DAFTAR PUSTAKA

Alrizzaqi, M. M., Regasari, R., Putri, M., & Wardani, N. H. (2018). *Implementasi Metode Dempster-Shafer untuk Mendiagnosis Jenis Tumor Jinak pada Manusia* (Vol. 2, Nomor 5). http://j-ptiik.ub.ac.id

Arisanti, J. P., Saptarina, N., & Andarini, Y. D. (2020). Evaluasi Penggunaan Obat Kemoterapi Pada Penderita Kanker Payudara Di RSUP Dr. Seoradji Tirtonegoro Periode 2018. *Pharmaceutical Journal of Islamic Pharmacy*, *4*(2), 1–8.

Brown, J. M., Twentyman, P. R., & Zamvil, S. S. (t.t.). *RIF-1 Tumor In Vitro and Response of the X-Radiation (Cell Survival, in C3H/Km Mice to Chemotherapeutic Regrowth Delay, Agents, and Activated and Tumor Control), Macrophages*. http://jnci.oxfordjournals.org/

C. Henry Edwards, & David E. Penney. (2015). *Differential Differential Equations Equations and Boundary and Boundary Value Problems* (5 ed.). Pearson.

Carey, B. L., Ahmed, M., Puckett, S., & Lyles, D. S. (2008). Early Steps of the Virus Replication Cycle Are Inhibited in Prostate Cancer Cells Resistant to Oncolytic Vesicular Stomatitis Virus. *Journal of Virology*, *82*(24), 12104–12115. https://doi.org/10.1128/JVI.01508-08

Chiocca, E. A. (2008). The host response to cancer virotherapy. *Current opinion in molecular therapeutics*, *10*(1), 38–45.

Corless, R. M., Gonnet, G. H., Hare, D. E. G., Jeffrey, D. J., & Knuth, D. E. (1996). On the LambertW function. *Advances in Computational Mathematics*, *5*(1), 329–359. https://doi.org/10.1007/BF02124750

Cripe, T. P., Wang, P.-Y., Marcato, P., Mahller, Y. Y., & Lee, P. W. (2009). Targeting cancer-initiating cells with oncolytic viruses. *Molecular therapy : the journal of the American Society of Gene Therapy*, *17*(10), 1677–1682. https://doi.org/10.1038/mt.2009.193

D'Alessandro, A., Deaconu, A. F., Mandolesi, S., Fabrizio, F. P., Lombardi, M., Liguori, G., Pepe, G., Marino, N., Stingi, A., D'Alessandro, A., & Giordano, A. (2024). Liquid biopsy-based technologies: a promising tool for biomarker identification in her2-low breast cancer patients for improved therapeutic outcomes. *Journal of Cancer Metastasis and Treatment*. https://doi.org/10.20517/2394-4722.2024.63

Debela, D. T., Muzazu, S. G. Y., Heraro, K. D., Ndalama, M. T., Mesele, B. W., Haile, D. C., Kitui, S. K., & Manyazewal, T. (2021). New approaches

and procedures for cancer treatment: Current perspectives. Dalam *SAGE Open Medicine* (Vol. 9). SAGE Publications Ltd. https://doi.org/10.1177/20503121211034366

Dennis G. Zill, & Michael R. Cullen. (2009). *Differential Equations with Boundary-Value Problems* (7 ed.). Brooks/Cole Publishing Company.

Garber, K. (2006). China approves world's first oncolytic virus therapy for cancer treatment. *Journal of the National Cancer Institute*, *98*(5), 298–300. https://doi.org/10.1093/jnci/djj111

J. Margolis, & M. R. Grever. (2000). Pentostatin (Nipent): A review of potential toxicity and its management. *Seminars in Oncology*, *27*(3 SUPPL. 5), 9–14.

Kemenkes. (2024a). *Buku Panduan Pelaksanaan Hari Kanker Sedunia* (Kemenkes, Ed.).

