```
> restart:Digits:=20:
> imax:=200;
  #mu:=2;
  #mu:=3:
  #mu:=3.2:
  #mu:=3.5:
  #mu:=evalf(1+sqrt(6)):
  mu:=4:
  x0:=0.2;
  halfmax:=imax/2; # Initialize
```

$$imax := 200$$

$$x0 := 0.2$$

$$halfmax := 100 \quad (1)$$

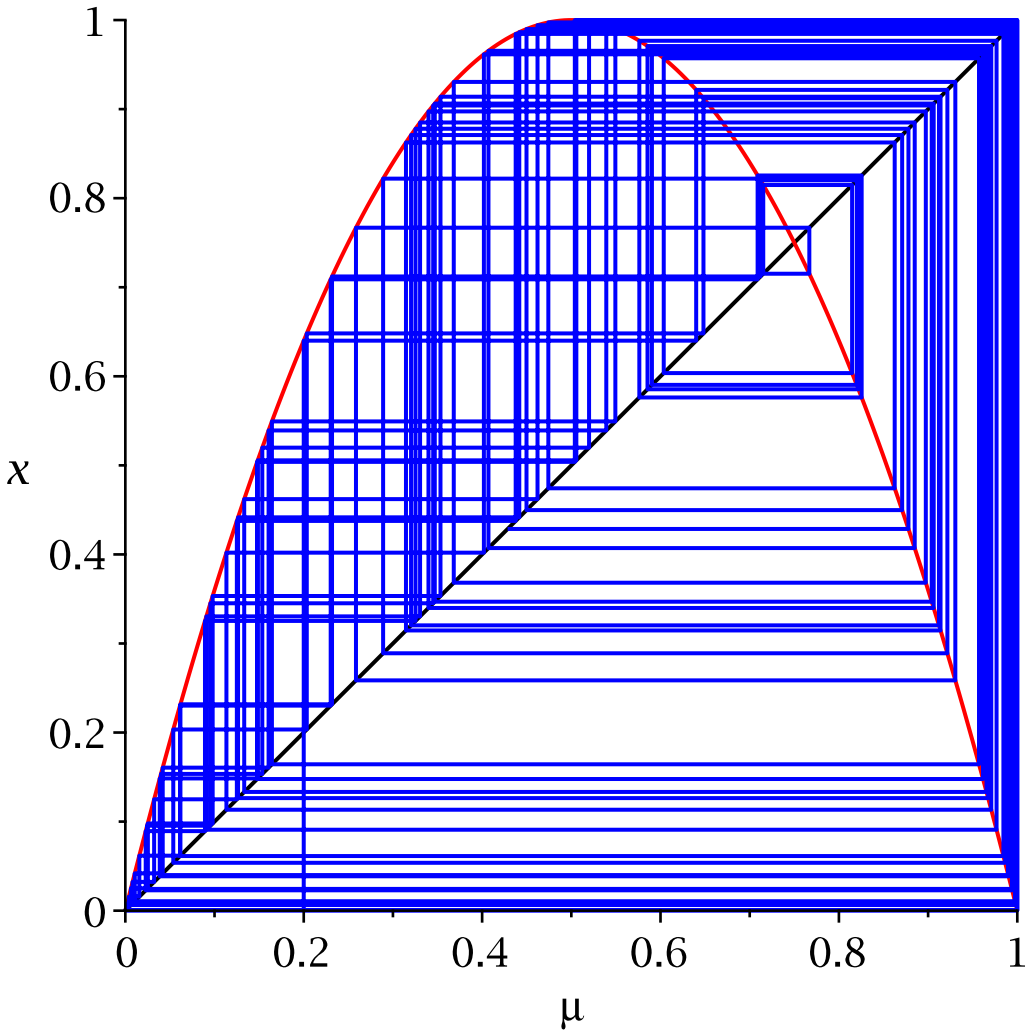
```
> f:=array(0..10^4): ff:=array(0..10^4):
> f[0]:=x0;
```

