\ln(119), \ln(211)-2\ln(177)+\ln(134),$
$\ln(260)-2\ln(211)+\ln(177), \ln(305)-2\ln(260)+\ln(211), \ln(387)-2\ln(305)+\ln(260), \ln(454)-2\ln(387)+\ln(305),$
$\ln(549)-2\ln(454)+\ln(387), \ln(748)-2\ln(549)+\ln(454), \ln(930)-2\ln(748)+\ln(549), \ln(1082)-2\ln(930)+\ln(748),$
$\ln(1360)-2\ln(1082)+\ln(930), \ln(1855)-2\ln(1360)+\ln(1082), \ln(2315)-2\ln(1855)+\ln(1360), \ln(2587)-2\ln(2315)$
$+\ln(1855), \ln(3054)-2\ln(2587)+\ln(2315), \ln(3526)-2\ln(3054)+\ln(2587), \ln(3954)-2\ln(3526)+\ln(3054), \ln(4663)$
$-2\ln(3954)+\ln(3526), \ln(5241)-2\ln(4663)+\ln(3954), \ln(5959)-2\ln(5241)+\ln(4663), \ln(6590)-2\ln(5959)$
$+\ln(5241), \ln(7278)-2\ln(6590)+\ln(5959), \ln(7889)-2\ln(7278)+\ln(6590), \ln(8494)-2\ln(7889)+\ln(7278), \ln(9070)$
$-2\ln(8494)+\ln(7889), \ln(9708)-2\ln(9070)+\ln(8494), \ln(10231)-2\ln(9708)+\ln(9070), \ln(10917)-2\ln(10231)$
$+\ln(9708), \ln(11710)-2\ln(10917)+\ln(10231), \ln(12507)-2\ln(11710)+\ln(10917), \ln(13314)-2\ln(12507)+\ln(11710),$
$\ln(14136)-2\ln(13314)+\ln(12507), \ln(14939)-2\ln(14136)+\ln(13314), \ln(15761)-2\ln(14939)+\ln(14136), \ln(16590)$
$-2\ln(15761)+\ln(14939), \ln(17432)-2\ln(16590)+\ln(15761), \ln(18350)-2\ln(17432)+\ln(16590), \ln(19425)-2\ln(18350)$
$+\ln(17432), \ln(20558)-2\ln(19425)+\ln(18350), \ln(21637)-2\ln(20558)+\ln(19425), \ln(22700)-2\ln(21637)+\ln(20558),$
$\ln(23662)-2\ln(22700)+\ln(21637), \ln(24580)-2\ln(23662)+\ln(22700), \ln(25525)-2\ln(24580)+\ln(23662), \ln(26462)$
$-2\ln(25525)+\ln(24580), \ln(27369)-2\ln(26462)+\ln(25525), \ln(28290)-2\ln(27369)+\ln(26462), \ln(29188)-2\ln(28290)$
$+\ln(27369)]$

$[\ln(3), -2\ln(3), 2\ln(2), 2\ln(3)-6\ln(2)+\ln(5), 9\ln(2)-3\ln(5)-\ln(3), 2\ln(3)-11\ln(2)+3\ln(5), \ln(11)-6\ln(3)+9\ln(2)$
$-\ln(5), \ln(12)-3\ln(11)+6\ln(3)-3\ln(2), \ln(17)-3\ln(12)+3\ln(11)-2\ln(3), \ln(18)-3\ln(17)+3\ln(12)-\ln(11),$
$\ln(35)-3\ln(18)+3\ln(17)-\ln(12), -2\ln(35)+3\ln(18)-\ln(17), \ln(35)-\ln(18), 0, \ln(41)-\ln(35), -2\ln(41)+2\ln(35),$
$2\ln(7)-\ln(35), \ln(85)-6\ln(7)+2\ln(41), \ln(112)-3\ln(85)+6\ln(7)-\ln(41), \ln(119)-3\ln(112)+3\ln(85)-2\ln(7),$
$-2\ln(119)+3\ln(112)-\ln(85), \ln(134)-\ln(112), \ln(177)-3\ln(134)+2\ln(119), \ln(211)-3\ln(177)+3\ln(134)-\ln(119),$

