```
function rocontrol
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;%0.12
picap =0.05;%0 .25,0.01
tildpi=0.12;
alpha=0.16;%16
pibrave=0.11;%0.11
barpi=0.07;
arrowpi=0.04;
la=73;
lb=20;
lf=14950;
lh=317;
ma=0.19;
mb=0.25;
mf=0.239;%0.189
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=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;
R02 = ((bita^2*pi*pibrave*la*lb*lf.*(1-eta_1.*u1).*(1-eta_4.*u4)+
alpha^2*barpi*tildpi*lb*lh*lf.*(1-eta_2.*u2).*(1-eta_4.*u4)
+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_3.*u3).*(1-eta_4.*u4)).*(mf^2*lh*la*lb);
R03 = ((bita^2*pi*pibrave*la*lb*lf.*(1-eta_4.*u4)+
alpha^2*barpi*tildpi*lb*lh*lf.*(1-eta_2.*u2).*(1-eta_4.*u4)
+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_3.*u3).*(1-eta_4.
*u4)).*(mf^2*lh*la*lb);
R04 = ((bita^2*pi*pibrave*la*lb*lf.*(1-eta_4.*u4)+ alpha^2*barpi*tildpi*lb*lh*lf.*(1-
eta_4.*u4)+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_3.*u3).*(1-eta_4.*u4)).*
(mf^2*lh*la*lb);
```

```
R05 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_4.*u4)+ alpha^2*barpi*tildpi*lb*lh*lf.*(1-
eta_4.*u4)+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_4.*u4))./(mf^2*lh*la*lb);
R06 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_4.*u4)+ alpha^2*barpi*tildpi*lb*lh*lf.*(1-
eta_2.*u2).*(1-eta_4.*u4)+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_4.*u4))./
(mf^2*lh*la*lb);
R07 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1).*(1-eta_4.*u4)+
alpha^2*barpi*tildpi*lb*lh*lf*(1-eta_4.*u4)+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_3.
*u3).*(1-eta_4.*u4)).*(mf^2*lh*la*lb);
R08 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1).*(1-eta_4.*u4)+
alpha^2*barpi*tildpi*lb*lh*lf*(1-eta_4.*u4)+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_4.
*u4)).*(mf^2*lh*la*lb);
R09 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1)+
alpha^2*barpi*tildpi*lb*lh*lf+alpha^2*picap*arrowpi*la*lh*lf)).*(mf^2*lh*la*lb);
R010 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1)+
alpha^2*barpi*tildpi*lb*lh*lf+alpha^2*picap*arrowpi*la*lh*lf).*(1-eta_3.*u3)).*
(mf^2*lh*la*lb);
R011 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1).*(1-eta_4.*u4)+
alpha^2*barpi*tildpi*lb*lh*lf*(1-eta_2.*u2).*(1-eta_4.*u4)
+alpha^2*picap*arrowpi*la*lh*lf)*(1-eta_4.*u4)).*(mf^2*lh*la*lb);
R012 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1)+ alpha^2*barpi*tildpi*lb*lh*lf.*(1-
eta_2.*u2)+alpha^2*picap*arrowpi*la*lh*lf)).*(mf^2*lh*la*lb);
R013 = ((bita^2*pi*pibrave*la*lb*lf*(1-eta_1.*u1)+ alpha^2*barpi*tildpi*lb*lh*lf.*(1-
eta_2.*u2)+alpha^2*picap*arrowpi*la*lh*lf)*(1-eta_3.*u3)).*(mf^2*lh*la*lb);
figure(1)
plot(t,R02,'g');
hold on;
plot(t,R03);
hold on;
plot(t,R04,'r');
hold on;
plot(t,R05,'g');
hold on;
plot(t,R06,'r');
hold on;
plot(t,R07,'g');
hold on;
plot(t,R08,'r');
hold on;
plot(t,R09,'g');
hold on;
plot(t,R010,'r');
hold on;
plot(t,R011,'g');
hold on;
plot(t,R012,'r');
hold on;
plot(t,R013,'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;%0.0004,0.04,0.0004,0.0712
lf=14950;%1/14,12
picap =0.05;%0 .25,0.01
mf=0.189;%0.71420,.071428,1,0.0789,0.189,0.289
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=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.*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(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 ];
```