$$f_0 := 0.2 \quad (2)$$

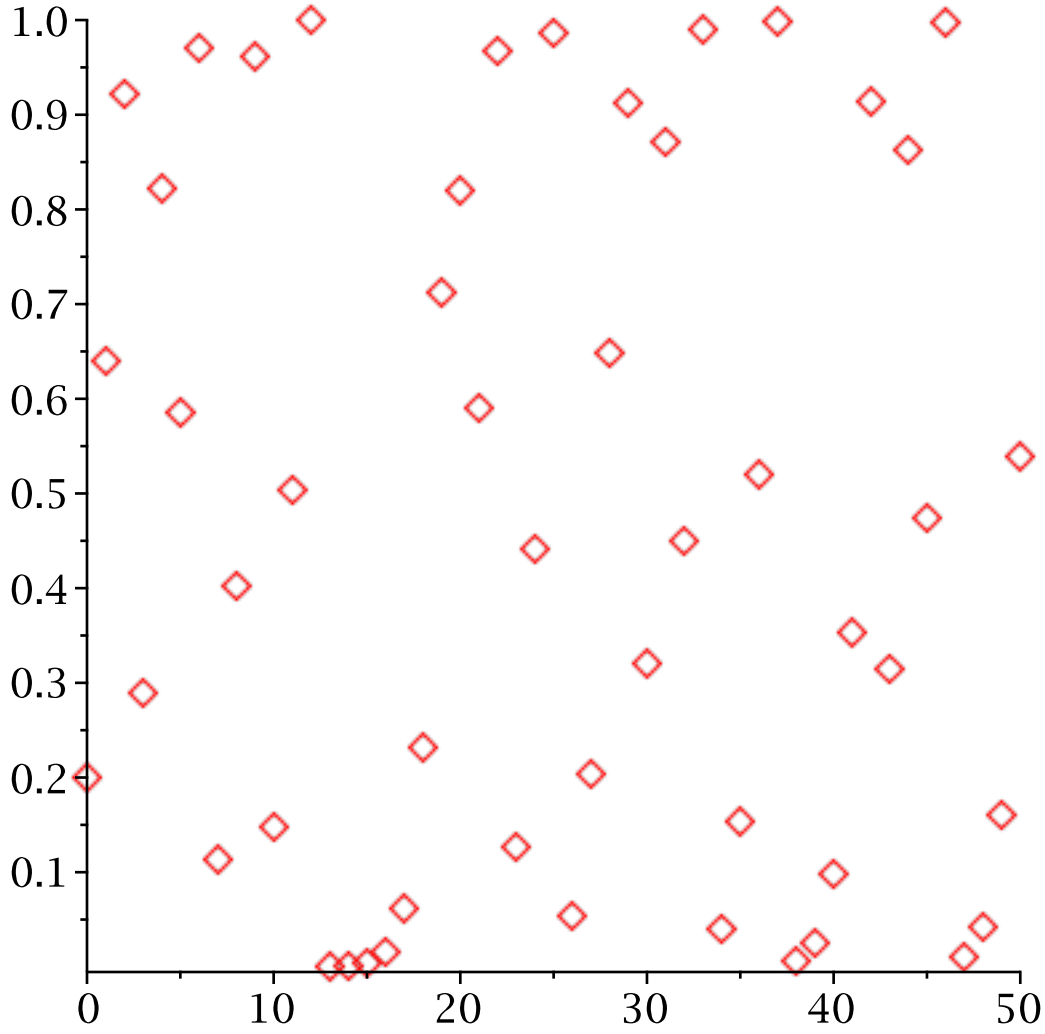
```
> for i from 0 to imax do    # Define the logistic map
  f[i+1]:= mu*f[i]*(1-f[i]):
  end do:

> ff[0]:=[f[0],0]; ff[1]:=[f[0],f[1]]:
```

