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LAMPIRAN

Lampiran 1. Titik Kesetimbangan, Analisis Kestabilan Lokal, dan Analisis Kestabilan Global dari E_K

```
> restart
> with(LinearAlgebra) :
>
> r1 := 0.44;
  r2 := 0.18;
  r3 := 0.0245;
  b1 := 9.8 * 10^(-8);
  b2 := 1 * 10^(-9);
  b3 := 1 * 10^(-10);
  rho1 := 1.1 * 10^(-10);
  rho2 := 4.8 * 10^(-10);
  mu1 := 0.01;
  mu2 := 0.0412;
  alpha1 := 1.101 * 10^(-7);
  alpha2 := 3.422 * 10^(-10);
  betaa := 6.2 * 10^(-9);
  gamma1 := 0.01;
  q1 := 0.9;
  q2 := 1 * 10^(-12);
  q3 := 1 * 10^(-5);
  q4 := 2 * 10^(-11);
  delta1 := 0.0357;
  u0 := 0.5;
>
> EKC := 0;
  EKH := (r2 * gamma1 - mu1 * gamma1 - q2 * delta1 * u0) / (r2 * b2 * gamma1);
  EKIP := (mu2 * gamma1 + q4 * delta1 * u0) / (betaa * gamma1);
  EKIS := (r3 * betaa * gamma1 - r3 * b3 * mu2 * gamma1 - r3 * b3 * q4 * delta1 * u0 - betaa
      * q3 * delta1 * u0) / (((betaa)^2) * gamma1);
  EKDK := (delta1 * u0) / gamma1;
```

$$EKC := 0$$

$$EKH := 9.444444444\ 10^{8}$$

$$EKIP := 6.645161297\ 10^{6}$$

$$EKIS := 3.946107960\ 10^{6}$$

$$EKDK := 1.785000000 \qquad \textbf{(1)}$$

```
> xi1 := r1 - 2 * r1 * b1 * EKC - rho1 * EKH - alpha1 * EKIS - q1 * EKDK;
  xi2 := -rho1 * EKC;
  xi3 := -alpha1 * EKC;
  xi4 := -q1 * EKC;
  xi5 := -rho2 * EKH;
  xi6 := r2 - 2 * r2 * b2 * EKH - mu1 - rho2 * EKC - q2 * EKDK;
  xi7 := -q2 * EK1H;
  xi8 := r3 - 2 * r3 * b3 * EKIP - betaa * EKIS - q3 * EKDK;
  xi9 := -betaa * EKIP;
  xi10 := -q3 * EKIP;
  xi11 := -alpha2 * EKIS;
```

```
xi12 := betaa * EKIS;
xi13 := betaa * EKIP - mu2 - alpha2 * EKC - q4 * EKDK;
xi14 := -q4 * EKIS;
xi15 := -gamma1;
>
> j1 := -(xi13 + xi15 + xi6 + xi8 + xi1) / 2;
  j2 := ((xi1 + xi15 + xi6 + xi8) * xi13 + (xi1 + xi6 + xi8) * xi15 + (xi6 + xi8) * xi1 - xi5 * xi2
      - xi11 * xi3 + xi8 * xi6 - xi12 * xi9) / 4;
  j3 := (((-xi1 - xi13 - xi8) * xi6 + (-xi1 - xi13) * xi8 - xi13 * xi1 + xi5 * xi2 + xi11 * xi3 + xi12
      * xi9) * xi15 + ((-xi1 - xi13) * xi8 - xi13 * xi1 + xi11 * xi3 + xi12 * xi9) * xi6 + (-xi1 * xi13
      + xi11 * xi3 + xi2 * xi5) * xi8 + xi1 * xi12 * xi9 + xi13 * xi2 * xi5) / 8;
  j4 := ((((xi1 + xi13) * xi8 + xi13 * xi1 - xi11 * xi3 - xi12 * xi9) * xi6 + (xi1 * xi13 - xi11 * xi3 - xi2
      * xi5) * xi8 - xi1 * xi12 * xi9 - xi13 * xi2 * xi5) * xi15 + ((xi1 * xi13 - xi11 * xi3) * xi8 - xi1 * xi12
      * xi9) * xi6 - xi5 * xi2 * (-xi12 * xi9 + xi13 * xi8)) / 16;
  j5 := -(xi15 * (-xi1 * xi12 * xi6 * xi9 + xi1 * xi13 * xi6 * xi8 - xi11 * xi3 * xi6 * xi8 + xi12 * xi2
      * xi5 * xi9 - xi13 * xi2 * xi5 * xi8)) / 32;

> QK1 := j1;
  QK2 := j1 * j2 - j3;
  QK3 := j1 * j2 * j3 + j1 * j5 - (((j3)^2) + ((j1)^2) * j4);
  QK4 := j1 * j2 * j3 * j4 + 2 * j1 * j4 * j5 + j2 * j3 * j5 - ((j1)^2) * ((j4)^2) - ((j3)^2) * j4
      - ((j5)^2) - j1 * ((j2)^2) * j5;
  QK5 := j1 * j2 * j3 * j4 * j5 + ((j3)^3) * (2 * j1 * j4 + j2 * j3) - j5 * (((j1)^2) * ((j4)^2)
      + ((j3)^2) * j4 + ((j5)^2) + j1 * ((j2)^2) * j5);
```

$$QK1 := 0.9424358278$$
$$QK2 := 0.07234711297$$
$$QK3 := 0.00002625427262$$
$$QK4 := 8.86742499\ 10^{-13}$$
$$QK5 := 1.798933273\ 10^{-14} \quad (2)$$

```
> JK := [ xi1   xi2   0     xi3   xi4
          xi5   xi6   0     0     xi7
          0     0     xi8   xi9   xi10
          xi11  0     xi12  xi13  xi14
          0     0     0     0     xi15 ];
```

$$JK := \left[\left[-1.704855375, -0., 0, -0., -0.\right], \left[-0.4533333333, -0.1700000000, 0, 0, -\frac{1}{1000000000000}\ EK1H\right], \left[0, 0, -0.00001628064036, -0.04120000004, -66.45161297\right], \left[-0.001350358144, 0, 0.02446586935, 4.30000000\ 10^{-12}, -0.00007892215920\right], \left[0, 0, 0, 0, -0.01\right]\right] \quad (3)$$

```
> JKT := Transpose(JK);
```

$$JKT := \left[\left[-1.704855375,\ -0.4533333333,\ 0,\ -0.001350358144,\ 0\right],\right.$$
$$\left[-0.,\ -0.1700000000,\ 0,\ 0,\ 0\right],$$
$$\left[0,\ 0,\ -0.00001628064036,\ 0.02446586935,\ 0\right],$$
$$\left[-0.,\ 0,\ -0.04120000004,\ 4.30000000\ 10^{-12},\ 0\right],$$
$$\left.\left[-0.,\ -\frac{1}{1000000000000}\ EK1H,\ -66.45161297,\ -0.00007892215920,\ -0.01\right]\right] \quad (4)$$

```
> RK := IdentityMatrix(5);
```

$$RK := \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (5)$$

```
>
> PK_Matlab := [[10.7099068494393, -3.24289408172308, -46.0926015395673,
      -453.686768255177, -637967.949433706],
     [-3.24289408172308, 2.94117647061912, 0, 0, -0.0154320987655851],
     [-46.0926015395673, 0, 48948.667659411, 12.1359223195922, -29370459.1628123],
     [-453.686768255177, 0, 12.1359223195922, 82428.5161360171, 120924996.150701],
     [-637967.949433706, -0.0154320987655851, -29370459.1628123, 120924996.150701,
      195170484160.659]]
> PK := PK_Matlab;
```

$$PK := [[10.7099068494393,\ -3.24289408172308,\ -46.0926015395673,\ -453.686768255177,\ -6.37967949433706\ 10^{5}],$$
$$[-3.24289408172308,\ 2.94117647061912,\ 0,\ 0,\ -0.0154320987655851],$$
$$[-46.0926015395673,\ 0,\ 48948.667659411,\ 12.1359223195922,\ -2.93704591628123\ 10^{7}],$$
$$[-453.686768255177,\ 0,\ 12.1359223195922,\ 82428.5161360171,\ 1.20924996150701\ 10^{8}],$$
$$[-6.37967949433706\ 10^{5},\ -0.0154320987655851,\ -2.93704591628123\ 10^{7},\ 1.20924996150701\ 10^{8},\ 1.95170484160659\ 10^{11}]] \quad (6)$$

```
> PKT := Transpose(PK);
```

$$PKT := [[10.7099068494393,\ -3.24289408172308,\ -46.0926015395673,\ -453.686768255177,\ -6.37967949433706\ 10^{5}],$$
$$[-3.24289408172308,\ 2.94117647061912,\ 0,\ 0,\ -0.0154320987655851],$$
$$[-46.0926015395673,\ 0,\ 48948.667659411,\ 12.1359223195922,\ -2.93704591628123\ 10^{7}], \quad (7)$$

$$\left[-453.686768255177,\ 0,\ 12.1359223195922,\ 82428.5161360171,\ 1.20924996150701\ 10^{8}\right],$$
$$\left[-6.37967949433706\ 10^{5},\ -0.0154320987655851,\ -2.93704591628123\ 10^{7},\right.$$
$$\left.1.20924996150701\ 10^{8},\ 1.95170484160659\ 10^{11}\right]]$$

> $DetSubMatPk1 := PK(1,1);$

$$DetSubMatPk1 := 10.7099068494393 \tag{8}$$

> $DetSubMatPk2 := Determinant(PK(1..2,1..2));$

$$DetSubMatPk2 := 20.98336400 \tag{9}$$

> $DetSubMatPk3 := Determinant(PK(1..3,1..3));$

$$DetSubMatPk3 := 1.020859099\ 10^{6} \tag{10}$$

> $DetSubMatPk4 := Determinant(PK(1..4,1..4));$

$$DetSubMatPk4 := 5.451648852\ 10^{10} \tag{11}$$

> $DetSubMatPk5 := Determinant(PK)$

$$DetSubMatPk5 := 6.849711091\ 10^{18} \tag{12}$$

> $f1 := r1*C - r1*b1*C*C - rho1*H*C - alpha1*IS*C - q1*DK*C;$
$f2 := r2*H - r2*b2*H*H - mu1*H - rho2*C*H - q2*DK*H;$
$f3 := r3*IP - r3*b3*IP*IP - betaa*IS*IP - q3*DK*IP;$
$f4 := betaa*IP*IS - mu2*IS - alpha2*C*IS - q4*DK*IS;$
$f5 := delta1*u0 - gamma1*DK;$

> $f := \begin{bmatrix} f1 \\ f2 \\ f3 \\ f4 \\ f5 \end{bmatrix};$

> $fT := Transpose(f);$

> $fTP := fT.PK;$

>

> $VK1 := fTP(1,1);$

$$VK1 := -4.618111834\ 10^{-7}\ C^{2} - 9.638916165\ C\ DK + 3.78499405\ 10^{-10}\ C\ H \tag{13}$$
$$- 0.000001023909132\ C\ IS + 4.712359014\ C + 3.242894082\ 10^{-12}\ DK\ H$$
$$+ 5.837209348\ 10^{-10}\ H^{2} - 0.5512919939\ H + 0.0004609260154\ DK\ IP$$
$$+ 1.129268738\ 10^{-10}\ IP^{2} - 0.000002527083834\ IP\ IS - 1.129268738\ IP$$
$$+ 9.073735366\ 10^{-9}\ DK\ IS + 18.69189485\ IS + 6379.679494\ DK - 11387.72790$$

> $VK2 := fTP(1,2);$

$$VK2 := 1.398335928\ 10^{-7}\ C^{2} + 2.918604674\ C\ DK - 1.055046357\ 10^{-9}\ C\ H \tag{14}$$
$$+ 3.570426384\ 10^{-7}\ C\ IS - 1.426873396\ C - 2.941176471\ 10^{-12}\ DK\ H$$
$$- 5.294117648\ 10^{-10}\ H^{2} + 0.5000000001\ H - 0.0002754629630 + 0.0001543209877\ DK$$

> $VK3 := fTP(1,3);$

$$VK3 := 0.000001987512978\ C^{2} + 41.48334139\ C\ DK + 5.070186169\ 10^{-9}\ C\ H \tag{15}$$
$$+ 0.000005070642517\ C\ IS - 20.28074468\ C - 5.242626960\ 10^{5} - 0.4894866766\ DK\ IP$$

$$-1.199242358\ 10^{-7}\ IP^2 - 0.0003034064968\ IP\ IS + 1199.242358\ IP$$
$$-2.427184464\ 10^{-10}\ DK\ IS - 0.4999999996\ IS + 2.937045916\ 10^5\ DK$$

> $VK4 := fTP(1,4);$

$$VK4 := 0.00001956297345\ C^2 + 408.3180915\ C\ DK + 4.990554451\ 10^{-8}\ C\ H \quad (16)$$
$$+ 0.00002174387497\ C\ IS - 199.6221781\ C + 2.158511182\ 10^6$$
$$- 0.0001213592232\ DK\ IP - 2.973300968\ 10^{-11}\ IP^2 + 0.0005109815574\ IP\ IS$$
$$+ 0.2973300968\ IP - 0.000001648570323\ DK\ IS - 3396.054865\ IS$$
$$- 1.209249962\ 10^6\ DK$$

> $VK5 := fTP(1,5);$

$$VK5 := 0.02750917798\ C^2 + 5.741711545\ 10^5\ C\ DK + 0.00007017648184\ C\ H \quad (17)$$
$$+ 0.02885973753\ C\ IS - 2.807058977\ 10^5\ C + 1.543209877\ 10^{-14}\ DK\ H$$
$$+ 2.777777779\ 10^{-12}\ H^2 - 0.002623456791\ H + 293.7045916\ DK\ IP$$
$$+ 0.00007195762494\ IP^2 + 0.9318318232\ IP\ IS - 7.195762494\ 10^5\ IP$$
$$- 0.002418499924\ DK\ IS - 4.982109843\ 10^6\ IS - 1.951704842\ 10^9\ DK$$
$$+ 3.483793143\ 10^9$$

> $A1 := f(1,1);$

$$A1 := -4.312000000\ 10^{-8}\ C^2 - 0.9\ C\ DK - 1.100000000\ 10^{-10}\ C\ H - 1.101000000\ 10^{-7}\ C\ IS \quad (18)$$
$$+ 0.44\ C$$

> $A2 := f(2,1);$

$$A2 := -4.800000000\ 10^{-10}\ C\ H - \frac{1}{1000000000000}\ DK\ H - 1.800000000\ 10^{-10}\ H^2 + 0.17\ H \quad (19)$$