$\ln(260) - 3\ln(211) + 3\ln(177) - \ln(134), \ln(305) - 3\ln(260) + 3\ln(211) - \ln(177), \ln(387) - 3\ln(305) + 3\ln(260) - \ln(211), \ln(454) - 3\ln(387) + 3\ln(305) - \ln(260), \ln(549) - 3\ln(454) + 3\ln(387) - \ln(305), \ln(748) - 3\ln(549) + 3\ln(454) - \ln(387), \ln(930) - 3\ln(748) + 3\ln(549) - \ln(454), \ln(1082) - 3\ln(930) + 3\ln(748) - \ln(549), \ln(1360) - 3\ln(1082) + 3\ln(930) - \ln(748), \ln(1855) - 3\ln(1360) + 3\ln(1082) - \ln(930), \ln(2315) - 3\ln(1855) + 3\ln(1360) - \ln(1082), \ln(2587) - 3\ln(2315) + 3\ln(1855) - \ln(1360), \ln(3054) - 3\ln(2587) + 3\ln(2315) - \ln(1855), \ln(3526) - 3\ln(3054) + 3\ln(2587) - \ln(2315), \ln(3954) - 3\ln(3526) + 3\ln(3054) - \ln(2587), \ln(4663) - 3\ln(3954) + 3\ln(3526) - \ln(3054), \ln(5241) - 3\ln(4663) + 3\ln(3954) - \ln(3526), \ln(5959) - 3\ln(5241) + 3\ln(4663) - \ln(3954), \ln(6590) - 3\ln(5959) + 3\ln(5241) - \ln(4663), \ln(7278) - 3\ln(6590) + 3\ln(5959) - \ln(5241), \ln(7889) - 3\ln(7278) + 3\ln(6590) - \ln(5959), \ln(8494) - 3\ln(7889) + 3\ln(7278) - \ln(6590), \ln(9070) - 3\ln(8494) + 3\ln(7889) - \ln(7278), \ln(9708) - 3\ln(9070) + 3\ln(8494) - \ln(7889), \ln(10231) - 3\ln(9708) + 3\ln(9070) - \ln(8494), \ln(10917) - 3\ln(10231) + 3\ln(9708) - \ln(9070), \ln(11710) - 3\ln(10917) + 3\ln(10231) - \ln(9708), \ln(12507) - 3\ln(11710) + 3\ln(10917) - \ln(10231), \ln(13314) - 3\ln(12507) + 3\ln(11710) - \ln(10917), \ln(14136) - 3\ln(13314) + 3\ln(12507) - \ln(11710), \ln(14939) - 3\ln(14136) + 3\ln(13314) - \ln(12507), \ln(15761) - 3\ln(14939) + 3\ln(14136) - \ln(13314), \ln(16590) - 3\ln(15761) + 3\ln(14939) - \ln(14136), \ln(17432) - 3\ln(16590) + 3\ln(15761) - \ln(14939), \ln(18350) - 3\ln(17432) + 3\ln(16590) - \ln(15761), \ln(19425) - 3\ln(18350) + 3\ln(17432) - \ln(16590), \ln(20558) - 3\ln(19425) + 3\ln(18350) - \ln(17432), \ln(21637) - 3\ln(20558) + 3\ln(19425) - \ln(18350), \ln(22700) - 