

```
clear all
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
lh=317;
bita=0.24;
pi=0.18;
mh=0.00004;%0.0004,0.4,0.0712
lf=14950%1/14,12
picap =0.05;%0 .25,0.01
mf=0.189;%0.71420,.071428,1,0.0789,0.189
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
R0 = (bita^2*pi*pibrave*la*lb*lf+
alpha^2*barpi*tildpi*lb*lh*lf+alpha^2*picap*arrowpi*la*lh*lf)/(mf^2*lh*la*lb);
tspan=[0 300];
x0=[300,50,30,20,15,8,1500,500]; % period orbit
[t,x] = ode45('CLTWof1' tspan,x0);
figure(11)
plot(t,x(:,1));
hold on;
figure(12)
plot(t,x(:,2));
hold on;
figure(13)
plot(t,x(:,3));
hold on;
figure(14)
plot(t,x(:,4));
hold on;
figure(15)
plot(t,x(:,5));
hold on;
figure(16)
plot(t,x(:,6));
hold on;
figure(17)
plot(t,x(:,7));
hold on;
figure(18)
plot(t,x(:,8));
hold on;
```

```
function yp= CLTWof1 (t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
yp (1,:)= lh-bita.*pi.*y(8).*y(1)./(y(1)+y(2))- mh.*y(1);
yp (2,:)= bita.*pi.*y (8).*y(1)./y(1)+y(2))- mh.*y(2);
yp (3,:)= la-alpha.*tildpi.*y(8).*y(3)./(y(3)+y(4))- ma.*y(3);
yp (4,:)= alpha.*tildpi.*y(8).*y(3)./(y(3)+y(4))- ma.*y(4);
yp (5,:)= lb-alpha.*picap*y(8).*y(5)./(y(5)+y(6))- mb.*y(5);
yp (6,:)= alpha.*picap.*y(8).*y(5)/(y(5)+y(6))- mb.*y(6);
yp (7,:)= lf-bita.*pibrave.*y(7).*y(2)./(y(1)+y(2))-alpha.*barpi.*y(7).*y(4)./(y(3)+y(4))-alpha.*arrowpi.*y(7).*y (6)/(y(5)+y(6))- mf.*y(7);
yp (8,:)= bita.*pibrave.*y(7).*y(2)./(y(1)+y(2))+alpha.*barpi.*y(7).*y(4)./(y(3)+y(4)) +alpha.*arrowpi.*y(7).*y (6)./(y(5)+y(6))- mf.*y(8);
```

```

function controlall
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0 .25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
% u1=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*(y(1,:)./((y(1,:)+y(2,:)).*(w_1))),1),0);
u2=max(min((y(12,:)- y(11,:)).*eta_2.*alpha.*tildpi.*y(8,:).*(y(3,:)./((y(3,:)+y(4,:)).*(w_2))),1),0);
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha.*picap.*y(8,:).*(y(5,:)./((y(5,:)+y(6,:)).*(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(2,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)' + row_2*y(4,:)' + row_3*y(6,:)' + row_4*y(7,:)' + row_5*y(8,:)' + 0.5*((w_1)*(u1)*(u1)' + (w_2)*(u2)*(u2)' + w_3*(u3)*(u3)' + w_4*(u4)*(u4)'))./n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;
figure(16)
plot(t,y(7,:));

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hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
plot(t,u1,'y');
% figure(3)
hold on;
plot(t,u2, 'r');
hold on;
% figure(4)
plot(t,u3, 'g');
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWOfl',tspan,x0);
figure(10)
plot(t,x(:,1),'r');
hold on;
figure(11)
plot(t,x(:,2),'g');
hold on;
figure(12)
plot(t,x(:,3),'y');
hold on;
figure(13)
plot(t,x(:,4),'m');
hold on;
figure(14)
plot(t,x(:,5),'k');
hold on;
figure(15)
plot(t,x(:,6),'g');
hold on;
figure(16)
plot(t,x(:,7),'r');
hold on;
figure(17)
plot(t,x(:,8),'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004;%0.0004,0712
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01
mf=0.189;%0.71420,.071428,1,0.0789,0.289

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la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
% u1=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*(y(1,:)+y(2,:)).*(w_1))),1),0);
u2=max(min((y(12,:)- y(11,:)).*eta_2.*alpha.*tildpi.*y(8,:).*(y(3,:)+y(4,:)).*(w_2))),1),0);
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha.*picap.*y(8,:).*(y(5,:)+y(6,:)).*(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:)).*((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);

dydt=[(lh.*(y(1)+y(2))-bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1))- mh.*y(1).*(y(1)+y(2)))./(y(1)+y(2)));
      (bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1))- mh.*y(2).*(y(1)+y(2)))./(y(1)+y(2)));
      (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))- ma.*y(3).*(y(3)+y(4)))./(y(3)+y(4)));
      (alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))- ma.*y(4).*(y(3)+y(4)))./(y(3)+y(4)));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))- mb.*y(5).*(y(5)+y(6)))./(y(5)+y(6)));
      (alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))- mb.*y(6).*(y(5)+y(6)))./(y(5)+y(6)));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(7).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(8).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))));
      (y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2))+ mh.*(y(1)+y(2))^2)-y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2))- y(15).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2))+ y(16).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)))/(y(1)+y(2))^2);
      (-row_1.*(y(1)+y(2)^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2))+ y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2))+ mh.*(y(1)+y(2))^2) +y(15).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)- y(16).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2);
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4))+ ma.*(y(3)+y(4))^2)-y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4))- y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)+ y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)))./(y(3)+y(4))^2);
      (-row_2.*(y(3)+y(4)^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))+ y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))+ ma.*(y(3)+y(4))^2) + y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)- y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^2);
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6))+ mb.*(y(5)+y(6))^2)-y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6))-y(15).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)+y(16).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2);

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        (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5))+ y(14).*(
(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5)+ mb.*(y(5)+y(6))^2) + y(15).*alpha.*arrowpi.*y
(7).*(1-eta_4.*u4).*y(5)- y(16).*alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(5))./(y(5)+y
(6))^2;

        (-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.
*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y
(2)).*(y(5)+y(6))+ y(15).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))
+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).
*y(2).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*
(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y
(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));

        (-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y
(1).*(y(3)+y(4)).*(y(5)+y(6))-y(10).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)+y(4)).*(y(5)
+y(6)) +y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))- y(12).
*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-
eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y
(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).
*(y(3)+y(4)).*(y(5)+y(6)))]);
R0 = (bita^2*pi*pibrave*la*lb*lf+
alpha^2*barpi*tildpi*lb*lh*lf+alpha^2*picap*arrowpi*la*lh*lf)./(mf^2*lh*la*lb);
function res= BVP_bc(ya,yb)
res= [ya(1)-10
      ya(2)-600
      ya(3)-5
      ya(4)-260
      ya(5)-2
      ya(6)-150
      ya(7)-80000
      ya(8)-12000
      yb(9)-0
      yb(10)-0
      yb(11)-0
      yb(12)-0
      yb(13)-0
      yb(14)-0
      yb(15)-0
      yb(16)-0 ];
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function controlul
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u1=0;
u2=max(min((y(12,:)- y(11,:)).*eta_2.*alpha.*tildpi.*y(8,:).*y(3,:)./(((y(3,:)+y(4,:)).*
*(w_2))),1),0);
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha*picap.*y(8,:).*y(5,:)./(((y(5,:)+y(6,:)).*
*(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*
*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*
*arrowpi.*y(7,:).*y(6,:).*y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+
y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)' + row_2*y(4,:)' + row_3*y(6,:)' + row_4*y(7,:)' + row_5*y(8,:)' + 0.5*
((w_1)*(u1)*(u1)' + (w_2)*(u2)*(u2)' + w_3*(u3)*(u3)' + w_4*(u4)*(u4)')) ./ n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;

