Homework5.1

Blue&Megan

20230316

1 "Naive" stochastic simulation

Here we set $n_0 = 1000, k = 2, \Delta t = 0.001$. We stimulate it 4 times and get the following result.

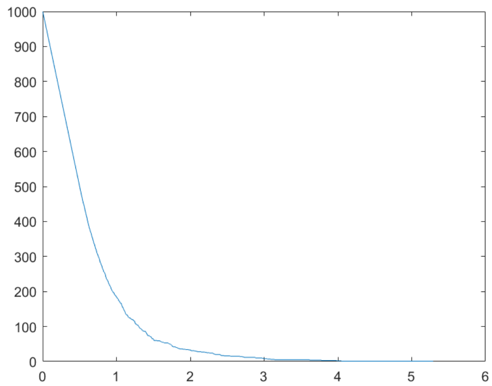

Figure 1: Simulation1

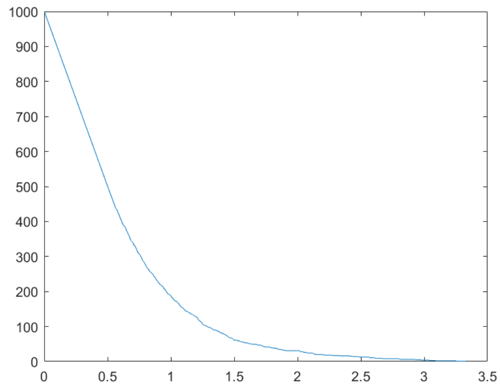

Figure 2: Simulation2

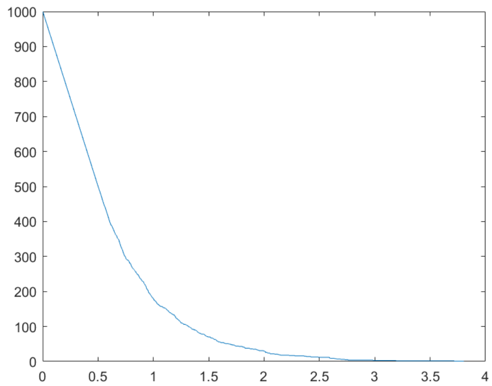

Figure 3: Simulation3

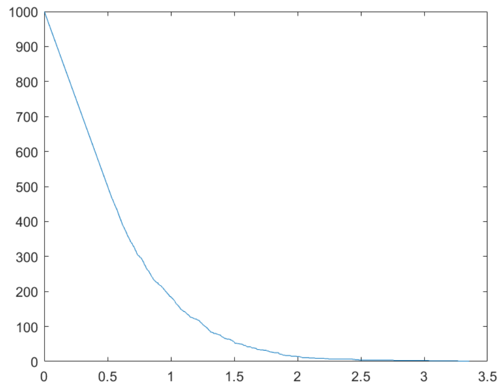

Figure 4: Simulation4

2 Gillespie stochastic simulation algorithm

Here we set $n_0 = 100, k = 2$. We simulation it 10 times and print the deterministic function on the same plot. Then we print the mean.