3\ln(21637) + 3\ln(20558) - \ln(19425), \ln(23662) - 3\ln(22700) + 3\ln(21637) - \ln(20558), \ln(24580) - 3\ln(23662) + 3\ln(22700) - \ln(21637), \ln(25525) - 3\ln(24580) + 3\ln(23662) - \ln(22700), \ln(26462) - 3\ln(25525) + 3\ln(24580) - \ln(23662), \ln(27369) - 3\ln(26462) + 3\ln(25525) - \ln(24580), \ln(28290) - 3\ln(27369) + 3\ln(26462) - \ln(25525), \ln(29188) - 3\ln(28290) + 3\ln(27369) - \ln(26462)]$




```
> 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

` `

$$M := 29190.36848$$

$$N(t) = 29190.36848 - \frac{29190.36848}{e^{0.1377192299\,t - 7.795966363} + 1}$$

Chi2 := 4995.557242

Next day forecast: 26752

The level of 0.5 M is reached at 34 apr

The level of 0.85 M is reached at 46 apr

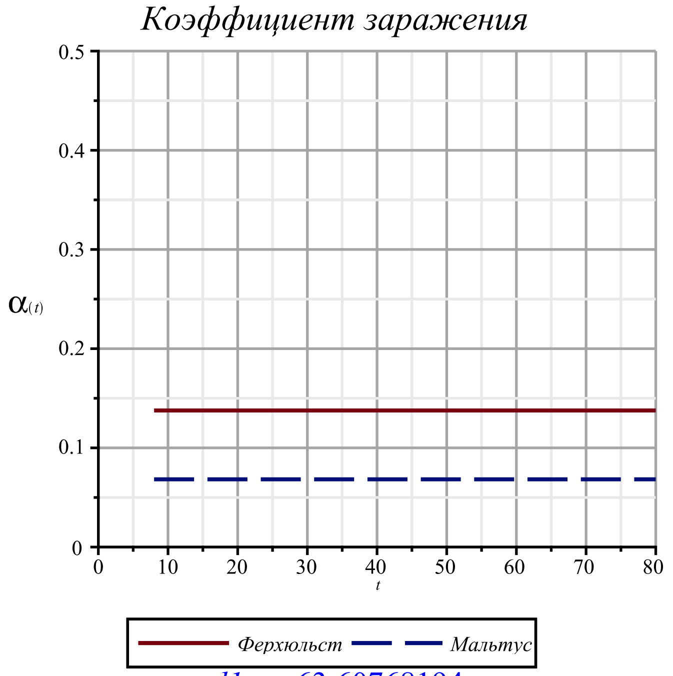
\` \`

Approximation of the infection schedule by solving the Malthus equation

\` \`

$$N(t) = e^{0.06829885811\, t + 5.506105097}$$

[0.1377192299]



$d1$:= 63.60768194

$K\_$:= 29190.36848

$alpha\_$:= 0.1377192299

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

\` \`

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

\` \`

$$M := 30675.24014$$

$$N(t) = 30675.24014 - \frac{30675.24014}{e^{3.085613677\,10^{-6}\,t^4 - 0.0005033785700\,t^3 + 0.02718989511\,t^2 - 0.3785226257\,t - 6.271787470} + 1}$$

$$Chi2 := 334.9471548$$

Next day forecast: 29421

The level of 0.5 M is reached at   -32 apr

The level of 0.85 M is reached at   46 apr

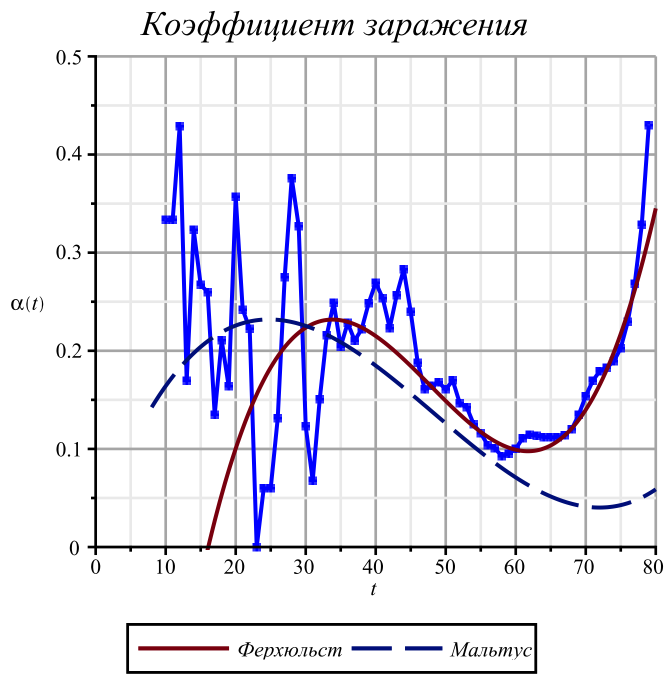
\` \`

Approximation of the infection schedule by solving the Malthus equation

\` \`

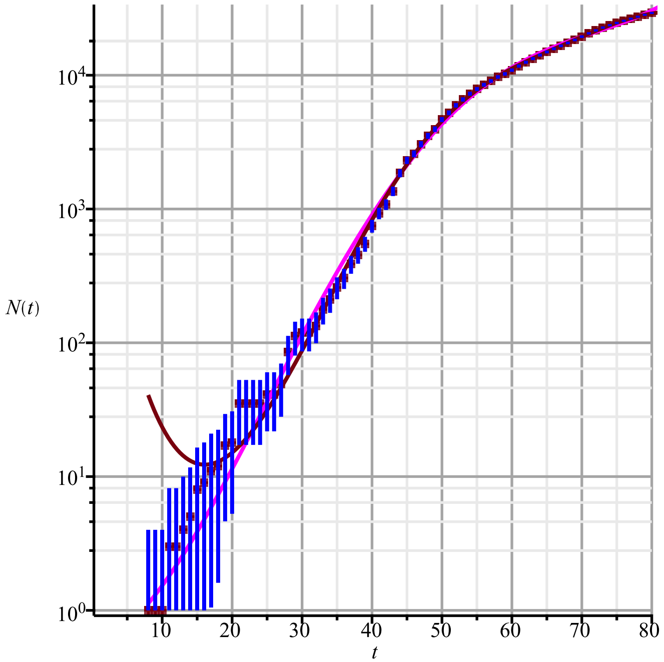
$$N(t) = e^{9.107351936\,10^{-7}\,t^4 - 0.0001506683805\,t^3 + 0.006302094212\,t^2 + 0.1302513311\,t - 0.01779454360}$$

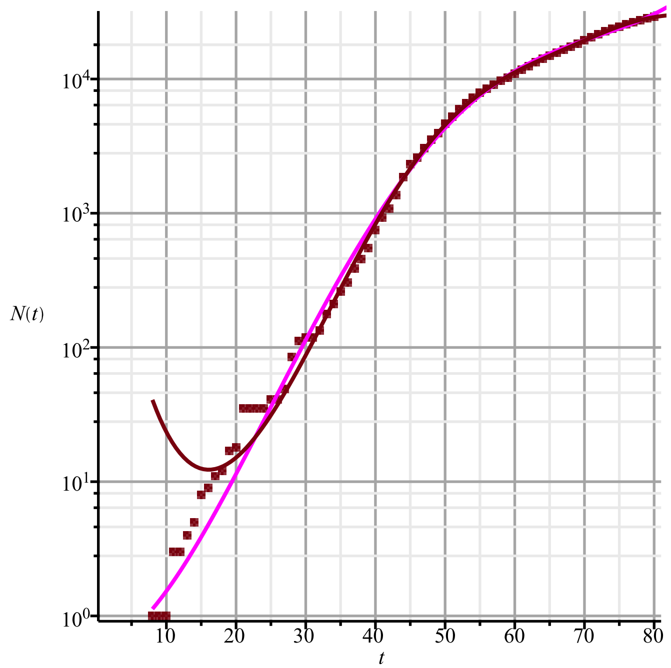
$$[-0.837411269000000, 0.0773360310000000, -0.00176932725900000, 0.00001234245471]$$



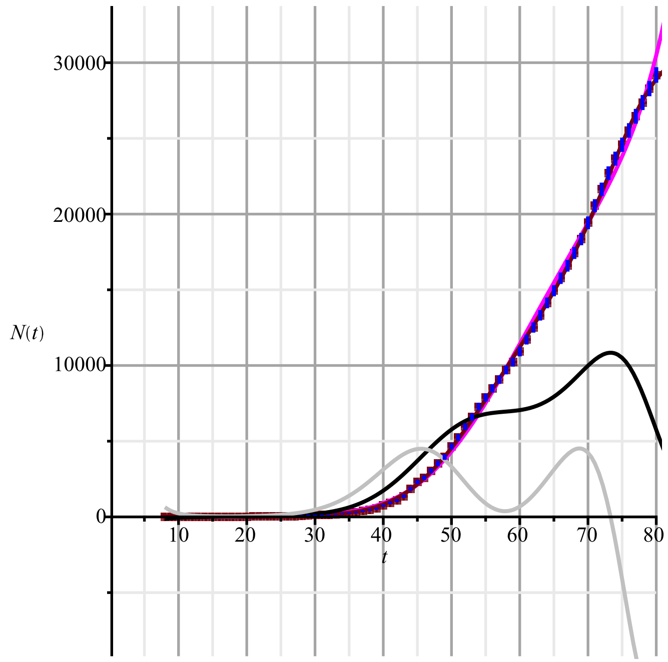