```

```

figure(16)
plot(t,y(7,:));
hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
% plot(t,u1);
% figure(3)
plot(t,u2, 'r');
hold on;
% figure(4)
plot(t,u3, 'g');
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWOfl',tspan,x0);
figure(10)
plot(t,x(:,1),'r');
hold on;
figure(11)
plot(t,x(:,2),'g');
hold on;
figure(12)
plot(t,x(:,3),'y');
hold on;
figure(13)
plot(t,x(:,4),'m');
hold on;
figure(14)
plot(t,x(:,5),'k');
hold on;
figure(15)
plot(t,x(:,6),'g');
hold on;
figure(16)
plot(t,x(:,7),'r');
hold on;
figure(17)
plot(t,x(:,8),'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004;%0.004,0.04,0.0712
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01

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```

mf=0.189;%0.71420,.071428,1,0.0789,0.289
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
ul=0;
% ul=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*(y(1,:))./(((y(1,:)+y(2,:)).*(w_1))),1),0);
u2=max(min((y(12,:)- y(11,:)).*eta_2*alpha.*tildpi.*y(8,:).*(y(3,:))./(((y(3,:)+y(4,:)).*(w_2))),1),0);
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha.*picap.*y(8,:).*(y(5,:))./(((y(5,:)+y(6,:)).*(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:)).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(6,:)).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);

dydt=[(lh.*(y(1)+y(2))-bita.*pi*(1-eta_1.*ul).*(y(8).*(y(1))- mh.*y(1).*(y(1)+y(2)))./(y(1)+y(2)));
      (bita.*pi.*(1-eta_1.*ul).*(y(8).*(y(1))- mh.*y(2).*(y(1)+y(2)))./(y(1)+y(2)));
      (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))- ma.*y(3).*(y(3)+y(4)))./(y(3)+y(4)));
      (alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))- ma.*y(4).*(y(3)+y(4)))./(y(3)+y(4)));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))- mb.*y(5).*(y(5)+y(6)))./(y(5)+y(6)));
      (alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))- mb.*y(6).*(y(5)+y(6)))./(y(5)+y(6)));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(7).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(8).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (y(9).*(bita.*pi.*(1-eta_1.*ul).*(y(8).*(y(2))+ mh.*(y(1)+y(2))^2)-y(10).*(bita.*pi.*(1-eta_1.*ul).*(y(8).*(y(2))- y(15).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2))+ y(16).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)))/(y(1)+y(2))^2);
      (-row_1.*(y(1)+y(2)^2)- y(9).*(bita.*pi.*(1-eta_1.*ul).*(y(8).*(y(2))+ y(10).*(bita.*pi.*(1-eta_1.*ul).*(y(8).*(y(2))+ mh.*(y(1)+y(2))^2 +y(15).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)- y(16).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2);
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4))+ ma.*(y(3)+y(4))^2)-y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4))- y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)+ y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)./(y(3)+y(4))^2);
      (-row_2.*(y(3)+y(4)^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)))+ y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))+ ma.*(y(3)+y(4))^2 + y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)- y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^2);
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6))+ mb.*(y(5)+y(6))^2)-y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6))-y(15).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4).*(y(3)- y(16).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^2);

