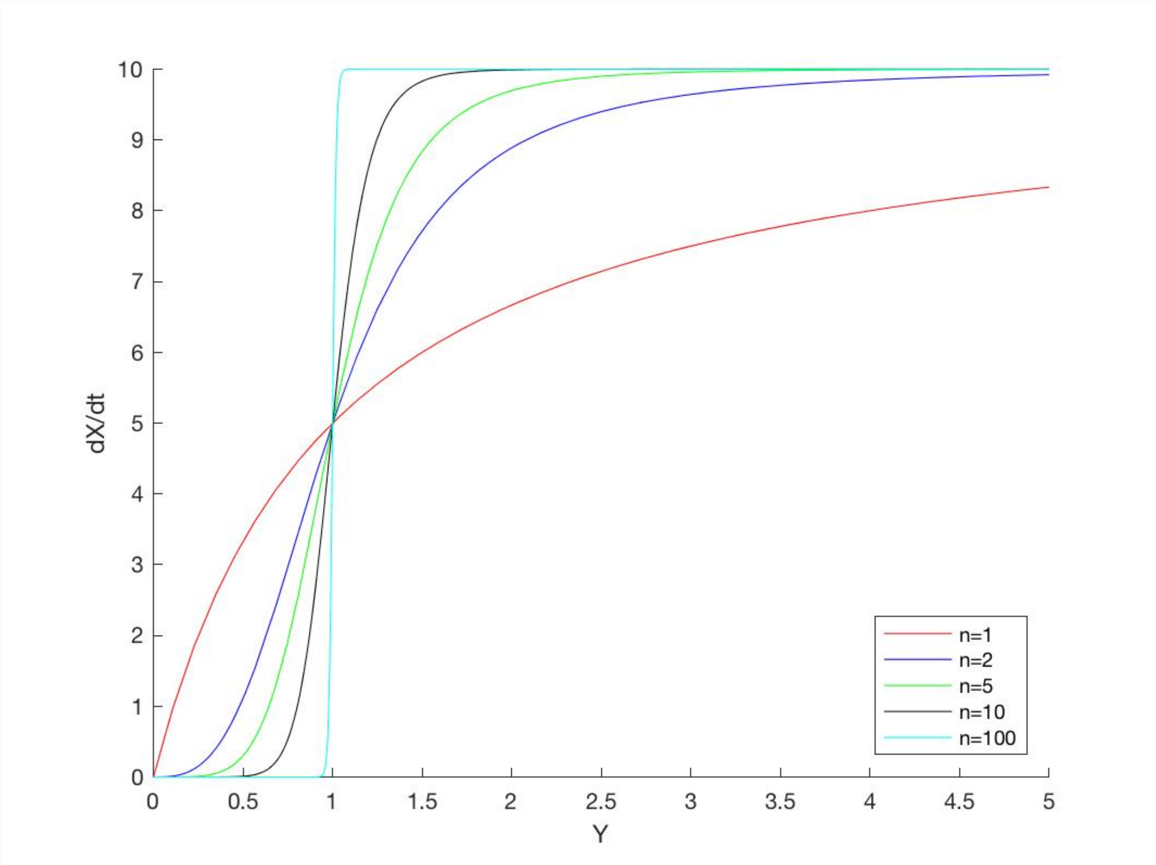
ASSIGNMENT 7

Exercise 1.4.1

1. Modify the MATLAB function to model gene expression in the presence of an activator.

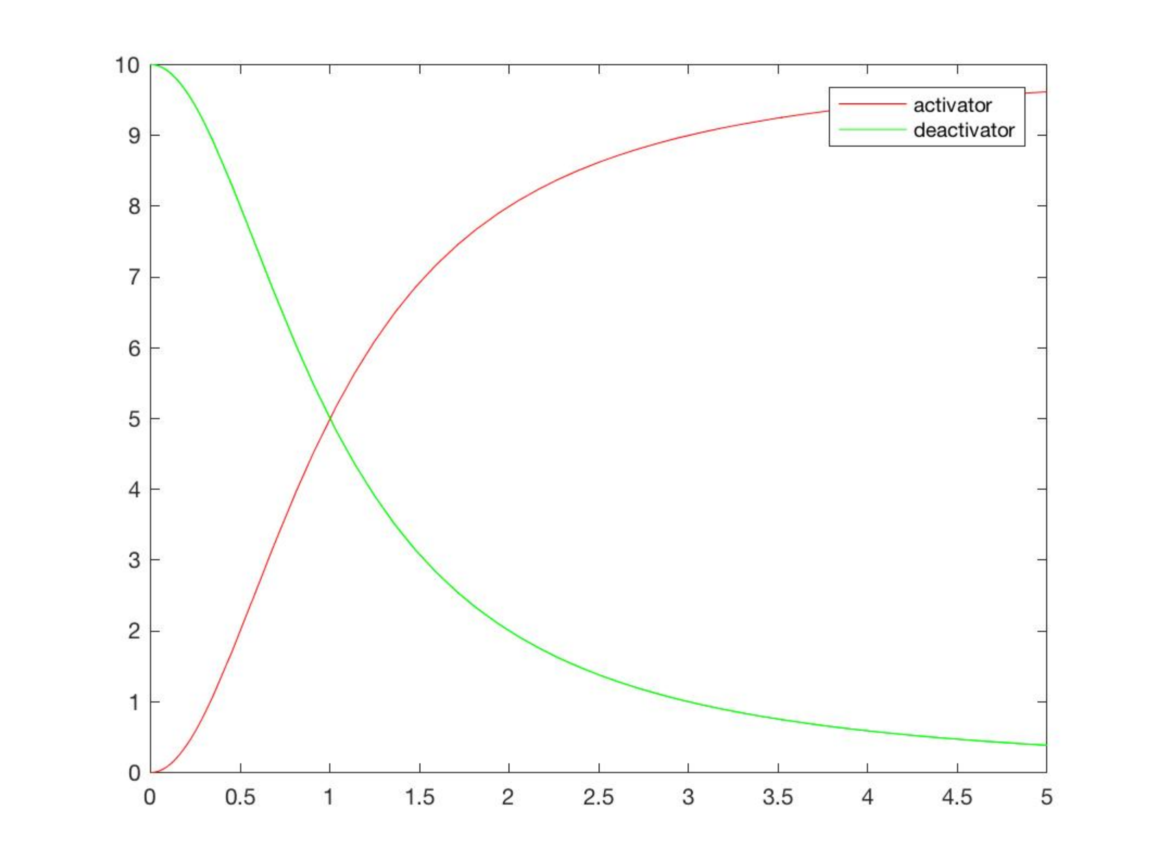
```
v = @(Y,K,k,n) k*Y^n/(K^n + Y^n);
ns = [1 3 5 10 100];
cols = ['r' 'b' 'g' 'k' 'c'];
limits = [0 5];
fig = figure;
hold on
for i=1:5,
    vt = @(Y) v(Y,1,10,ns(i));
    fplot(vt,limits,cols(i));
end
axis([0 5 0 10]);
ylabel('dX/dt');
xlabel('Y');
legend('n=1','n=2','n=5','n=10','n=100','Location','SouthEast');
saveas(fig, 'plot1','jpg');
```



2. Overlay plots for the activator and repressor cases, using parameter values of $K = 1, k = 10$ and $n = 2$.

```
v = @(Y,K,k,n) k*Y^n/(K^n + Y^n);
v1 = @(Y,K,k,n) k*K^n/(K^n + Y^n);
% n = 2; K = 1; k = 10;
vt = @(Y) v(Y,1,10,2);
v1t = @(Y) v1(Y,1,10,2);

fig= figure;
fplot(vt,limits, 'r');
hold on
fplot(v1t,limits, 'g');
legend('v1','v1t')
saveas(fig, 'plot2','jpg');
```



3. What do you notice about the graphs?

   With an activator, there is an increase in gene expression, while there is a decrease in the presence of a repressor.

