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

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

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

  #valp := [11.3603305375848, 14475.0879688793, 0.0765869162260003, 0.135376422146201,
  0.209261126269982, 0.153145171332402, #0.106398829547104, 0.106093197464564, 0.159923251386689,
  0.200585027191738, 0.0222217255445156, 0.0124207218170124, #0.000954521220352052];

  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:
```

$$Region := SPB$$

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

$valp :=$ [11.34559215, 14531.33433, 0.07651405402, 0.1357064959, 0.2088665537, 0.1529316885, 0.1062966889, 0.1061385194, 0.1591816715, 0.2012023713, 0.02219897076, 0.01230862757, 0.00009541581785]

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

` `

SPB

"OK"

tA := [[5, 3, 20, 1, 0, 0], [6, 3, 20, 1, 0, 0], [7, 3, 20, 2, 0, 0], [8, 3, 20, 2, 0, 0], [9, 3, 20, 2, 0, 0], [10, 3, 20, 2, 0, 0], [11, 3, 20, 2, 0, 0], [12, 3, 20, 2, 0, 0], [13, 3, 20, 5, 0, 0], [14, 3, 20, 6, 0, 0], [15, 3, 20, 6, 0, 0], [16, 3, 20, 9, 0, 2], [17, 3, 20, 9, 0, 2], [18, 3, 20, 9, 0, 2], [19, 3, 20, 10, 0, 2], [20, 3, 20, 14, 0, 2], [21, 3, 20, 16, 0, 2], [22, 3, 20, 16, 0, 2], [23, 3, 20, 16, 0, 2], [24, 3, 20, 21, 0, 2], [25, 3, 20, 21, 0, 5], [26, 3, 20, 26, 0, 5], [27, 3, 20, 26, 0, 5], [28, 3, 20, 37, 0, 5], [29, 3, 20, 42, 1, 5], [30, 3, 20, 50, 1, 5], [31, 3, 20, 98, 2, 7], [1, 4, 20, 125, 2, 7], [2, 4, 20, 147, 2, 7], [3, 4, 20, 156, 2, 7], [4, 4, 20, 171, 2, 7], [5, 4, 20, 191, 2, 7], [6, 4, 20, 226, 2, 32], [7, 4, 20, 295, 2, 32], [8, 4, 20, 329, 2, 32], [9, 4, 20, 373, 4, 43], [10, 4, 20, 408, 4, 43], [11, 4, 20, 488, 4, 74], [12, 4, 20, 557, 4, 74], [13, 4, 20, 678, 4, 78], [14, 4, 20, 799, 4, 78], [15, 4, 20, 929, 5, 95], [16, 4, 20, 1083, 7, 110], [17, 4, 20, 1507, 7, 131], [18, 4, 20, 1646, 8, 232], [19, 4, 20, 1760, 8, 239], [20, 4, 20, 1846, 8, 241], [21, 4, 20, 1973, 11, 280], [22, 4, 20, 2267, 14, 327], [23, 4, 20, 2458, 17, 368], [24, 4, 20, 2711, 20, 411], [25, 4, 20, 2926, 23, 460], [26, 4, 20, 3077, 27, 489], [27, 4, 20, 3238, 27, 489], [28, 4, 20, 3436, 27, 544], [29, 4, 20, 3726, 29, 708], [30, 4, 20, 4062, 29, 779], [1, 5, 20, 4411, 33, 779], [2, 5, 20, 4734, 33, 877], [3, 5, 20, 5029, 34, 1061], [4, 5, 20, 5346, 37, 1197], [5, 5, 20, 5572, 37, 1468], [6, 5, 20, 5884, 40, 1532], [7, 5, 20, 6190, 44, 1552], [8, 5, 20, 6565, 48, 1597], [9, 5, 20, 6990, 53, 1662], [10, 5, 20, 7404, 53, 1674], [11, 5, 20, 7711, 56, 1681], [12, 5, 20, 8050, 58, 1784], [13, 5, 20, 8485, 63, 1848], [14, 5, 20, 8945, 69, 1899], [15, 5, 20, 9486, 74, 2005], [16, 5, 20, 10011, 80, 2109], [17, 5, 20, 10462, 85, 2175], [18, 5, 20, 10887, 90, 2209], [19, 5, 20, 11340, 95, 2272]]

dd := 4

SPB

T = [1, 1, 2, 2, 2, 2, 2, 2, 5, 6, 6, 9, 9, 9, 10, 14, 16, 16, 16, 21, 21, 26, 26, 37, 42, 50, 98, 125, 147, 156, 171, 191, 226, 295, 329, 373, 408, 488, 557, 678, 799, 929, 1083, 1507, 1646, 1760, 1846, 1973, 2267, 2458, 2711, 2926, 3077, 3238, 3436, 3726, 4062, 4411, 4734, 5029, 5346, 5572, 5884, 6190, 6565, 6990, 7404, 7711, 8050, 8485, 8945, 9486, 10011, 10462, 10887, 11340]

$T1$ = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 2, 2, 2, 2, 2, 2, 2, 2, 2, 5, 5, 5, 5, 5, 5, 7, 7, 7, 7, 7, 7, 32, 32, 32, 43, 43, 74, 74, 78, 78, 95, 110, 131, 232, 239, 241, 280, 327, 368, 411, 460, 489, 489, 544, 708, 779, 779, 877, 1061, 1197, 1468, 1532, 1552, 1597, 1662, 1674, 1681, 1784, 1848, 1899, 2005, 2109, 2175, 2209, 2272]

$T2$ = [1, 1, 2, 2, 2, 2, 2, 2, 5, 6, 6, 7, 7, 7, 8, 12, 14, 14, 14, 19, 16, 21, 21, 32, 36, 44, 89, 116, 138, 147, 162, 182, 192, 261, 295, 326, 361, 410, 479, 596, 717, 829, 966, 1369, 1406, 1513, 1597, 1682, 1926, 2073, 2280, 2443, 2561, 2722, 2865, 2989, 3254, 3599, 3824, 3934, 4112, 4067, 4312, 4594, 4920, 5275, 5677, 5974, 6208, 6574, 6977, 7407, 7822, 8202, 8588, 8973]

$T3$ = [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, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 4, 4, 4, 4, 4, 4, 5, 7, 7, 8, 8, 8, 11, 14, 17, 20, 23, 27, 27, 27, 29, 29, 33, 33, 34, 37, 37, 40, 44, 48, 53, 53, 56, 58, 63, 69, 74, 80, 85, 90, 95]

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[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
  );
```