Kemenkes. (2024b, Mei 6). *Kanker Masih Membebani Dunia*. https://sehatnegeriku.kemkes.go.id/baca/blog/20240506/3045408/kanker-masih-membebani-dunia/.

Kim, Y.-N., Gulhan, D. C., Jin, H., Glodzik, D., & Park, P. J. (2024). Recent Advances in Genomic Approaches for the Detection of Homologous Recombination Deficiency. *Cancer Research and Treatment*, *56*(4), 975–990. https://doi.org/10.4143/crt.2024.154

Komori, T. (2022). The 2021 WHO classification of tumors, 5th edition, central nervous system tumors: the 10 basic principles. *Brain Tumor Pathology*, *39*(2), 47–50. https://doi.org/10.1007/s10014-022-00428-3

Malinzi, J., Eladdadi, A., & Sibanda, P. (2017). Modelling the spatiotemporal dynamics of chemovirotherapy cancer treatment. *Journal of Biological Dynamics*, *11*(1), 244–274. https://doi.org/10.1080/17513758.2017.1328079

Malinzi, J., Ouifki, R., Eladdadi, A., Torres, D. F. M., & White, K. A. J. (2018). Enhancement of chemotherapy using oncolytic virotherapy: Mathematical and optimal control analysis. *Mathematical Biosciences and Engineering*, *15*(6), 1435–1463. https://doi.org/10.3934/mbe.2018066

Malinzi, J., & Soltani, M. (2019). Mathematical Analysis of a Mathematical Model of Chemovirotherapy: Effect of Drug Infusion Method. *Computational and Mathematical Methods in Medicine*, *2019*. https://doi.org/10.1155/2019/7576591

Millar, A. W., & Lynch, K. P. (2003). Rethinking clinical trials for cytostatic drugs. *Nature reviews. Cancer*, *3*(7), 540–545. https://doi.org/10.1038/nrc1124

Mokhtari, R. B., Homayouni, T. S., Baluch, N., Morgatskaya, E., Kumar, S., Das, B., & Yeger, H. (2017). *Combination Therapy In Combating Cancer Systematic Review: Combination Therapy In Combating Cancer Background* (Vol. 8, Nomor 23). www.impactjournals.com/oncotarget

Morrissey, K. M., Yuraszeck, T. M., Li, C.-C., Zhang, Y., & Kasichayanula, S. (2016). Immunotherapy and Novel Combinations in Oncology: Current Landscape, Challenges, and Opportunities. *Clinical and translational science*, *9*(2), 89–104. https://doi.org/10.1111/cts.12391

Mulyani, & Nuryani. (2013). *Kanker Payudara dan PMS pada Kehamilan*. Nuha Medika.

Murray, J. D. (Ed.). (2002). *Mathematical Biology* (Vol. 17). Springer New York. https://doi.org/10.1007/b98868

Olsder. (1998). *Mathematical Systems Theory* (2 ed.). University Press.

Phan, T. (2017). A model of sovereign debt with private information. *Journal of Economic Dynamics and Control*, *83*, 1–17. https://doi.org/10.1016/j.jedc.2017.07.011

Pinho, S. T. R., Freedman+, H. I., & Nani, F. (2002). A Chemotherapy Model for the Treatment of Cancer with Metastasis. Dalam *COMPUTER MODELLING PERGAMON Mathematical and Computer Modelling* (Vol. 36). www.elsevier.com/locate/mcm

Prestwich, R. J., Harrington, K. J., Pandha, H. S., Vile, R. G., Melcher, A. A., & Errington, F. (2008). Oncolytic viruses: a novel form of immunotherapy. *Expert review of anticancer therapy*, *8*(10), 1581–1588. https://doi.org/10.1586/14737140.8.10.1581

Subiono. (2010). *Matematika Sistem*. Jurusan Matematika.

Supriyanto W. (2014). *Kanker Deteksi Dini, Pengobatan, dan Penyembuhannya* (Supriyanto, Ed.). Parama Ilmu.