> $A3 := f(3,1);$

$$A3 := -\frac{1}{100000}\ DK\ IP - 2.450000000\ 10^{-12}\ IP^2 - 6.200000000\ 10^{-9}\ IP\ IS + 0.0245\ IP \quad (20)$$

> $A4 := f(4,1);$

$$A4 := -3.422000000\ 10^{-10}\ C\ IS - \frac{1}{50000000000}\ DK\ IS + 6.200000000\ 10^{-9}\ IP\ IS - 0.0412\ IS \quad (21)$$

> $A5 := f(5,1);$

$$A5 := -0.01\ DK + 0.01785 \quad (22)$$

> $VK := fTP.f;$

$$VK := (-4.618111834\ 10^{-7}\ C^2 - 9.638916165\ C\ DK + 3.78499405\ 10^{-10}\ C\ H \quad (23)$$
$$- 0.000001023909132\ C\ IS + 4.712359014\ C + 3.242894082\ 10^{-12}\ DK\ H$$
$$+ 5.837209348\ 10^{-10}\ H^2 - 0.5512919939\ H + 0.0004609260154\ DK\ IP$$
$$+ 1.129268738\ 10^{-10}\ IP^2 - 0.000002527083834\ IP\ IS - 1.129268738\ IP$$
$$+ 9.073735366\ 10^{-9}\ DK\ IS + 18.69189485\ IS + 6379.679494\ DK - 11387.72790)\ ($$
$$-4.312000000\ 10^{-8}\ C^2 - 0.9\ C\ DK - 1.100000000\ 10^{-10}\ C\ H - 1.101000000\ 10^{-7}\ C\ IS$$
$$+ 0.44\ C) + (1.398335928\ 10^{-7}\ C^2 + 2.918604674\ C\ DK - 1.055046357\ 10^{-9}\ C\ H$$
$$+ 3.570426384\ 10^{-7}\ C\ IS - 1.426873396\ C - 2.941176471\ 10^{-12}\ DK\ H$$
$$- 5.294117648\ 10^{-10}\ H^2 + 0.5000000001\ H - 0.0002754629630 + 0.0001543209877\ DK)$$

$$
\begin{aligned}
&\left(-4.800000000\,10^{-10}\,C\,H-\frac{1}{1000000000000}\,DK\,H-1.800000000\,10^{-10}\,H^2+0.17\,H\right)\\
&+\left(0.000001987512978\,C^2+41.48334139\,C\,DK+5.070186169\,10^{-9}\,C\,H\right.\\
&+0.000005070642517\,C\,IS-20.28074468\,C-5.242626960\,10^5-0.4894866766\,DK\,IP\\
&-1.199242358\,10^{-7}\,IP^2-0.0003034064968\,IP\,IS+1199.242358\,IP\\
&\left.-2.427184464\,10^{-10}\,DK\,IS-0.4999999996\,IS+2.937045916\,10^5\,DK\right)\left(\right.\\
&\left.-\frac{1}{100000}\,DK\,IP-2.450000000\,10^{-12}\,IP^2-6.200000000\,10^{-9}\,IP\,IS+0.0245\,IP\right)\\
&+\left(0.00001956297345\,C^2+408.3180915\,C\,DK+4.990554451\,10^{-8}\,C\,H\right.\\
&+0.00002174387497\,C\,IS-199.6221781\,C+2.158511182\,10^6\\
&-0.0001213592232\,DK\,IP-2.973300968\,10^{-11}\,IP^2+0.0005109815574\,IP\,IS\\
&+0.2973300968\,IP-0.000001648570323\,DK\,IS-3396.054865\,IS\\
&\left.-1.209249962\,10^6\,DK\right)\left(-3.422000000\,10^{-10}\,C\,IS-\frac{1}{50000000000}\,DK\,IS\right.\\
&\left.+6.200000000\,10^{-9}\,IP\,IS-0.0412\,IS\right)+\left(0.02750917798\,C^2+5.741711545\,10^5\,C\,DK\right.\\
&+0.00007017648184\,C\,H+0.02885973753\,C\,IS-2.807058977\,10^5\,C\\
&+1.543209877\,10^{-14}\,DK\,H+2.777777779\,10^{-12}\,H^2-0.002623456791\,H\\
&+293.7045916\,DK\,IP+0.00007195762494\,IP^2+0.9318318232\,IP\,IS\\
&-7.195762494\,10^5\,IP-0.002418499924\,DK\,IS-4.982109843\,10^6\,IS\\
&\left.-1.951704842\,10^9\,DK+3.483793143\,10^9\right)\,(-0.01\,DK+0.01785)
\end{aligned}
$$

Lampiran 2. Matriks P_K

```
clc; close all;
%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);
gamma1 = 0.01;
q1 = 0.08;
q2 = 1*10^(-12);
q3 = 1*10^(-5);
q4 = 2*10^(-11);
delta1 = 0.0357;
u0 = 0.5;
%EK
EKC = 0;
EKH = (r2*gamma1-mu1*gamma1-q2*delta1*u0)/(r2*b2*gamma1);
EKIP = (mu2*gamma1+q4*delta1*u0)/(beta*gamma1);
EKIS = (r3*beta*gamma1-r3*b3*mu2*gamma1-r3*b3*q4*delta1*u0-
beta*q3*delta1*u0)/(((beta)^2)*gamma1);
EKDK = (delta1*u0)/gamma1;
%Nilai JK
xi1 = r1-2*r1*b1*EKC-rho1*EKH-alpha1*EKIS-q1*EKDK;
xi2 = -rho1*EKC;
xi3 = -alpha1*EKC;
xi4 = -q1*EKC;
xi5 = -rho2*EKH;
xi6 = r2-2*r2*b2*EKH-mu1-rho2*EKC-q2*EKDK;
xi7 = -q2*E1H;
xi8 = r3-2*r3*b3*EKIP-beta*EKIS-q3*EKDK;
xi9 = -beta*EKIP;
xi10= -q3*EKIP;
xi11= -alpha2*EKIS;
xi12= beta*EKIS;
xi13= beta*EKIP-mu2-alpha2*EKC-q4*EKDK;
xi14= -q4*EKIS;
xi15= -gamma1;
%Matriks JK
JK = [xi1 xi2 0 xi3 xi4; xi5 xi6 0 0 xi7; 0 0 xi8 xi9 xi10; xi11 0
xi12 xi13 xi14; 0 0 0 0 xi15]
JKT = transpose(JK);
%Matriks RK
RK = eye(5);
s P by Lyapunov Eq
 lyap(JKT,RK);
a(PK_Ly,15)
```

Lampiran 3. Titik Kesetimbangan, Analisis Kestabilan Lokal, dan Analisis Kestabilan Global dari E_I

```
> restart
> with(LinearAlgebra) :
> r1 := 0.44;
  r2 := 0.18;
  r3 := 0.0245;
  b1 := 9.8 * 10^(-8);
  b2 := 1 * 10^(-9);
  b3 := 1 * 10^(-10);
  rho1 := 1.1 * 10^(-10);
  rho2 := 4.8 * 10^(-10);
  mu1 := 0.01;
  mu2 := 0.0412;
  alpha1 := 1.101 * 10^(-7);
  alpha2 := 3.422 * 10^(-10);
  betaa := 6.2 * 10^(-9);
  gamma2 := 0.02;
  s1 := 1 * 10^(-2);
  s2 := 1 * 10^(-5);
  delta2 := 0.0179;
  v0 := 0.4;
>
> EIC := 0;
  EIH := (r2-mu1) / (r2 * b2);
  EIIP := (mu2 * gamma2 + s2 * delta2 * v0) / (betaa * gamma2);
  EIIS := (r3 * betaa * gamma2 - r3 * b3 * mu2 * gamma2 + r3 * b3 * s2 * delta2 * v0 + betaa * s1
      * delta2 * v0) / (((betaa)^2) * gamma2);
  EIDI := (delta2 * v0) / gamma2;
```

$$EIC := 0$$

$$EIH := 9.444444444\ 10^{8}$$

$$EIIP := 6.645738710\ 10^{6}$$

$$EIIS := 4.526406575\ 10^{6}$$

$$EIDI := 0.3580000000 \quad \textbf{(1)}$$

```
> ze1 := r1 - 2 * r1 * b1 * EIC - rho1 * EIH - alpha1 * EIIS;
  ze2 := -rho1 * EIC;
  ze3 := -alpha1 * EIC;
  ze4 := -rho2 * EIH;
  ze5 := r2 - 2 * r2 * b2 * EIH - mu1 - rho2 * EIC;
  ze6 := r3 - 2 * r3 * b3 * EIIP - betaa * EIIS + s1 * EIDI;
  ze7 := -betaa * EIIP;
  ze8 := s1 * EIIP;
  ze9 := -alpha2 * EIIS;
  ze10 := betaa * EIIS;
  ze11 := betaa * EIIP - mu2 - alpha2 * EIC + s2 * EIDI;
  ze12 := s2 * EIIS;
  ze13 := -gamma2;
```

```
> k1 := -(ze1 + ze5 + ze6 + ze11 + ze13) / 2;
  k2 := ((ze1 + ze13 + ze5 + ze6) * ze11 + (ze1 + ze5 + ze6) * ze13 + (ze5 + ze6) * ze1 - ze2
      * ze4 - ze3 * ze9 + ze6 * ze5 - ze10 * ze7) / 4;
  k3 := (((-ze1 - ze11 - ze6) * ze5 + (-ze1 - ze11) * ze6 - ze11 * ze1 + ze4 * ze2 + ze9 * ze3 + ze10
      * ze7) * ze13 + ((-ze1 - ze11) * ze6 - ze11 * ze1 + ze9 * ze3 + ze10 * ze7) * ze5 + (-ze1 * ze11
      + ze2 * ze4 + ze3 * ze9) * ze6 + ze1 * ze10 * ze7 + ze11 * ze2 * ze4) / 8;
  k4 := ((((ze1 + ze11) * ze6 + ze11 * ze1 - ze9 * ze3 - ze10 * ze7) * ze5 + (ze1 * ze11 - ze2 * ze4
      - ze3 * ze9) * ze6 - ze1 * ze10 * ze7 - ze11 * ze2 * ze4) * ze13 + ((ze1 * ze11 - ze3 * ze9) * ze6 - ze1
      * ze10 * ze7) * ze5 - ze2 * ze4 * (-ze10 * ze7 + ze11 * ze6)) / 16;
  k5 := (ze13 * (ze1 * ze10 * ze5 * ze7 - ze1 * ze11 * ze5 * ze6 - ze10 * ze2 * ze4 * ze7 + ze11 * ze2 * ze4
      * ze6 + ze3 * ze5 * ze6 * ze9)) / 32;

> QI1 := k1;
  QI2 := k1 * k2 - k3;
  QI3 := k1 * k2 * k3 + k1 * k5 - ((k3)^2) - ((k1)^2) * k4;
  QI4 := k1 * k2 * k3 * k4 + 2 * k1 * k4 * k5 + k2 * k3 * k5 - ((k1)^2) * ((k4)^2) - ((k3)^2) * k4
      - ((k5)^2) - k1 * ((k2)^2) * k5;
  QI5 := k1 * k2 * k3 * k4 * k5 + ((k3)^3) * (2 * k1 * k4 + k2 * k3) - k5 * (((k1)^2) * ((k4)^2)
      + ((k3)^2) * k4 + ((k5)^2) + k1 * ((k2)^2) * k5);
```

$$QI1 := 0.1761276888$$
$$QI2 := 0.001438220417$$
$$QI3 := 9.922177293\ 10^{-8}$$
$$QI4 := 1.3181127\ 10^{-16}$$
$$QI5 := 3.330398808\ 10^{-18} \quad (2)$$

$$> JI := \begin{bmatrix} ze1 & ze2 & 0 & ze3 & 0 \\ ze4 & ze5 & 0 & 0 & 0 \\ 0 & 0 & ze6 & ze7 & ze8 \\ ze9 & 0 & ze10 & ze11 & ze12 \\ 0 & 0 & 0 & 0 & ze13 \end{bmatrix};$$

$$JI := [[-0.1622462528, -0., 0, -0., 0], \quad (3)$$
$$[-0.4533333333, -0.1700000000, 0, 0, 0],$$
$$[0, 0, -0.000016284880, -0.04120358000, 66457.38710],$$
$$[-0.001548936330, 0, 0.02806372076, 0.000007160000000, 45.26406575],$$
$$[0, 0, 0, 0, -0.02]]$$

```
> JIT := Transpose(JI);
```

$$JIT := \begin{bmatrix} -0.1622462528 & -0.4533333333 & 0 & -0.001548936330 & 0 \\ -0. & -0.1700000000 & 0 & 0 & 0 \\ 0 & 0 & -0.000016284880 & 0.02806372076 & 0 \\ -0. & 0 & -0.04120358000 & 0.000007160000000 & 0 \\ 0 & 0 & 66457.38710 & 45.26406575 & -0.02 \end{bmatrix} \quad (4)$$

```
> RI := IdentityMatrix(5);
```

$$RI := \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (5)$$

```
> PI_Matlab := [[ 26.1024026539695, -4.01308764745829,  -214.250828184631,
      -1236.81689436281,  1297965612.57463],
     [-4.01308764745829,  2.94117647058824, 0, 0, 0],
     [-214.250828184631, 0, 92116.1433076938,  35.6367993722714, 78785600321.2914],
     [ -1236.81689436281, 0, 35.6367993722714,  135246.328753909, -161945909555.493],
     [ 1297965612.57463, 0, 78785600321.2914, -161945909555.493,  2.61427740395228e17]]
```