$$ff_0 := [0.2, 0] \quad (3)$$

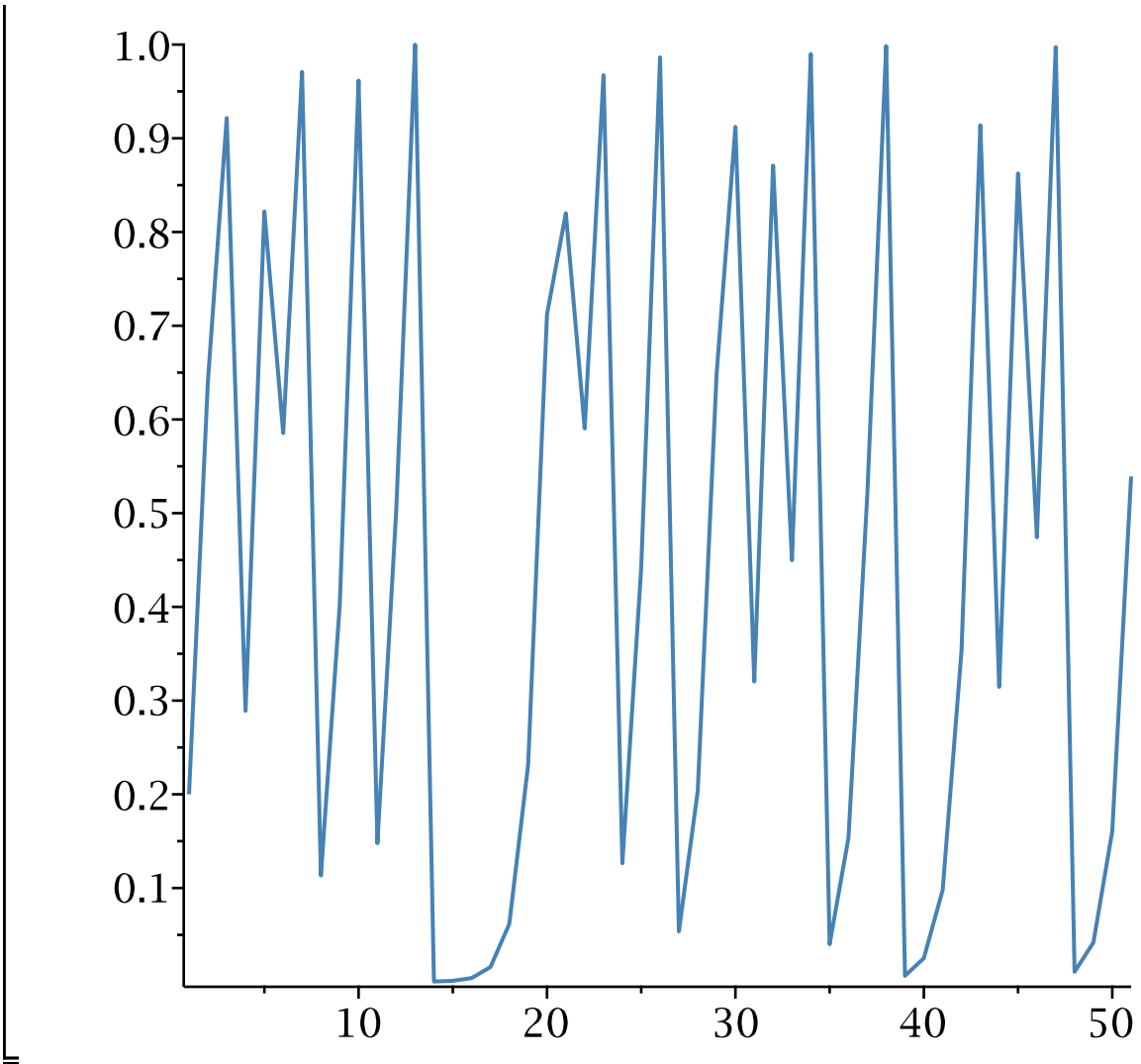
```
> for i from 1 to halfmax do
> ff[2*i]:=[f[i],f[i]]:  ff[2*i+1]:=[f[i],f[i+1]]:
  end do:
> ll:=[ff[n]$n=0..imax]:  # List the co-cordinates
> with(plots):
> M:= plot(ll,x=0..1,y=0..1,style=line,color=blue):
> N:=plot(x,x=0..1,color=black):
> P:=plot(mu*x*(1-x),x=0..1,color=red):
> display({M,N,P},labels=['mu','x']);
```




```
> PP:=pointplot({seq([n,f[n]],n=0..50)},color="red",symbolsize=20)
```