The replicability of oncolytic virus: Defining conditions in tumor virotherapy. (2011). *Mathematical Biosciences and Engineering*, *8*(3), 841–860. https://doi.org/10.3934/mbe.2011.8.841

Tomblyn, M. B., Katin, M. J., & Wallner, P. E. (2013). The new golden era for radioimmunotherapy: not just for lymphomas anymore. *Cancer control :*

journal of the Moffitt Cancer Center, *20*(1), 60–71. https://doi.org/10.1177/107327481302000109

Touchefeu, Y., Franken, P., & Harrington, K. J. (2012). Radiovirotherapy: principles and prospects in oncology. *Current pharmaceutical design*, *18*(22), 3313–3320. https://doi.org/10.2174/1381612811209023313

Vichaya, E. G., Chiu, G. S., Krukowski, K., Lacourt, T. E., Kavelaars, A., Dantzer, R., Heijnen, C. J., & Walker, A. K. (2015). Mechanisms of chemotherapy-induced behavioral toxicities. *Frontiers in neuroscience*, *9*, 131. https://doi.org/10.3389/fnins.2015.00131

World Health Organization. (2020). *Cancer*. 2020. https://www.who.int/news-room/fact-sheets/detail/cancer

World Health Organization. (2024, Februari 1). *Global cancer burden growing, amidst mounting need for services*. https://www.who.int/news/item/01-02-2024-global-cancer-burden-growing--amidst-mounting-need-for-services.

Yuliana Jao. (2019). *Analisis Kestabilan Model Waktu Tunda Respon Patogen terhadap Penambahan Protein Terapeutik Pada Sistem Imun Inang [Bachelor Thesis]*. Universitas Hasanuddin.

Zulkarnain, I., Surarso, B., & Purnami, N. (2017). Penurunan Hemoglobin, Neutrofil, dan Trombosit Pascakemoterapi Cisplatin-Paclitaxel Pada Penderita Tumor Ganas Kepala dan Leher. *Jurnal THT*, *10*(1), 1–10.

LAMPIRAN

Lampiran 1 Hubungan λ dan τ_2 pada persamaan (127)

```
clear
clc

r=0.02;
a1=250;
q=100;
d4=4.17;
k2=100000;
C=q/d4;
A1=(a1*C)/(k2+C);

fp = fimplicit(@(x,y) y-r+A1*exp(-y*x), [-3 11 -12 4]);
fp.Color = 'b';
fp.LineWidth = 1.5;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.75);
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.75);

hold on
xline(7.07,'--','\tau_{2}=
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal')
xline(10,'--','\tau_{2} >
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal')
xline(3,'--','\tau_{2} <
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal')
hold off

xlabel('\tau_{2} (hari)', 'Fontsize', 10)
ylabel('\lambda','FontSize',10)
title('Hubungan \tau_{2} terhadap \lambda')
```

Lampiran 2 Hubungan τ_2 terhadap bagian real λ pada persamaan (127)

```
clear
clc

r=0.02;
a1=250;
q=100;
d4=4.17;
k2=100000;
C=q/d4;
```

```
A1=(a1*C)/(k2+C);

syms x y
fp = fimplicit(@(x,y) y-r+A1*exp(-y*x)*cos(x*sqrt((A1*exp(-y*x))^2-(y-r)^2)), [-0.5 20 -
10 1]);
fp.Color = 'b';
fp.LineWidth = 1;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.75); % Draw line for Y axis.
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.75); % Draw line for X axis.
xlabel('\tau_{2} (hari)', 'Fontsize', 10)
ylabel('bagian real','FontSize',10)
title('Hubungan \tau_{2} terhadap bagian real akar kompleks eigen')
```