(6)

```
> P_I := PI_Matlab;
```

$$P\_I := [[26.1024026539695, -4.01308764745829, -214.250828184631, -1236.81689436281, 1.29796561257463\ 10^{9}], [-4.01308764745829, 2.94117647058824, 0, 0, 0], [-214.250828184631, 0, 92116.1433076938, 35.6367993722714, 7.87856003212914\ 10^{10}], [-1236.81689436281, 0, 35.6367993722714, 1.35246328753909\ 10^{5}, -1.61945909555493\ 10^{11}], [1.29796561257463\ 10^{9}, 0, 7.87856003212914\ 10^{10}, -1.61945909555493\ 10^{11}, 2.61427740395228\ 10^{17}]] \quad (7)$$

```
> P_IT := Transpose(P_I);
```

$$P\_IT := [[26.1024026539695, -4.01308764745829, -214.250828184631, -1236.81689436281, 1.29796561257463\ 10^{9}], [-4.01308764745829, 2.94117647058824, 0, 0, 0], [-214.250828184631, 0, 92116.1433076938, 35.6367993722714, 7.87856003212914\ 10^{10}], [-1236.81689436281, 0, 35.6367993722714, 1.35246328753909\ 10^{5}, -1.61945909555493\ 10^{11}], [1.29796561257463\ 10^{9}, 0, 7.87856003212914\ 10^{10}, -1.61945909555493\ 10^{11}, 2.61427740395228\ 10^{17}]] \quad (8)$$

```
>
> DetSubMatPi1 := P_I(1, 1);
```

$$DetSubMatPi1 := 26.1024026539695 \quad (9)$$

```
> DetSubMatPi2 := Determinant(P_I(1..2, 1..2));
```

$$DetSubMatPi2 := 60.66690005 \tag{10}$$

> $DetSubMatPi3 := Determinant(P\_I(1..3, 1..3));$

$$DetSubMatPi3 := 5.453390808\ 10^{6} \tag{11}$$

> $DetSubMatPi4 := Determinant(P\_I(1..4, 1..4));$

$$DetSubMatPi4 := 3.231608495\ 10^{11} \tag{12}$$

> $DetSubMatPi5 := Determinant(P\_I(1..5, 1..5));$

$$DetSubMatPi5 := 1.750427973\ 10^{25} \tag{13}$$

> $g1 := r1*C - r1*b1*C*C - rho1*H*C - alpha1*IS*C - q1*DK*C;$
> $g2 := r2*H - r2*b2*H*H - mu1*H - rho2*C*H - q2*DK*H;$
> $g3 := r3*IP - r3*b3*IP*IP - betaa*IS*IP - q3*DK*IP;$
> $g4 := betaa*IP*IS - mu2*IS - alpha2*C*IS - q4*DK*IS;$
> $g5 := delta1*u0 - gamma1*DK;$

> $g := \begin{bmatrix} g1 \\ g2 \\ g3 \\ g4 \\ g5 \end{bmatrix};$

> $gT := Transpose(g);$

> $gTP := gT.P\_I;$

> $VI1 := gTP(1,1);$

$$\begin{aligned} VI1 := {} & -26.1024026539695\ q1\ DK\ C - 0.000001125535602\ C^2 - 9.44982221\ 10^{-10}\ C\ H \\ & - 0.000002450635791\ C\ IS + 11.48505717\ C + 4.01308764745829\ q2\ DK\ H \\ & + 7.223557765\ 10^{-10}\ H^2 - 0.6822249000\ H + 214.250828184631\ q3\ DK\ IP \\ & + 5.249145291\ 10^{-10}\ IP^2 - 0.000006339909608\ IP\ IS - 5.249145291\ IP \\ & + 1236.81689436281\ q4\ DK\ IS + 50.95685603\ IS - 1.29796561257463\ 10^{9}\ DK\ \gamma 1 \\ & + 1.29796561257463\ 10^{9}\ \delta 1\ u0 \end{aligned} \tag{14}$$

> $VI2 := gTP(1,2);$

$$\begin{aligned} VI2 := {} & 4.01308764745829\ q1\ DK\ C + 1.730443393\ 10^{-7}\ C^2 - 9.703250648\ 10^{-10}\ C\ H \\ & + 4.418409499\ 10^{-7}\ C\ IS - 1.765758565\ C - 2.94117647058824\ q2\ DK\ H \\ & - 5.294117648\ 10^{-10}\ H^2 + 0.5000000001\ H \end{aligned} \tag{15}$$

> $VI3 := gTP(1,3);$

$$\begin{aligned} VI3 := {} & 214.250828184631\ q1\ DK\ C + 0.000009238495712\ C^2 + 2.356759110\ 10^{-8}\ C\ H \\ & + 0.00002357682127\ C\ IS - 94.27036441\ C - 92116.1433076938\ q3\ DK\ IP \\ & - 2.256845511\ 10^{-7}\ IP^2 - 0.0005708991403\ IP\ IS + 2256.845511\ IP \\ & - 35.6367993722714\ q4\ DK\ IS - 1.468236134\ IS - 7.87856003212914\ 10^{10}\ DK\ \gamma 1 \\ & + 7.87856003212914\ 10^{10}\ \delta 1\ u0 \end{aligned} \tag{16}$$

> $VI4 := gTP(1,4);$

$$VI4 := 1236.81689436281\ q1\ DK\ C + 0.00005333154447\ C^2 + 1.360498583\ 10^{-7}\ C\ H \tag{17}$$

$$+0.00008989224628\,C\,IS-544.1994334\,C-35.6367993722714\,q3\,DK\,IP$$
$$-8.731015846\,10^{-11}\,IP^2+0.0008383062904\,IP\,IS+0.8731015846\,IP$$
$$-1.35246328753909\,10^{5}\,q4\,DK\,IS-5572.148747\,IS+1.61945909555493\,10^{11}\,DK\,\gamma 1$$
$$-1.61945909555493\,10^{11}\,\delta 1\,u0$$

> $VI5 := gTP(1,5);$

$$VI5 := -1.29796561257463\,10^{9}\,q1\,DK\,C-55.96827723\,C^2-0.1427762174\,C\,H \quad (18)$$
$$-87.48812373\,C\,IS+5.711048697\,10^{8}\,C-7.87856003212914\,10^{10}\,q3\,DK\,IP$$
$$-0.1930247208\,IP^2-1492.535362\,IP\,IS+1.930247208\,10^{9}\,IP$$
$$+1.61945909555493\,10^{11}\,q4\,DK\,IS+6.672171476\,10^{9}\,IS$$
$$-2.61427740395228\,10^{17}\,DK\,\gamma 1+2.61427740395228\,10^{17}\,\delta 1\,u0$$

> $B1 := g(1,1);$

$$B1 := -q1\,DK\,C-4.312000000\,10^{-8}\,C^2-1.100000000\,10^{-10}\,C\,H-1.101000000\,10^{-7}\,C\,IS \quad (19)$$
$$+0.44\,C$$

> $B2 := g(2,1);$

$$B2 := -q2\,DK\,H-4.800000000\,10^{-10}\,C\,H-1.800000000\,10^{-10}\,H^2+0.17\,H \quad (20)$$

> $B3 := g(3,1);$

$$B3 := -q3\,DK\,IP-2.450000000\,10^{-12}\,IP^2-6.200000000\,10^{-9}\,IP\,IS+0.0245\,IP \quad (21)$$

> $B4 := g(4,1);$

$$B4 := -q4\,DK\,IS-3.422000000\,10^{-10}\,C\,IS+6.200000000\,10^{-9}\,IP\,IS-0.0412\,IS \quad (22)$$

> $B5 := g(5,1);$

$$B5 := -DK\,\gamma 1+\delta 1\,u0 \quad (23)$$

> $VI := gTP.g;$

$$VI := (-26.1024026539695\,q1\,DK\,C-0.000001125535602\,C^2-9.44982221\,10^{-10}\,C\,H \quad (24)$$
$$-0.000002450635791\,C\,IS+11.48505717\,C+4.01308764745829\,q2\,DK\,H$$
$$+7.223557765\,10^{-10}\,H^2-0.6822249000\,H+214.250828184631\,q3\,DK\,IP$$
$$+5.249145291\,10^{-10}\,IP^2-0.000006339909608\,IP\,IS-5.249145291\,IP$$
$$+1236.81689436281\,q4\,DK\,IS+50.95685603\,IS-1.29796561257463\,10^{9}\,DK\,\gamma 1$$
$$+1.29796561257463\,10^{9}\,\delta 1\,u0)\,(-q1\,DK\,C-4.312000000\,10^{-8}\,C^2$$
$$-1.100000000\,10^{-10}\,C\,H-1.101000000\,10^{-7}\,C\,IS+0.44\,C)$$
$$+(4.01308764745829\,q1\,DK\,C+1.730443393\,10^{-7}\,C^2-9.703250648\,10^{-10}\,C\,H$$
$$+4.418409499\,10^{-7}\,C\,IS-1.765758565\,C-2.94117647058824\,q2\,DK\,H$$
$$-5.294117648\,10^{-10}\,H^2+0.5000000001\,H)\,(-q2\,DK\,H-4.800000000\,10^{-10}\,C\,H$$
$$-1.800000000\,10^{-10}\,H^2+0.17\,H)+(214.250828184631\,q1\,DK\,C$$
$$+0.000009238495712\,C^2+2.356759110\,10^{-8}\,C\,H+0.00002357682127\,C\,IS$$
$$-94.27036441\,C-92116.1433076938\,q3\,DK\,IP-2.256845511\,10^{-7}\,IP^2$$
$$-0.0005708991403\,IP\,IS+2256.845511\,IP-35.6367993722714\,q4\,DK\,IS$$
$$-1.468236134\,IS-7.87856003212914\,10^{10}\,DK\,\gamma 1+7.87856003212914\,10^{10}\,\delta 1\,u0)\,($$

$$
\begin{aligned}
&-q3\,DK\,IP - 2.450000000\,10^{-12}\,IP^2 - 6.200000000\,10^{-9}\,IP\,IS + 0.0245\,IP\big) \\
&+ \big(1236.81689436281\,q1\,DK\,C + 0.00005333154447\,C^2 + 1.360498583\,10^{-7}\,C\,H \\
&+ 0.00008989224628\,C\,IS - 544.1994334\,C - 35.6367993722714\,q3\,DK\,IP \\
&- 8.731015846\,10^{-11}\,IP^2 + 0.0008383062904\,IP\,IS + 0.8731015846\,IP \\
&- 1.35246328753909\,10^{5}\,q4\,DK\,IS - 5572.148747\,IS + 1.61945909555493\,10^{11}\,DK\,\gamma I \\
&- 1.61945909555493\,10^{11}\,\delta I\,u0\big)\,\big(-q4\,DK\,IS - 3.422000000\,10^{-10}\,C\,IS \\
&+ 6.200000000\,10^{-9}\,IP\,IS - 0.0412\,IS\big) + \big(-1.29796561257463\,10^{9}\,q1\,DK\,C \\
&- 55.96827723\,C^2 - 0.1427762174\,C\,H - 87.48812373\,C\,IS + 5.711048697\,10^{8}\,C \\
&- 7.87856003212914\,10^{10}\,q3\,DK\,IP - 0.1930247208\,IP^2 - 1492.535362\,IP\,IS \\
&+ 1.930247208\,10^{9}\,IP + 1.61945909555493\,10^{11}\,q4\,DK\,IS + 6.672171476\,10^{9}\,IS \\
&- 2.61427740395228\,10^{17}\,DK\,\gamma I + 2.61427740395228\,10^{17}\,\delta I\,u0\big)\,\big(-DK\,\gamma I + \delta I\,u0\big)
\end{aligned}
$$

Lampiran 4. Matriks P_I

```
clc; close all;
%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);
gamma2 = 0.02;
s1 = 1*10^(-2);
s2 = 1*10^(-5);
delta2 = 0.0179;
v0 = 0.4;
%EI
EIC = 0;
EIH = (r2-mu1)/(r2*b2);
EIIP = (mu2*gamma2+s2*delta2*v0)/(beta*gamma2);
EIIS = (r3*beta*gamma2-
r3*b3*mu2*gamma2+r3*b3*s2*delta2*v0+beta*s1*delta2*v0)/(((beta)^2)
*gamma2);
EIDI = (delta2*v0)/gamma2;
%Nilai JI
ze1 = r1-2*r1*b1*EIC-rho1*EIH-alpha1*EIIS;
ze2 = -rho1*EIC;
ze3 = -alpha1*EIC;
ze4 = -rho2*EIH;
ze5 = r2-2*r2*b2*EIH-mu1-rho2*EIC;
ze6 = r3-2*r3*b3*EIIP-beta*EIIS+s1*EIDI;
ze7 = -beta*EIIP;
ze8 = s1*EIIP;
ze9 = -alpha2*EIIS;
ze10= beta*EIIS;
ze11= beta*EIIP-mu2-alpha2*EIC+s2*EIDI;
ze12= s2*EIIS;
ze13= -gamma2;
%Matriks JI dan JIT
JI = [ze1 ze2 0 ze3 0; ze4 ze5 0 0 0; 0 0 ze6 ze7 ze8; ze9 0 ze10
ze11 ze12; 0 0 0 0 ze13]
JIT = transpose(JI);
%Matriks RI
RI = eye(5);
%Matriks PI by Lyapunov Eq
PI_Ly = lyap(JIT,RI);
PI_Ly=vpa(PI_Ly,15)
```

Lampiran 5. Penjabaran $j_1, j_2, \ldots, j_5$ pada Analisis Kestabilan Lokal E_K

```
> restart
> with(LinearAlgebra) :
> J1 := Matrix([[ξ1, ξ2, 0, ξ3, ξ4], [ξ5, ξ6, 0, 0, ξ7], [0, 0, ξ8, ξ9, ξ10], [ξ11, 0, ξ12, ξ13, ξ14], [0, 0, 0, 0, ξ15]]);
> M1 := IdentityMatrix(5)
> P1 := J1 - M1·λ
```

$$P1 := \begin{bmatrix} -\lambda+\xi1 & \xi2 & 0 & \xi3 & \xi4 \\ \xi5 & -\lambda+\xi6 & 0 & 0 & \xi7 \\ 0 & 0 & -\lambda+\xi8 & \xi9 & \xi10 \\ \xi11 & 0 & \xi12 & -\lambda+\xi13 & \xi14 \\ 0 & 0 & 0 & 0 & -\lambda+\xi15 \end{bmatrix} \quad (1)$$

```
> C1 := CharacteristicPolynomial(P1, λ)
```