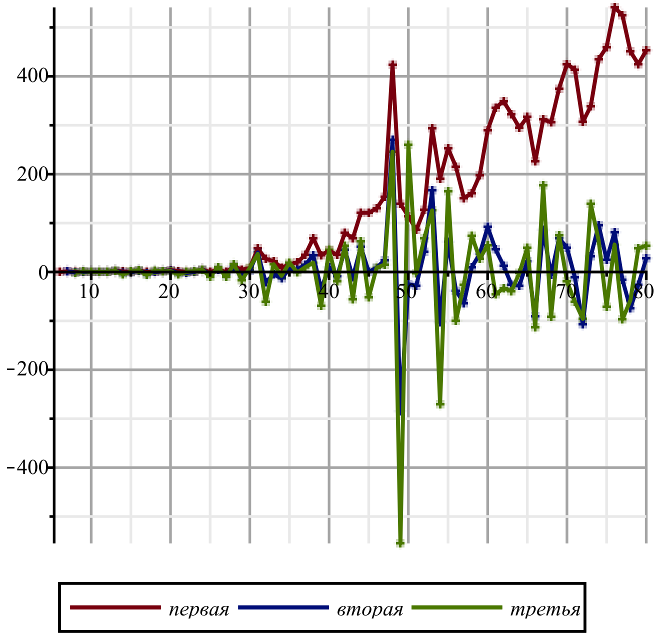
$$h := x \mapsto x$$

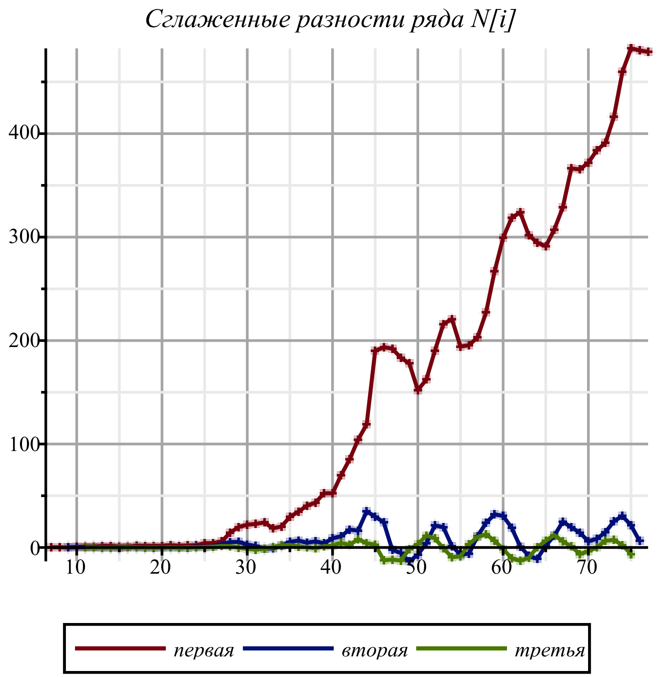
[0, 1, 0, 0, 0, 0, 0, 3, 1, 0, 3, 0, 0, 1, 4, 2, 0, 0, 5, 0, 5, 0, 11, 5, 8, 48, 27, 22, 9, 15, 20, 35, 69, 34, 44, 35, 80, 69, 121, 121, 130, 154, 424, 139, 114, 86, 127, 294, 191, 253, 215, 151, 161, 198, 290, 336, 349, 323, 295, 317, 226, 312, 306, 375, 425, 414, 307, 339, 435, 460, 541, 525, 451, 425, 453]

[1, −1, 0, 0, 0, 0, 3, −2, −1, 3, −3, 0, 1, 3, −2, −2, 0, 5, −5, 5, −5, 11, −6, 3, 40, −21, −5, −13, 6, 5, 15, 34, −35, 10, −9, 45, −11, 52, 0, 9, 24, 270, −285, −25, −28, 41, 167, −103, 62, −38, −64, 10, 37, 92, 46, 13, −26, −28, 22, −91, 86, −6, 69, 50, −11, −107, 32, 96, 25, 81, −16, −74, −26, 28]

[−2, 1, 0, 0, 0, 3, −5, 1, 4, −6, 3, 1, 2, −5, 0, 2, 5, −10, 10, −10, 16, −17, 9, 37, −61, 16, −8, 19, −1, 10, 19, −69, 45, −19, 54, −56, 63, −52, 9, 15, 246, −555, 260, −3, 69, 126, −270, 165, −100, −26, 74, 27, 55, −46, −33, −39, −2, 50, −113, 177, −92, 75, −19, −61, −96, 139, 64, −71, 56, −97, −58, 48, 54]