```

```

*u4)+y(16).*alpha.*arrowpi.*y(6).*y(7).*(1-eta_4.*u4))./(y(5)+y(6))^2;
    (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5))+ y(14).*(
(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5)+ mb.*(y(5)+y(6))^2) + y(15).*alpha.*arrowpi.*y
(7).*(1-eta_4.*u4).*y(5)- y(16).*alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(5))./(y(5)+y
(6))^2;
    (-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.*
*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y
(2)).*(y(5)+y(6))+ y(15).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))
+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).
*y(2).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*
(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y
(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
    (-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y
(1).*(y(3)+y(4)).*(y(5)+y(6))-y(10).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)+y(4)).*(y(5)
+y(6)) +y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))- y(12).
*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-
eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y
(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).
*(y(3)+y(4)).*(y(5)+y(6)))]);
R0 = (bita^2*pi*pibrave*la*lb*lf+
alpha^2*barpi*tildpi*lb*lh*lf+alpha^2*picap*arrowpi*la*lh*lf)./(mf^2*lh*la*lb);
function res= BVP_bc(ya,yb)
res= [ya(1)-10
      ya(2)-600
      ya(3)-5
      ya(4)-260
      ya(5)-2
      ya(6)-150
      ya(7)-80000
      ya(8)-12000
      yb(9)-0
      yb(10)-0
      yb(11)-0
      yb(12)-0
      yb(13)-0
      yb(14)-0
      yb(15)-0
      yb(16)-0 ];

```

```

function controlulu2
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u1=0;
u2=0;
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha*picap.*y(8,:).*y(5,:)./(((y(5,:)+y(6,:)).*(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+alpha.*barpi.*y(7,:).*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*y(6,:).*y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)+ row_2*y(4,:)+ row_3*y(6,:)+row_4*y(7,:)+row_5*y(8,:)+0.5*((w_1)*(u1)*(u1)+(w_2)*(u2)*(u2)+w_3*(u3)*(u3)+w_4*(u4)*(u4)))./n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;
figure(16)

```

```

plot(t,y(7,:));
hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
% plot(t,u1);
% figure(3)
% plot(t,u1);
% hold on;
% figure(4)
plot(t,u3,'r');
hold on;
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWOfl',tspan,x0);
figure(10)
plot(t,x(:,1),'r');
hold on;
figure(11)
plot(t,x(:,2),'g');
hold on;
figure(12)
plot(t,x(:,3),'y');
hold on;
figure(13)
plot(t,x(:,4),'m');
hold on;
figure(14)
plot(t,x(:,5),'k');
hold on;
figure(15)
plot(t,x(:,6),'g');
hold on;
figure(16)
plot(t,x(:,7),'r');
hold on;
figure(17)
plot(t,x(:,8),'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004;%0.0004,0.0712,0.4
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01

```

```

mf=0.189;%0.71420,.071428,1,0.0789,0.289
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
u1=0;
u2=0;
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha.*picap.*y(8,:).*(y(5,:)+y(6,:)).*(w_3))),1,0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))).*((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1,0);

dydt=[(lh.*(y(1)+y(2))-bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*(y(1)+y(2))))./(y(1)+y(2)));
      (bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*(y(2).*(y(1)+y(2))))./(y(1)+y(2)));
      (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*(y(3)+y(4))))./(y(3)+y(4)));
      (alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*(y(3)+y(4))))./(y(3)+y(4)));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*(y(5)+y(6))))./(y(5)+y(6)));
      (alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*(y(5)+y(6))))./(y(5)+y(6)));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(3)+y(4))- mf.*(y(7).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))).*((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*(y(8).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))).*((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))));
      (y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2)-y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)- y(15).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)+ y(16).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2))))./(y(1)+y(2))^2;
      (-row_1.*(y(1)+y(2)^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2) +y(15).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)- y(16).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2;
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)+ ma.*(y(3)+y(4))^2)-y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)- y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)+ y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)))./(y(3)+y(4))^2;
      (-row_2.*(y(3)+y(4)^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)+ y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)+ ma.*(y(3)+y(4))^2) + y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)- y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3))))./(y(3)+y(4))^2;
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)+ mb.*(y(5)+y(6))^2)-y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)-y(15).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)+y(16).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15).*(alpha.*arrowpi.*y(7)

```

```

(7).*(1-eta_4.*u4).*y(5)- y(16).*alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(5))./(y(5)+y
(6))^2;

(-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.*
*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y
(2)).*(y(5)+y(6))+ y(15).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))
+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).
*y(2).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*
(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y
(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));

(-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y
(1).*(y(3)+y(4)).*(y(5)+y(6))-y(10).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)+y(4)).*(y(5)
+y(6)) +y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))- y(12).
*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-
eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y
(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).
*(y(3)+y(4)).*(y(5)+y(6)))]];
function res= BVP_bc(ya,yb)
res= [ya(1)-10

```

```

ya(2)-600
ya(3)-5
ya(4)-260
ya(5)-2
ya(6)-150
ya(7)-80000
ya(8)-12000
yb(9)-0
yb(10)-0
yb(11)-0
yb(12)-0
yb(13)-0
yb(14)-0
yb(15)-0
yb(16)-0 ];

```

```

function controlulu2u3
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u1=0;
u2=0;
u3=0;
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*
(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:)*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.
*arrowpi.*y(7,:).*y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+
y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)+ row_2*y(4,:)+ row_3*y(6,:)+row_4*y(7,:)+row_5*y(8,:)+0.5*
((w_1)*(u1)*(u1)+(w_2)*(u2)*(u2)+w_3*(u3)*(u3)+w_4*(u4)*(u4)))./n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;
figure(16)
plot(t,y(7,:));