Lampiran 3 Hubungan τ_2 terhadap bagian imajiner λ pada persamaan (127)

```
clear
clc

r=0.02;
a1=250;
q=100;
d4=4.17;
k2=100000;
C=q/d4;
A1=(a1*C)/(k2+C);

fp = fimplicit(@(x,y) y-A1*exp(-x*(-r-y*cot(y*x)))*sin(y*x), [0 7 -4 4]);
fp.Color = 'b';
fp.LineWidth = 1;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.1);
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.1);
xlabel('\tau_{2} (hari)', 'Fontsize', 10)
ylabel('bagian imajiner','FontSize',10)
title('Hubungan \tau_{2} terhadap bagian imajiner akar kompleks eigen')
```

Lampiran 4 Hubungan λ dan q pada persamaan (127)

```
clear
clc

r=0.02;
a1=250;
q=100;
d4=4.17;
k2=100000;
```

```
fp = fimplicit(@(x,y) y-r+(a1*(x/d4))/(k2+(x/d4))*exp(-y*3), [0 300 -1.5 0.2]);
fp.Color = 'b';
fp.LineWidth = 1.5;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.75);
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.75);

hold on
xline(217,'--','\tau_{2}=
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHor
izontalAlignment','center')
xline(270,'--','\tau_{2} >
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHor
izontalAlignment','center')
xline(100,'--','\tau_{2} <
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHor
izontalAlignment','center')
xline(33.3627,'--
','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHorizontalAlig
nment','center')
hold off

xlabel('q (ml/mm^{3})', 'Fontsize', 10)
ylabel('\lambda','FontSize',10)
title('Hubungan q terhadap \lambda')

text(22.36,-0.05,'33.36')
```

Lampiran 5 Hubungan λ dan τ_2 pada persamaan (177)

```
clear
clc

delta=0.05;
a2=260;
q=100;
d4=4.17;
k2=100000;
C=q/d4;
A2=(a2*C)/(k2+C);

fp = fimplicit(@(x,y) y+delta+A2*exp(-y*x), [-2 9 -15 5]);
fp.Color = 'b';
fp.LineWidth = 1.5;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.75); % Draw line for Y axis.
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.75); % Draw line for X axis.
```

```
hold on
xline(4.67,'--','\tau_{2}=
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal')
xline(7,'--','\tau_{2} >
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal')
xline(2,'--','\tau_{2} <
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal')
hold off

xlabel('\tau_{2} (hari)', 'Fontsize', 10)
ylabel('\lambda','FontSize',10)
title('Hubungan \tau_{2} terhadap \lambda')
```

Lampiran 6 Hubungan τ_2 terhadap bagian real λ pada persamaan (127)

```
clear
clc

delta=0.05;
a2=260;
q=100;
d4=4.17;
k2=100000;
C=q/d4;
A2=(a2*C)/(k2+C);

syms x y
fp = fimplicit(@(x,y) y+delta+A2*exp(-y*x)*cos(x*sqrt((A2*exp(-y*x))^2-(y+delta)^2)),
[-0.5 20 -10 1]);
fp.Color = 'b';
fp.LineWidth = 1;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.75); % Draw line for Y axis.
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.75); % Draw line for X axis.
xlabel('\tau_{2} (hari)', 'Fontsize', 10)
ylabel('bagian real','FontSize',10)
title('Hubungan \tau_{2} terhadap bagian real akar kompleks eigen')
```

Lampiran 7 Hubungan τ_2 terhadap bagian imajiner λ pada persamaan (127)

```
clear
clc

delta=0.05;
a2=260;
q=100;
```

```
d4=4.17;
k2=100000;
C=q/d4;
A2=(a2*C)/(k2+C);

fp = fimplicit(@(x,y) y-A2*exp(-x*(-delta-y*cot(y*x)))*sin(y*x), [0 7 -4 4]);
fp.Color = 'b';
fp.LineWidth = 1;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.1); % Draw line for Y axis.
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.1); % Draw line for X axis.
xlabel('\tau_{2} (hari)', 'Fontsize', 10)
ylabel('bagian imajiner','FontSize',10)
title('Hubungan \tau_{2} terhadap bagian imajiner akar kompleks eigen')
```