$$\begin{aligned} C1 := {} & \lambda^5 - (-5\lambda + \xi15 + \xi13 + \xi8 + \xi6 + \xi1)\lambda^4 - (-10\lambda^2 + 4\lambda\xi1 + 4\lambda\xi13 + 4\lambda\xi15 \\ & + 4\lambda\xi6 + 4\lambda\xi8 - \xi1\xi13 - \xi1\xi15 - \xi1\xi6 - \xi1\xi8 + \xi11\xi3 + \xi12\xi9 - \xi13\xi15 \\ & - \xi13\xi6 - \xi13\xi8 - \xi15\xi6 - \xi15\xi8 + \xi2\xi5 - \xi6\xi8)\lambda^3 - (-10\lambda^3 + 6\lambda^2\xi1 + 6\lambda^2\xi13 \\ & + 6\lambda^2\xi15 + 6\lambda^2\xi6 + 6\lambda^2\xi8 - 3\lambda\xi1\xi13 - 3\lambda\xi1\xi15 - 3\lambda\xi1\xi6 - 3\lambda\xi1\xi8 \\ & + 3\lambda\xi11\xi3 + 3\lambda\xi12\xi9 - 3\lambda\xi13\xi15 - 3\lambda\xi13\xi6 - 3\lambda\xi13\xi8 - 3\lambda\xi15\xi6 \\ & - 3\lambda\xi15\xi8 + 3\lambda\xi2\xi5 - 3\lambda\xi6\xi8 - \xi1\xi12\xi9 + \xi1\xi13\xi15 + \xi1\xi13\xi6 + \xi1\xi13\xi8 \\ & + \xi1\xi15\xi6 + \xi1\xi15\xi8 + \xi1\xi6\xi8 - \xi11\xi15\xi3 - \xi11\xi3\xi6 - \xi11\xi3\xi8 - \xi12\xi15\xi9 \\ & - \xi12\xi6\xi9 + \xi13\xi15\xi6 + \xi13\xi15\xi8 - \xi13\xi2\xi5 + \xi13\xi6\xi8 - \xi15\xi2\xi5 + \xi15\xi6\xi8 \\ & - \xi2\xi5\xi8)\lambda^2 - (-3\xi15\lambda^2\xi1 - 3\xi15\lambda^2\xi13 - 3\xi15\lambda^2\xi6 - 3\xi15\lambda^2\xi8 + 3\lambda^2\xi11\xi3 \\ & + 3\lambda^2\xi12\xi9 - 3\lambda^2\xi1\xi13 - 3\lambda^2\xi1\xi6 - 3\lambda^2\xi1\xi8 - 3\lambda^2\xi13\xi6 - 3\lambda^2\xi13\xi8 \\ & + 3\lambda^2\xi2\xi5 - 3\lambda^2\xi6\xi8 + 4\xi15\lambda^3 + 4\lambda^3\xi1 + 4\lambda^3\xi13 + 4\lambda^3\xi6 + 4\lambda^3\xi8 \\ & - 2\lambda\xi1\xi12\xi9 - 2\lambda\xi11\xi3\xi6 - 2\lambda\xi11\xi3\xi8 - 2\lambda\xi12\xi6\xi9 + \xi1\xi12\xi6\xi9 \\ & + \xi11\xi3\xi6\xi8 - \xi12\xi2\xi5\xi9 + 2\lambda\xi1\xi13\xi6 + 2\lambda\xi1\xi13\xi8 + 2\lambda\xi1\xi6\xi8 \\ & - 2\lambda\xi13\xi2\xi5 + 2\lambda\xi13\xi6\xi8 - 2\lambda\xi2\xi5\xi8 - \xi1\xi13\xi6\xi8 + \xi13\xi2\xi5\xi8 \\ & + 2\xi15\lambda\xi1\xi13 + 2\xi15\lambda\xi1\xi6 + 2\xi15\lambda\xi1\xi8 - 2\xi15\xi11\xi3\lambda - 2\xi15\xi12\xi9\lambda \\ & + 2\xi15\lambda\xi13\xi6 + 2\xi15\lambda\xi13\xi8 - 2\xi15\lambda\xi2\xi5 + 2\xi15\lambda\xi6\xi8 + \xi15\xi1\xi12\xi9 \end{aligned} \quad (2)$$

$$-\xi 15\,\xi 1\,\xi 13\,\xi 6-\xi 15\,\xi 1\,\xi 13\,\xi 8-\xi 15\,\xi 1\,\xi 6\,\xi 8+\xi 15\,\xi 11\,\xi 3\,\xi 6+\xi 15\,\xi 11\,\xi 3\,\xi 8$$
$$+\xi 15\,\xi 12\,\xi 6\,\xi 9+\xi 15\,\xi 13\,\xi 2\,\xi 5-\xi 15\,\xi 13\,\xi 6\,\xi 8+\xi 15\,\xi 2\,\xi 5\,\xi 8-5\,\lambda^4)\,\lambda+(\lambda-\xi 15)\,($$
$$-\lambda^2\,\xi 11\,\xi 3-\lambda^2\,\xi 12\,\xi 9+\lambda^2\,\xi 1\,\xi 13+\lambda^2\,\xi 1\,\xi 6+\lambda^2\,\xi 1\,\xi 8+\lambda^2\,\xi 13\,\xi 6+\lambda^2\,\xi 13\,\xi 8$$
$$-\lambda^2\,\xi 2\,\xi 5+\lambda^2\,\xi 6\,\xi 8-\lambda^3\,\xi 1-\lambda^3\,\xi 13-\lambda^3\,\xi 6-\lambda^3\,\xi 8+\lambda\,\xi 1\,\xi 12\,\xi 9+\lambda\,\xi 11\,\xi 3\,\xi 6$$
$$+\lambda\,\xi 11\,\xi 3\,\xi 8+\lambda\,\xi 12\,\xi 6\,\xi 9-\xi 1\,\xi 12\,\xi 6\,\xi 9-\xi 11\,\xi 3\,\xi 6\,\xi 8+\xi 12\,\xi 2\,\xi 5\,\xi 9-\lambda\,\xi 1\,\xi 13\,\xi 6$$
$$-\lambda\,\xi 1\,\xi 13\,\xi 8-\lambda\,\xi 1\,\xi 6\,\xi 8+\lambda\,\xi 13\,\xi 2\,\xi 5-\lambda\,\xi 13\,\xi 6\,\xi 8+\lambda\,\xi 2\,\xi 5\,\xi 8+\xi 1\,\xi 13\,\xi 6\,\xi 8$$
$$-\xi 13\,\xi 2\,\xi 5\,\xi 8+\lambda^4)$$

> $C11 := \dfrac{C1}{coeff(C1,\lambda^5)}$

$$C11 := \frac{1}{32}\lambda^5-\frac{1}{32}\,(-5\,\lambda+\xi 15+\xi 13+\xi 8+\xi 6+\xi 1)\,\lambda^4-\frac{1}{32}\,(-10\,\lambda^2+4\,\lambda\,\xi 1 \qquad (3)$$
$$+4\,\lambda\,\xi 13+4\,\lambda\,\xi 15+4\,\lambda\,\xi 6+4\,\lambda\,\xi 8-\xi 1\,\xi 13-\xi 1\,\xi 15-\xi 1\,\xi 6-\xi 1\,\xi 8+\xi 11\,\xi 3$$
$$+\xi 12\,\xi 9-\xi 13\,\xi 15-\xi 13\,\xi 6-\xi 13\,\xi 8-\xi 15\,\xi 6-\xi 15\,\xi 8+\xi 2\,\xi 5-\xi 6\,\xi 8)\,\lambda^3-\frac{1}{32}\,($$
$$-10\,\lambda^3+6\,\lambda^2\,\xi 1+6\,\lambda^2\,\xi 13+6\,\lambda^2\,\xi 15+6\,\lambda^2\,\xi 6+6\,\lambda^2\,\xi 8-3\,\lambda\,\xi 1\,\xi 13-3\,\lambda\,\xi 1\,\xi 15$$
$$-3\,\lambda\,\xi 1\,\xi 6-3\,\lambda\,\xi 1\,\xi 8+3\,\lambda\,\xi 11\,\xi 3+3\,\lambda\,\xi 12\,\xi 9-3\,\lambda\,\xi 13\,\xi 15-3\,\lambda\,\xi 13\,\xi 6-3\,\lambda\,\xi 13\,\xi 8$$
$$-3\,\lambda\,\xi 15\,\xi 6-3\,\lambda\,\xi 15\,\xi 8+3\,\lambda\,\xi 2\,\xi 5-3\,\lambda\,\xi 6\,\xi 8-\xi 1\,\xi 12\,\xi 9+\xi 1\,\xi 13\,\xi 15+\xi 1\,\xi 13\,\xi 6$$
$$+\xi 1\,\xi 13\,\xi 8+\xi 1\,\xi 15\,\xi 6+\xi 1\,\xi 15\,\xi 8+\xi 1\,\xi 6\,\xi 8-\xi 11\,\xi 15\,\xi 3-\xi 11\,\xi 3\,\xi 6-\xi 11\,\xi 3\,\xi 8$$
$$-\xi 12\,\xi 15\,\xi 9-\xi 12\,\xi 6\,\xi 9+\xi 13\,\xi 15\,\xi 6+\xi 13\,\xi 15\,\xi 8-\xi 13\,\xi 2\,\xi 5+\xi 13\,\xi 6\,\xi 8-\xi 15\,\xi 2\,\xi 5$$
$$+\xi 15\,\xi 6\,\xi 8-\xi 2\,\xi 5\,\xi 8)\,\lambda^2-\frac{1}{32}\,(-3\,\xi 15\,\lambda^2\,\xi 1-3\,\xi 15\,\lambda^2\,\xi 13-3\,\xi 15\,\lambda^2\,\xi 6$$
$$-3\,\xi 15\,\lambda^2\,\xi 8+3\,\lambda^2\,\xi 11\,\xi 3+3\,\lambda^2\,\xi 12\,\xi 9-3\,\lambda^2\,\xi 1\,\xi 13-3\,\lambda^2\,\xi 1\,\xi 6-3\,\lambda^2\,\xi 1\,\xi 8$$
$$-3\,\lambda^2\,\xi 13\,\xi 6-3\,\lambda^2\,\xi 13\,\xi 8+3\,\lambda^2\,\xi 2\,\xi 5-3\,\lambda^2\,\xi 6\,\xi 8+4\,\xi 15\,\lambda^3+4\,\lambda^3\,\xi 1+4\,\lambda^3\,\xi 13$$
$$+4\,\lambda^3\,\xi 6+4\,\lambda^3\,\xi 8-2\,\lambda\,\xi 1\,\xi 12\,\xi 9-2\,\lambda\,\xi 11\,\xi 3\,\xi 6-2\,\lambda\,\xi 11\,\xi 3\,\xi 8-2\,\lambda\,\xi 12\,\xi 6\,\xi 9$$
$$+\xi 1\,\xi 12\,\xi 6\,\xi 9+\xi 11\,\xi 3\,\xi 6\,\xi 8-\xi 12\,\xi 2\,\xi 5\,\xi 9+2\,\lambda\,\xi 1\,\xi 13\,\xi 6+2\,\lambda\,\xi 1\,\xi 13\,\xi 8$$
$$+2\,\lambda\,\xi 1\,\xi 6\,\xi 8-2\,\lambda\,\xi 13\,\xi 2\,\xi 5+2\,\lambda\,\xi 13\,\xi 6\,\xi 8-2\,\lambda\,\xi 2\,\xi 5\,\xi 8-\xi 1\,\xi 13\,\xi 6\,\xi 8$$
$$+\xi 13\,\xi 2\,\xi 5\,\xi 8+2\,\xi 15\,\lambda\,\xi 1\,\xi 13+2\,\xi 15\,\lambda\,\xi 1\,\xi 6+2\,\xi 15\,\lambda\,\xi 1\,\xi 8-2\,\xi 15\,\xi 11\,\xi 3\,\lambda$$
$$-2\,\xi 15\,\xi 12\,\xi 9\,\lambda+2\,\xi 15\,\lambda\,\xi 13\,\xi 6+2\,\xi 15\,\lambda\,\xi 13\,\xi 8-2\,\xi 15\,\lambda\,\xi 2\,\xi 5+2\,\xi 15\,\lambda\,\xi 6\,\xi 8$$
$$+\xi 15\,\xi 1\,\xi 12\,\xi 9-\xi 15\,\xi 1\,\xi 13\,\xi 6-\xi 15\,\xi 1\,\xi 13\,\xi 8-\xi 15\,\xi 1\,\xi 6\,\xi 8+\xi 15\,\xi 11\,\xi 3\,\xi 6$$
$$+\xi 15\,\xi 11\,\xi 3\,\xi 8+\xi 15\,\xi 12\,\xi 6\,\xi 9+\xi 15\,\xi 13\,\xi 2\,\xi 5-\xi 15\,\xi 13\,\xi 6\,\xi 8+\xi 15\,\xi 2\,\xi 5\,\xi 8-5\,\lambda^4)\,\lambda$$
$$+\frac{1}{32}\,(\lambda-\xi 15)\,(-\lambda^2\,\xi 11\,\xi 3-\lambda^2\,\xi 12\,\xi 9+\lambda^2\,\xi 1\,\xi 13+\lambda^2\,\xi 1\,\xi 6+\lambda^2\,\xi 1\,\xi 8+\lambda^2\,\xi 13\,\xi 6$$
$$+\lambda^2\,\xi 13\,\xi 8-\lambda^2\,\xi 2\,\xi 5+\lambda^2\,\xi 6\,\xi 8-\lambda^3\,\xi 1-\lambda^3\,\xi 13-\lambda^3\,\xi 6-\lambda^3\,\xi 8+\lambda\,\xi 1\,\xi 12\,\xi 9$$

$$+\lambda\,\xi 11\,\xi 3\,\xi 6+\lambda\,\xi 11\,\xi 3\,\xi 8+\lambda\,\xi 12\,\xi 6\,\xi 9-\xi 1\,\xi 12\,\xi 6\,\xi 9-\xi 11\,\xi 3\,\xi 6\,\xi 8+\xi 12\,\xi 2\,\xi 5\,\xi 9$$
$$-\lambda\,\xi 1\,\xi 13\,\xi 6-\lambda\,\xi 1\,\xi 13\,\xi 8-\lambda\,\xi 1\,\xi 6\,\xi 8+\lambda\,\xi 13\,\xi 2\,\xi 5-\lambda\,\xi 13\,\xi 6\,\xi 8+\lambda\,\xi 2\,\xi 5\,\xi 8$$
$$+\xi 1\,\xi 13\,\xi 6\,\xi 8-\xi 13\,\xi 2\,\xi 5\,\xi 8+\lambda^4)$$

> $j0 := coeff(\ C11, \lambda, 5)$

$$j0 := 1 \tag{4}$$

> $j1 := coeff(\ C11, \lambda, 4)$

$$j1 := -\frac{1}{2}\,\xi 13-\frac{1}{2}\,\xi 15-\frac{1}{2}\,\xi 6-\frac{1}{2}\,\xi 8-\frac{1}{2}\,\xi 1 \tag{5}$$

> $j2 := coeff(\ C11, \lambda, 3)$

$$j2 := \frac{7}{32}\,\xi 15\,\xi 13+\frac{7}{32}\,\xi 15\,\xi 8+\frac{7}{32}\,\xi 15\,\xi 6+\frac{7}{32}\,\xi 15\,\xi 1-\frac{1}{32}\,\xi 15\,(-\xi 1-\xi 13-\xi 6 \tag{6}$$
$$-\xi 8)+\frac{1}{4}\,\xi 13\,\xi 8+\frac{1}{4}\,\xi 13\,\xi 6+\frac{1}{4}\,\xi 13\,\xi 1-\frac{1}{4}\,\xi 5\,\xi 2+\frac{1}{4}\,\xi 6\,\xi 1+\frac{1}{4}\,\xi 8\,\xi 6$$
$$+\frac{1}{4}\,\xi 8\,\xi 1-\frac{1}{4}\,\xi 11\,\xi 3-\frac{1}{4}\,\xi 12\,\xi 9$$