```

```

hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
% plot(t,u1);
% figure(3)
% plot(t,u1);
% hold on;
% figure(4)
% plot(t,u2);
% hold on;
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWOfl',tspan,x0);
figure(10)
plot(t,x(:,1),'r');
hold on;
figure(11)
plot(t,x(:,2),'g');
hold on;
figure(12)
plot(t,x(:,3),'y');
hold on;
figure(13)
plot(t,x(:,4),'m');
hold on;
figure(14)
plot(t,x(:,5),'k');
hold on;
figure(15)
plot(t,x(:,6),'g');
hold on;
figure(16)
plot(t,x(:,7),'r');
hold on;
figure(17)
plot(t,x(:,8),'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004; %0.004,0.0004,00312,0.0712
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01
mf=0.189;%0.71420,.071428,1,0.0789,0.289

```



```

la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
u1=0;
u2=0;
u3=0;
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*
(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*
*arrowpi.*y(7,:).*y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+
y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
dydt=[(lh.*(y(1)+y(2))-bita*pi.*(1-eta_1.*u1).*y(8).*y(1)- mh.*y(1).*(y(1)+y(2)))./(y
(1)+y(2));
      (bita.*pi.*(1-eta_1.*u1).*y(8).*y(1)- mh.*y(2).*(y(1)+y(2)))./(y(1)+y(2));
      (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*y(8).*y(3)- ma.*y(3).*(y(3)+y
(4)))./(y(3)+y(4));
      (alpha.*tildpi.*(1-eta_2.*u2).*y(8).*y(3)- ma.*y(4).*(y(3)+y(4)))./(y(3)+y(4));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5)- mb.*y(5).*(y(5)+y(6))).
/(y(5)+y(6));
      (alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5)- mb.*y(6).*(y(5)+y(6)))./(y(5)+y(6));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*y
(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*y(4).*(y(1)+y(2)).*(y
(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(7).
*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.
*y(7).*(1-eta_4.*u4).*y(4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.
*u4).*y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(8).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))).
/((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (y(9).*(bita.*pi.*(1-eta_1.*u1).*y(8).*y(2)+ mh.*(y(1)+y(2))^2)-y(10).*bita.*pi.*
(1-eta_1.*u1).*y(8).*y(2)- y(15).*bita.*pibrave.*(1-eta_4.*u4).*y(7).*y(2)+ y(16).
*bita.*pibrave.*(1-eta_4.*u4).*y(7).*y(2))/(y(1)+y(2))^2;
      (-row_1.*(y(1)+y(2))^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*y(8).*y(2))+ y(10).*
(bita.*pi.*(1-eta_1.*u1).*y(8).*y(2)+ mh.*(y(1)+y(2))^2) +y(15).*bita.*pibrave.*y(7).*y
(1).*(1-eta_4.*u4)- y(16).*bita.*pibrave.*y(7).*y(1).*(1-eta_4.*u4))./(y(1)+y(2))^2;
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*y(8).*y(4)+ ma.*(y(3)+y(4))^2)-y(12).
*alpha.*tildpi.*(1-eta_2.*u2).*y(8).*y(4)- y(15).*alpha.*barpi.*y(7).*(1-eta_4.*u4).*y
(4)+ y(16).*alpha.*barpi.*y(7).*(1-eta_4.*u4).*y(4))./(y(3)+y(4))^2;
      (-row_2.*(y(3)+y(4))^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*y(8).*y(3))+ y(12).
*(alpha.*tildpi.*(1-eta_2.*u2).*y(8).*y(3)+ ma.*(y(3)+y(4))^2) + y(15).*alpha.*barpi.*y
(7).*(1-eta_4.*u4).*y(3)- y(16).*alpha.*barpi.*y(7).*(1-eta_4.*u4).*y(3))./(y(3)+y(4))
^2;
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(6)+ mb.*(y(5)+y(6))^2)-y(14).
*alpha.*picap.*(1-eta_3.*u3).*y(8).*y(6)-y(15).*alpha.*arrowpi.*y(6).*y(7).*(1-eta_4.
*u4)+y(16).*alpha.*arrowpi.*y(6).*y(7).*(1-eta_4.*u4))./(y(5)+y(6))^2;
      (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5))+ y(14).*
(alpha.*picap.*(1-eta_3.*u3).*y(8).*y(5)+ mb.*(y(5)+y(6))^2) + y(15).*alpha.*arrowpi.*y
(7).*(1-eta_4.*u4).*y(5)- y(16).*alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(5))./(y(5)+y
(6))^2;
      (-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.

```

```

*u4).*(y(3)+y(4)).*(y(5)+y(6))+y(15)*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y
(2)).*(y(5)+y(6))+ y(15).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))
+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).
*y(2).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*
(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y
(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
(-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y
(1).*(y(3)+y(4)).*(y(5)+y(6))-y(10).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)
+y(4)).*(y(5)+y(6)) +y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)
*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-
eta_3.*u3).*(y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*(y
(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).
*(y(3)+y(4)).*(y(5)+y(6)))]];
function res= BVP_bc(ya,yb)
res= [ya(1)-10

```

```

ya(2)-600
ya(3)-5
ya(4)-260
ya(5)-2
ya(6)-150
ya(7)-80000
ya(8)-12000
yb(9)-0
yb(10)-0
yb(11)-0
yb(12)-0
yb(13)-0
yb(14)-0
yb(15)-0
yb(16)-0 ];

```

```

function controlulu3
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u1=0;
u3=0;
u2=max(min((y(12,:)- y(11,:)).*eta_2.*alpha.*tildpi.*y(8,:).*(y(3,:)+y(4,:)).*(w_2))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(2,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:)))./(((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4)))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)+ row_2*y(4,:)+ row_3*y(6,:)'+row_4*y(7,:)'+row_5*y(8,:)'+0.5*((w_1)*(u1)*(u1)+(w_2)*(u2)*(u2)+w_3*(u3)*(u3)'+w_4*(u4)*(u4)'))./n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;
figure(16)

