Lab 1 by Cole Bardin   Section 61

Bertalanffy Model of a Tumor

Part A

Question 1

```
clc, clear, close all
syms x C;
y = (75 + 25*x^2)/(1-x^4)
```

y =

$$-\frac{25\,x^2+75}{x^4-1}$$

```
Y = int(y, x) + C
```

Y = $C + 25\,\mathrm{atan}(x) + 50\,\mathrm{atanh}(x)$

```
check = diff(Y,x)-y;
simplify(check)
```

ans = 0

Questions 2-3

```
clc, clear, close all
syms y(t);
DE = diff(y,t) + 5*y == 13 + 15*t
```

DE(t) =

$$\frac{\partial}{\partial t}\;y(t) + 5\;y(t) = 15\,t + 13$$

```
sol_gen = dsolve(DE)
```

sol_gen =

$$3\,t + \frac{C_1\,\mathrm{e}^{-5\,t}}{5} + 2$$

```
sol_spec = dsolve(DE, y(0)==0)
```

sol_spec = $3\,t - 2\,\mathrm{e}^{-5\,t} + 2$

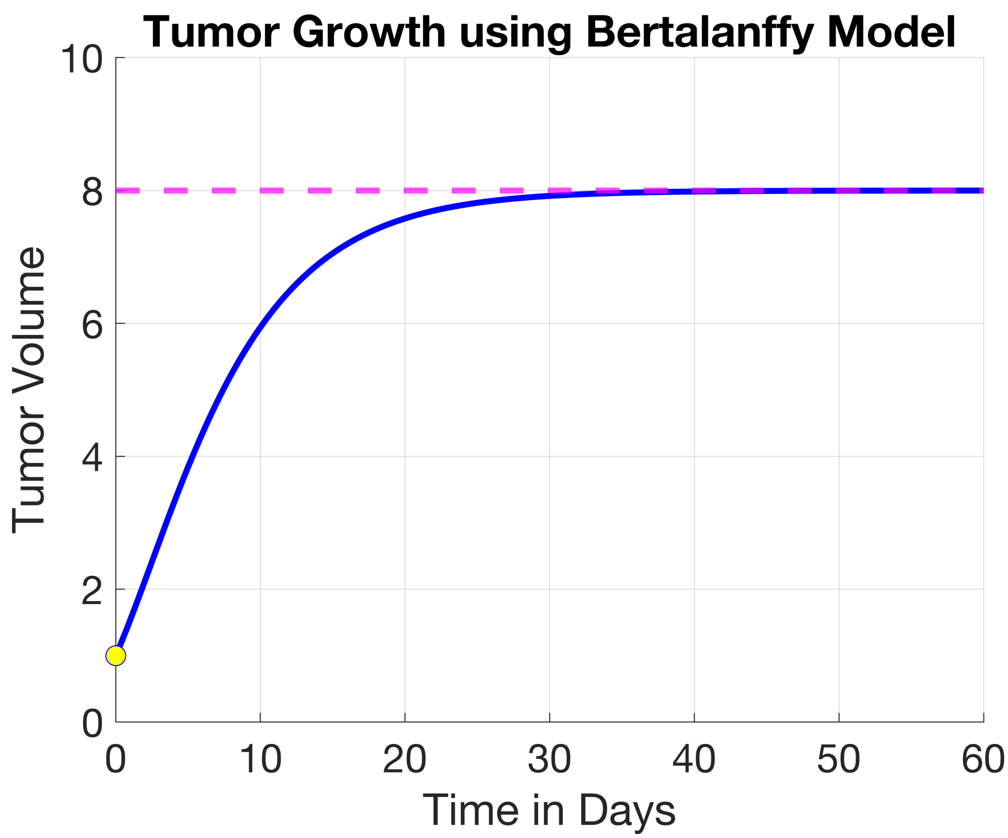
Questions 4-5

```
clc, clear, close all
a = 1; b = a/2;
syms V(t);
DE = diff(V,t) == a*(V^(2/3)) - b*V;

sol = dsolve(DE, V(0)==1);
sol = sol(1) % Parse out first real answer
```

```
sol =
```