> $j3 := coeff(\ C11, \lambda, 2)$

$$j3 := -\frac{3}{32}\,\xi 15\,\xi 1\,\xi 13-\frac{3}{32}\,\xi 15\,\xi 13\,\xi 8+\frac{3}{32}\,\xi 15\,\xi 11\,\xi 3-\frac{3}{32}\,\xi 15\,\xi 13\,\xi 6-\frac{3}{32}\,\xi 15\,\xi 6\,\xi 8 \tag{7}$$
$$+\frac{3}{32}\,\xi 15\,\xi 2\,\xi 5+\frac{3}{32}\,\xi 15\,\xi 12\,\xi 9-\frac{3}{32}\,\xi 15\,\xi 1\,\xi 6-\frac{3}{32}\,\xi 15\,\xi 1\,\xi 8+\frac{1}{8}\,\xi 1\,\xi 12\,\xi 9$$
$$-\frac{1}{8}\,\xi 1\,\xi 13\,\xi 6-\frac{1}{8}\,\xi 1\,\xi 13\,\xi 8-\frac{1}{8}\,\xi 1\,\xi 6\,\xi 8+\frac{1}{8}\,\xi 11\,\xi 3\,\xi 6+\frac{1}{8}\,\xi 11\,\xi 3\,\xi 8$$
$$+\frac{1}{8}\,\xi 12\,\xi 6\,\xi 9+\frac{1}{8}\,\xi 13\,\xi 2\,\xi 5-\frac{1}{8}\,\xi 13\,\xi 6\,\xi 8+\frac{1}{8}\,\xi 2\,\xi 5\,\xi 8-\frac{1}{32}\,\xi 15\,(\xi 1\,\xi 13+\xi 1\,\xi 6$$
$$+\xi 1\,\xi 8-\xi 11\,\xi 3-\xi 12\,\xi 9+\xi 13\,\xi 6+\xi 13\,\xi 8-\xi 2\,\xi 5+\xi 6\,\xi 8)$$

> $j4 := coeff(\ C11, \lambda, 1)$

$$j4 := -\frac{1}{32}\,\xi 15\,\xi 1\,\xi 12\,\xi 9-\frac{1}{16}\,\xi 1\,\xi 12\,\xi 6\,\xi 9+\frac{1}{32}\,\xi 15\,\xi 1\,\xi 13\,\xi 6+\frac{1}{32}\,\xi 15\,\xi 1\,\xi 13\,\xi 8 \tag{8}$$
$$+\frac{1}{16}\,\xi 1\,\xi 13\,\xi 6\,\xi 8+\frac{1}{32}\,\xi 15\,\xi 1\,\xi 6\,\xi 8-\frac{1}{32}\,\xi 15\,\xi 11\,\xi 3\,\xi 6-\frac{1}{32}\,\xi 15\,\xi 11\,\xi 3\,\xi 8$$
$$-\frac{1}{16}\,\xi 11\,\xi 3\,\xi 6\,\xi 8-\frac{1}{32}\,\xi 15\,\xi 12\,\xi 6\,\xi 9+\frac{1}{16}\,\xi 12\,\xi 2\,\xi 5\,\xi 9-\frac{1}{32}\,\xi 15\,\xi 13\,\xi 2\,\xi 5$$
$$+\frac{1}{32}\,\xi 15\,\xi 13\,\xi 6\,\xi 8-\frac{1}{16}\,\xi 13\,\xi 2\,\xi 5\,\xi 8-\frac{1}{32}\,\xi 15\,\xi 2\,\xi 5\,\xi 8-\frac{1}{32}\,\xi 15\,(\xi 1\,\xi 12\,\xi 9$$
$$-\xi 1\,\xi 13\,\xi 6-\xi 1\,\xi 13\,\xi 8-\xi 1\,\xi 6\,\xi 8+\xi 11\,\xi 3\,\xi 6+\xi 11\,\xi 3\,\xi 8+\xi 12\,\xi 6\,\xi 9+\xi 13\,\xi 2\,\xi 5$$
$$-\xi 13\,\xi 6\,\xi 8+\xi 2\,\xi 5\,\xi 8)$$

> $j5 := coeff(\ C11, \lambda, 0)$

$$j5 := -\frac{1}{32}\,\xi 15\,(-\xi 1\,\xi 12\,\xi 6\,\xi 9+\xi 1\,\xi 13\,\xi 6\,\xi 8-\xi 11\,\xi 3\,\xi 6\,\xi 8+\xi 12\,\xi 2\,\xi 5\,\xi 9-\xi 13\,\xi 2\,\xi 5\,\xi 8) \tag{9}$$

Lampiran 6. Penjabaran $k_1, k_2, \ldots, k_5$ pada Analisis Kestabilan Lokal E_I

```
> restart
> with(LinearAlgebra) :
> J2 := Matrix([[ζ1, ζ2, 0, ζ3, 0], [ζ4, ζ5, 0, 0, 0], [0, 0, ζ6, ζ7, ζ8], [ζ9, 0, ζ10, ζ11, ζ12], [0, 0, 0, 0, ζ13]]);
> M2 := IdentityMatrix(5)
> P2 := J2 - M2·λ
```

$$P2 := \begin{bmatrix} -\lambda+\zeta 1 & \zeta 2 & 0 & \zeta 3 & 0 \\ \zeta 4 & -\lambda+\zeta 5 & 0 & 0 & 0 \\ 0 & 0 & -\lambda+\zeta 6 & \zeta 7 & \zeta 8 \\ \zeta 9 & 0 & \zeta 10 & -\lambda+\zeta 11 & \zeta 12 \\ 0 & 0 & 0 & 0 & -\lambda+\zeta 13 \end{bmatrix} \quad (1)$$

```
> C2 := CharacteristicPolynomial(P2, λ)
```

$$\begin{aligned} C2 := {} & \lambda^5 - (-5\lambda + \zeta 13 + \zeta 11 + \zeta 6 + \zeta 5 + \zeta 1)\lambda^4 - (-\zeta 1\,\zeta 11 - \zeta 1\,\zeta 13 - \zeta 1\,\zeta 5 - \zeta 1\,\zeta 6 \\ & + 4\,\zeta 1\,\lambda + \zeta 10\,\zeta 7 - \zeta 11\,\zeta 13 - \zeta 11\,\zeta 5 - \zeta 11\,\zeta 6 + 4\,\zeta 11\,\lambda - \zeta 13\,\zeta 5 - \zeta 13\,\zeta 6 + 4\,\zeta 13\,\lambda \\ & + \zeta 2\,\zeta 4 + \zeta 3\,\zeta 9 - \zeta 5\,\zeta 6 + 4\,\zeta 5\,\lambda + 4\,\zeta 6\,\lambda - 10\lambda^2)\lambda^3 - (-\zeta 1\,\zeta 10\,\zeta 7 + \zeta 1\,\zeta 11\,\zeta 13 \\ & + \zeta 1\,\zeta 11\,\zeta 5 + \zeta 1\,\zeta 11\,\zeta 6 - 3\,\zeta 1\,\zeta 11\,\lambda + \zeta 1\,\zeta 13\,\zeta 5 + \zeta 1\,\zeta 13\,\zeta 6 - 3\,\zeta 1\,\zeta 13\,\lambda + \zeta 1\,\zeta 5\,\zeta 6 \\ & - 3\,\zeta 1\,\zeta 5\,\lambda - 3\,\zeta 1\,\zeta 6\,\lambda + 6\,\zeta 1\,\lambda^2 - \zeta 10\,\zeta 13\,\zeta 7 - \zeta 10\,\zeta 5\,\zeta 7 + 3\,\zeta 10\,\zeta 7\,\lambda + \zeta 11\,\zeta 13\,\zeta 5 \\ & + \zeta 11\,\zeta 13\,\zeta 6 - 3\,\zeta 11\,\zeta 13\,\lambda - \zeta 11\,\zeta 2\,\zeta 4 + \zeta 11\,\zeta 5\,\zeta 6 - 3\,\zeta 11\,\zeta 5\,\lambda - 3\,\zeta 11\,\zeta 6\,\lambda + 6\,\zeta 11\,\lambda^2 \\ & - \zeta 13\,\zeta 2\,\zeta 4 - \zeta 13\,\zeta 3\,\zeta 9 + \zeta 13\,\zeta 5\,\zeta 6 - 3\,\zeta 13\,\zeta 5\,\lambda - 3\,\zeta 13\,\zeta 6\,\lambda + 6\,\zeta 13\,\lambda^2 - \zeta 2\,\zeta 4\,\zeta 6 \\ & + 3\,\zeta 2\,\zeta 4\,\lambda - \zeta 3\,\zeta 5\,\zeta 9 - \zeta 3\,\zeta 6\,\zeta 9 + 3\,\zeta 3\,\zeta 9\,\lambda - 3\,\zeta 5\,\zeta 6\,\lambda + 6\,\zeta 5\,\lambda^2 + 6\,\zeta 6\,\lambda^2 - 10\lambda^3)\lambda^2 \\ & - (\zeta 1\,\zeta 10\,\zeta 5\,\zeta 7 - 2\,\zeta 1\,\zeta 10\,\zeta 7\,\lambda - \zeta 10\,\zeta 2\,\zeta 4\,\zeta 7 - 2\,\zeta 10\,\zeta 5\,\zeta 7\,\lambda + \zeta 3\,\zeta 5\,\zeta 6\,\zeta 9 \\ & - 2\,\zeta 3\,\zeta 5\,\zeta 9\,\lambda - 2\,\zeta 3\,\zeta 6\,\zeta 9\,\lambda - \zeta 1\,\zeta 11\,\zeta 5\,\zeta 6 + 2\,\zeta 1\,\zeta 11\,\zeta 5\,\lambda + 2\,\zeta 1\,\zeta 11\,\zeta 6\,\lambda + 2\,\zeta 1\,\zeta 5\,\zeta 6\,\lambda \\ & + \zeta 11\,\zeta 2\,\zeta 4\,\zeta 6 - 2\,\zeta 11\,\zeta 2\,\zeta 4\,\lambda + 2\,\zeta 11\,\zeta 5\,\zeta 6\,\lambda - 2\,\zeta 2\,\zeta 4\,\zeta 6\,\lambda + \zeta 13\,\zeta 1\,\zeta 10\,\zeta 7 \\ & - \zeta 13\,\zeta 1\,\zeta 11\,\zeta 5 - \zeta 13\,\zeta 1\,\zeta 11\,\zeta 6 + 2\,\zeta 13\,\zeta 1\,\zeta 11\,\lambda - \zeta 13\,\zeta 1\,\zeta 5\,\zeta 6 + 2\,\zeta 13\,\zeta 1\,\zeta 5\,\lambda \\ & + 2\,\zeta 13\,\zeta 1\,\zeta 6\,\lambda + \zeta 13\,\zeta 10\,\zeta 5\,\zeta 7 - 2\,\zeta 13\,\zeta 10\,\zeta 7\,\lambda + \zeta 13\,\zeta 11\,\zeta 2\,\zeta 4 - \zeta 13\,\zeta 11\,\zeta 5\,\zeta 6 \\ & + 2\,\zeta 13\,\zeta 11\,\zeta 5\,\lambda + 2\,\zeta 13\,\zeta 11\,\zeta 6\,\lambda + \zeta 13\,\zeta 2\,\zeta 4\,\zeta 6 - 2\,\zeta 13\,\zeta 2\,\zeta 4\,\lambda + \zeta 13\,\zeta 3\,\zeta 5\,\zeta 9 \\ & + \zeta 13\,\zeta 3\,\zeta 6\,\zeta 9 - 2\,\zeta 13\,\zeta 9\,\zeta 3\,\lambda + 2\,\zeta 13\,\zeta 5\,\zeta 6\,\lambda + 4\,\zeta 13\,\lambda^3 + 4\,\zeta 1\,\lambda^3 + 4\,\zeta 11\,\lambda^3 + 4\,\zeta 5\,\lambda^3 \\ & + 4\,\zeta 6\,\lambda^3 - 5\lambda^4 + 3\,\zeta 10\,\zeta 7\,\lambda^2 + 3\,\zeta 3\,\zeta 9\,\lambda^2 - 3\,\zeta 1\,\zeta 11\,\lambda^2 - 3\,\zeta 1\,\zeta 5\,\lambda^2 - 3\,\zeta 1\,\zeta 6\,\lambda^2 \end{aligned} \quad (2)$$

$$-3\,\zeta_1\,\zeta_5\,\lambda^2-3\,\zeta_1\,\zeta_6\,\lambda^2+3\,\zeta_2\,\zeta_4\,\lambda^2-3\,\zeta_5\,\zeta_6\,\lambda^2-3\,\zeta_{13}\,\zeta_1\,\lambda^2-3\,\zeta_{13}\,\zeta_{11}\,\lambda^2$$
$$-3\,\zeta_{13}\,\zeta_5\,\lambda^2-3\,\zeta_{13}\,\zeta_6\,\lambda^2)\,\lambda+(-\lambda+\zeta_{13})\,(\zeta_1\,\zeta_{10}\,\zeta_5\,\zeta_7-\zeta_1\,\zeta_{10}\,\zeta_7\,\lambda-\zeta_{10}\,\zeta_2\,\zeta_4\,\zeta_7$$
$$-\zeta_{10}\,\zeta_5\,\zeta_7\,\lambda+\zeta_3\,\zeta_5\,\zeta_6\,\zeta_9-\zeta_3\,\zeta_5\,\zeta_9\,\lambda-\zeta_3\,\zeta_6\,\zeta_9\,\lambda-\zeta_1\,\zeta_{11}\,\zeta_5\,\zeta_6+\zeta_1\,\zeta_{11}\,\zeta_5\,\lambda$$
$$+\zeta_1\,\zeta_{11}\,\zeta_6\,\lambda+\zeta_1\,\zeta_5\,\zeta_6\,\lambda+\zeta_{11}\,\zeta_2\,\zeta_4\,\zeta_6-\zeta_{11}\,\zeta_2\,\zeta_4\,\lambda+\zeta_{11}\,\zeta_5\,\zeta_6\,\lambda-\zeta_2\,\zeta_4\,\zeta_6\,\lambda+\zeta_1\,\lambda^3$$
$$+\zeta_{11}\,\lambda^3+\zeta_5\,\lambda^3+\zeta_6\,\lambda^3-\lambda^4+\zeta_{10}\,\zeta_7\,\lambda^2+\zeta_3\,\zeta_9\,\lambda^2-\zeta_1\,\zeta_{11}\,\lambda^2-\zeta_1\,\zeta_5\,\lambda^2-\zeta_1\,\zeta_6\,\lambda^2$$
$$-\zeta_{11}\,\zeta_5\,\lambda^2-\zeta_{11}\,\zeta_6\,\lambda^2+\zeta_2\,\zeta_4\,\lambda^2-\zeta_5\,\zeta_6\,\lambda^2)$$