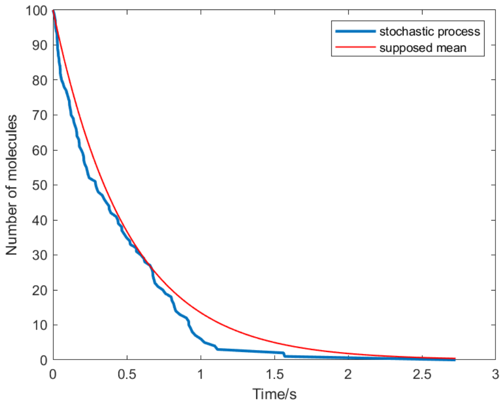

Figure 5: Simulation1

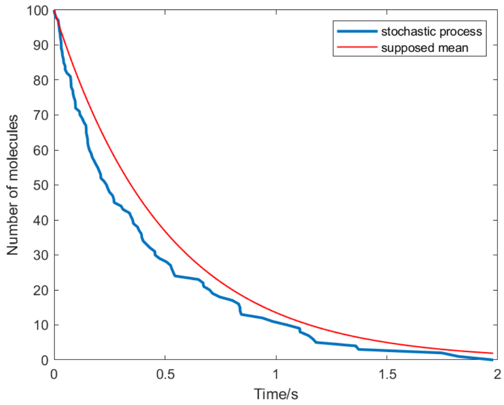

Figure 6: Simulation2

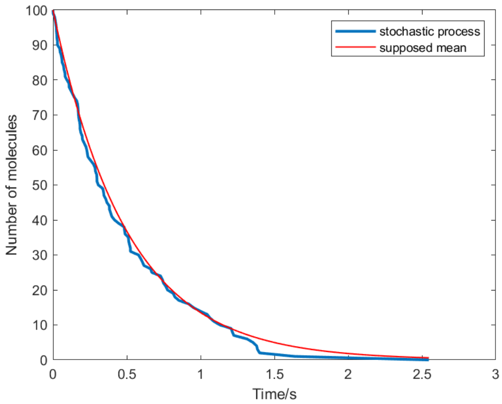

Figure 7: Simulation3

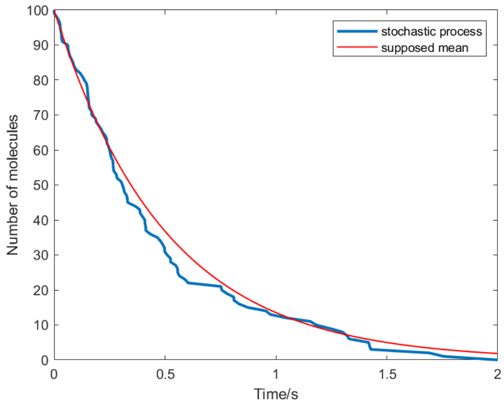

Figure 8: Simulation4

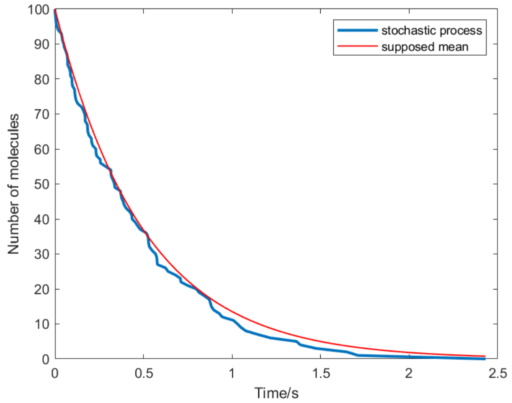

Figure 9: Simulation5

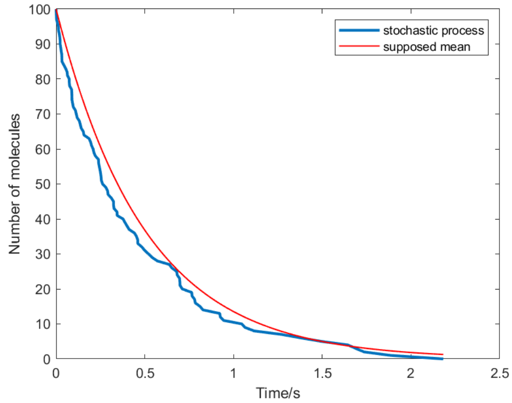

Figure 10: Simulation6

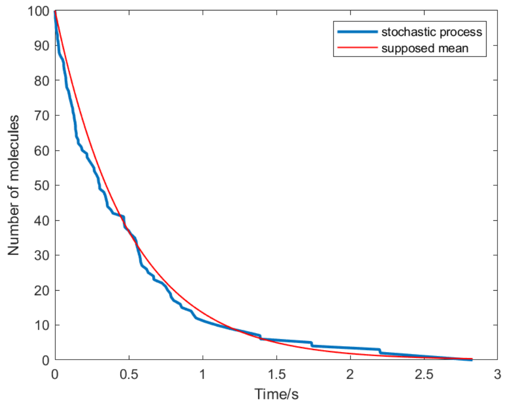

Figure 11: Simulation7

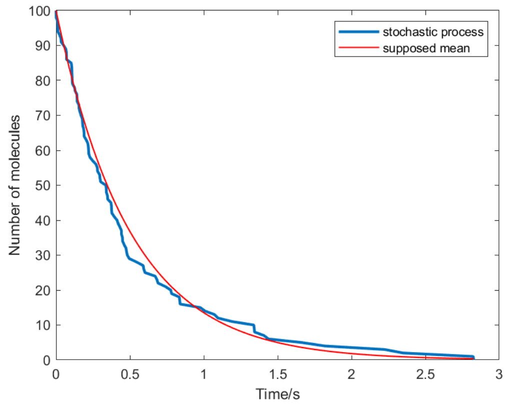

Figure 12: Simulation8