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=[``,``,``]),
```

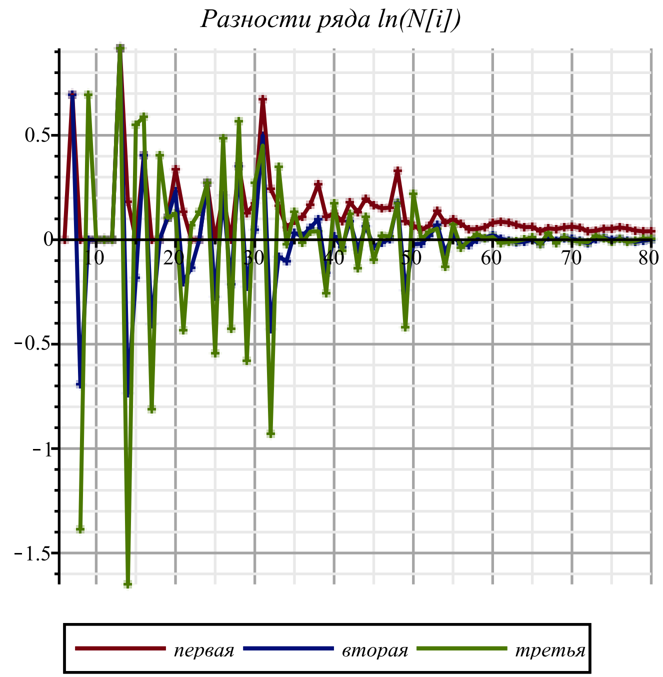
```
title=`                    ln(N[i])`,titlefont=[roman,15],gridlines=true
);
```

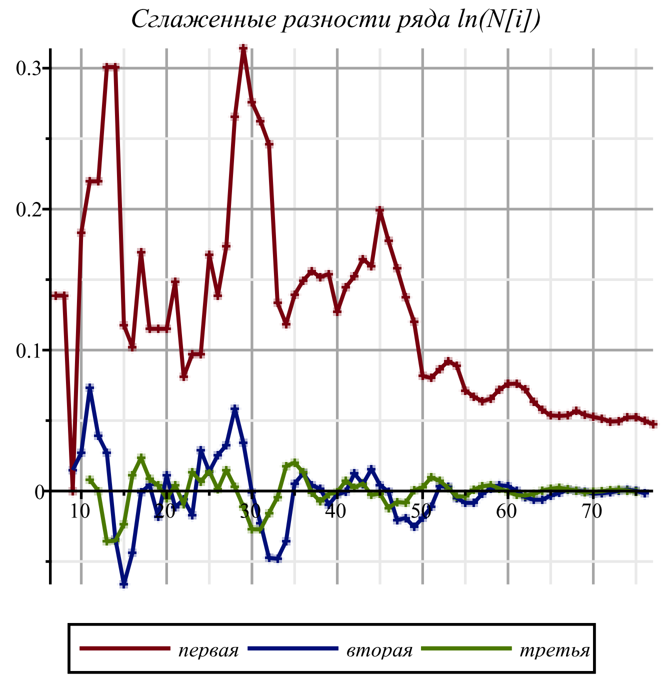
$$h := x \mapsto \ln(x)$$

[0, ln(2), 0, 0, 0, 0, 0, ln(5) − ln(2), ln(6) − ln(5), 0, 2 ln(3) − ln(6), 0, 0, ln(10) − 2 ln(3), ln(14) − ln(10), 4 ln(2) − ln(14), 0, 0, ln(21) − 4 ln(2), 0, ln(26) − ln(21), 0, ln(37) − ln(26), ln(42) − ln(37), ln(50) − ln(42), ln(98) − ln(50), 3 ln(5) − ln(98), ln(147) − 3 ln(5), ln(156) − ln(147), ln(171) − ln(156), ln(191) − ln(171), ln(226) − ln(191), ln(295) − ln(226), ln(329) − ln(295), ln(373) − ln(329), ln(408) − ln(373), ln(488) − ln(408), ln(557) − ln(488), ln(678) − ln(557), ln(799) − ln(678), ln(929) − ln(799), ln(1083) − ln(929), ln(1507) − ln(1083), ln(1646) − ln(1507), ln(1760) − ln(1646), ln(1846) − ln(1760), ln(1973) − ln(1846), ln(2267) − ln(1973), ln(2458) − ln(2267), ln(2711) − ln(2458), ln(2926) − ln(2711), ln(3077) − ln(2926), ln(3238) − ln(3077), ln(3436) − ln(3238), ln(3726) − ln(3436), ln(4062) − ln(3726), ln(4411) − ln(4062), ln(4734) − ln(4411), ln(5029) − ln(4734), ln(5346) − ln(5029), ln(5572) − ln(5346), ln(5884) − ln(5572), ln(6190) − ln(5884), ln(6565) − ln(6190), ln(6990) − ln(6565), ln(7404) − ln(6990), ln(7711) − ln(7404), ln(8050) − ln(7711), ln(8485) − ln(8050), ln(8945) − ln(8485), ln(9486) − ln(8945), ln(10011) − ln(9486), ln(10462) − ln(10011), ln(10887) − ln(10462), ln(11340) − ln(10887)]

[ln(2), -ln(2), 0, 0, 0, 0, ln(5) − ln(2), ln(6) − 2 ln(5) + ln(2), -ln(6) + ln(5), 2 ln(3) − ln(6), -2 ln(3) + ln(6), 0, ln(10) − 2 ln(3), ln(14) − 2 ln(10) + 2 ln(3), 4 ln(2) − 2 ln(14) + ln(10), -4 ln(2) + ln(14), 0, ln(21) − 4 ln(2), -ln(21) + 4 ln(2), ln(26) − ln(21), -ln(26) + ln(21), ln(37) − ln(26), ln(42) − 2 ln(37) + ln(26), ln(50) − 2 ln(42) + ln(37), ln(98) − 2 ln(50) + ln(42), 3 ln(5) − 2 ln(98) + ln(50), ln(147) − 6 ln(5) + ln(98), ln(156) − 2 ln(147) + 3 ln(5), ln(171) − 2 ln(156) + ln(147), ln(191) − 2 ln(171) + ln(156), ln(226) − 2 ln(191) + ln(171), ln(295) − 2 ln(226) + ln(191), ln(329) − 2 ln(295) + ln(226), ln(373) − 2 ln(329) + ln(295), ln(408) − 2 ln(373) + ln(329), ln(488) − 2 ln(408) + ln(373), ln(557) − 2 ln(488) + ln(408), ln(678) − 2 ln(557) + ln(488), ln(799) − 2 ln(678) + ln(557), ln(929) − 2 ln(799) + ln(678), ln(1083) − 2 ln(929) + ln(799), ln(1507) − 2 ln(1083) + ln(929), ln(1646) − 2 ln(1507) + ln(1083), ln(1760) − 2 ln(1646) + ln(1507), ln(1846) − 2 ln(1760) + ln(1646), ln(1973) − 2 ln(1846) + ln(1760), ln(2267) − 2 ln(1973) + ln(1846), ln(2458) − 2 ln(2267) + ln(1973), ln(2711) − 2 ln(2458) + ln(2267), ln(2926) − 2 ln(2711) + ln(2458), ln(3077) − 2 ln(2926) + ln(2711), ln(3238) − 2 ln(3077) + ln(2926), ln(3436) − 2 ln(3238) + ln(3077), ln(3726) − 2 ln(3436) + ln(3238), ln(4062) − 2 ln(3726) + ln(3436), ln(4411) − 2 ln(4062) + ln(3726), ln(4734) − 2 ln(4411) + ln(4062), ln(5029) − 2 ln(4734) + ln(4411), ln(5346) − 2 ln(5029) + ln(4734), ln(5572) − 2 ln(5346) + ln(5029), ln(5884) − 2 ln(5572) + ln(5346), ln(6190) − 2 ln(5884) + ln(5572), ln(6565) − 2 ln(6190) + ln(5884), ln(6990) − 2 ln(6565) + ln(6190), ln(7404) − 2 ln(6990) + ln(6565), ln(7711) − 2 ln(7404) + ln(6990), ln(8050) − 2 ln(7711) + ln(7404), ln(8485) − 2 ln(8050) + ln(7711), ln(8945) − 2 ln(8485) + ln(8050), ln(9486) − 2 ln(8945) + ln(8485), ln(10011) − 2 ln(9486) + ln(8945), ln(10462) − 2 ln(10011) + ln(9486), ln(10887) − 2 ln(10462) + ln(10011), ln(11340) − 2 ln(10887) + ln(10462)]

$$
\begin{aligned}
&[-2\ln(2), \ln(2), 0, 0, 0, \ln(5)-\ln(2), \ln(6)-3\ln(5)+2\ln(2), -2\ln(6)+3\ln(5)-\ln(2), 2\ln(3)-\ln(5), -4\ln(3)+2\ln(6),\\
&2\ln(3)-\ln(6), \ln(10)-2\ln(3), \ln(14)-3\ln(10)+4\ln(3), 4\ln(2)-3\ln(14)+3\ln(10)-2\ln(3), -8\ln(2)+3\ln(14)\\
&-\ln(10), 4\ln(2)-\ln(14), \ln(21)-4\ln(2), -2\ln(21)+8\ln(2), \ln(26)-4\ln(2), -2\ln(26)+2\ln(21), \ln(37)-\ln(21), \ln(42)\\
&-3\ln(37)+2\ln(26), \ln(50)-3\ln(42)+3\ln(37)-\ln(26), \ln(98)-3\ln(50)+3\ln(42)-\ln(37), 3\ln(5)-3\ln(98)+3\ln(50)\\
&-\ln(42), \ln(147)-9\ln(5)+3\ln(98)-\ln(50), \ln(156)-3\ln(147)+9\ln(5)-\ln(98), \ln(171)-3\ln(156)+3\ln(147)\\
&-3\ln(5), \ln(191)-3\ln(171)+3\ln(156)-\ln(147), \ln(226)-3\ln(191)+3\ln(171)-\ln(156), \ln(295)-3\ln(226)+3\ln(191)\\
&-\ln(171), \ln(329)-3\ln(295)+3\ln(226)-\ln(191), \ln(373)-3\ln(329)+3\ln(295)-\ln(226), \ln(408)-3\ln(373)+3\ln(329)\\
&-\ln(295), \ln(488)-3\ln(408)+3\ln(373)-\ln(329), \ln(557)-3\ln(488)+3\ln(408)-\ln(373), \ln(678)-3\ln(557)+3\ln(488)\\
&-\ln(408), \ln(799)-3\ln(678)+3\ln(557)-\ln(488), \ln(929)-3\ln(799)+3\ln(678)-\ln(557), \ln(1083)-3\ln(929)\\
&+3\ln(799)-\ln(678), \ln(1507)-3\ln(1083)+3\ln(929)-\ln(799), \ln(1646)-3\ln(1507)+3\ln(1083)-\ln(929), \ln(1760)\\
&-3\ln(1646)+3\ln(1507)-\ln(1083), \ln(1846)-3\ln(1760)+3\ln(1646)-\ln(1507), \ln(1973)-3\ln(1846)+3\ln(1760)\\
&-\ln(1646), \ln(2267)-3\ln(1973)+3\ln(1846)-\ln(1760), \ln(2458)-3\ln(2267)+3\ln(1973)-\ln(1846), \ln(2711)\\
&-3\ln(2458)+3\ln(2267)-\ln(1973), \ln(2926)-3\ln(2711)+3\ln(2458)-\ln(2267), \ln(3077)-3\ln(2926)+3\ln(2711)\\
&-\ln(2458), \ln(3238)-3\ln(3077)+3\ln(2926)-\ln(2711), \ln(3436)-3\ln(3238)+3\ln(3077)-\ln(2926), \ln(3726)\\
&-3\ln(3436)+3\ln(3238)-\ln(3077), \ln(4062)-3\ln(3726)+3\ln(3436)-\ln(3238), \ln(4411)-3\ln(4062)+3\ln(3726)\\
&-\ln(3436), \ln(4734)-3\ln(4411)+3\ln(4062)-\ln(3726), \ln(5029)-3\ln(4734)+3\ln(4411)-\ln(4062), \ln(5346)\\
&-3\ln(5029)+3\ln(4734)-\ln(4411), \ln(5572)-3\ln(5346)+3\ln(5029)-\ln(4734), \ln(5884)-3\ln(5572)+3\ln(5346)\\
&-\ln(5029), \ln(6190)-3\ln(5884)+3\ln(5572)-\ln(5346), \ln(6565)-3\ln(6190)+3\ln(5884)-\ln(5572), \ln(6990)\\
&-3\ln(6565)+3\ln(6190)-\ln(5884), \ln(7404)-3\ln(6990)+3\ln(6565)-\ln(6190), \ln(7711)-3\ln(7404)+3\ln(6990)\\
&-\ln(6565), \ln(8050)-3\ln(7711)+3\ln(7404)-\ln(6990), \ln(8485)-3\ln(8050)+3\ln(7711)-\ln(7404), \ln(8945)\\
&-3\ln(8485)+3\ln(8050)-\ln(7711), \ln(9486)-3\ln(8945)+3\ln(8485)-\ln(8050), \ln(10011)-3\ln(9486)+3\ln(8945)\\
&-\ln(8485), \ln(10462)-3\ln(10011)+3\ln(9486)-\ln(8945), \ln(10887)-3\ln(10462)+3\ln(10011)-\ln(9486), \ln(11340)\\
&-3\ln(10887)+3\ln(10462)-\ln(10011)]
\end{aligned}
$$


Разности ряда ln(N[i])
0.5
0
-0.5
-1
-1.5
10
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
  );
```