Lampiran 8 Hubungan λ dan q pada persamaan (177)

```
clc
clear all
delta=0.05;
a2=260;
q=100;
d4=4.17;
k2=100000;

fp = fimplicit(@(x,y) y+delta+((a2*(x/d4))/(k2+(x/d4)))*exp(-y*3), [-2 220 -3 1]);
fp.Color = 'b';
fp.LineWidth = 1.5;
line([0,0], ylim, 'Color', 'k', 'LineWidth', 0.75); % Draw line for Y axis.
line(xlim, [0,0], 'Color', 'k', 'LineWidth', 0.75); % Draw line for X axis.
hold on
xline(200,'--','\tau_{2}=
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHor
izontalAlignment','center')
xline(169,'--','\tau_{2} >
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHor
izontalAlignment','center')
xline(120,'--','\tau_{2} <
\tau_{2}^{*}','LabelVerticalAlignment','middle','LabelOrientation','horizontal','LabelHor
izontalAlignment','center')
hold off
xlabel('q (ml/mm^{3})', 'Fontsize', 10)
ylabel('\lambda','FontSize',10)
title('Hubungan q terhadap \lambda')
```

Lampiran 9 Simulasi numerik tanpa waktu tunda

```
function dy = F_Sistem_Non_Delay(~,y,~)
   clc;close all;

   K=1000000;
   r=0.02;
   b=250;
   beta=0.1;
   delta=0.05;
   a1=250;
   a2=260;
   b1=0.0008;
   b2=0.0001;
   b3=0.0002;
   d1=0.03;
   d2=0.05;
   d3=0.01;
   d4=4.17;
   k1=100000;
   k2=100000;
   k3=100000;
   p1=0.7;
   p2=0.5;
   g=50;

   dy = zeros(6,1);
   dy(1) = r*y(1)*(1-(y(1)+y(2))/K)-(beta*y(1)*y(3))/(k1+y(1))-b1*y(1)*y(5)-
(a1*y(1)*y(6))/(k2+y(6));
   dy(2) = (beta*y(1)*y(3))/(k1+y(1))-delta*y(2)-b2*y(5)*y(2)-b3*y(4)*y(2)-
(a2*y(2)*y(6))/(k3+y(6));
   dy(3) = b*delta*y(2)-(beta*y(1)*y(3))/(k1+y(1))-d1*y(3);
   dy(4) = p1*y(2)-d2*y(4);
   dy(5) = (p2*(y(1)+y(2)))/(k3+(y(1)+y(2)))-d3*y(5);
   dy(6) = g-d4*y(6);

end

clc;
clear;
time1 = linspace(0,100,100);

n1 = 10000;
n2 = 100;
n3 = 500;
n4 = 100;
n5 = 100;
```

```
n6 = 100;

S = [n1;n2;n3;n4;n5;n6];

soll = ode45(@F_Sistem_Non_Delay,time1,S);

T1 = soll.x';
Y1 = soll.y';
T2 = soll.x';
Y2 = soll.y';
T3 = soll.x';
Y3 = soll.y';
T4 = soll.x';
Y4 = soll.y';
T5 = soll.x';
Y5 = soll.y';
T6 = soll.x';
Y6 = soll.y';

P1 = spline (T1, Y1(:,1), time1);
P2 = spline (T2, Y2(:,2), time1);
P3 = spline (T3, Y3(:,3), time1);
P4 = spline (T4, Y4(:,4), time1);
P5 = spline (T5, Y5(:,5), time1);
P6 = spline (T6, Y6(:,6), time1);

%Subplot 1
%subplot(3, 2, 1);
plot(time1, P1,'color','k', 'LineWidth', 1.5)
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('P(t)','FontSize',14)
title('Jumlah sel tumor belum terinfeksi virus dalam tubuh', 'Fontsize', 12)

plot(time1, P2,'color','k', 'LineWidth', 1.5)
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('Q(t)','FontSize',14)
title('Jumlah sel tumor terinfeksi virus dalam tubuh', 'Fontsize', 12)

plot(time1, P3,'color','k', 'LineWidth', 1.5)
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('V(t)','FontSize',14)
title('Jumlah partikel virus bebas dalam tubuh', 'Fontsize', 12)
```

```
plot(time1, P4,'color','k', 'LineWidth', 1.5)
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('E_{V}(t)','FontSize',14)
title('Jumlah sel imun terhadap virus dalam tubuh', 'Fontsize', 12)

plot(time1, P5,'color','k', 'LineWidth', 1.5)
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('E_{T}(t)','FontSize',14)
title('Jumlah sel imun terhadap tumor dalam tubuh', 'Fontsize', 12)

plot(time1, P6,'color','k', 'LineWidth', 1.5)
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('C(t)','FontSize',14)
title('Konsentrasi obat kemoterapi dalam tubuh', 'Fontsize', 12)

%axes('Position',[.7 .2 .2 .2])
%box on
%plot(time2,P2)
%xlim([0 5])
%ylim([0 5])
axes('Position',[.7 .2 .2 .2])
box on
for i=1:LL
   plot(time1, G{i},'linewidth', 1.5)
   if i==1
      hold on
   end
end
xlim([32 35])
ylim([600 750])
```