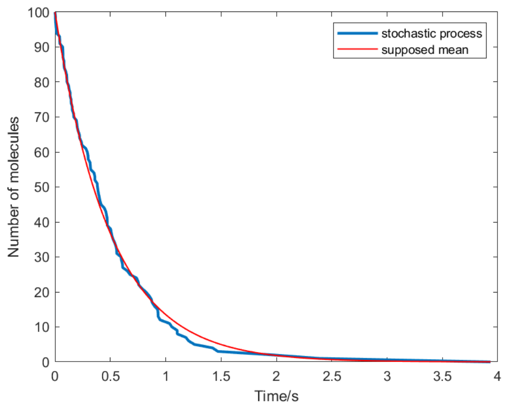

Figure 13: Simulation9

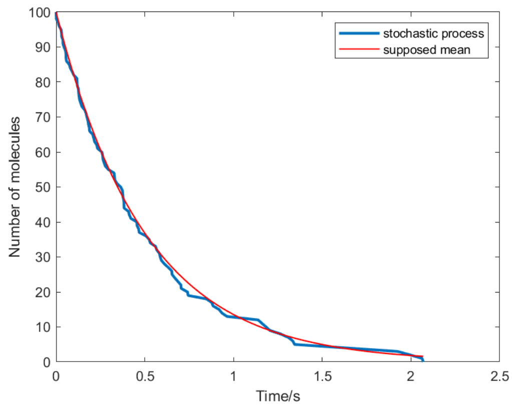

Figure 14: Simulation10

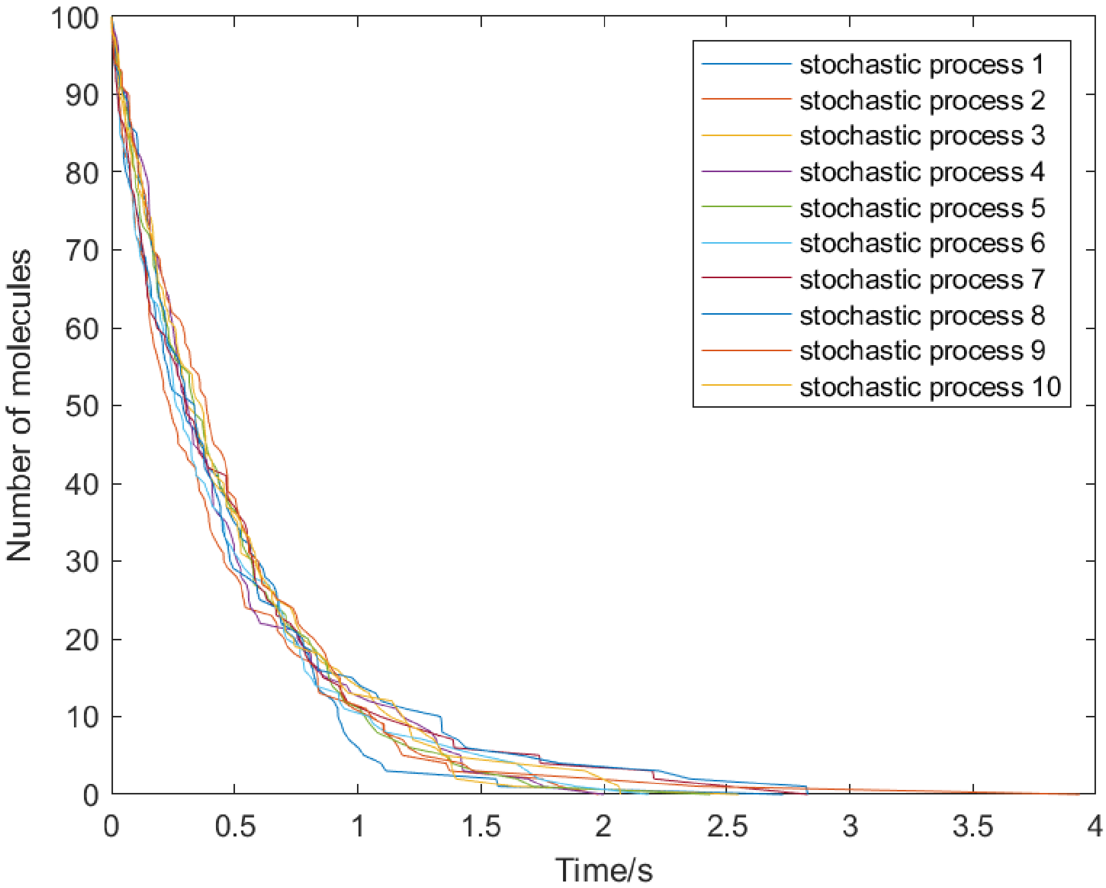

Figure 15: mean

3 Gillespie SSA for 2 reactions

First, we compute the deterministic function and get:

$$a = \frac{k_2}{k_1} + \frac{N_0 - \frac{k2}{k1}}{\exp^{k_1} t} \tag{1}$$

Then we set $n_0 = 100, k_1 = 2, k_2 = 4$. We simulation it 10 times and print the deterministic function on the same plot.Then we print the mean.