```
> df:=unapply(diff(f(i),i),i): ddf:=unapply(diff(f(i),i,i),i):

  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
);
```

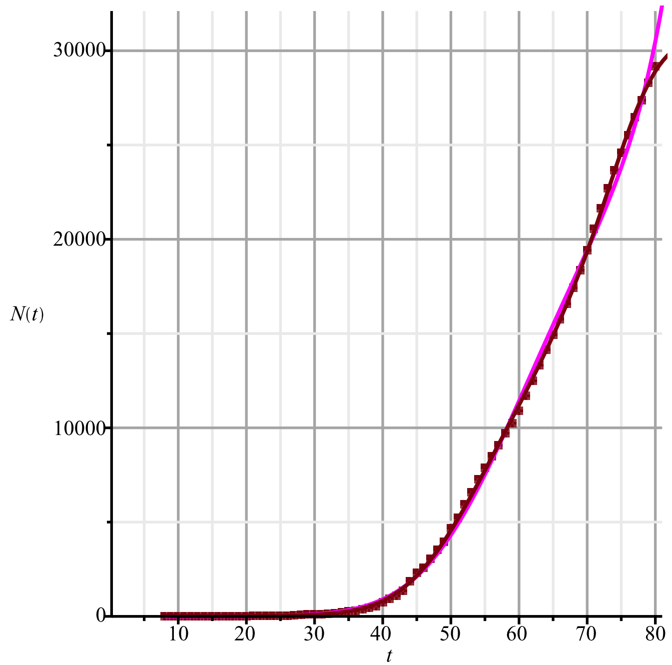




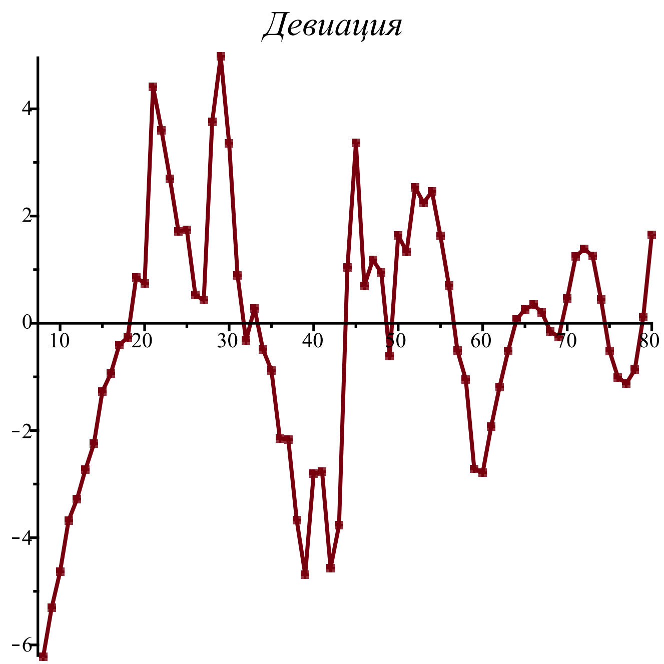
10^4
10^3
10^2
10^1
10^0
$N(t)$
10
20
30
40
50
60
70
80
t



30000
20000
10000
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(%);
```