Exercise 1.4.4

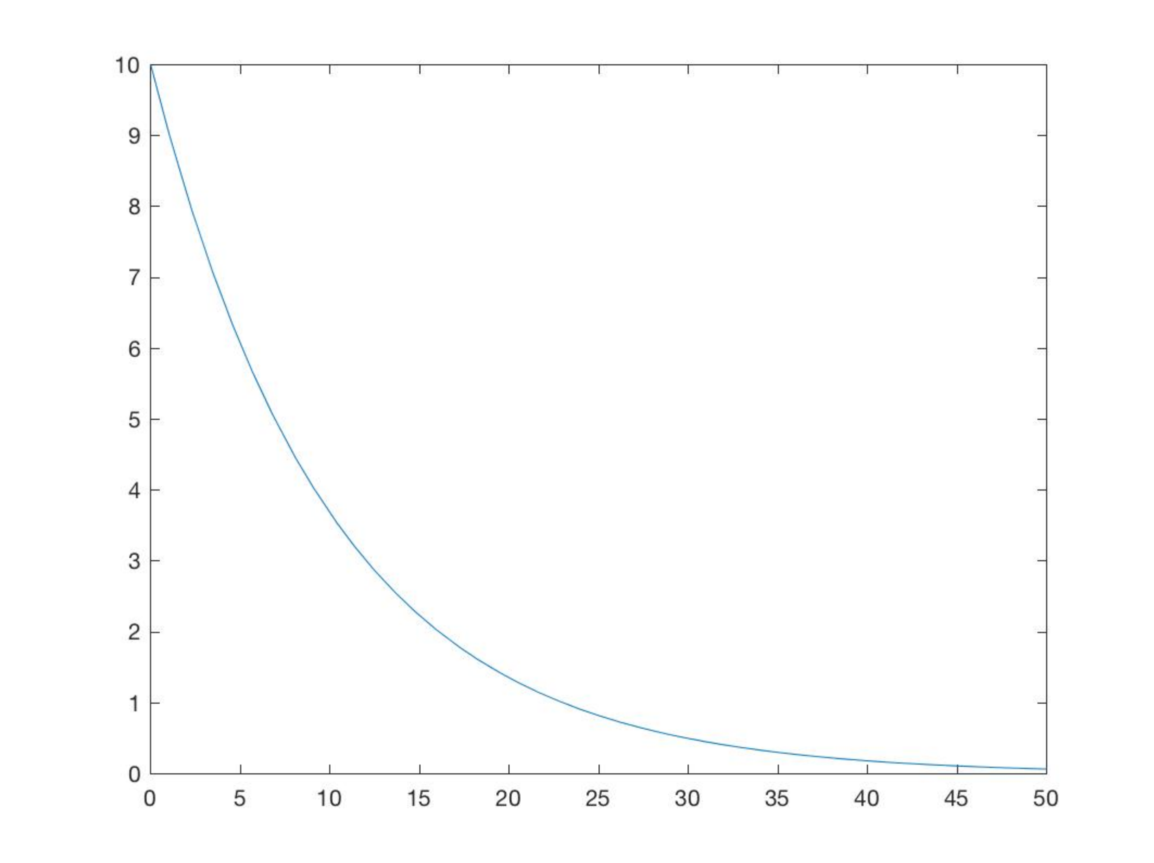
1. Look at the code which models expression of X regulated by transcription factor Y in a system described by the equations $\frac{dX}{dt} = gY - bX$ and $\frac{dY}{dt} = c$. Consider a process in which $c = 0.1, b = 1, g = 1$ and the initial concentrations are $X_0 = 0.1$ and $Y_0 = 10$.

```
r=dsolve('DX=g*Y - b*X','DY=-c*Y','X(0)=X0','Y(0)=Y0','t');
X=simplify(r.X)
% (Y0*g*exp(-c*t))/(b - c) - (exp(-b*t)*(X0*c - X0*b + Y0*g))/(b - c)
Y=simplify(r.Y)
% Y0*exp(-c*t)
```

2. Modify the MATLAB code to solve the differential equations if the concentration of Y is now described by $\frac{dY}{/}dt = -cY$ with initial condition that $Y(t=0) = Y_0$ and $X(t=0) = X_0$.

```
syms t Y0 c
mY = matlabFunction (Y, 'vars', [t Y0 c]);
fY_1 = @ (t) mY (t,10,0.1);
fig = figure;
fplot (fY_1, [0 50])
saveas(fig, 'plot3','jpg');
```