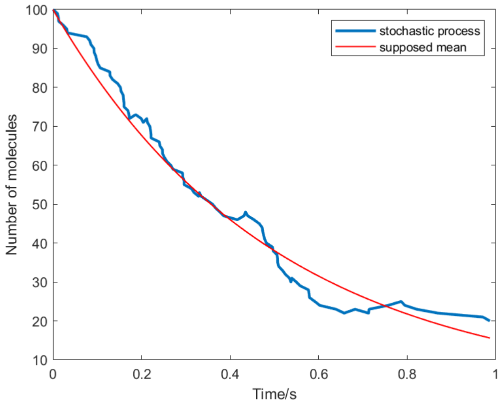

Figure 16: Simulation1

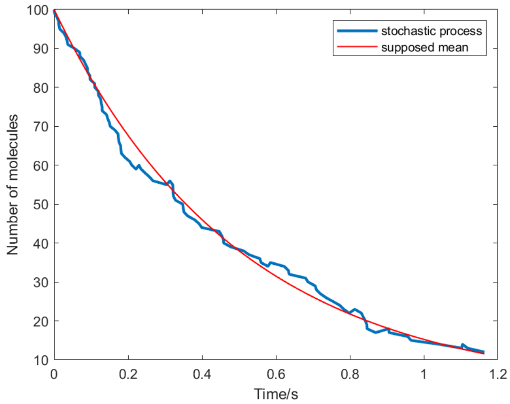

Figure 17: Simulation2

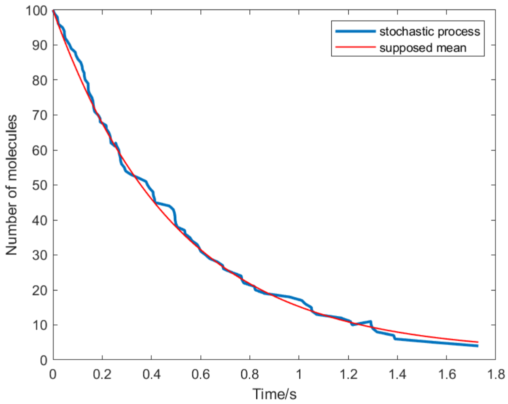

Figure 18: Simulation3

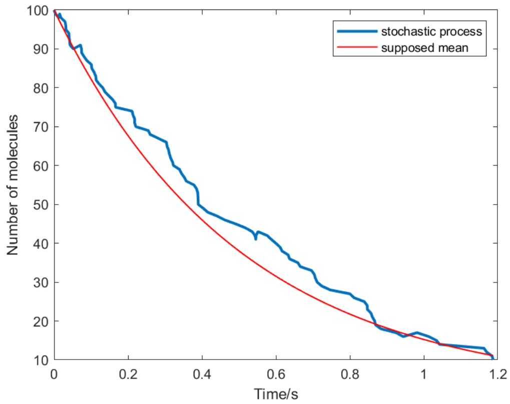

Figure 19: Simulation4

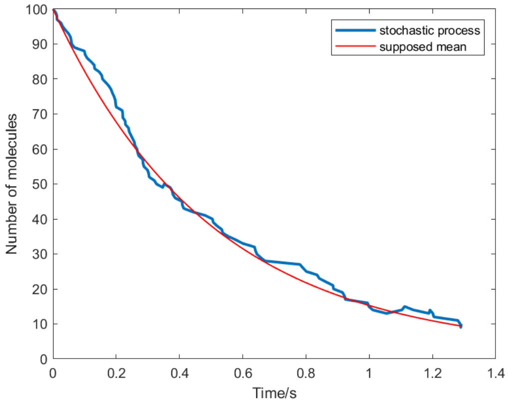

Figure 20: Simulation5