Lampiran 10 Simulasi numerik dengan variasi parameter tanpa waktu tunda

```
function dy = F_Sistem_Non_Delay1(~,y,~)
   clc;close all;

   global g
   K=1000000;
   r=0.02;
   beta=0.1;
   b=250;
   delta=0.05;
   a1=250;
```

```
    a2=260;
    b1=0.0008;
    b2=0.0001;
    b3=0.0002;
    d1=0.03;
    d2=0.05;
    d3=0.01;
    d4=4.17;
    k1=100000;
    k2=100000;
    k3=100000;
    p1=0.7;
    p2=0.5;

    dy = zeros(6,1);
    dy(1) = r*y(1)*(1-(y(1)+y(2))/K)-(beta*y(1)*y(3))/(k1+y(1))-b1*y(1)*y(5)-
(a1*y(1)*y(6))/(k2+y(6));
    dy(2) = (beta*y(1)*y(3))/(k1+y(1))-delta*y(2)-b2*y(5)*y(2)-b3*y(4)*y(2)-
(a2*y(2)*y(6))/(k3+y(6));
    dy(3) = b*delta*y(2)-(beta*y(1)*y(3))/(k1+y(1))-d1*y(3);
    dy(4) = p1*y(2)-d2*y(4);
    dy(5) = (p2*(y(1)+y(2)))/(k3+(y(1)+y(2)))-d3*y(5);
    dy(6) = g-d4*y(6);

end

clc;
clear;
time1 = linspace(0,100,100);

n1 = 10000;
n2 = 100;
n3 = 500;
n4 = 100;
n5 = 100;
n6 = 100;

S = [n1;n2;n3;n4;n5;n6];
Nilai_g = [0 25 50 75 100];
LL = length(Nilai_g);
Legend=cell(LL,1);
for i=1:LL
    global g
    g = Nilai_g(i);
    soll = ode45(@F_Sistem_Non_Delay1,time1,S);
```

```
    T1 = soll.x';
    Y1 = soll.y';
    T2 = soll.x';
    Y2 = soll.y';
    T3 = soll.x';
    Y3 = soll.y';
    T4 = soll.x';
    Y4 = soll.y';
    T5 = soll.x';
    Y5 = soll.y';
    T6 = soll.x';
    Y6 = soll.y';

    P1 = spline (T1, Y1(:,1), time1);
    P2 = spline (T2, Y2(:,2), time1);
    P3 = spline (T3, Y3(:,3), time1);
    P4 = spline (T4, Y4(:,4), time1);
    P5 = spline (T5, Y5(:,5), time1);
    P6 = spline (T6, Y6(:,6), time1);

    G{i}=P1;

    Legend{i}=sprintf('q = %.4g',Nilai_g(i));
end

for i=1:LL
    plot(time1, G{i},'linewidth', 1.5)
    if i==1
        hold on
    end
end

lgd=legend(Legend)
fontsize(lgd,12,'points')
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('(P)(t)','FontSize',14)
title('Variasi q pada jumlah sel tumor belum terinfeksi virus dalam
tubuh','FontSize',10)
```