```

```

plot(t,y(7,:));
hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
% plot(t,u1);
% figure(3)
% plot(t,u1);
% hold on;
% figure(4)
plot(t,u2, 'r');
hold on;
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWOfl',tspan,x0);
figure(10)
plot(t,x(:,1), 'r');
hold on;
figure(11)
plot(t,x(:,2), 'g');
hold on;
figure(12)
plot(t,x(:,3), 'y');
hold on;
figure(13)
plot(t,x(:,4), 'm');
hold on;
figure(14)
plot(t,x(:,5), 'k');
hold on;
figure(15)
plot(t,x(:,6), 'g');
hold on;
figure(16)
plot(t,x(:,7), 'r');
hold on;
figure(17)
plot(t,x(:,8), 'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004; %0.004,0.0004,00312,0.0712,0.4
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01

```

```

mf=0.189;%0.71420,.071428,1,0.0789,0.289
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
u1=0;
u3=0;
u2=max(min((y(12,:)- y(11,:)).*eta_2.*alpha.*tildpi.*y(8,:).*(y(3,:)+y(4,:)).*(w_2))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:)))./(((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
dydt=[(lh.*(y(1)+y(2))-bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*y(1).*(y(1)+y(2)))./(y(1)+y(2)));
      (bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*y(2).*(y(1)+y(2)))./(y(1)+y(2)));
      (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*y(3).*(y(3)+y(4)))./(y(3)+y(4)));
      (alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*y(4).*(y(3)+y(4)))./(y(3)+y(4)));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*y(5).*(y(5)+y(6)))./(y(5)+y(6)));
      (alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*y(6).*(y(5)+y(6)))./(y(5)+y(6)));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(7).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(8).*(y(1)+y(2).*(y(3)+y(4)).*(y(5)+y(6)))./(((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))));
      (y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2)-y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)- y(15).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)+ y(16).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)))/(y(1)+y(2))^2;
      (-row_1.*(y(1)+y(2)^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2))+ y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2) +y(15).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)- y(16).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2;
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)+ ma.*(y(3)+y(4))^2)-y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)- y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)+ y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)))./(y(3)+y(4))^2;
      (-row_2.*(y(3)+y(4)^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))+ y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)+ ma.*(y(3)+y(4))^2) + y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)- y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^2;
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)+ mb.*(y(5)+y(6))^2)-y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)-y(15).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)+y(16).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15).*(alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(5)- y(16).*(alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(5)))./(y(5)+y(6))^2;

```

```

(6))^2;
    (-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.
*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y
(2)).*(y(5)+y(6))+ y(15).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))
+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).
*y(2).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*
(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y
(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
    (-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9)*bita.*(1-eta_1.*u1).*pi.*y
(1).*(y(3)+y(4)).*(y(5)+y(6))-y(10).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)+y(4)).*(y(5)
+y(6)) +y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))- y(12).
*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-
eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y
(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).
*(y(3)+y(4)).*(y(5)+y(6)))]];
function res= BVP_bc(ya,yb)
res= [ya(1)-10
ya(2)-600
ya(3)-5
ya(4)-260
ya(5)-2
ya(6)-150
ya(7)-80000
ya(8)-12000
yb(9)-0
yb(10)-0
yb(11)-0
yb(12)-0
yb(13)-0
yb(14)-0
yb(15)-0
yb(16)-0 ];
```

```

function controlu2
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u2=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*y(1,:)./(((y(1,:)+y(2,:)).*
(w_1))),1),0);
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha*picap.*y(8,:).*y(5,:)./(((y(5,:)+y(6,:)).*
(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*
(y(5,:)+y(6,:))+ alpha.*barpi*y(7,:).*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.
*arrowpi.*y(7,:).*y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+
y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)+ row_2*y(4,:)+ row_3*y(6,:)'+row_4*y(7,:)'+row_5*y(8,:)'+0.5*
((w_1)*(u1)*(u1)'+(w_2)*(u2)*(u2)+w_3*(u3)*(u3)'+w_4*(u4)*(u4)'))/n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;

```

```

figure(16)
plot(t,y(7,:));
hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
% plot(t,u1);
% figure(3)
plot(t,u1, 'r');
hold on;
% figure(4)
plot(t,u3,'g');
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWof1',tspan,x0);
figure(10)
plot(t,x(:,1),'r');
hold on;
figure(11)
plot(t,x(:,2),'g');
hold on;
figure(12)
plot(t,x(:,3),'y');
hold on;
figure(13)
plot(t,x(:,4),'m');
hold on;
figure(14)
plot(t,x(:,5),'k');
hold on;
figure(15)
plot(t,x(:,6),'g');
hold on;
figure(16)
plot(t,x(:,7),'r');
hold on;
figure(17)
plot(t,x(:,8),'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004; %0.004,0.0004,00312,0.0712,0.4
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01