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

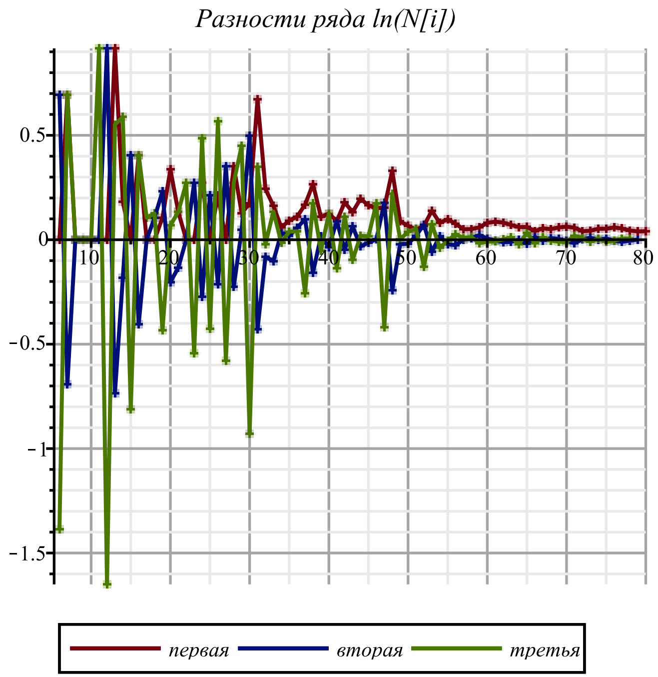
$[0, \ln(2), 0, 0, 0, 0, 0, \ln(5) - \ln(2), \ln(6) - \ln(5), 0, 2\ln(3) - \ln(6), 0, 0, \ln(10) - 2\ln(3), \ln(14) - \ln(10), 4\ln(2) - \ln(14), 0, 0,$
$\ln(21) - 4\ln(2), 0, \ln(26) - \ln(21), 0, \ln(37) - \ln(26), \ln(42) - \ln(37), \ln(50) - \ln(42), \ln(98) - \ln(50), 3\ln(5) - \ln(98),$
$\ln(147) - 3\ln(5), \ln(156) - \ln(147), \ln(171) - \ln(156), \ln(191) - \ln(171), \ln(226) - \ln(191), \ln(295) - \ln(226), \ln(329)$
$- \ln(295), \ln(373) - \ln(329), \ln(408) - \ln(373), \ln(488) - \ln(408), \ln(557) - \ln(488), \ln(678) - \ln(557), \ln(799) - \ln(678),$

$\ln(929)-\ln(799), \ln(1083)-\ln(929), \ln(1507)-\ln(1083), \ln(1646)-\ln(1507), \ln(1760)-\ln(1646), \ln(1846)-\ln(1760),$
$\ln(1973)-\ln(1846), \ln(2267)-\ln(1973), \ln(2458)-\ln(2267), \ln(2711)-\ln(2458), \ln(2926)-\ln(2711), \ln(3077)-\ln(2926),$
$\ln(3238)-\ln(3077), \ln(3436)-\ln(3238), \ln(3726)-\ln(3436), \ln(4062)-\ln(3726), \ln(4411)-\ln(4062), \ln(4734)-\ln(4411),$
$\ln(5029)-\ln(4734), \ln(5346)-\ln(5029), \ln(5572)-\ln(5346), \ln(5884)-\ln(5572), \ln(6190)-\ln(5884), \ln(6565)-\ln(6190),$
$\ln(6990)-\ln(6565), \ln(7404)-\ln(6990), \ln(7711)-\ln(7404), \ln(8050)-\ln(7711), \ln(8485)-\ln(8050), \ln(8945)-\ln(8485),$
$\ln(9486)-\ln(8945), \ln(10011)-\ln(9486), \ln(10462)-\ln(10011), \ln(10887)-\ln(10462), \ln(11340)-\ln(10887)]$

$[\ln(2), -\ln(2), 0, 0, 0, 0, \ln(5)-\ln(2), \ln(6)-2\ln(5)+\ln(2), -\ln(6)+\ln(5), 2\ln(3)-\ln(6), -2\ln(3)+\ln(6), 0, \ln(10)-2\ln(3),$
$\ln(14)-2\ln(10)+2\ln(3), 4\ln(2)-2\ln(14)+\ln(10), -4\ln(2)+\ln(14), 0, \ln(21)-4\ln(2), -\ln(21)+4\ln(2), \ln(26)$
$-\ln(21), -\ln(26)+\ln(21), \ln(37)-\ln(26), \ln(42)-2\ln(37)+\ln(26), \ln(50)-2\ln(42)+\ln(37), \ln(98)-2\ln(50)+\ln(42),$
$3\ln(5)-2\ln(98)+\ln(50), \ln(147)-6\ln(5)+\ln(98), \ln(156)-2\ln(147)+3\ln(5), \ln(171)-2\ln(156)+\ln(147), \ln(191)$
$-2\ln(171)+\ln(156), \ln(226)-2\ln(191)+\ln(171), \ln(295)-2\ln(226)+\ln(191), \ln(329)-2\ln(295)+\ln(226), \ln(373)$
$-2\ln(329)+\ln(295), \ln(408)-2\ln(373)+\ln(329), \ln(488)-2\ln(408)+\ln(373), \ln(557)-2\ln(488)+\ln(408), \ln(678)$
$-2\ln(557)+\ln(488), \ln(799)-2\ln(678)+\ln(557), \ln(929)-2\ln(799)+\ln(678), \ln(1083)-2\ln(929)+\ln(799), \ln(1507)$
$-2\ln(1083)+\ln(929), \ln(1646)-2\ln(1507)+\ln(1083), \ln(1760)-2\ln(1646)+\ln(1507), \ln(1846)-2\ln(1760)+\ln(1646),$
$\ln(1973)-2\ln(1846)+\ln(1760), \ln(2267)-2\ln(1973)+\ln(1846), \ln(2458)-2\ln(2267)+\ln(1973), \ln(2711)-2\ln(2458)$
$+\ln(2267), \ln(2926)-2\ln(2711)+\ln(2458), \ln(3077)-2\ln(2926)+\ln(2711), \ln(3238)-2\ln(3077)+\ln(2926), \ln(3436)$
$-2\ln(3238)+\ln(3077), \ln(3726)-2\ln(3436)+\ln(3238), \ln(4062)-2\ln(3726)+\ln(3436), \ln(4411)-2\ln(4062)$
$+\ln(3726), \ln(4734)-2\ln(4411)+\ln(4062), \ln(5029)-2\ln(4734)+\ln(4411), \ln(5346)-2\ln(5029)+\ln(4734), \ln(5572)$
$-2\ln(5346)+\ln(5029), \ln(5884)-2\ln(5572)+\ln(5346), \ln(6190)-2\ln(5884)+\ln(5572), \ln(6565)-2\ln(6190)$
$+\ln(5884), \ln(6990)-2\ln(6565)+\ln(6190), \ln(7404)-2\ln(6990)+\ln(6565), \ln(7711)-2\ln(7404)+\ln(6990), \ln(8050)$
$-2\ln(7711)+\ln(7404), \ln(8485)-2\ln(8050)+\ln(7711), \ln(8945)-2\ln(8485)+\ln(8050), \ln(9486)-2\ln(8945)$
$+\ln(8485), \ln(10011)-2\ln(9486)+\ln(8945), \ln(10462)-2\ln(10011)+\ln(9486), \ln(10887)-2\ln(10462)+\ln(10011),$
$\ln(11340)-2\ln(10887)+\ln(10462)]$