3. Plot the concentration $Y(t)$ against time.

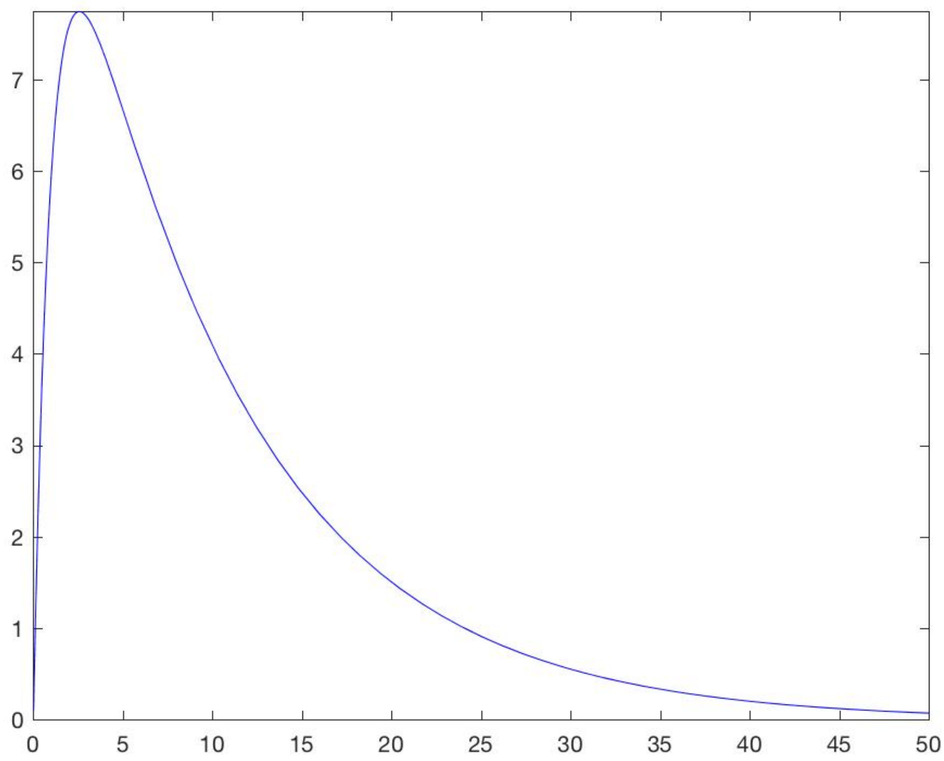


4. Examine the solution for $Y(t)$ you found. What type of mathematical function is it?

   An exponential decline.

5. Plot $X(t)$ against time.

```
syms t b X0 c g Y0
mX = matlabFunction (X, 'vars', [t b X0 c g Y0]);
fX_1 = @ (t) mX (t,1,0.1,0.1,1,10);
fig = figure;
fplot (fX_1, [0 50], 'b')
saveas(fig, 'plot4','jpg');
```



6. How has modifying $\frac{dY}{dt}$ changed the behavior of $X(t)$?

   $fX1$ decays exponentially after an initial peak, while $fX1$ simply undergoes an exponential decay. This could potentially be explained if $fY1$ is an activator for $fX1$.

Exercise 1.5.1

1. Another toggle system can be modelled with the equations

$$\frac{du}{dt} = \frac{\alpha_1}{\exp(\beta v)} - u$$
$$\frac{dv}{dt} = \frac{\alpha_2}{\exp(\gamma u)} - v.$$

   Modify the MATLAB code to numerically integrate these equations. Take $\alpha_1, \alpha_2 = 10, \beta, \gamma = 3$ Hint: You can then re-run the same toggle system code. Only `toggle.m` needs to be altered. (Remember to also change the values of β and γ).

```
% toggle.m
function ydot=toggle(t,y)
    alpha1 = 10.0;
    alpha2 = 10.0;
    beta = 3.0;
    gamma = 3.0;

    du = -y(1) + alpha1/(1+(y(2)^beta));
    dv = -y(2) + alpha2/(1+(y(1)^gamma));

    ydot = [du; dv]
```

2. Plot the concentrations of u and v when $u_0, v_0 = 0.1, 1.0$ and $u_0, v_0 = 5.0, 4.0$

```
timespan = [0 15];
fig = figure
subplot (2,1,1);
y0 = [0.1 1.0];
[t,y] = ode45 (@ toggle,timespan,y0);
plot (t,y)
ylabel ('u,v')
xlabel('time')
legend ('u','v', 'Location','SouthEast')
subplot (2,1,2);
y0 = [5.0 4.0];
[t,y] = ode45 (@toggle,timespan,y0);
plot (t,y)
ylabel ('u,v')
xlabel ('time')
legend ('u','v','Location','SouthEast')
saveas(fig, 'plot5','jpg');
```