```



```
mf=0.189; %0.71420, .071428, 1, 0.0789, 0.289
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2; eta_2=0.3; eta_3=0.1; eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02; row_5=0.04;
u2=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*(y(1,:))./(((y(1,:)+y(2,:)).*(w_1))),1),0);
u3=max(min((y(14,:)- y(13,:)).*eta_3.*alpha.*picap.*y(8,:).*(y(5,:))./(((y(5,:)+y(6,:)).*(w_3))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:)).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(6,:)).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
dydt=[(lh.*(y(1)+y(2))-bita.*pi.*(1-eta_1.*u1).*(y(8)).*(y(1)- mh.*(y(1)).*(y(1)+y(2)))./(y(1)+y(2)));
      (bita.*pi.*(1-eta_1.*u1).*(y(8)).*(y(1)- mh.*(y(2)).*(y(1)+y(2)))./(y(1)+y(2)));
      (la.*(y(3)+y(4))-alpha*tildpi.*(1-eta_2.*u2).*(y(8)).*(y(3)- ma.*(y(3)).*(y(3)+y(4)))./(y(3)+y(4)));
      (alpha.*tildpi.*(1-eta_2.*u2).*(y(8)).*(y(3)- ma.*(y(4)).*(y(3)+y(4)))./(y(3)+y(4)));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)- mb.*(y(5)).*(y(5)+y(6)))./(y(5)+y(6)));
      (alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)- mb.*(y(6)).*(y(5)+y(6)))./(y(5)+y(6)));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2)).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)).*(y(1)+y(2)).*(y(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6)).*(y(1)+y(2)).*(y(3)+y(4))- mf.*(y(7)).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2)).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6)).*(y(1)+y(2)).*(y(3)+y(4))- mf.*(y(8)).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8)).*(y(2)+ mh.*(y(1)+y(2))^2)-y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8)).*(y(2)- y(15)).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7)).*(y(2)+ y(16)).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7)).*(y(2)))/(y(1)+y(2))^2);
      (-row_1.*(y(1)+y(2))^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8)).*(y(2))+ y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8)).*(y(2)+ mh.*(y(1)+y(2))^2) +y(15)).*(bita.*pibrave.*y(7)).*(y(1).*(1-eta_4.*u4)- y(16)).*(bita.*pibrave.*y(7)).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2;
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8)).*(y(4)+ ma.*(y(3)+y(4))^2)-y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8)).*(y(4)- y(15)).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)+ y(16)).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)))./(y(3)+y(4))^2);
      (-row_2.*(y(3)+y(4))^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8)).*(y(3)+ y(12)).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8)).*(y(3)+ ma.*(y(3)+y(4))^2) + y(15)).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)- y(16)).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^2;
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(6)+ mb.*(y(5)+y(6))^2)-y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(6)-y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)+y(16)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_3.*(y(5)+y(6))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_4.*(y(1)+y(2))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_5.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_6.*(y(5)+y(6))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_7.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_8.*(y(5)+y(6))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_9.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_10.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_11.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_12.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_13.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_14.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_15.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_16.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_17.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha.*arrowpi.*y(6)).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_18.*(y(3)+y(4))^2)- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8)).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15)).*(alpha
```

```

(7).*(1-eta_4.*u4).*y(5)- y(16).*alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(5))./(y(5)+y(6))^2;

(-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(5)+y(6))-y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));

(-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)+y(4)).*(y(5)+y(6))+y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))-y(12).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))]];
function res= BVP_bc(ya,yb)
res= [ya(1)-10

```

```

ya(2)-600
ya(3)-5
ya(4)-260
ya(5)-2
ya(6)-150
ya(7)-80000
ya(8)-12000
yb(9)-0
yb(10)-0
yb(11)-0
yb(12)-0
yb(13)-0
yb(14)-0
yb(15)-0
yb(16)-0 ];

```

```

function controlu2u3
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u2=0;
u3=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*y(1,:)./(((y(1,:)+y(2,:)).*(w_1))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)+ row_2*y(4,:)+ row_3*y(6,:)+row_4*y(7,:)+row_5*y(8,:)'+0.5*((w_1)*(u1)*(u1)+(w_2)*(u2)*(u2)+w_3*(u3)*(u3)'+w_4*(u4)*(u4)))/n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;
figure(16)

```

```

plot(t,y(7,:));
hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
plot(t,u1, 'r');
hold on;
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWOfl',tspan,x0);
figure(10)
plot(t,x(:,1), 'r');
hold on;
figure(11)
plot(t,x(:,2), 'g');
hold on;
figure(12)
plot(t,x(:,3), 'y');
hold on;
figure(13)
plot(t,x(:,4), 'm');
hold on;
figure(14)
plot(t,x(:,5), 'k');
hold on;
figure(15)
plot(t,x(:,6), 'g');
hold on;
figure(16)
plot(t,x(:,7), 'r');
hold on;
figure(17)
plot(t,x(:,8), 'g');
hold on;

```

```

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004; %0.004,0.0004,00312,0.0712,0.4
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01

```

```

mf=0.189;%0.71420,.071428,1,0.0789,0.289
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
u2=0;
u3=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita.*pi.*y(8,:).*(y(1,:)./((y(1,:)+y(2,:)).*(w_1))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(2,:).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*arrowpi.*y(7,:).*(y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./((y(1,:)+y(2,:)).*(y(3,:)+y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
dydt=[(lh.*(y(1)+y(2))-bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*y(1).*(y(1)+y(2)))./(y(1)+y(2)));
      (bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*y(2).*(y(1)+y(2)))./(y(1)+y(2)));
      (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*y(3).*(y(3)+y(4)))./(y(3)+y(4)));
      (alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*y(4).*(y(3)+y(4)))./(y(3)+y(4)));
      (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*y(5).*(y(5)+y(6)))./(y(5)+y(6)));
      (alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*y(6).*(y(5)+y(6)))./(y(5)+y(6)));
      (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(7).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(8).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));
      (y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2)-y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)- y(15).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)+ y(16).*(bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)))/(y(1)+y(2))^2;
      (-row_1.*(y(1)+y(2)^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ y(10).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2) +y(15).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)- y(16).*(bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2;
      (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)+ ma.*(y(3)+y(4))^2)-y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)- y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)+ y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)))./(y(3)+y(4))^2;
      (-row_2.*(y(3)+y(4)^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))+ y(12).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)+ ma.*(y(3)+y(4))^2) + y(15).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)- y(16).*(alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^2;
      (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)+ mb.*(y(5)+y(6))^2)-y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)-y(15).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)+y(16).*(alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
      (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))+ y(14).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15).*(alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(5)- y(16).*(alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(5)))./(y(5)+y(6))^2;