$[-2\ln(2), \ln(2), 0, 0, 0, \ln(5)-\ln(2), \ln(6)-3\ln(5)+2\ln(2), -2\ln(6)+3\ln(5)-\ln(2), 2\ln(3)-\ln(5), -4\ln(3)+2\ln(6),$
$2\ln(3)-\ln(6), \ln(10)-2\ln(3), \ln(14)-3\ln(10)+4\ln(3), 4\ln(2)-3\ln(14)+3\ln(10)-2\ln(3), -8\ln(2)+3\ln(14)$
$-\ln(10), 4\ln(2)-\ln(14), \ln(21)-4\ln(2), -2\ln(21)+8\ln(2), \ln(26)-4\ln(2), -2\ln(26)+2\ln(21), \ln(37)-\ln(21), \ln(42)$
$-3\ln(37)+2\ln(26), \ln(50)-3\ln(42)+3\ln(37)-\ln(26), \ln(98)-3\ln(50)+3\ln(42)-\ln(37), 3\ln(5)-3\ln(98)+3\ln(50)$
$-\ln(42), \ln(147)-9\ln(5)+3\ln(98)-\ln(50), \ln(156)-3\ln(147)+9\ln(5)-\ln(98), \ln(171)-3\ln(156)+3\ln(147)$
$-3\ln(5), \ln(191)-3\ln(171)+3\ln(156)-\ln(147), \ln(226)-3\ln(191)+3\ln(171)-\ln(156), \ln(295)-3\ln(226)+3\ln(191)$
$-\ln(171), \ln(329)-3\ln(295)+3\ln(226)-\ln(191), \ln(373)-3\ln(329)+3\ln(295)-\ln(226), \ln(408)-3\ln(373)+3\ln(329)$