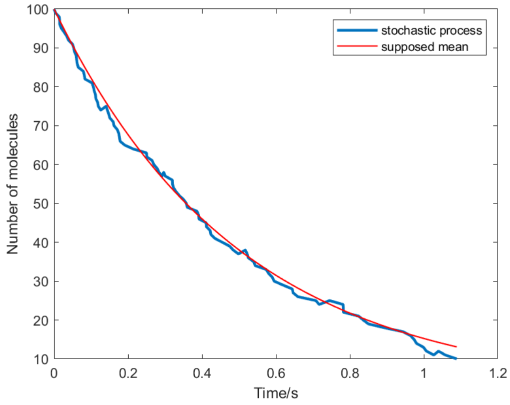

Figure 21: Simulation6

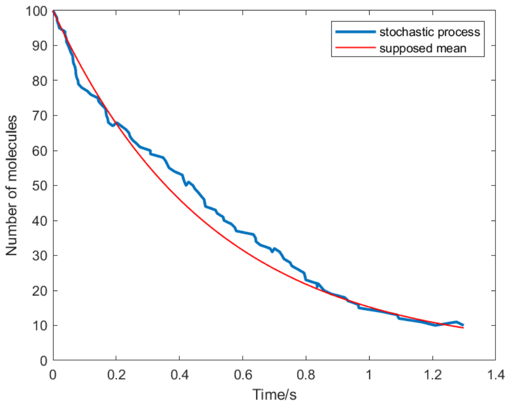

Figure 22: Simulation7

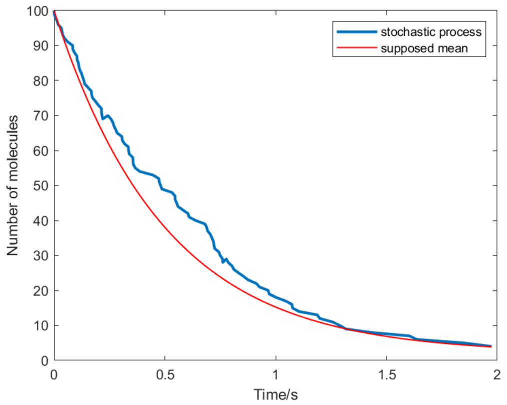

Figure 23: Simulation8

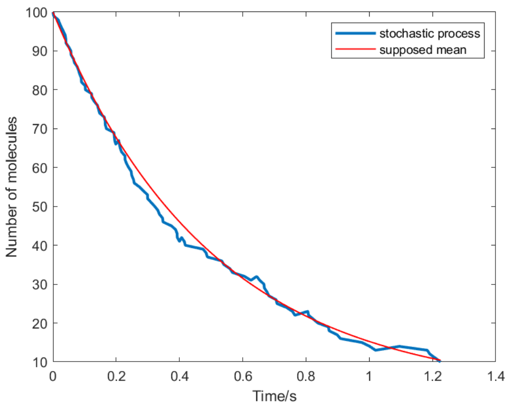

Figure 24: Simulation9

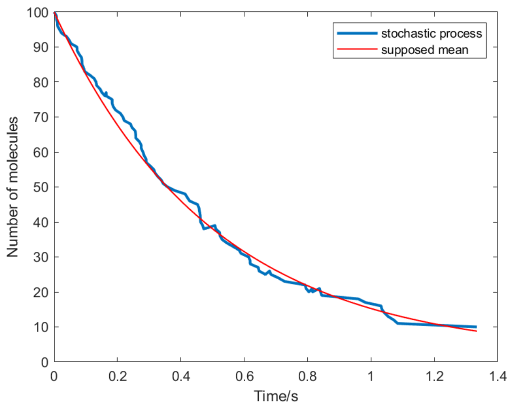

Figure 25: Simulation10