> $C22 := \dfrac{C2}{coeff(C2, \lambda^5)}$

$$C22 := \frac{1}{32}\,\lambda^5-\frac{1}{32}\,(-5\,\lambda+\zeta_{13}+\zeta_{11}+\zeta_6+\zeta_5+\zeta_1)\,\lambda^4-\frac{1}{32}\,(-\zeta_1\,\zeta_{11}-\zeta_1\,\zeta_{13} \qquad (3)$$
$$-\zeta_1\,\zeta_5-\zeta_1\,\zeta_6+4\,\zeta_1\,\lambda+\zeta_{10}\,\zeta_7-\zeta_{11}\,\zeta_{13}-\zeta_{11}\,\zeta_5-\zeta_{11}\,\zeta_6+4\,\zeta_{11}\,\lambda-\zeta_{13}\,\zeta_5$$
$$-\zeta_{13}\,\zeta_6+4\,\zeta_{13}\,\lambda+\zeta_2\,\zeta_4+\zeta_3\,\zeta_9-\zeta_5\,\zeta_6+4\,\zeta_5\,\lambda+4\,\zeta_6\,\lambda-10\,\lambda^2)\,\lambda^3-\frac{1}{32}\,($$
$$-\zeta_1\,\zeta_{10}\,\zeta_7+\zeta_1\,\zeta_{11}\,\zeta_{13}+\zeta_1\,\zeta_{11}\,\zeta_5+\zeta_1\,\zeta_{11}\,\zeta_6-3\,\zeta_1\,\zeta_{11}\,\lambda+\zeta_1\,\zeta_{13}\,\zeta_5+\zeta_1\,\zeta_{13}\,\zeta_6$$
$$-3\,\zeta_1\,\zeta_{13}\,\lambda+\zeta_1\,\zeta_5\,\zeta_6-3\,\zeta_1\,\zeta_5\,\lambda-3\,\zeta_1\,\zeta_6\,\lambda+6\,\zeta_1\,\lambda^2-\zeta_{10}\,\zeta_{13}\,\zeta_7-\zeta_{10}\,\zeta_5\,\zeta_7$$
$$+3\,\zeta_{10}\,\zeta_7\,\lambda+\zeta_{11}\,\zeta_{13}\,\zeta_5+\zeta_{11}\,\zeta_{13}\,\zeta_6-3\,\zeta_{11}\,\zeta_{13}\,\lambda-\zeta_{11}\,\zeta_2\,\zeta_4+\zeta_{11}\,\zeta_5\,\zeta_6$$
$$-3\,\zeta_{11}\,\zeta_5\,\lambda-3\,\zeta_{11}\,\zeta_6\,\lambda+6\,\zeta_{11}\,\lambda^2-\zeta_{13}\,\zeta_2\,\zeta_4-\zeta_{13}\,\zeta_3\,\zeta_9+\zeta_{13}\,\zeta_5\,\zeta_6-3\,\zeta_{13}\,\zeta_5\,\lambda$$
$$-3\,\zeta_{13}\,\zeta_6\,\lambda+6\,\zeta_{13}\,\lambda^2-\zeta_2\,\zeta_4\,\zeta_6+3\,\zeta_2\,\zeta_4\,\lambda-\zeta_3\,\zeta_5\,\zeta_9-\zeta_3\,\zeta_6\,\zeta_9+3\,\zeta_3\,\zeta_9\,\lambda$$
$$-3\,\zeta_5\,\zeta_6\,\lambda+6\,\zeta_5\,\lambda^2+6\,\zeta_6\,\lambda^2-10\,\lambda^3)\,\lambda^2-\frac{1}{32}\,(\zeta_1\,\zeta_{10}\,\zeta_5\,\zeta_7-2\,\zeta_1\,\zeta_{10}\,\zeta_7\,\lambda$$
$$-\zeta_{10}\,\zeta_2\,\zeta_4\,\zeta_7-2\,\zeta_{10}\,\zeta_5\,\zeta_7\,\lambda+\zeta_3\,\zeta_5\,\zeta_6\,\zeta_9-2\,\zeta_3\,\zeta_5\,\zeta_9\,\lambda-2\,\zeta_3\,\zeta_6\,\zeta_9\,\lambda-\zeta_1\,\zeta_{11}\,\zeta_5\,\zeta_6$$
$$+2\,\zeta_1\,\zeta_{11}\,\zeta_5\,\lambda+2\,\zeta_1\,\zeta_{11}\,\zeta_6\,\lambda+2\,\zeta_1\,\zeta_5\,\zeta_6\,\lambda+\zeta_{11}\,\zeta_2\,\zeta_4\,\zeta_6-2\,\zeta_{11}\,\zeta_2\,\zeta_4\,\lambda$$
$$+2\,\zeta_{11}\,\zeta_5\,\zeta_6\,\lambda-2\,\zeta_2\,\zeta_4\,\zeta_6\,\lambda+\zeta_{13}\,\zeta_1\,\zeta_{10}\,\zeta_7-\zeta_{13}\,\zeta_1\,\zeta_{11}\,\zeta_5-\zeta_{13}\,\zeta_1\,\zeta_{11}\,\zeta_6$$
$$+2\,\zeta_{13}\,\zeta_1\,\zeta_{11}\,\lambda-\zeta_{13}\,\zeta_1\,\zeta_5\,\zeta_6+2\,\zeta_{13}\,\zeta_1\,\zeta_5\,\lambda+2\,\zeta_{13}\,\zeta_1\,\zeta_6\,\lambda+\zeta_{13}\,\zeta_{10}\,\zeta_5\,\zeta_7$$
$$-2\,\zeta_{13}\,\zeta_{10}\,\zeta_7\,\lambda+\zeta_{13}\,\zeta_{11}\,\zeta_2\,\zeta_4-\zeta_{13}\,\zeta_{11}\,\zeta_5\,\zeta_6+2\,\zeta_{13}\,\zeta_{11}\,\zeta_5\,\lambda+2\,\zeta_{13}\,\zeta_{11}\,\zeta_6\,\lambda$$
$$+\zeta_{13}\,\zeta_2\,\zeta_4\,\zeta_6-2\,\zeta_{13}\,\zeta_2\,\zeta_4\,\lambda+\zeta_{13}\,\zeta_3\,\zeta_5\,\zeta_9+\zeta_{13}\,\zeta_3\,\zeta_6\,\zeta_9-2\,\zeta_{13}\,\zeta_9\,\zeta_3\,\lambda$$
$$+2\,\zeta_{13}\,\zeta_5\,\zeta_6\,\lambda+4\,\zeta_{13}\,\lambda^3+4\,\zeta_1\,\lambda^3+4\,\zeta_{11}\,\lambda^3+4\,\zeta_5\,\lambda^3+4\,\zeta_6\,\lambda^3-5\,\lambda^4+3\,\zeta_{10}\,\zeta_7\,\lambda^2$$
$$+3\,\zeta_3\,\zeta_9\,\lambda^2-3\,\zeta_1\,\zeta_{11}\,\lambda^2-3\,\zeta_1\,\zeta_5\,\lambda^2-3\,\zeta_1\,\zeta_6\,\lambda^2-3\,\zeta_{11}\,\zeta_5\,\lambda^2-3\,\zeta_{11}\,\zeta_6\,\lambda^2$$
$$+3\,\zeta_2\,\zeta_4\,\lambda^2-3\,\zeta_5\,\zeta_6\,\lambda^2-3\,\zeta_{13}\,\zeta_1\,\lambda^2-3\,\zeta_{13}\,\zeta_{11}\,\lambda^2-3\,\zeta_{13}\,\zeta_5\,\lambda^2-3\,\zeta_{13}\,\zeta_6\,\lambda^2)\,\lambda$$
$$+\frac{1}{32}\,(-\lambda+\zeta_{13})\,(\zeta_1\,\zeta_{10}\,\zeta_5\,\zeta_7-\zeta_1\,\zeta_{10}\,\zeta_7\,\lambda-\zeta_{10}\,\zeta_2\,\zeta_4\,\zeta_7-\zeta_{10}\,\zeta_5\,\zeta_7\,\lambda$$
$$+\zeta_3\,\zeta_5\,\zeta_6\,\zeta_9-\zeta_3\,\zeta_5\,\zeta_9\,\lambda-\zeta_3\,\zeta_6\,\zeta_9\,\lambda-\zeta_1\,\zeta_{11}\,\zeta_5\,\zeta_6+\zeta_1\,\zeta_{11}\,\zeta_5\,\lambda+\zeta_1\,\zeta_{11}\,\zeta_6\,\lambda$$
$$+\zeta_1\,\zeta_5\,\zeta_6\,\lambda+\zeta_{11}\,\zeta_2\,\zeta_4\,\zeta_6-\zeta_{11}\,\zeta_2\,\zeta_4\,\lambda+\zeta_{11}\,\zeta_5\,\zeta_6\,\lambda-\zeta_2\,\zeta_4\,\zeta_6\,\lambda+\zeta_1\,\lambda^3+\zeta_{11}\,\lambda^3$$

$$+\zeta 5\,\lambda^3+\zeta 6\,\lambda^3-\lambda^4+\zeta 10\,\zeta 7\,\lambda^2+\zeta 3\,\zeta 9\,\lambda^2-\zeta 1\,\zeta 11\,\lambda^2-\zeta 1\,\zeta 5\,\lambda^2-\zeta 1\,\zeta 6\,\lambda^2-\zeta 11\,\zeta 5\,\lambda^2$$
$$-\zeta 11\,\zeta 6\,\lambda^2+\zeta 2\,\zeta 4\,\lambda^2-\zeta 5\,\zeta 6\,\lambda^2)$$

> $k0 := coeff(\ C22, \lambda, 5)$

$$k0 := 1 \tag{4}$$

> $k1 := coeff(\ C22, \lambda, 4)$

$$k1 := -\frac{1}{2}\,\zeta 1-\frac{1}{2}\,\zeta 5-\frac{1}{2}\,\zeta 6-\frac{1}{2}\,\zeta 11-\frac{1}{2}\,\zeta 13 \tag{5}$$

> $k2 := coeff(\ C22, \lambda, 3)$

$$k2 := -\frac{1}{4}\,\zeta 10\,\zeta 7-\frac{1}{4}\,\zeta 3\,\zeta 9+\frac{1}{4}\,\zeta 1\,\zeta 11+\frac{1}{4}\,\zeta 1\,\zeta 5+\frac{1}{4}\,\zeta 1\,\zeta 6+\frac{1}{4}\,\zeta 11\,\zeta 5+\frac{1}{4}\,\zeta 11\,\zeta 6 \tag{6}$$
$$-\frac{1}{4}\,\zeta 2\,\zeta 4+\frac{1}{4}\,\zeta 5\,\zeta 6+\frac{7}{32}\,\zeta 13\,\zeta 1+\frac{7}{32}\,\zeta 13\,\zeta 11+\frac{7}{32}\,\zeta 13\,\zeta 5+\frac{7}{32}\,\zeta 13\,\zeta 6$$
$$+\frac{1}{32}\,\zeta 13\,(\zeta 1+\zeta 11+\zeta 5+\zeta 6)$$

> $k3 := coeff(\ C22, \lambda, 2)$

$$k3 := -\frac{1}{8}\,\zeta 1\,\zeta 11\,\zeta 5-\frac{3}{32}\,\zeta 13\,\zeta 5\,\zeta 6-\frac{1}{8}\,\zeta 1\,\zeta 5\,\zeta 6+\frac{3}{32}\,\zeta 13\,\zeta 10\,\zeta 7+\frac{1}{8}\,\zeta 3\,\zeta 6\,\zeta 9 \tag{7}$$
$$-\frac{3}{32}\,\zeta 13\,\zeta 11\,\zeta 6+\frac{3}{32}\,\zeta 13\,\zeta 9\,\zeta 3+\frac{1}{8}\,\zeta 3\,\zeta 5\,\zeta 9+\frac{1}{8}\,\zeta 11\,\zeta 2\,\zeta 4-\frac{1}{8}\,\zeta 11\,\zeta 5\,\zeta 6$$
$$-\frac{3}{32}\,\zeta 13\,\zeta 1\,\zeta 6-\frac{3}{32}\,\zeta 13\,\zeta 11\,\zeta 5+\frac{1}{8}\,\zeta 1\,\zeta 10\,\zeta 7+\frac{1}{8}\,\zeta 10\,\zeta 5\,\zeta 7+\frac{1}{8}\,\zeta 2\,\zeta 4\,\zeta 6$$
$$-\frac{3}{32}\,\zeta 13\,\zeta 1\,\zeta 5+\frac{3}{32}\,\zeta 13\,\zeta 2\,\zeta 4-\frac{1}{8}\,\zeta 1\,\zeta 11\,\zeta 6-\frac{3}{32}\,\zeta 13\,\zeta 1\,\zeta 11+\frac{1}{32}\,\zeta 13\,(-\zeta 1\,\zeta 11$$
$$-\zeta 1\,\zeta 5-\zeta 1\,\zeta 6+\zeta 10\,\zeta 7-\zeta 11\,\zeta 5-\zeta 11\,\zeta 6+\zeta 2\,\zeta 4+\zeta 3\,\zeta 9-\zeta 5\,\zeta 6)$$