$- \ln(295), \ln(488) - 3\ln(408) + 3\ln(373) - \ln(329), \ln(557) - 3\ln(488) + 3\ln(408) - \ln(373), \ln(678) - 3\ln(557) + 3\ln(488)$
$- \ln(408), \ln(799) - 3\ln(678) + 3\ln(557) - \ln(488), \ln(929) - 3\ln(799) + 3\ln(678) - \ln(557), \ln(1083) - 3\ln(929)$
$+ 3\ln(799) - \ln(678), \ln(1507) - 3\ln(1083) + 3\ln(929) - \ln(799), \ln(1646) - 3\ln(1507) + 3\ln(1083) - \ln(929), \ln(1760)$
$- 3\ln(1646) + 3\ln(1507) - \ln(1083), \ln(1846) - 3\ln(1760) + 3\ln(1646) - \ln(1507), \ln(1973) - 3\ln(1846) + 3\ln(1760)$
$- \ln(1646), \ln(2267) - 3\ln(1973) + 3\ln(1846) - \ln(1760), \ln(2458) - 3\ln(2267) + 3\ln(1973) - \ln(1846), \ln(2711)$
$- 3\ln(2458) + 3\ln(2267) - \ln(1973), \ln(2926) - 3\ln(2711) + 3\ln(2458) - \ln(2267), \ln(3077) - 3\ln(2926) + 3\ln(2711)$
$- \ln(2458), \ln(3238) - 3\ln(3077) + 3\ln(2926) - \ln(2711), \ln(3436) - 3\ln(3238) + 3\ln(3077) - \ln(2926), \ln(3726)$
$- 3\ln(3436) + 3\ln(3238) - \ln(3077), \ln(4062) - 3\ln(3726) + 3\ln(3436) - \ln(3238), \ln(4411) - 3\ln(4062) + 3\ln(3726)$
$- \ln(3436), \ln(4734) - 3\ln(4411) + 3\ln(4062) - \ln(3726), \ln(5029) - 3\ln(4734) + 3\ln(4411) - \ln(4062), \ln(5346)$
$- 3\ln(5029) + 3\ln(4734) - \ln(4411), \ln(5572) - 3\ln(5346) + 3\ln(5029) - \ln(4734), \ln(5884) - 3\ln(5572) + 3\ln(5346)$
$- \ln(5029), \ln(6190) - 3\ln(5884) + 3\ln(5572) - \ln(5346), \ln(6565) - 3\ln(6190) + 3\ln(5884) - \ln(5572), \ln(6990)$
$- 3\ln(6565) + 3\ln(6190) - \ln(5884), \ln(7404) - 3\ln(6990) + 3\ln(6565) - \ln(6190), \ln(7711) - 3\ln(7404) + 3\ln(6990)$
$- \ln(6565), \ln(8050) - 3\ln(7711) + 3\ln(7404) - \ln(6990), \ln(8485) - 3\ln(8050) + 3\ln(7711) - \ln(7404), \ln(8945)$
$- 3\ln(8485) + 3\ln(8050) - \ln(7711), \ln(9486) - 3\ln(8945) + 3\ln(8485) - \ln(8050), \ln(10011) - 3\ln(9486) + 3\ln(8945)$
$- \ln(8485), \ln(10462) - 3\ln(10011) + 3\ln(9486) - \ln(8945), \ln(10887) - 3\ln(10462) + 3\ln(10011) - \ln(9486), \ln(11340)$
$- 3\ln(10887) + 3\ln(10462) - \ln(10011)]$




```
> 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

` `

$$M := 11342.37476$$

$$N(t) = 11342.37476 - \frac{11342.37476}{e^{0.1273592714\,t - 7.801871537} + 1}$$

$Chi2 := 1398.499948$

Next day forecast: 9996

The level of 0.5 M is reached at 35 apr

The level of 0.85 M is reached at 49 apr

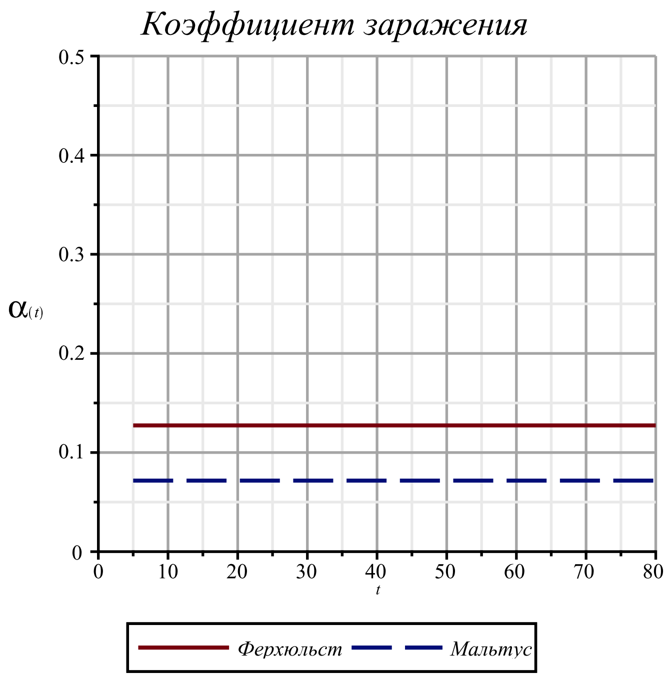
\` \`

Approximation of the infection schedule by solving the Malthus equation

\` \`

$$N(t) = e^{0.07168670941\,t + 4.061147549}$$

$$[0.1273592714]$$



$d1 := 65.25876390$

$K\_ := 11342.37476$

$alpha\_ := 0.1273592714$

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

` `

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

` `

$$M := 14237.28217$$

$$N(t) = 14237.28217 - \frac{14237.28217}{e^{1.429013308\ 10^{-6}\ t^4 - 0.0002431249094\ t^3 + 0.01313835729\ t^2 - 0.09599565753\ t - 8.167476882} + 1}$$

$$Chi2 := 212.2370327$$

Next day forecast: 11801

The level of 0.5 M is reached at 41 apr

The level of 0.85 M is reached at 52 apr

` `

Approximation of the infection schedule by solving the Malthus equation

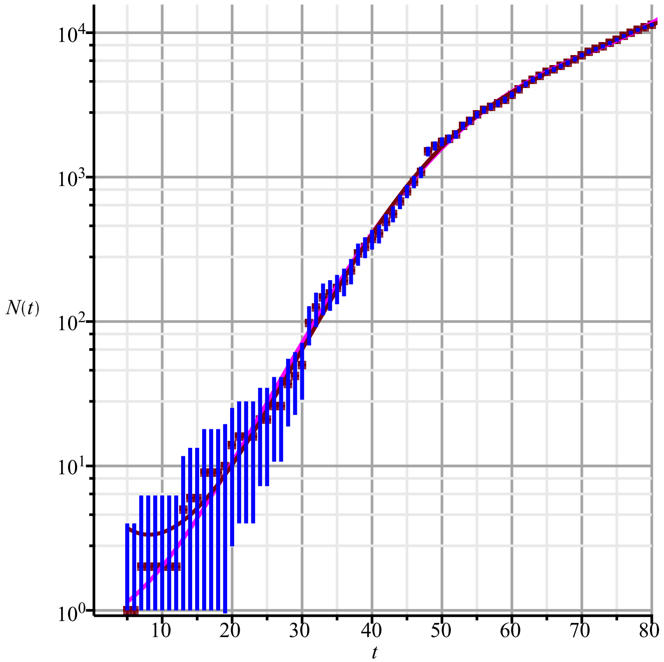
` `

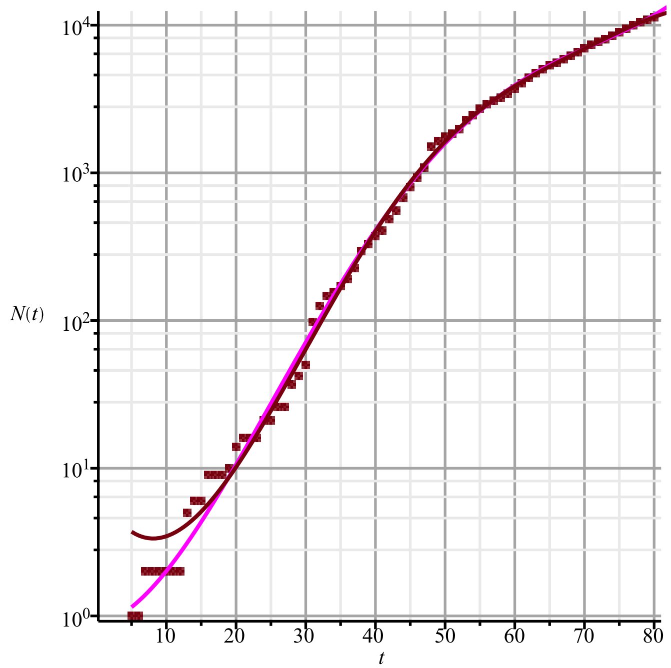
$$N(t) = e^{7.215877955\ 10^{-7}\ t^4 - 0.0001281422841\ t^3 + 0.006201697490\ t^2 + 0.07457631737\ t + 0.05598033495}$$

$$[-0.213138338900000,\ 0.0323860829700000,\ -0.000797967367000000,\ 5.716053232\ 10^{-6}]$$

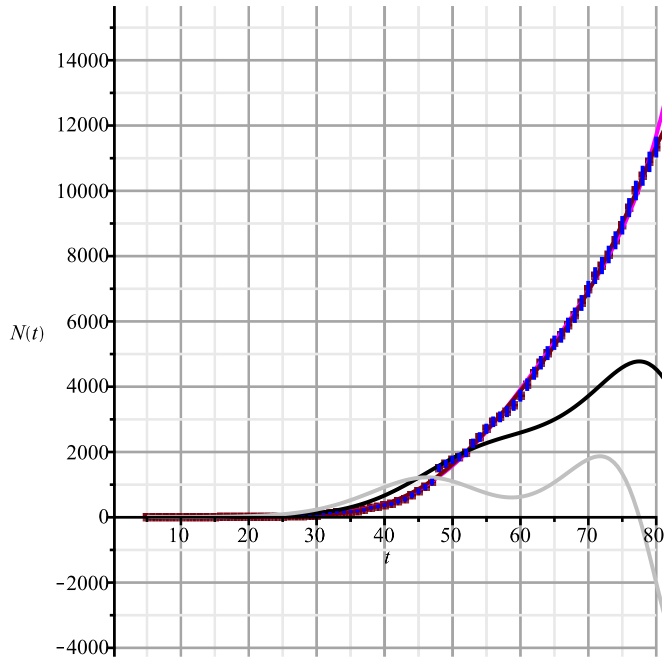

```
> df:=unapply(diff(f(i),i),i): ddf:=unapply(diff(f(i),i,i),i):