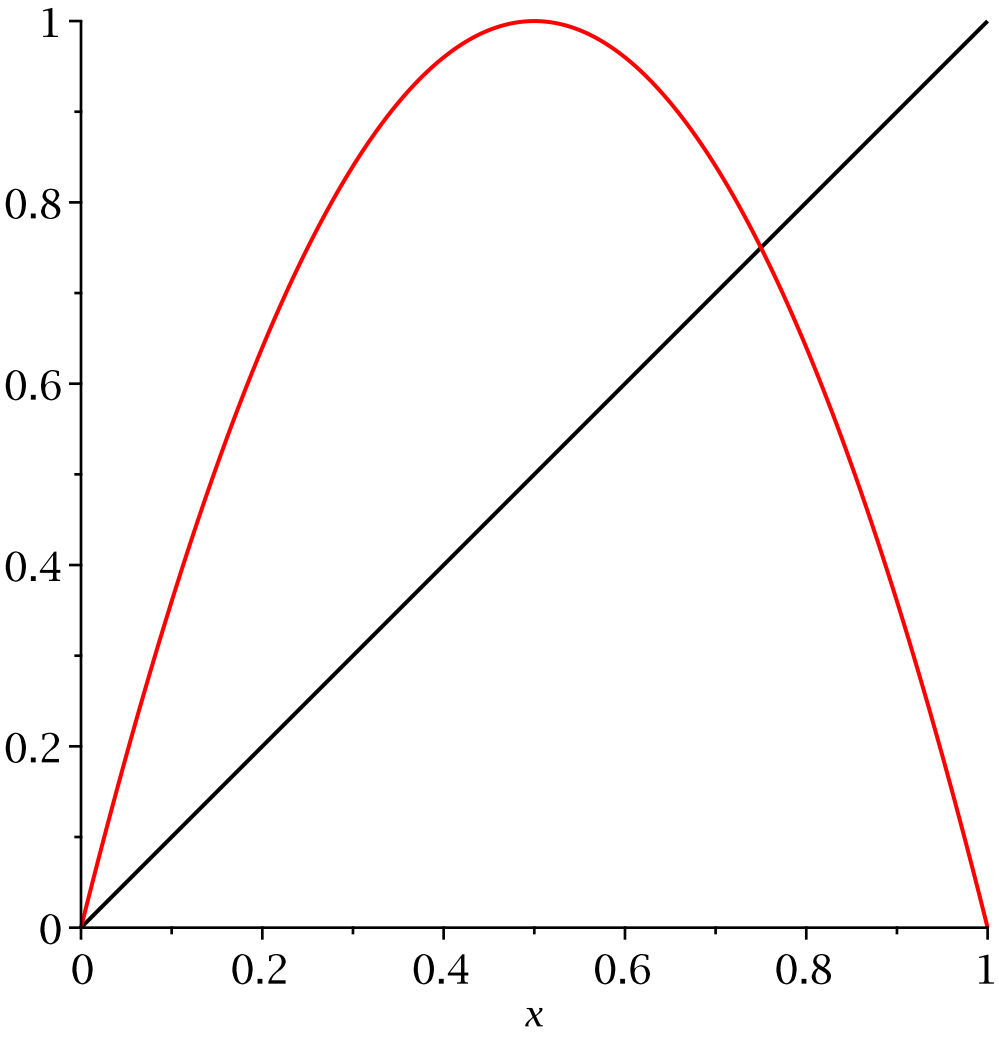



```
> PL:=listplot([f[n]$n=0..50],color="SteelBlue")
```