> $k4 := coeff(\ C22, \lambda, 1)$

$$k4 := -\frac{1}{32}\,\zeta 13\,\zeta 1\,\zeta 10\,\zeta 7-\frac{1}{16}\,\zeta 1\,\zeta 10\,\zeta 5\,\zeta 7+\frac{1}{32}\,\zeta 13\,\zeta 1\,\zeta 11\,\zeta 5+\frac{1}{32}\,\zeta 13\,\zeta 1\,\zeta 11\,\zeta 6 \tag{8}$$
$$+\frac{1}{16}\,\zeta 1\,\zeta 11\,\zeta 5\,\zeta 6+\frac{1}{32}\,\zeta 13\,\zeta 1\,\zeta 5\,\zeta 6-\frac{1}{32}\,\zeta 13\,\zeta 10\,\zeta 5\,\zeta 7+\frac{1}{16}\,\zeta 10\,\zeta 2\,\zeta 4\,\zeta 7$$
$$-\frac{1}{32}\,\zeta 13\,\zeta 11\,\zeta 2\,\zeta 4+\frac{1}{32}\,\zeta 13\,\zeta 11\,\zeta 5\,\zeta 6-\frac{1}{16}\,\zeta 11\,\zeta 2\,\zeta 4\,\zeta 6-\frac{1}{32}\,\zeta 13\,\zeta 2\,\zeta 4\,\zeta 6$$
$$-\frac{1}{32}\,\zeta 13\,\zeta 3\,\zeta 5\,\zeta 9-\frac{1}{32}\,\zeta 13\,\zeta 3\,\zeta 6\,\zeta 9-\frac{1}{16}\,\zeta 3\,\zeta 5\,\zeta 6\,\zeta 9+\frac{1}{32}\,\zeta 13\,(-\zeta 1\,\zeta 10\,\zeta 7$$
$$+\zeta 1\,\zeta 11\,\zeta 5+\zeta 1\,\zeta 11\,\zeta 6+\zeta 1\,\zeta 5\,\zeta 6-\zeta 10\,\zeta 5\,\zeta 7-\zeta 11\,\zeta 2\,\zeta 4+\zeta 11\,\zeta 5\,\zeta 6-\zeta 2\,\zeta 4\,\zeta 6$$
$$-\zeta 3\,\zeta 5\,\zeta 9-\zeta 3\,\zeta 6\,\zeta 9)$$

> $k5 := coeff(\ C22, \lambda, 0)$

$$k5 := \frac{1}{32}\,\zeta 13\,(\zeta 1\,\zeta 10\,\zeta 5\,\zeta 7-\zeta 1\,\zeta 11\,\zeta 5\,\zeta 6-\zeta 10\,\zeta 2\,\zeta 4\,\zeta 7+\zeta 11\,\zeta 2\,\zeta 4\,\zeta 6+\zeta 3\,\zeta 5\,\zeta 6\,\zeta 9) \tag{9}$$

Lampiran 7. Simulasi Numerik untuk Sistem Tanpa Terapi

```
function dy =  F_TanpaTerapi (t,y)
clc; close all;

%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);

%Sistem Tanpa Terapi
dy = zeros(4,1);

dy(1)= r1*y(1)-r1*b1*y(1)*y(1)-rho1*y(2)*y(1)-alpha1*y(4)*y(1);
dy(2)= r2*y(2)-r2*b2*y(2)*y(2)-mu1*y(2)-rho2*y(1)*y(2);
dy(3)= r3*y(3)-r3*b3*y(3)*y(3)-beta*y(4)*y(3);
dy(4)= beta*y(3)*y(4)-mu2*y(4)-alpha2*y(1)*y(4);
end

%SIMULASI NUMERIK:
%Tanpa Pengaruh Terapi
clc; clear all;
time1 = linspace(0,350);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History1 = [ na1; na2; na3; na4 ];

%----------------------------TANPA TERAPI-------------------------
sol0 = ode23s(@F_TanpaTerapi, time1, History1);
S1 = sol0.x'; X1 = sol0.y';
S2 = sol0.x'; X2 = sol0.y';
S3 = sol0.x'; X3 = sol0.y';
S4 = sol0.x'; X4 = sol0.y';
P1 = spline (S1, X1(:,1),time1);
P2 = spline (S2, X2(:,2),time1);
P3 = spline (S3, X3(:,3),time1);
P4 = spline (S4, X4(:,4),time1);


 (321)
ime1, P1, 'black', 'LineWidth', 1.5)

'Waktu (Hari)','Fontsize',12)
```

```
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, P2, 'black', 'LineWidth', 1.5)
hold on
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, P3, 'black', 'LineWidth', 1.5)
hold on
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, P4, 'black', 'LineWidth', 1.5)
hold on
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');
```

Lampiran 8. Simulasi Numerik untuk Sistem Kemoterapi Konstan

```
function dy =  F_Kemo_Konstan (t,y)
clc; close all;

%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);
gamma1 = 0.01;
q1 = 0.9;
q2 = 1*10^(-12);
q3 = 1*10^(-5);
q4 = 2*10^(-11);
delta1 = 0.0357;
u0 = 0.5;

%Sistem Kemoterapi Konstan
dy = zeros(5,1);

dy(1)= r1*y(1)-r1*b1*y(1)*y(1)-rho1*y(2)*y(1)-alpha1*y(4)*y(1)-
q1*y(5)*y(1);
dy(2)= r2*y(2)-r2*b2*y(2)*y(2)-mu1*y(2)-rho2*y(1)*y(2)-
q2*y(5)*y(2);
dy(3)= r3*y(3)-r3*b3*y(3)*y(3)-beta*y(4)*y(3)-q3*y(5)*y(3);
dy(4)= beta*y(3)*y(4)-mu2*y(4)-alpha2*y(1)*y(4)-q4*y(5)*y(4);
dy(5)= delta1*u0-gamma1*y(5);
end

%SIMULASI NUMERIK:
%Pengaruh Pemberian Kemoterapi secara Konstan
clc; clear all;
time1 = linspace(0,350);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History2 = [ na1; na2; na3; na4; na5 ];

%          ------------------KEMOTERAPI KONSTAN----------------------
          ode23s(@F_Kemo_Konstan, time1, History2);
          l1.x'; Y1 = sol1.y';
          l1.x'; Y2 = sol1.y';
          l1.x'; Y3 = sol1.y';
          l1.x'; Y4 = sol1.y';
```

```
T5 = sol1.x'; Y5 = sol1.y';
Q1 = spline (T1, Y1(:,1),time1);
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%Plot
subplot (321)
plot (time1, Q1,'red', 'LineWidth', 1.5);
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');

subplot (325)
plot (time1, Q5,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('DK (mg/L)', 'Fontsize', 12)
title ('(e)');
```

Lampiran 9. Simulasi Numerik untuk Sistem Kemoterapi Periodik

```
function dy =  F_Kemo_Periodik (t,y)
clc; close all;

%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);
gamma1 = 0.01;
q1 = 0.9;
q2 = 1*10^(-12);
q3 = 1*10^(-5);
q4 = 2*10^(-11);
delta1 = 0.0357;
psi1 = 2;
omega = 0.2;
u0 = 0.5;

%Sistem Kemoterapi Periodik
dy = zeros(5,1);

dy(1)= r1*y(1)-r1*b1*y(1)*y(1)-rho1*y(2)*y(1)-alpha1*y(4)*y(1)-
q1*y(5)*y(1);
dy(2)= r2*y(2)-r2*b2*y(2)*y(2)-mu1*y(2)-rho2*y(1)*y(2)-
q2*y(5)*y(2);
dy(3)= r3*y(3)-r3*b3*y(3)*y(3)-beta*y(4)*y(3)-q3*y(5)*y(3);
dy(4)= beta*y(3)*y(4)-mu2*y(4)-alpha2*y(1)*y(4)-q4*y(5)*y(4);
dy(5)= delta1*(u0+psi1*sin(omega*t))-gamma1*y(5);
end

%SIMULASI NUMERIK:
%Pengaruh Pemberian Kemoterapi secara Periodik
clc; clear all;
time1 = linspace(0,350);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History2 = [ na1; na2; na3; na4; na5 ];

----------KEMOTERAPI PERIODIK----------
ode23s(@F_Kemo_Periodik, time1, History2);
l1.x'; Y1 = sol1.y';
l1.x'; Y2 = sol1.y';
```

```
T3 = sol1.x'; Y3 = sol1.y';
T4 = sol1.x'; Y4 = sol1.y';
T5 = sol1.x'; Y5 = sol1.y';
Q1 = spline (T1, Y1(:,1),time1);
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%Plot
subplot (321)
plot (time1, Q1,'red', 'LineWidth', 1.5);
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');

subplot (325)
plot (time1, Q5,'red', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('DK (mg/L)', 'Fontsize', 12)
title ('(e)');
```

Lampiran 10. Simulasi Numerik untuk Sistem Imunoterapi Konstan

```
function dy =  F_Imuno_Konstan (t,y)
clc; close all;

%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);
gamma2 = 0.02;
s1 = 1*10^(-2);
s2 = 1*10^(-5);
delta2 = 0.0179;
v0 = 0.4;

%Sistem Imunoterapi Konstan
dy = zeros(5,1);

dy(1)= r1*y(1)-r1*b1*y(1)*y(1)-rho1*y(2)*y(1)-alpha1*y(4)*y(1);
dy(2)= r2*y(2)-r2*b2*y(2)*y(2)-mu1*y(2)-rho2*y(1)*y(2);
dy(3)= r3*y(3)-r3*b3*y(3)*y(3)-beta*y(4)*y(3)+s1*y(5)*y(3);
dy(4)= beta*y(3)*y(4)-mu2*y(4)-alpha2*y(1)*y(4)+s2*y(5)*y(4);
dy(5)= delta2*v0-gamma2*y(5);
end

%SIMULASI NUMERIK:
%Pengaruh Pemberian Imunoterapi secara Konstan
clc; clear all;
time1 = linspace(0,350);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History2 = [ na1; na2; na3; na4; na5 ];

%-------------------------IMUNOTERAPI KONSTAN---------------------
sol1 = ode23s(@F_Imuno_Konstan, time1, History2);
T1 = sol1.x'; Y1 = sol1.y';
T2 = sol1.x'; Y2 = sol1.y';
T3 = sol1.x'; Y3 = sol1.y';
     l1.x'; Y4 = sol1.y';
     l1.x'; Y5 = sol1.y';
     line (T1, Y1(:,1),time1);
     line (T2, Y2(:,2),time1);
     line (T3, Y3(:,3),time1);
```

```
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%Plot
subplot (321)
plot (time1, Q1,'blue', 'LineWidth', 1.5);
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');

subplot (325)
plot (time1, Q5,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('DI (mg/L)', 'Fontsize', 12)
title ('(e)');
```

Lampiran 11. Simulasi Numerik untuk Sistem Imunoterapi Periodik

```
function dy =  F_Imuno_Periodik (t,y)
clc; close all;

%Nilai Parameter
r1 = 0.44;
r2 = 0.18;
r3 = 0.0245;
b1 = 9.8*10^(-8);
b2 = 1*10^(-9);
b3 = 1*10^(-10);
rho1 = 1.1*10^(-10);
rho2 = 4.8*10^(-10);
mu1 = 0.01;
mu2 = 0.0412;
alpha1 = 1.101*10^(-7);
alpha2 = 3.422*10^(-10);
beta = 6.2*10^(-9);
gamma2 = 0.02;
s1 = 1*10^(-2);
s2 = 1*10^(-5);
delta2 = 0.0179;
psi2 = 2;
omega = 0.2;
v0 = 0.4;

%Sistem Imunoterapi Periodik
dy = zeros(5,1);

dy(1)= r1*y(1)-r1*b1*y(1)*y(1)-rho1*y(2)*y(1)-alpha1*y(4)*y(1);
dy(2)= r2*y(2)-r2*b2*y(2)*y(2)-mu1*y(2)-rho2*y(1)*y(2);
dy(3)= r3*y(3)-r3*b3*y(3)*y(3)-beta*y(4)*y(3)+s1*y(5)*y(3);
dy(4)= beta*y(3)*y(4)-mu2*y(4)-alpha2*y(1)*y(4)+s2*y(5)*y(4);
dy(5)= delta2*(v0+psi2*sin(omega*t))-gamma2*y(5);
end

%SIMULASI NUMERIK:
%Pengaruh Pemberian Imunoterapi secara Periodik
clc; clear all;
time1 = linspace(0,350);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History2 = [ na1; na2; na3; na4; na5 ];

%-------------------------IMUNOTERAPI PERIODIK--------------------
sol1 = ode23s(@F_Imuno_Periodik, time1, History2);
T1 = sol1.x'; Y1 = sol1.y';
     l1.x'; Y2 = sol1.y';
     l1.x'; Y3 = sol1.y';
     l1.x'; Y4 = sol1.y';
     l1.x'; Y5 = sol1.y';
     line (T1, Y1(:,1),time1);
```

```
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%Plot
subplot (321)
plot (time1, Q1,'blue', 'LineWidth', 1.5);
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');

subplot (325)
plot (time1, Q5,'blue', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('DI (mg/L)', 'Fontsize', 12)
title ('(e)');
```

Lampiran 12. Simulasi Numerik untuk Sistem Kombinasi Imunoterapi Konstan-Kemoterapi Konstan

```
%SIMULASI NUMERIK KOMBINASI:
%Pengaruh Pemberian Imunoterapi Konstan-Kemoterapi Konstan
clc; clear all;

%-------------------------TERAPI PERTAMA-------------------------
time1 = linspace(0,60);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History1 = [ na1; na2; na3; na4; na5 ];

%Imunoterapi Konstan
sol1 = ode23s(@F_Imuno_Konstan, time1, History1);
T1 = sol1.x'; Y1 = sol1.y';
T2 = sol1.x'; Y2 = sol1.y';
T3 = sol1.x'; Y3 = sol1.y';
T4 = sol1.x'; Y4 = sol1.y';
T5 = sol1.x'; Y5 = sol1.y';
Q1 = spline (T1, Y1(:,1),time1);
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%-------------------------TERAPI KEDUA-------------------------
time2 = linspace(60,350);
%Kondisi Awal
na11 = 7.774e+06;
na22 = 9.238e+08;
na33 = 1.484e+06;
na44 = 2.56e+04;
na55 = 0;
History2 = [ na11; na22; na33; na44; na55 ];

%Kemoterapi Konstan
sol01 = ode23s(@F_Kemo_Konstan, time2, History2);
T01 = sol01.x'; Y01 = sol01.y';
T02 = sol01.x'; Y02 = sol01.y';
T03 = sol01.x'; Y03 = sol01.y';
T04 = sol01.x'; Y04 = sol01.y';
T05 = sol01.x'; Y05 = sol01.y';
Q01 = spline (T01, Y01(:,1),time2);
Q02 = spline (T02, Y02(:,2),time2);
Q03 = spline (T03, Y03(:,3),time2);
Q04 = spline (T04, Y04(:,4),time2);
      pline (T05, Y05(:,5),time2);


     (321)
    ime1, Q1, 'g',time2, Q01, 'g', 'LineWidth', 1.5);
    'Waktu (Hari)','Fontsize',12)
```

```
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2, 'g',time2, Q02, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3, 'g',time2, Q03, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4, 'g',time2, Q04, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');
```