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

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

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

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

```
> 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});
```

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

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

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

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

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

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

$$\{\lambda = 0\}, \{\lambda = 0\} \quad \textbf{(8}$$

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

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

```
> 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<70,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`),%);
```

$$\alpha := (t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8) \mapsto \begin{cases} (-0.00004287429258 \cdot k1x1 + 0.0001020408163 \cdot k1x2 - 0.00009803921574 \cdot k1x3 + 0.\ldots \\ (-0.00003322259134 \cdot k1x2 + 0.0001449275363 \cdot k1x3 - 0.0002380952381 \cdot k1x\ldots \\ (-0.0001073537306 \cdot k1x3 + 0.0006944444445 \cdot k1x4 - 0.001358695652 \cdot \ldots \\ (-0.0004528985509 \cdot k1x4 + 0.002083333333 \cdot k1x5 - 0.001893939394 \cdot k\ldots \\ (-0.0007575757577 \cdot k1x5 + 0.001262626263 \cdot k1x6 - 0.0008658008661 \cdot \ldots \end{cases}$$

$$\beta := (t, k2a, k2b) \mapsto \begin{cases} k2a & t < 70 \\ k2b & otherwise \end{cases}$$

res := [*t* = **proc**(*t*) ... **end proc**, *A*(*t*) = **proc**(*t*) ... **end proc**, *B*(*t*) = **proc**(*t*) ... **end proc**, *C*(*t*) = **proc**(*t*) ... **end proc**]

[12.11547222, 40685.61891, 0.08860157496, 0.1194914102, 0.206504248, 0.1639018944, 0.08136304104, 0.09362917651, 0.1050655024, 0.104521194, 0.004380244938, 0.01024923215, 0.00009329616206]