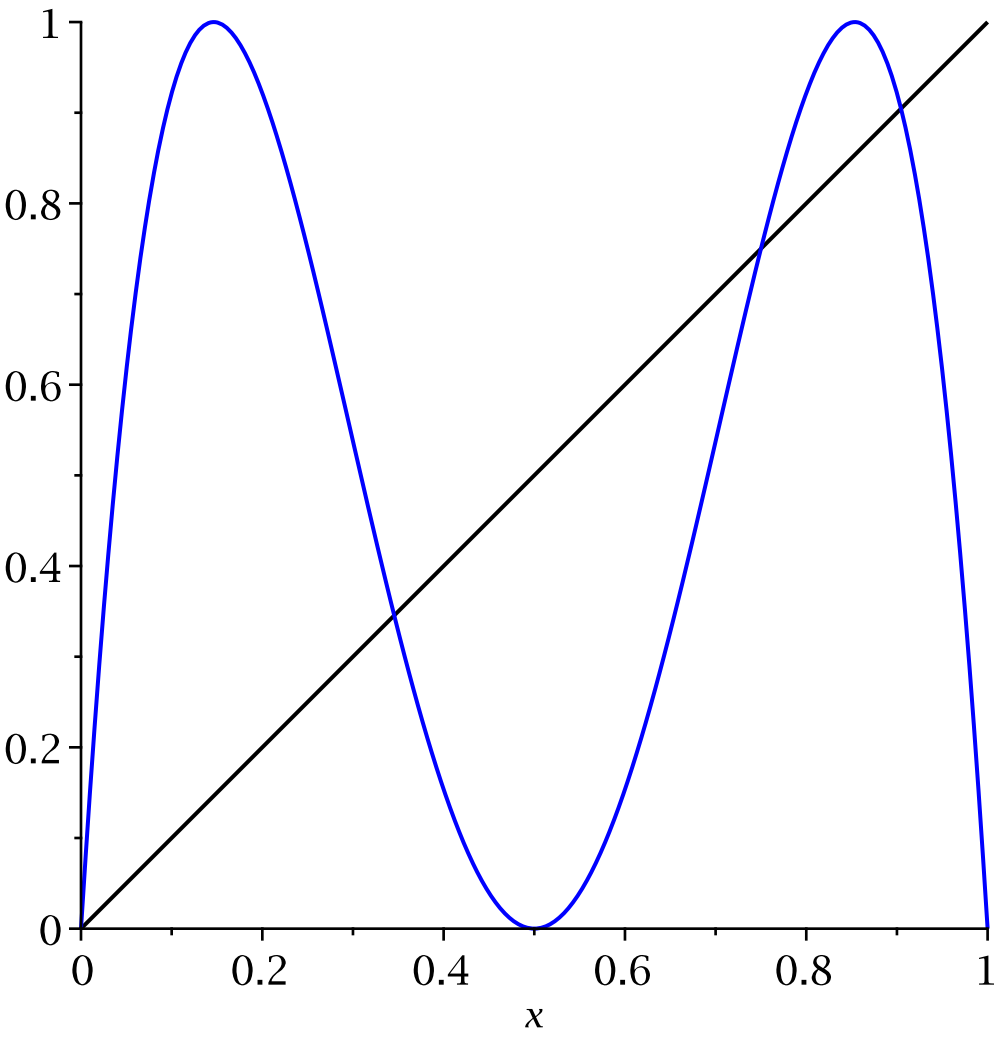



```
> #display({PP,PL})
```

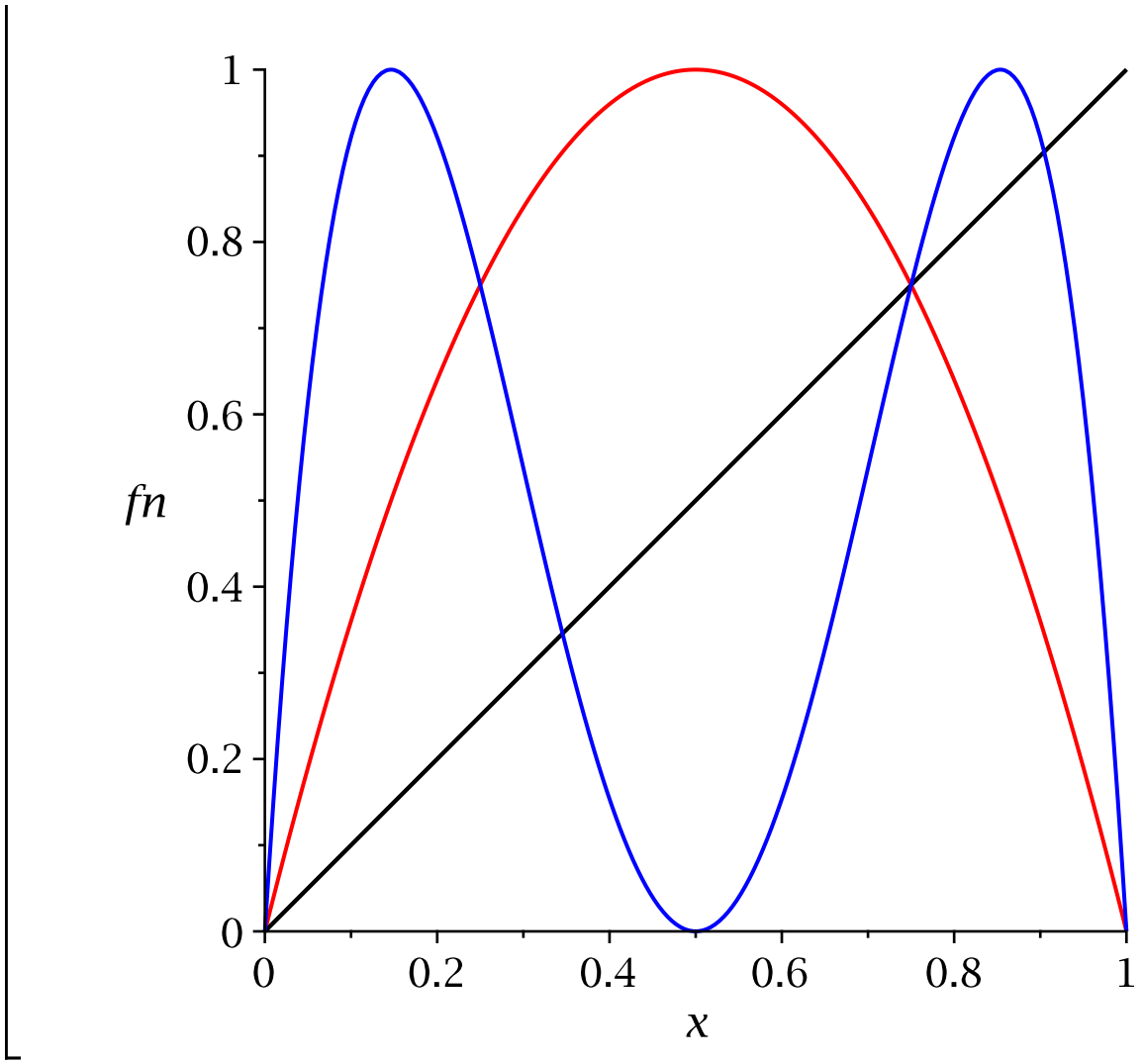
```
> # plotting functions of functions
> f1:= mu*x*(1-x):
  f2:= subs(x=mu*x*(1-x),f1):
  f3:= subs(x=f2,f2):
  f4:= subs(x=f3,f3):
> P1:=plot([x,f1],x=0..1,scaling=CONSTRAINED,color=[black,red]);
```




```
> P2:=plot([x,f2(x)],x=0..1,scaling=CONSTRAINED,color=[black,blue])
  ;
```