  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
);
```

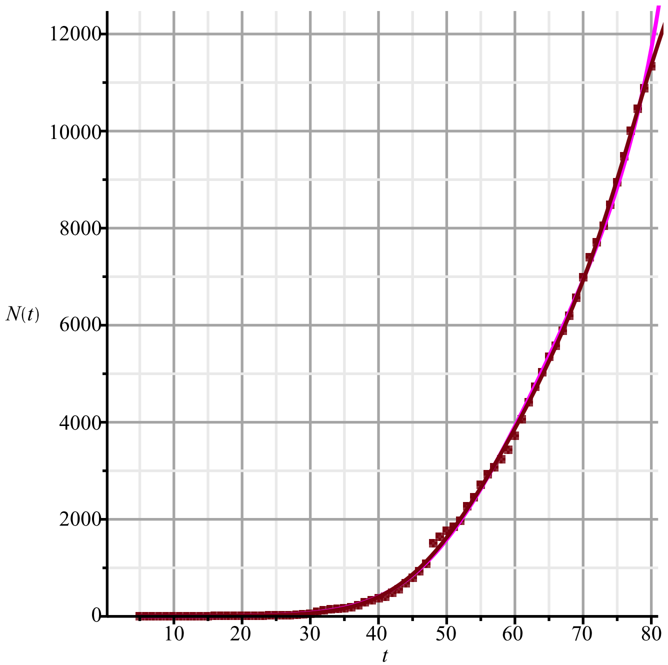




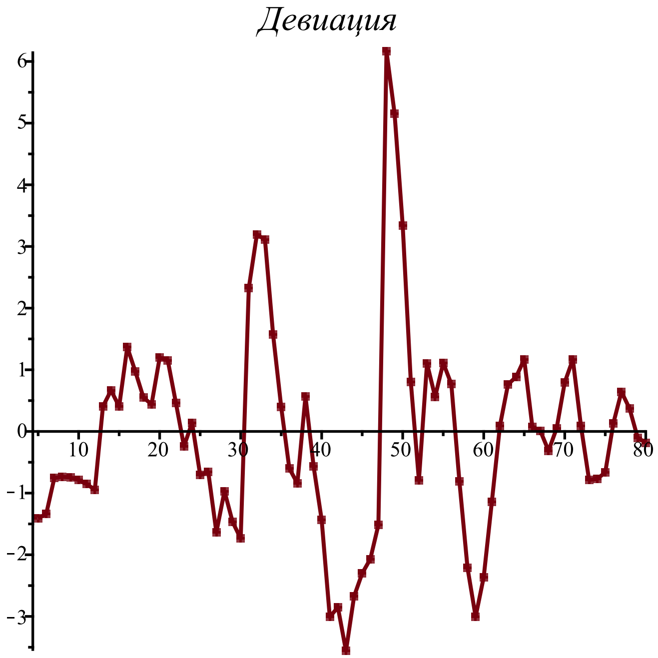
10^4
10^3
10^2
10^1
10^0
$N(t)$
10
20
30
40
50
60
70
80
t



14000
12000
10000
8000
6000
4000
2000
0
−2000
−4000
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),title=``     ,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(%);
```

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

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

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

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

```
> 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});
```

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

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

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

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

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

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

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

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

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

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

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

[11.34559215, 14531.33433, 0.07651405402, 0.1357064959, 0.2088665537, 0.1529316885, 0.1062966889, 0.1061385194, 0.1591816715, 0.2012023713, 0.02219897076, 0.01230862757, 0.00009541581785]

743.349780566288

743.349780566288

742.177551494445

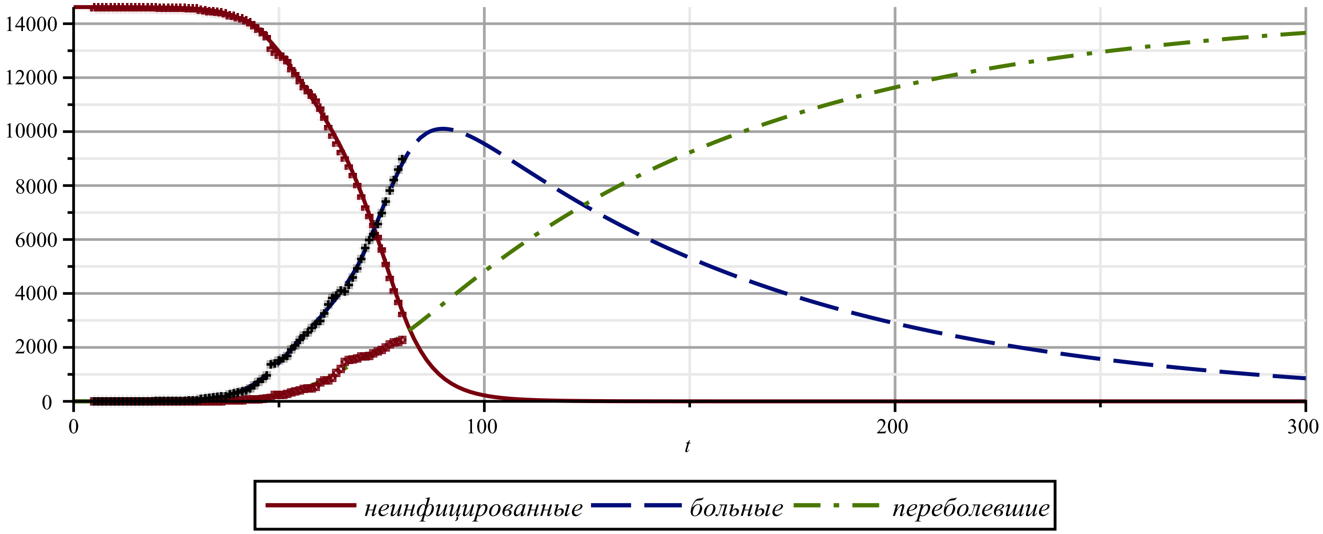
741.274962353396

740.414525099945
739.660148789923
735.689479004759
732.642623549470
732.595851000334

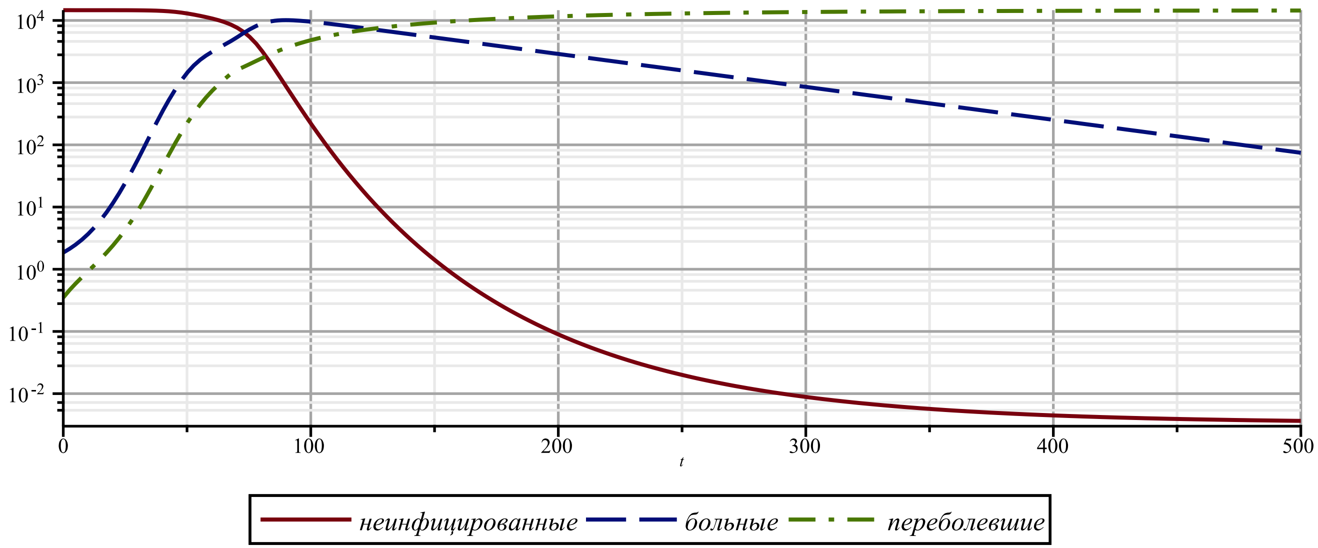
val := [11.3587206604216, 14617.2131685064, 0.0765903056909774, 0.136357628568500, 0.208270932909720, 0.152801373545001, 0.106458216711037, 0.106407573025571, 0.157368001654036, 0.202490835571148, 0.0223078797676930, 0.0120993811440648, 0.0000955363750265005]