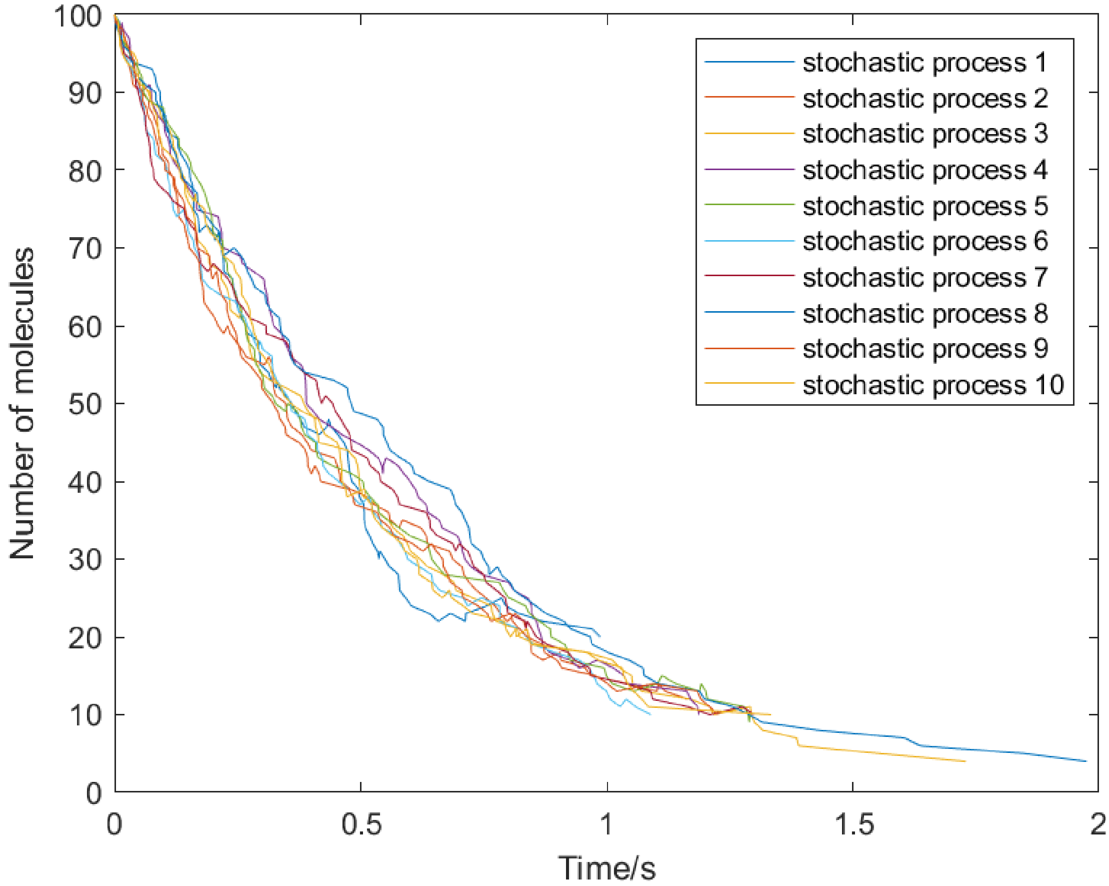

Figure 26: mean

4 code

4.1 "Naive" stochastic simulation

```
k=2;
deltat=0.001;
n0=1000;
naivess1(k,deltat,n0);
function naivess1(k,deltat,n0)
A=n0;
a=n0;
while a>0
    r=rand;
    if r<a*k*deltat
        a=a-1;
    end
    A=vertcat(A,a);
end
[m,n]=size(A);
x=linspace(deltat,m*deltat,m);
plot(x,A);
end
```