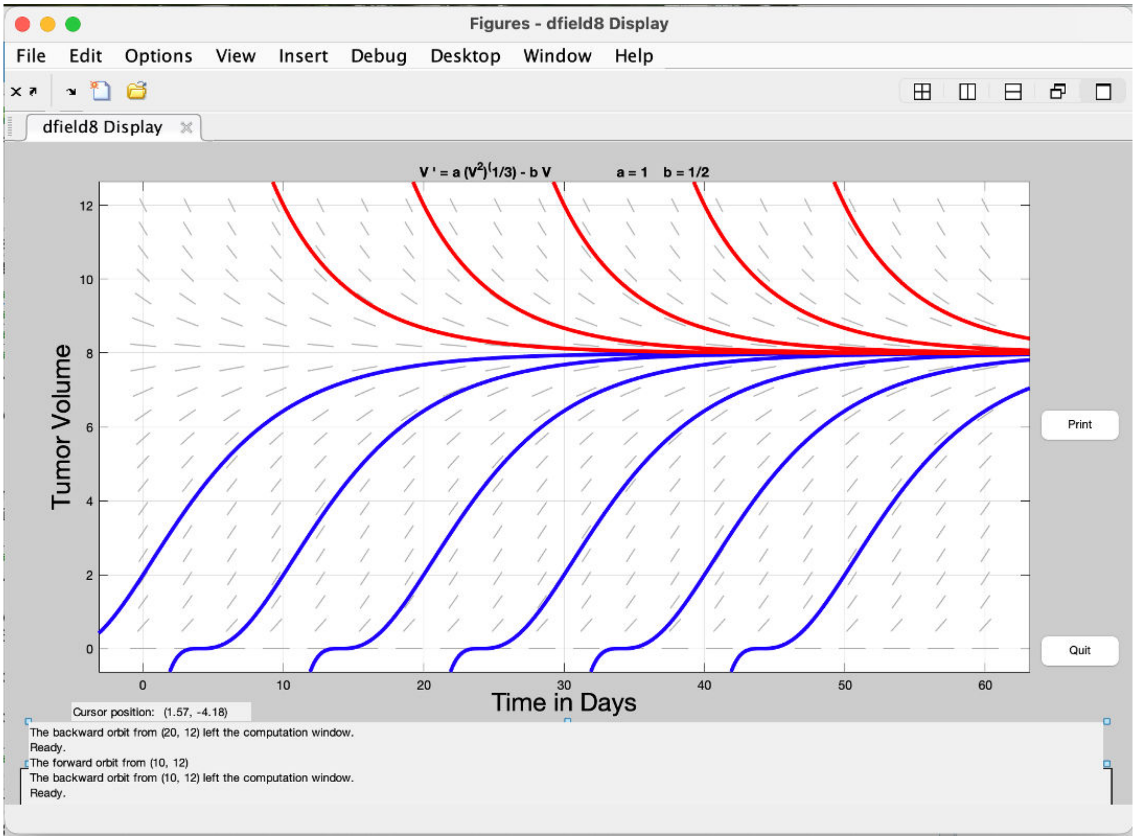
$$-\left(e^{-\frac{t}{6}}-2\right)^3$$

```

% Question 5
V = matlabFunction(sol);

figure('Name','Lab 1: Bertalanffy Model', 'NumberTitle','off');
Tmax = 60; % Plot the tumor for 60 days or about two months

hold on
x = 0:0.1:Tmax;
plot(x, V(x), 'b', 'LineWidth',3)
plot(0, V(0), 'bo', 'MarkerSize',10, 'MarkerFaceColor','y')
yline( (a/b)^3, 'm--', 'LineWidth',3 )

ax = gca; % current axes
ax.FontSize = 20;
% set(gca, 'fontsize', 20) % An alternative approach
% Customize the figure
grid on
axis([0 Tmax 0 10])

title("Tumor Growth using Bertalanffy Model")
ylabel("Tumor Volume")
xlabel("Time in Days")
```



Part B

Questions 6-7



Question 9

```
% Find at what volume the tumors are growing the fastest.
clear, clc
syms a b V
f = a * (V)^(2/3) - b * V ; % The RHS of the Bertalanffy DE.
% The tumors grow the fastest when f(V) is a maximum.
% That's when the derivative of f(V) wrt V is zero.
df = diff(f,V)
```

df =

$$\frac{2\,a}{3\,V^{1/3}} - b$$

```
V_max_growth = solve(df, V)
```

Warning: Solutions are only valid under certain conditions. To include parameters and conditions in the solution, specify the 'ReturnConditions' value as 'true'.

V_max_growth =

$$\frac{8\,a^3}{27\,b^3}$$

Question 10

```
clear, clc
a = 1; b = a/2;
```

```
syms r(t) pi; % Be sure to make pi symbolic!
a1 = sym(a * (1/(36*pi))^(1/3)), b1 = sym(b/3)
```

a1 =

$$\left(\frac{1}{36\,\pi}\right)^{1/3}$$

b1 =

$$\frac{1}{6}$$

```
% Enter the linearized Bertalanffy DE here using a1, b1 and r.
DE = diff(r,t) == a1 - b1*r;
% Use dsolve to find the solution with r(0)==(3/(4*pi))^ (1/3)
rt = dsolve(DE, r(0)==(3/(4*pi))^ (1/3) )
```

rt =

$$\mathrm{e}^{-\frac{t}{6}}\left(\left(\frac{3}{4\,\pi}\right)^{1/3}-6\,\left(\frac{1}{36\,\pi}\right)^{1/3}\right)+6\,\left(\frac{1}{36\,\pi}\right)^{1/3}$$

```
% Compute and simplify V(t) using the formula for the volume of a sphere of radius r.
Vt = simplify((4*pi/3)*(rt^3))
```

Vt =

$$\mathrm{e}^{-\frac{t}{2}}\,(2\,\mathrm{e}^{t/6}-1)^{3}$$