732.595851000334

SPB3c.jpg

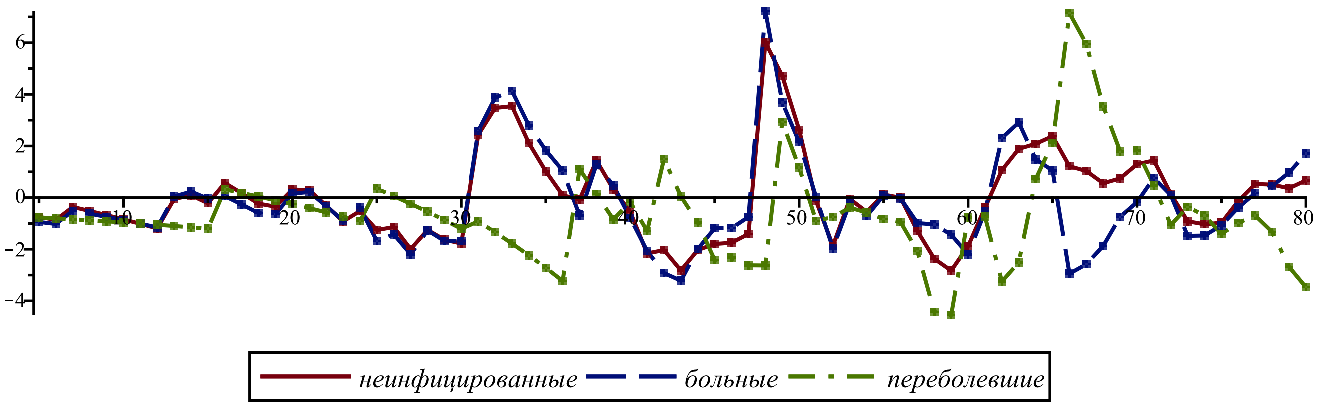



```
> logplot(map(q->q(t),v), t=0..500, legend=[``,``,``], linestyle=[solid,dash,dashdot],gridlines=true,size=[1000,400],legendstyle=[font=[roman,15]]);
```

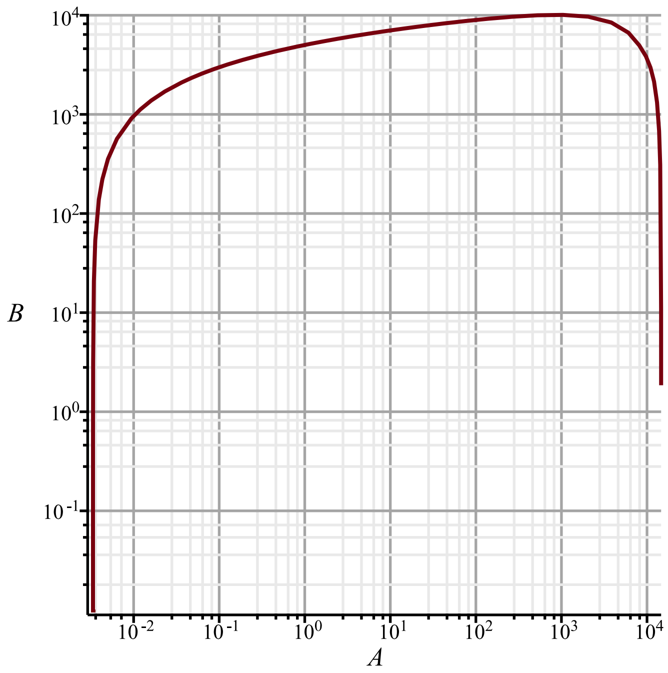



```
> display(
   plot([
    [[i,(T[i-dd]-(K_-A(i)))/sigma(K_-A(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T2[i-dd]-(B(i)))/sigma(B(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T1[i-dd]-(C(i)))/sigma(C(i))] $ i=1+dd..dd+nops(T)]
   ],linestyle=[solid,dash,dashdot],legend=[` `,` `,` `]                        ),
  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

SPB3c-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);
```

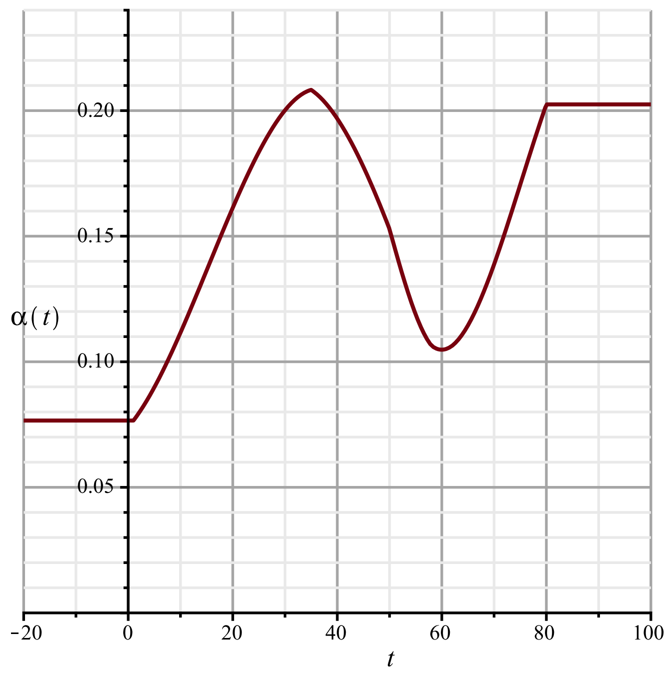


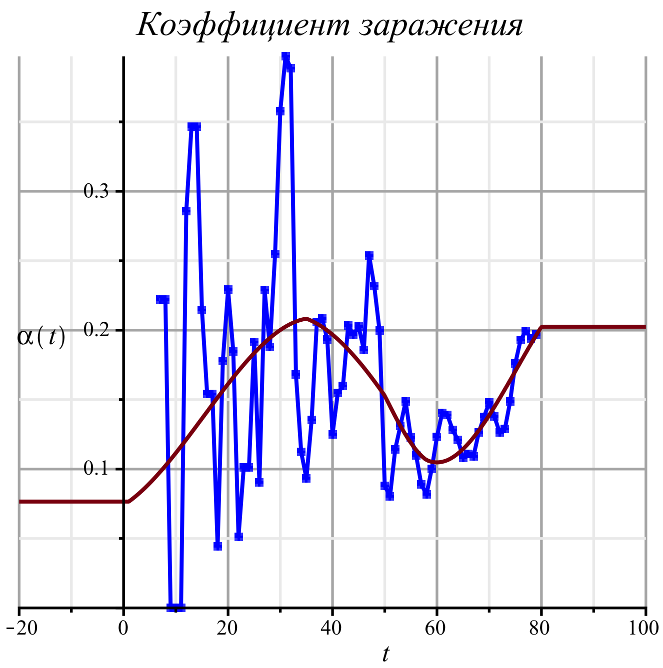

```
> [seq([i,(
   (T[i-dd]-T[i-dd-1]) /(T2[i-dd]+T2[i-dd-1]) /((1-T[i-dd]/K_)+(1-T[i-dd-1]/K_))
  )*4],i=1+dd+1..nops(T)+dd)]: [seq([%[i][1],(%[i-1][2]+%[i][2]+%[i+1][2])/3],i=2..nops(%)-1)]:
```

```
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]);
```

$$\begin{cases} 0.0765903056909774 & t < 1. \\ -3.84862964920808\ 10^{-6}\ t^3 + 0.000176473367889358\ t^2 + 0.00237304036491047\ t + 0.0740446405199615 & t < 35. \\ 2.72804522693861\ 10^{-6}\ t^3 - 0.000481194116053977\ t^2 + 0.0222674817334916\ t - 0.0985930738544079 & t < 50. \\ 0.0000212136959903423\ t^3 - 0.00312464218931587\ t^2 + 0.145751629362511\ t - 1.97488663036761 & t < 58. \\ -7.47786945863886\ 10^{-6}\ t^3 + 0.00175292393704114\ t^2 - 0.129572632868148\ t + 3.18385683017360 & t < 62. \\ -9.49787804158353\ 10^{-6}\ t^3 + 0.00214278561098058\ t^2 - 0.154531859766153\ t + 3.71412527026160 & t < 80. \\ 0.202490835571148 & 80. \le t \end{cases}$$

SPB3c-zar.jpg


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



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