2015.68898675881

2015.68898675881

2015.29675137787

2015.01821812815

2013.77277387940

2012.82606401376

2012.55840325208

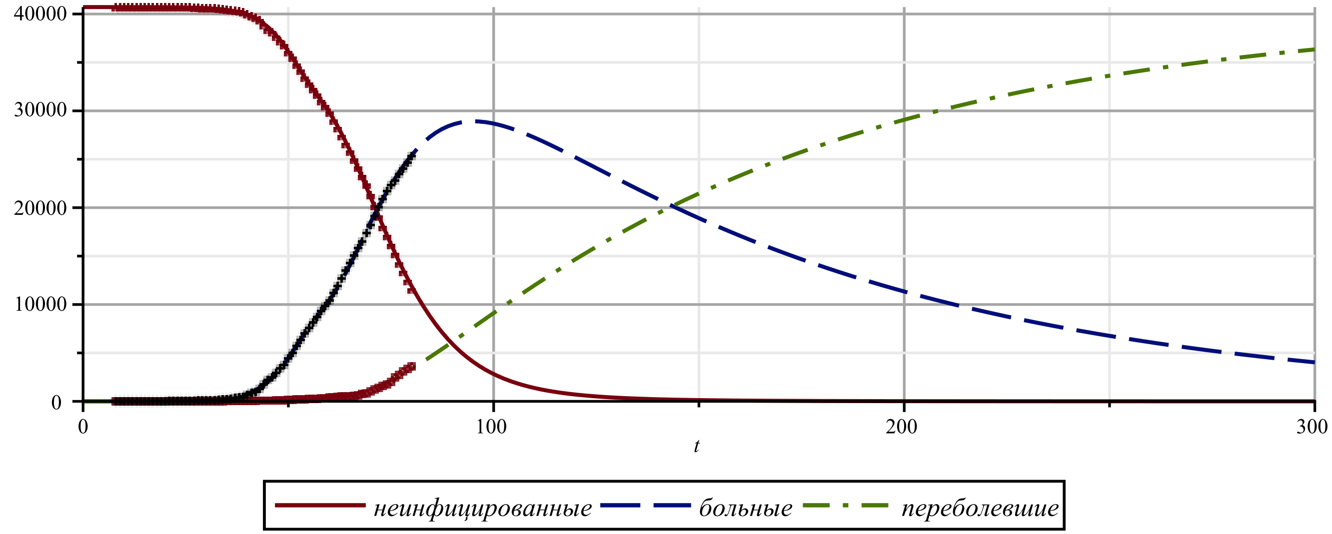
2012.20420344156

2012.08389553500

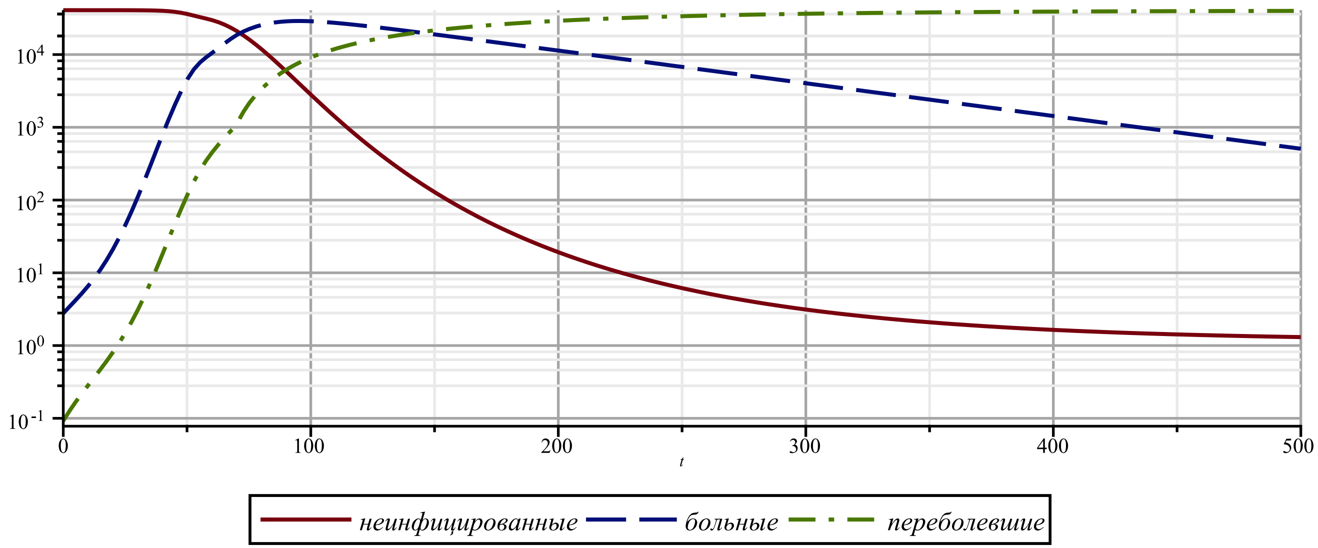
val := [12.1195611812185, 40717.7472873141, 0.0886366725340319, 0.119491590666531, 0.206380861976255, 0.163915548842873, 0.0814150138728160, 0.0936182854924602, 0.105100345581347, 0.104541654636340, 0.00437603224366961, 0.0102735794662165, 0.0000932963823698869]