```

```

(6))^2;
    (-row_4.*(y(1)+y(2)).*(y(3)+y(4))*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.
*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y
(2)).*(y(5)+y(6))+ y(15).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))
+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).
*y(2).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*
(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y
(1)+y(2)).*(y(3)+y(4))*(y(5)+y(6)));
    (-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y
(1).*(y(3)+y(4)).*(y(5)+y(6))-y(10).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)
+y(4)).*(y(5)+y(6)) +y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2)*(y(1)+y(2)).*(y(5)
*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-
eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y
(1)+y(2)).*(y(3)+y(4))+y(16)*mf.*(y(1)+y(2)).*(y(3)+y(4))*(y(5)+y(6)))./(y(1)+y(2)).
*(y(3)+y(4)).*(y(5)+y(6)))]);
function res= BVP_bc(ya,yb)
res= [ya(1)-10

```

```

ya(2)-600
ya(3)-5
ya(4)-260
ya(5)-2
ya(6)-150
ya(7)-80000
ya(8)-12000
yb(9)-0
yb(10)-0
yb(11)-0
yb(12)-0
yb(13)-0
yb(14)-0
yb(15)-0
yb(16)-0 ];

```

```

function controlu3
clc
solinit = bvpinit(linspace(0,10,100),[10 600 5 260 2 160 80000 13000 0 0 0 0 0 0 0 0]);
options = bvpset('Stats','on','RelTol',1e-1);
global bita pi picap alpha tildpi pibrave barpi arrowpi eta_1 eta_2 eta_3 eta_4 row_1
row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4 la lb lh lf
w_1=0.1;
w_2=0.1;
w_3=0.2;w_4=0.3;
bita=0.21;
pi=0.12;
picap =0.05;%0.25,0.01
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
sol = bvp4c(@BVP_ode, @BVP_bc, solinit, options);
t = sol.x;
y = sol.y;
u3=0;
u1=max(min((y(10,:)- y(9,:)).*eta_1.*bita*pi.*y(8,:).*y(1,:)./(((y(1,:)+y(2,:)).*
(w_1))),1),0);
u2=max(min((y(12,:)- y(11,:)).*eta_2.*alpha.*tildpi.*y(8,:).*y(3,:)./(((y(3,:)+y(4,:)).
*(w_2))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*y(2,:).*(y(3,:)+y(4,:)).*
(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*
arrowpi.*y(7,:).*y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+
y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
n = length(t);
J = 1*(row_1*y(2,:)+ row_2*y(4,:)+ row_3*y(6,:)'+row_4*y(7,:)+row_5*y(8,:)+0.5*
((w_1)*(u1)*(u1)'+(w_2)*(u2)*(u2)+w_3*(u3)*(u3)'+w_4*(u4)*(u4)))./n
figure (10)
plot(t,y(1,:));
hold on;
figure (11)
plot(t,y(2,:));
hold on;
figure(12)
plot(t,y(3,:));
hold on;
figure(13)
plot(t,y(4,:));
hold on;
figure(14)
plot(t,y(5,:));
hold on;
figure(15)
plot(t,y(6,:));
hold on;

```

```

figure(16)
plot(t,y(7,:));
hold on;
figure(17)
plot(t,y(8,:));
hold on;
figure(2)
% plot(t,u1);
% figure(3)
plot(t,u1, 'r');
hold on;
% figure(4)
plot(t,u2, 'g');
% figure(5)
plot(t,u4);
hold off;
tspan=[0 10];
% x0=[300,50,30,20,15,8,1500,500];% period orbit
x0=[10,600,5,260,2,150,80000,12000];
[t,x] = ode45('CLTWof1',tspan,x0);
figure(10)
plot(t,x(:,1),'r');
hold on;
figure(11)
plot(t,x(:,2),'g');
hold on;
figure(12)
plot(t,x(:,3),'y');
hold on;
figure(13)
plot(t,x(:,4),'m');
hold on;
figure(14)
plot(t,x(:,5),'k');
hold on;
figure(15)
plot(t,x(:,6),'g');
hold on;
figure(16)
plot(t,x(:,7),'r');
hold on;
figure(17)
plot(t,x(:,8),'g');
hold on;

function dydt = BVP_ode(t,y)
global lh bita pi mh picap la lb lf ma mb mf alpha tildpi pibrave barpi arrowpi
eta_1 eta_2 eta_3 eta_4 row_1 row_2 row_3 row_4 row_5 w_1 w_2 w_3 w_4
w_1=0.1;
w_2=0.1;w_3=0.2;w_4=0.3;
lh=317;
bita=0.21;
pi=0.12;
mh=0.00004; %0.004,0.0004,00312,0.0712,0.4,0.001
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01