4.2 Gillespie stochastic simulation algorithm

```
k=2;
deltat=0.01;
n0=100;
T1=gillespie(k,deltat,n0,'b1.png');
T2=gillespie(k,deltat,n0,'b2.png');
T3=gillespie(k,deltat,n0,'b3.png');
T4=gillespie(k,deltat,n0,'b4.png');
T5=gillespie(k,deltat,n0,'b5.png');
T6=gillespie(k,deltat,n0,'b6.png');
T7=gillespie(k,deltat,n0,'b7.png');
T8=gillespie(k,deltat,n0,'b8.png');
T9=gillespie(k,deltat,n0,'b9.png');
T10=gillespie(k,deltat,n0,'b10.png');
x=linspace(n0,0,n0+1);
plot(T1,x,'DisplayName','stochastic process 1');hold on
plot(T2,x,'DisplayName','stochastic process 2');
plot(T3,x,'DisplayName','stochastic process 3');
plot(T4,x,'DisplayName','stochastic process 4');
plot(T5,x,'DisplayName','stochastic process 5');
plot(T6,x,'DisplayName','stochastic process 6');
plot(T7,x,'DisplayName','stochastic process 7');
plot(T8,x,'DisplayName','stochastic process 8');
plot(T9,x,'DisplayName','stochastic process 9');
plot(T10,x,'DisplayName','stochastic process 10');
legend()
ylabel('Number of molecules')
xlabel('Time/s')
hold off
saveas(gcf, 'mean1.png');
function T=gillespie(k,deltat,n0,name)
```

```
T=linspace(0,n0,n0+1);
t=0;
a=n0;
for i=2:n0+1
    r=rand;
    t=t+log(1/r)/(a*k);
    a=a-1;
    T(i)=t;
end
x=linspace(n0,0,n0+1);
plot(T,x, 'LineWidth', 2,'DisplayName', 'stochastic process');hold on
T2=linspace(0,T(n0+1),1000);
Y=n0*exp(-k*T2);
plot(T2,Y,'r', 'LineWidth', 1,'DisplayName', 'supposed mean');
hold off
legend()
ylabel('Number of molecules')
xlabel('Time/s')
saveas(gcf, name);
end
```

4.3 Gillespie SSA for 2 reactions

```
k1=2;
k2=4;
n0=100;
[T1,A1]=gillespie2(k1,k2,n0,'c1.png');
[T2,A2]=gillespie2(k1,k2,n0,'c2.png');
[T3,A3]=gillespie2(k1,k2,n0,'c3.png');
[T4,A4]=gillespie2(k1,k2,n0,'c4.png');
[T5,A5]=gillespie2(k1,k2,n0,'c5.png');
[T6,A6]=gillespie2(k1,k2,n0,'c6.png');
[T7,A7]=gillespie2(k1,k2,n0,'c7.png');
[T8,A8]=gillespie2(k1,k2,n0,'c8.png');
[T9,A9]=gillespie2(k1,k2,n0,'c9.png');
[T10,A10]=gillespie2(k1,k2,n0,'c10.png');
plot(T1,A1,'DisplayName','stochastic process 1');hold on
plot(T2,A2,'DisplayName','stochastic process 2');
plot(T3,A3,'DisplayName','stochastic process 3');
plot(T4,A4,'DisplayName','stochastic process 4');
plot(T5,A5,'DisplayName','stochastic process 5');
plot(T6,A6,'DisplayName','stochastic process 6');
plot(T7,A7,'DisplayName','stochastic process 7');
plot(T8,A8,'DisplayName','stochastic process 8');
plot(T9,A9,'DisplayName','stochastic process 9');
plot(T10,A10,'DisplayName','stochastic process 10');
legend()
ylabel('Number of molecules')
xlabel('Time/s')
hold off
saveas(gcf, 'mean2.png');
function [T,A]=gillespie2(k1,k2,n0,name)
T=linspace(0,100,101);
A=linspace(0,101,101);
t=0;
```

```
A(1)=n0;
a=n0;
for i=2:101
    r1=rand;
    r2=rand;
    alpha=a*k1+k2;
    t=t+log(1/r1)/(alpha);
    if r2<k2/alpha
        a=a+1;
    else
        a=a-1;
    end
    A(i)=a;
    T(i)=t;
end
plot(T,A, 'LineWidth', 2,'DisplayName', 'stochastic process');hold on
T2=linspace(0,T(101),1000);
Y=k2/k1+(n0-k2/k1)*exp(-k1*T2);
plot(T2,Y,'r', 'LineWidth', 1,'DisplayName', 'supposed mean');
hold off
legend()
ylabel('Number of molecules')
xlabel('Time/s')
saveas(gcf,name);
end
```