2012.08389553500

Mosobl3c.jpg

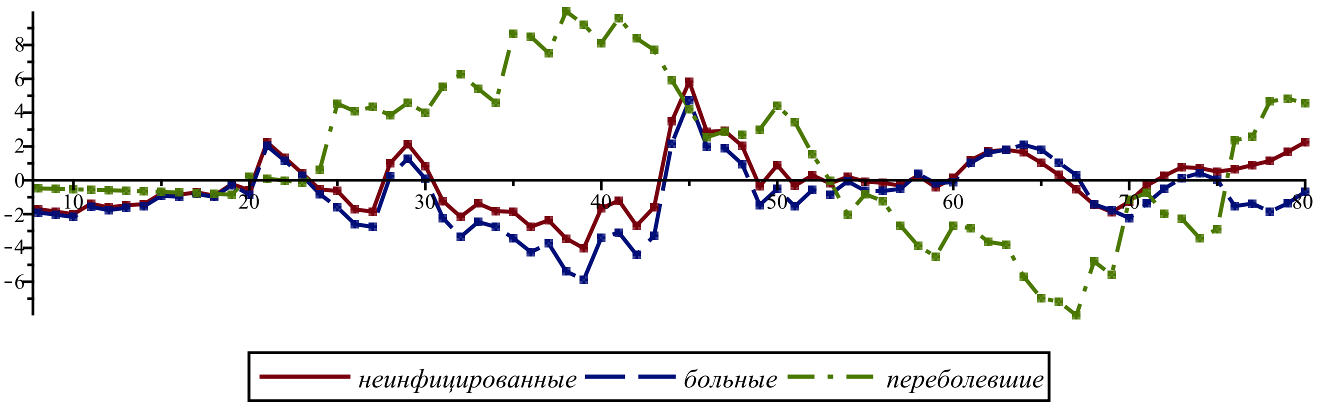



```
> logplot(map(q->q(t),v), t=0..500, legend=[``,``,``],
  linestyle=[solid,dash,dashdot],gridlines=true,size=[1000,400],legendstyle=[font=[roman,15]]);
```

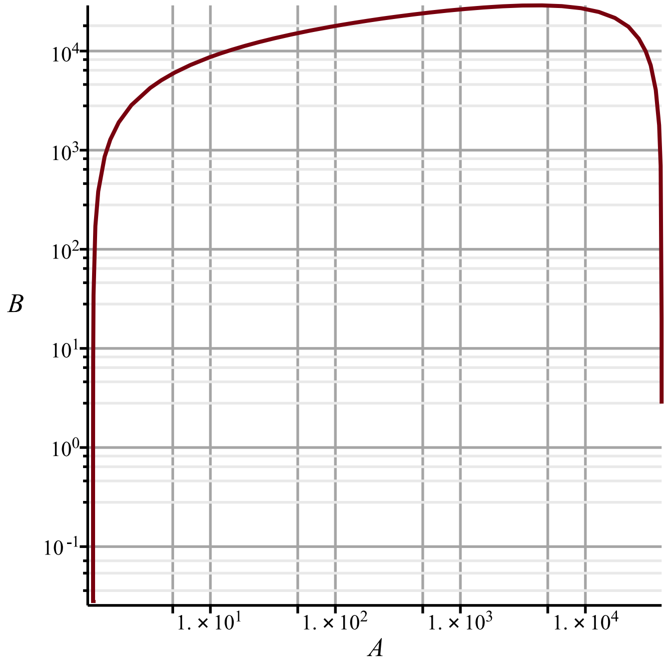



```
> display(
   plot([
    [[i,(T[i-dd]-(K_-A(i)))/sigma(K_-A(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T2[i-dd]-(B(i)))/sigma(B(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T1[i-dd]-(C(i)))/sigma(C(i))] $ i=1+dd..dd+nops(T)]
   ],linestyle=[solid,dash,dashdot],legend=[` `,` `,` `]                        ),
   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`),%);
```