```



```

mf=0.189;%0.71420,.071428,1,0.0789,0.189,0.289
la=73;
lb=20;
ma=0.19;
mb=0.25;
tildpi=0.12;
alpha=0.16;
pibrave=0.11;
barpi=0.07;
arrowpi=0.04;
eta_1=0.2;eta_2=0.3; eta_3=0.1;eta_4=0.4;
row_1=0.05; row_2=0.08; row_3=0.03; row_4=0.02;row_5=0.04;
u3=0;
u1=max(min((y(10,:)- y(9,:))*eta_1.*bita.*pi.*y(8,:).*(y(1,:)./(((y(1,:)+y(2,:)).*
(w_1))),1),0);
u2=max(min((y(12,:)- y(11,:))*eta_2.*alpha.*tildpi.*y(8,:).*(y(3,:)./(((y(3,:)+y(4,:)).
*(w_2))),1),0);
u4=max(min((y(16,:)- y(15,:)).*eta_4.*(bita.*pibrave.*y(7,:).*(y(2,:).*(y(3,:)+y(4,:)).*
(y(5,:)+y(6,:))+ alpha.*barpi.*y(7,:).*(y(4,:).*(y(1,:)+y(2,:)).*(y(5,:)+y(6,:))+alpha.*
*arrowpi.*y(7,:).*(y(6,:).*(y(3,:)+y(4,:)).*(y(1,:)+y(2,:))./(((y(1,:)+y(2,:)).*(y(3,:)+
y(4,:)).*(y(5,:)+y(6,:)).*(w_4))),1),0);
dydt=[(lh.*(y(1)+y(2))-bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*y(1).*(y(1)+y(2)))./(y(
(1)+y(2)));
    (bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(1)- mh.*y(2).*(y(1)+y(2)))./(y(1)+y(2)));
    (la.*(y(3)+y(4))-alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*y(3).*(y(3)+y(
(4)))./(y(3)+y(4)));
    (alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)- ma.*y(4).*(y(3)+y(4)))./(y(3)+y(4)));
    (lb.*(y(5)+y(6))-alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*y(5).*(y(5)+y(6))).
/(y(5)+y(6)));
    (alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)- mb.*y(6).*(y(5)+y(6)))./(y(5)+y(6)));
    (lf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(
(2).*(y(3)+y(4)).*(y(5)+y(6))-alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(
(5)+y(6))-alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(7).
*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))));
    (bita.*pibrave.*y(7).*(1-eta_4.*u4).*(y(2).*(y(3)+y(4)).*(y(5)+y(6))+alpha.*barpi.*
*y(7).*(1-eta_4.*u4).*(y(4).*(y(1)+y(2)).*(y(5)+y(6))+alpha.*arrowpi.*y(7).*(1-eta_4.*
*u4).*(y(6).*(y(1)+y(2)).*(y(3)+y(4))- mf.*y(8).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))).
/(((y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))));
    (y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2)-y(10).*bita.*pi.*
(1-eta_1.*u1).*(y(8).*(y(2)- y(15).*bita.*pibrave*(1-eta_4.*u4).*(y(7).*(y(2)+ y(16).
*bita.*pibrave.*(1-eta_4.*u4).*(y(7).*(y(2)))/(y(1)+y(2))^2;
    (-row_1.*(y(1)+y(2)^2)- y(9).*(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2))+ y(10).*
(bita.*pi.*(1-eta_1.*u1).*(y(8).*(y(2)+ mh.*(y(1)+y(2))^2) +y(15).*bita.*pibrave.*y(7).*(y(
(1).*(1-eta_4.*u4)- y(16).*bita.*pibrave.*y(7).*(y(1).*(1-eta_4.*u4)))./(y(1)+y(2))^2;
    (y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)+ ma.*(y(3)+y(4))^2)-y(12).
*alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(4)- y(15).*alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(
(4)+ y(16).*alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(4)))./(y(3)+y(4))^2;
    (-row_2.*(y(3)+y(4)^2)- y(11).*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3))+ y(12).
*(alpha.*tildpi.*(1-eta_2.*u2).*(y(8).*(y(3)+ ma.*(y(3)+y(4))^2) + y(15).*alpha.*barpi.*y(
(7).*(1-eta_4.*u4).*(y(3)- y(16).*alpha.*barpi.*y(7).*(1-eta_4.*u4).*(y(3)))./(y(3)+y(4))^
^2;
    (y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)+ mb.*(y(5)+y(6))^2)-y(14).
*alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(6)-y(15).*alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*
*u4)+y(16).*alpha.*arrowpi.*y(6).*(y(7).*(1-eta_4.*u4)))./(y(5)+y(6))^2;
    (-row_3.*(y(5)+y(6))^2- y(13).*(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5))+ y(14).*
(alpha.*picap.*(1-eta_3.*u3).*(y(8).*(y(5)+ mb.*(y(5)+y(6))^2) + y(15).*alpha.*arrowpi.*y(

```

```

(7).*(1-eta_4.*u4).*y(5)- y(16).*alpha.*arrowpi.*y(7).*(1-eta_4.*u4).*y(5))./(y(5)+y(6))^2;

(-row_4.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*bita.*pibrave.*(1-eta_4.*u4).*y(2).*(y(3)+y(4)).*(y(5)+y(6))+y(15).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4))+y(15).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*bita.*pibrave.*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))-y(16).*alpha.*barpi.*y(4).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(5)+y(6))- y(16).*alpha.*arrowpi.*y(6).*(1-eta_4.*u4).*(y(1)+y(2)).*(y(3)+y(4)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)));

(-row_5.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6))+y(9).*bita.*(1-eta_1.*u1).*pi.*y(1).*(y(3)+y(4)).*(y(5)+y(6))+y(11).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))- y(12).*alpha.*barpi.*y(3).*(1-eta_2.*u2).*(y(1)+y(2)).*(y(5)+y(6))+y(13).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))-y(14).*alpha.*picap.*(1-eta_3.*u3).*y(5).*(y(1)+y(2)).*(y(3)+y(4))+y(16).*mf.*(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))./(y(1)+y(2)).*(y(3)+y(4)).*(y(5)+y(6)))]);
function res= BVP_bc(ya,yb)
res= [ya(1)-10

```

```

ya(2)-600
ya(3)-5
ya(4)-260
ya(5)-2
ya(6)-150
ya(7)-80000
ya(8)-12000
yb(9)-0
yb(10)-0
yb(11)-0
yb(12)-0
yb(13)-0
yb(14)-0
yb(15)-0
yb(16)-0 ];

```