Lampiran 11 Simulasi numerik dengan variasi τ_1 dan τ_2

```
function dy = F_Sistem_With_Delay1(~,y,Z)
clc; close all;

    K=1000000;
```

```
    r=0.01;
    b=250;
    beta=0.1;
    delta=0.05115;
    a1=50;
    a2=60;
    b1=0.0008;
    b2=0.0001;
    b3=0.0002;
    d1=0.03;
    d2=0.05;
    d3=0.01;
    d4=4.17;
    k1=100000;
    k2=100000;
    k3=100000;
    p1=0.7;
    p2=0.5;
    g=5;

    dy = zeros(6,1);
    ylag1 = Z(:,1);
    ylag2 = Z(:,2);
    dy(1) = r*y(1)*(1-(y(1)+y(2))/K)-(beta*ylag1(1)*ylag1(3))/(k1+ylag1(1))-
b1*y(1)*y(5)-(a1*ylag2(1)*ylag2(6))/(k2+ylag2(6));
    dy(2) = (beta*ylag1(1)*ylag1(3))/(k1+ylag1(1))-delta*y(2)-b2*y(5)*y(2)-
b3*y(4)*y(2)-(a2*ylag2(2)*ylag2(6))/(k3+ylag2(6));
    dy(3) = b*delta*y(2)-(beta*y(1)*y(3))/(k1+y(1))-d1*y(3);
    dy(4) = p1*y(2)-d2*y(4);
    dy(5) = (p2*(y(1)+y(2)))/(k3+(y(1)+y(2)))-d3*y(5);
    dy(6) = g-d4*y(6);
end

clc ; clear all;

time1 = linspace(0,100,100);

n1 = 10000;
n2 = 200;
n3 = 500;
n4 = 100;
n5 = 100;
n6 = 100;

S = [n1;n2;n3;n4;n5;n6];
Nilai_lag1 = [0.33 0.5 0.66 0.83 1];
```

```
LL = length(Nilai_lag1);
Legend = cell(LL,1);

for i=1:LL
   lag1 = [0.33 0.5 0.66 0.83 1];
   lags = [lag1(i), 3];

   soll = dde23(@F_Sistem_With_Delay1,lags, S, time1);

   T1 = soll.x';
   Y1 = soll.y';
   T2 = soll.x';
   Y2 = soll.y';
   T3 = soll.x';
   Y3 = soll.y';
   T4 = soll.x';
   Y4 = soll.y';
   T5 = soll.x';
   Y5 = soll.y';
   T6 = soll.x';
   Y6 = soll.y';

   P1 = spline (T1, Y1(:,1), time1);
   P2 = spline (T2, Y2(:,2), time1);
   P3 = spline (T3, Y3(:,3), time1);
   P4 = spline (T4, Y4(:,4), time1);
   P5 = spline (T5, Y5(:,5), time1);
   P6 = spline (T6, Y6(:,6), time1);

   G{i} = P4;

   Legend{i}=sprintf('\\tau_{1} = %.4g',Nilai_lag1(i));
end

for i=1:LL
   plot(time1, G{i},'linewidth', 1.5)
   if i==1
      hold on
   end
end

lgd=legend(Legend)
fontsize(lgd,12,'points')
set(gca,'fontsize',16)
xlabel('Waktu (hari)', 'Fontsize', 14)
ylabel('V(t)','FontSize',14)
```

```
title('Variasi \tau_{1} pada jumlah sel imun terhadap virus dalam
tubuh','FontSize',10)

axes('Position',[.7 .2 .2 .2])
box on
for i=1:LL
    plot(time1, G{i},'linewidth', 1.5)
    if i==1
        hold on
    end
end
xlim([15 32])
ylim([1700 2000])
```