Mosobl3c-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);
```

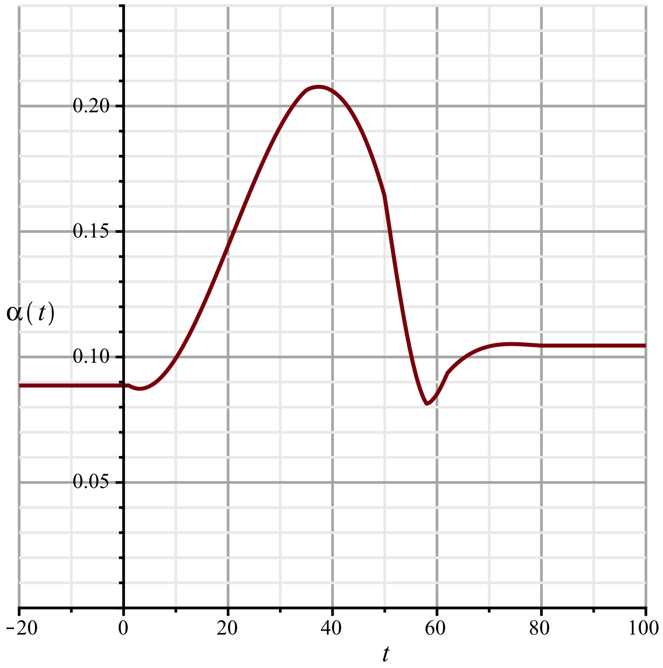



```
> [seq([i,(
   (T[i-dd]-T[i-dd-1]) /(T2[i-dd]+T2[i-dd-1]) /((1-T[i-dd]/K_)+(1-T[i-dd-1]/K_))
  )*4],i=1+dd+1..nops(T)+dd)]: [seq([%[i][1],(%[i-1][2]+%[i][2]+%[i+1][2])/3],i=2..nops(%)-1)]:
```

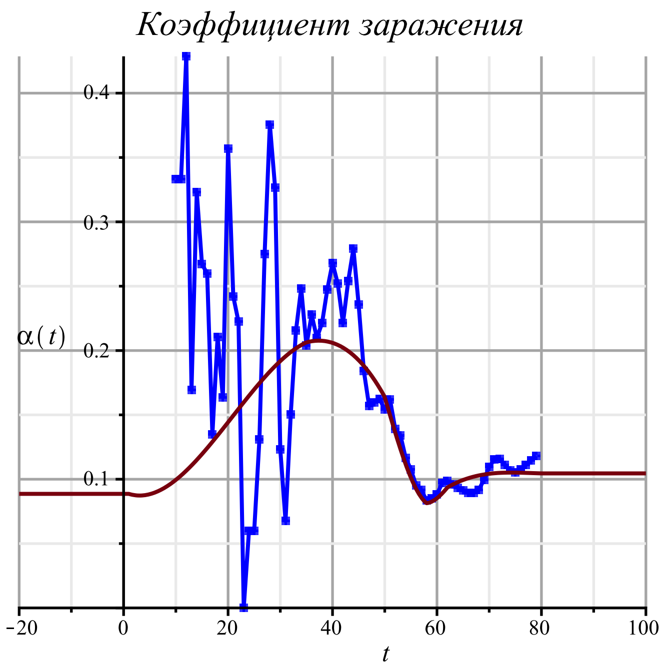
```
Palpha:=display(plot([%],color=blue),plot([%],style=point,symbolsize=8,symbol=solidcircle,color=
blue)):
#display(%,gridlines=true,labels=['t','alpha(t)'],labelfont=[roman,15],view=[0..nops(T)+dd,0.
.0.9]);

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]);
```

$$\begin{cases} 0.0886366725340319 & t < 1. \\ -5.46879439649574\ 10^{-6}\ t^3 + 0.000341865597004780\ t^2 - 0.00194794736543257\ t + 0.0902482230147406 & t < 35. \\ -2.79699457536031\ 10^{-6}\ t^3 + 0.0000746856183857201\ t^2 + 0.00613424696842957\ t + 0.0201134787797421 & t < 50. \\ 0.0000532925928387916\ t^3 - 0.00794612539426922\ t^2 + 0.380812691354265\ t - 5.67297964634473 & t < 58. \\ -0.0000542354355055108\ t^3 + 0.0103336394228231\ t^2 - 0.651026268667451\ t + 13.6605598439999 & t < 62. \\ 3.24433453390647\ 10^{-6}\ t^3 - 0.000759956177024291\ t^2 + 0.0591937691574649\ t - 1.42833960705123 & t < 80. \\ 0.104541654636340 & 80. \leq t \end{cases}$$

Mosobl3c-zar.jpg



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



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