Lampiran 13. Simulasi Numerik untuk Sistem Kombinasi Imunoterapi Konstan-Kemoterapi Periodik

```
%SIMULASI NUMERIK KOMBINASI:
%Pengaruh Pemberian Imunoterapi Konstan-Kemoterapi Periodik
clc; clear all;

%-------------------------TERAPI PERTAMA-------------------------
time1 = linspace(0,60);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History1 = [ na1; na2; na3; na4; na5 ];

%Imunoterapi Konstan
sol1 = ode23s(@F_Imuno_Konstan, time1, History1);
T1 = sol1.x'; Y1 = sol1.y';
T2 = sol1.x'; Y2 = sol1.y';
T3 = sol1.x'; Y3 = sol1.y';
T4 = sol1.x'; Y4 = sol1.y';
T5 = sol1.x'; Y5 = sol1.y';
Q1 = spline (T1, Y1(:,1),time1);
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%-------------------------TERAPI KEDUA-------------------------
time2 = linspace(60,350);
%Kondisi Awal
na11 = 7.774e+06;
na22 = 9.238e+08;
na33 = 1.484e+06;
na44 = 2.56e+04;
na55 = 0;
History2 = [ na11; na22; na33; na44; na55 ];

%Kemoterapi Periodik
sol01 = ode23s(@F_Kemo_Periodik, time2, History2);
T01 = sol01.x'; Y01 = sol01.y';
T02 = sol01.x'; Y02 = sol01.y';
T03 = sol01.x'; Y03 = sol01.y';
T04 = sol01.x'; Y04 = sol01.y';
T05 = sol01.x'; Y05 = sol01.y';
Q01 = spline (T01, Y01(:,1),time2);
Q02 = spline (T02, Y02(:,2),time2);
Q03 = spline (T03, Y03(:,3),time2);
Q04 = spline (T04, Y04(:,4),time2);
      pline (T05, Y05(:,5),time2);


      (321)
      ime1, Q1, 'g',time2, Q01, 'g', 'LineWidth', 1.5);
      'Waktu (Hari)','Fontsize',12)
```

```
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2, 'g',time2, Q02, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3, 'g',time2, Q03, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4, 'g',time2, Q04, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');
```

Lampiran 14. Simulasi Numerik untuk Sistem Kombinasi Imunoterapi Periodik-Kemoterapi Konstan

```
%SIMULASI NUMERIK KOMBINASI:
%Pengaruh Pemberian Imunoterapi Periodik-Kemoterapi Konstan
clc; clear all;

%-------------------------TERAPI PERTAMA-------------------------
time1 = linspace(0,60);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History1 = [ na1; na2; na3; na4; na5 ];

%Imunoterapi Periodik
sol1 = ode23s(@F_Imuno_Periodik, time1, History1);
T1 = sol1.x'; Y1 = sol1.y';
T2 = sol1.x'; Y2 = sol1.y';
T3 = sol1.x'; Y3 = sol1.y';
T4 = sol1.x'; Y4 = sol1.y';
T5 = sol1.x'; Y5 = sol1.y';
Q1 = spline (T1, Y1(:,1),time1);
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%-------------------------TERAPI KEDUA-------------------------
time2 = linspace(60,350);
%Kondisi Awal
na11 = 7.773e+06;
na22 = 9.238e+08;
na33 = 1.58e+06;
na44 = 2.603e+04;
na55 = 0;
History2 = [ na11; na22; na33; na44; na55 ];

%Kemoterapi Konstan
sol01 = ode23s(@F_Kemo_Konstan, time2, History2);
T01 = sol01.x'; Y01 = sol01.y';
T02 = sol01.x'; Y02 = sol01.y';
T03 = sol01.x'; Y03 = sol01.y';
T04 = sol01.x'; Y04 = sol01.y';
T05 = sol01.x'; Y05 = sol01.y';
Q01 = spline (T01, Y01(:,1),time2);
Q02 = spline (T02, Y02(:,2),time2);
Q03 = spline (T03, Y03(:,3),time2);
Q04 = spline (T04, Y04(:,4),time2);
      pline (T05, Y05(:,5),time2);


     (321)
    ime1, Q1, 'g',time2, Q01, 'g', 'LineWidth', 1.5);
    'Waktu (Hari)','Fontsize',12)
```

```
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2, 'g',time2, Q02, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3, 'g',time2, Q03, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4, 'g',time2, Q04, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');
```

Lampiran 15. Simulasi Numerik untuk Sistem Kombinasi Imunoterapi Periodik-Kemoterapi Periodik

```
%SIMULASI NUMERIK KOMBINASI
%Pengaruh Pemberian Imunoterapi Periodik-Kemoterapi Periodik
clc; clear all;

%-------------------------TERAPI PERTAMA-------------------------
time1 = linspace(0,60);
%Kondisi Awal
na1 = 10^6;
na2 = 10^9;
na3 = 3*10^5;
na4 = 3*10^5;
na5 = 0;
History1 = [ na1; na2; na3; na4; na5 ];

%Imunoterapi Periodik
sol1 = ode23s(@F_Imuno_Periodik, time1, History1);
T1 = sol1.x'; Y1 = sol1.y';
T2 = sol1.x'; Y2 = sol1.y';
T3 = sol1.x'; Y3 = sol1.y';
T4 = sol1.x'; Y4 = sol1.y';
T5 = sol1.x'; Y5 = sol1.y';
Q1 = spline (T1, Y1(:,1),time1);
Q2 = spline (T2, Y2(:,2),time1);
Q3 = spline (T3, Y3(:,3),time1);
Q4 = spline (T4, Y4(:,4),time1);
Q5 = spline (T5, Y5(:,5),time1);

%-------------------------TERAPI KEDUA-------------------------
time2 = linspace(60,350);
%Kondisi Awal
na11 = 7.773e+06;
na22 = 9.238e+08;
na33 = 1.58e+06;
na44 = 2.603e+04;
na55 = 0;
History2 = [ na11; na22; na33; na44; na55 ];

%Kemoterapi Periodik
sol01 = ode23s(@F_Kemo_Periodik, time2, History2);
T01 = sol01.x'; Y01 = sol01.y';
T02 = sol01.x'; Y02 = sol01.y';
T03 = sol01.x'; Y03 = sol01.y';
T04 = sol01.x'; Y04 = sol01.y';
T05 = sol01.x'; Y05 = sol01.y';
Q01 = spline (T01, Y01(:,1),time2);
Q02 = spline (T02, Y02(:,2),time2);
Q03 = spline (T03, Y03(:,3),time2);
Q04 = spline (T04, Y04(:,4),time2);
      pline (T05, Y05(:,5),time2);


     (321)
    ime1, Q1, 'g',time2, Q01, 'g', 'LineWidth', 1.5);
    'Waktu (Hari)','Fontsize',12)
```

```
ylabel('C (sel)', 'Fontsize', 12)
title ('(a)');

subplot (322)
plot (time1, Q2, 'g',time2, Q02, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
title ('(b)');

subplot (323)
plot (time1, Q3, 'g',time2, Q03, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Ip (sel)', 'Fontsize', 12)
title ('(c)');

subplot (324)
plot (time1, Q4, 'g',time2, Q04, 'g', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('Is (sel)', 'Fontsize', 12)
title ('(d)');
```

Lampiran 16. Perhitungan Efek Toksisitas terhadap Sel Normal yang Dihasilkan oleh Kemoterapi Tunggal dan Kombinasi Terapi

```
function dy =  F_Toksik_KemoK (t,y)
clc; close all;
%Nilai Parameter
gamma1 = 0.01;
q2 = 1*10^(-12);
delta1 = 0.0357;
u0 = 0.5;
%Efek Toksisitas Kemoterapi Konstan terhadap Sel Normal
dy = zeros(2,1);
dy(1)= -q2*y(2)*y(1);
dy(2)= delta1*u0-gamma1*y(2);
end

function dy =  F_Toksik_KemoP (t,y)
clc; close all;
%Nilai Parameter
gamma1 = 0.01;
q2 = 1*10^(-12);
delta1 = 0.0357;
psi1 = 2;
omega = 0.2;
u0 = 0.5;
%Efek Toksisitas Kemoterapi Periodik terhadap Sel Normal
dy = zeros(2,1);
dy(1)= -q2*y(2)*y(1);
dy(2)= delta1*(u0+psi1*sin(omega*t))-gamma1*y(2);
end

%Perhitungan Efek Sitotoksik dari KEMOTERAPI TUNGGAL
clc; clear all;
time1 = linspace(0,350);
%Kondisi Awal
na2 = 10^9;
na5 = 0;
History2 = [ na2; na5 ];
%-------------------------KEMOTERAPI KONSTAN----------------------
sol1 = ode23s(@F_Toksik_KemoK, time1, History2);
T2 = sol1.x'; Y2 = sol1.y';
Q2 = spline (T2, Y2(:,1),time1);
%Plot
plot (time1, Q2,'black', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
%Besar Efek Toksisitas dari Kemoterapi Konstan terhadap Sel Normal
ET_H_KK = trapz(T2, Y2(:,1))
%-------------------------KEMOTERAPI PERIODIK---------------------
sol11 = ode23s(@F_Toksik_KemoP, time1, History2);
T22 = sol11.x'; Y22 = sol11.y';
   pline (T22, Y22(:,1),time1);

   ime1, Q22,'black', 'LineWidth', 1.5)
  'Waktu (Hari)','Fontsize',12)
  'H (sel)', 'Fontsize', 12)
```

```
%Besar Efek Toksisitas dari Kemoterapi Periodik terhadap Sel
Normal
ET_H_KP = trapz(T22, Y22(:,1))


%Perhitungan Efek Sitotoksik dari KOMBINASI TERAPI
%IMUNOTERAPI KONSTAN-KEMOTERAPI KONSTAN:
clc; clear all;
%-------------------------TERAPI PERTAMA-------------------------
%Besar Efek Toksisitas Imunoterapi Konstan terhadap Sel Normal = 0
ET_H_IK = 0;
%-------------------------TERAPI KEDUA-------------------------
time1 = linspace(60,350);
%Kondisi Awal
na22 = 9.238e+08;
na55 = 0;
History1 = [ na22; na55 ];
%Kemoterapi Konstan
sol1 = ode23s(@F_Toksik_KemoK, time1, History1);
T2 = sol1.x'; Y2 = sol1.y';
Q2 = spline (T2, Y2(:,1),time1);
%Plot
plot (time1, Q2,'black', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
%Besar Efek Toksisitas dari Kemoterapi Konstan terhadap Sel Normal
ET_H_KK = trapz(T2, Y2(:,1));
%Total Efek Toksisitas dari Imunoterapi Konstan-Kemoterapi Konstan
terhadap Sel Normal
ET_H = ET_H_IK + ET_H_KK

%IMUNOTERAPI KONSTAN-KEMOTERAPI PERIODIK:
clc; clear all;
%-------------------------TERAPI PERTAMA-------------------------
%Besar Efek Toksisitas Imunoterapi Konstan terhadap Sel Normal = 0
ET_H_IK = 0;
%-------------------------TERAPI KEDUA-------------------------
time1 = linspace(60,350);
%Kondisi Awal
na22 = 9.238e+08;
na55 = 0;
History1 = [ na22; na55 ];
%Kemoterapi Periodik
sol1 = ode23s(@F_Toksik_KemoP, time1, History1);
T2 = sol1.x'; Y2 = sol1.y';
Q2 = spline (T2, Y2(:,1),time1);
%Plot
plot (time1, Q2,'black', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
%Besar Efek Toksisitas dari Kemoterapi Periodik terhadap Sel
Normal
 = trapz(T2, Y2(:,1));
Efek Toksisitas dari Imunoterapi Konstan-Kemoterapi
k terhadap Sel Normal
ET_H_IK + ET_H_KP
```

```
%IMUNOTERAPI PERIODIK-KEMOTERAPI KONSTAN:
clc; clear all;
%-------------------------TERAPI PERTAMA-------------------------
%Besar Efek Toksisitas Imunoterapi Periodik terhadap Sel Normal= 0
ET_H_IP = 0;
%-------------------------TERAPI KEDUA-------------------------
time1 = linspace(60,350);
%Kondisi Awal
na22 = 9.238e+08;
na55 = 0;
History1 = [ na22; na55 ];
%Kemoterapi Konstan
sol1 = ode23s(@F_Toksik_KemoK, time1, History1);
T2 = sol1.x'; Y2 = sol1.y';
Q2 = spline (T2, Y2(:,1),time1);
%Plot
plot (time1, Q2,'black', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
%Besar Efek Toksisitas dari Kemoterapi Konstan terhadap Sel Normal
ET_H_KK = trapz(T2, Y2(:,1));
%Total Efek Toksisitas dari Imunoterapi Periodik-Kemoterapi
Konstan terhadap Sel Normal
ET_H = ET_H_IP + ET_H_KK

%IMUNOTERAPI PERIODIK-KEMOTERAPI PERIODIK:
clc; clear all;
%-------------------------TERAPI PERTAMA-------------------------
%Besar Efek Toksisitas Imunoterapi Periodik terhadap Sel Normal= 0
ET_H_IP = 0;
%-------------------------TERAPI KEDUA-------------------------
time1 = linspace(60,350);
%Kondisi Awal
na22 = 9.238e+08;
na55 = 0;
History1 = [ na22; na55 ];
%Kemoterapi Periodik
sol1 = ode23s(@F_Toksik_KemoP, time1, History1);
T2 = sol1.x'; Y2 = sol1.y';
Q2 = spline (T2, Y2(:,1),time1);
%Plot
plot (time1, Q2,'black', 'LineWidth', 1.5)
xlabel('Waktu (Hari)','Fontsize',12)
ylabel('H (sel)', 'Fontsize', 12)
%Besar Efek Toksisitas dari Kemoterapi Periodik terhadap Sel
Normal
ET_H_KP = trapz(T2, Y2(:,1));
%Total Efek Toksisitas dari Imunoterapi Periodik-Kemoterapi
Periodik terhadap Sel Normal
ET_H = ET_H_IP + ET_H_KP
```

Berdasarkan hasil simulasi tersebut, diperoleh bahwa besar efek toksisitas dari kemoterapi tunggal baik kemoterapi konstan dan kemoterapi periodik, yaitu sebesar $3{,}50 \times 10^{11}$ sedangkan dari kombinasi terapi baik imunoterapi konstan-kemoterapi konstan, imunoterapi konstan-kemoterapi periodik, imunoterapi periodik-kemoterapi konstan, dan imunoterapi periodik-kemoterapi periodik, yaitu sebesar $2{,}65 \times 10^{11}$. Jika dilakukan perhitungan sebagai berikut:

$$\frac{3{,}50 \times 10^{11} - 2{,}65 \times 10^{11}}{3{,}50 \times 10^{11}} \times 100\% = 24{,}29\%,$$

maka diperoleh bahwa efek toksisitas terhadap sel normal yang dihasilkan oleh kombinasi terapi yaitu $24{,}29\%$ lebih rendah dibandingkan dengan yang dihasilkan oleh kemoterapi tunggal.