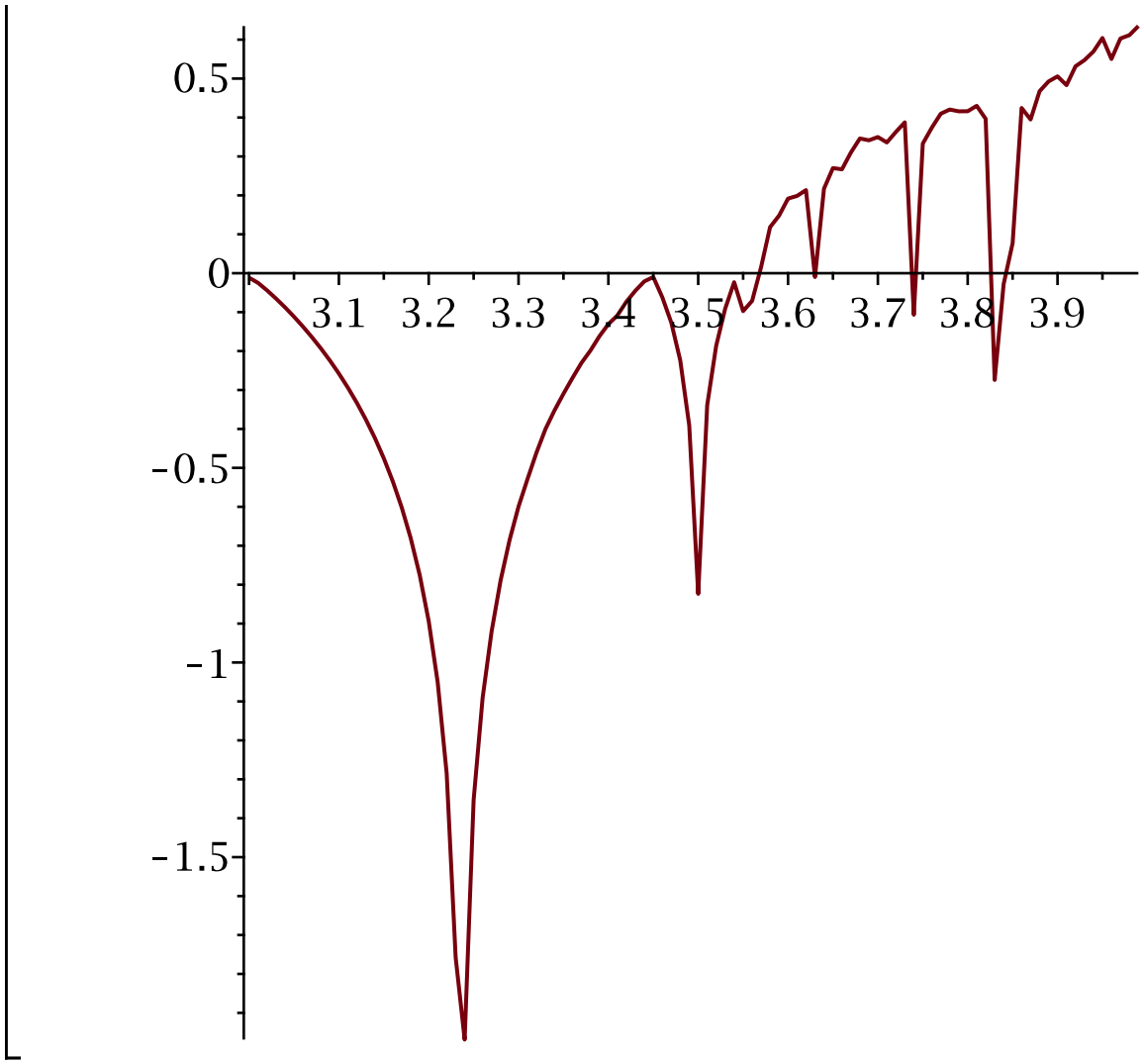

```
> #P4:=plot([x,f4],x=0..1,scaling=CONSTRAINED,color=[black,green]);
> display([P1,P2],labels=['x','fn'])
```


1
0.8
0.6
0.4
0.2
0
fn
0
0.2
0.4
0.6
0.8
1
x

```
> # Computing the Lypunov expoent
>
  iMax:=5*10^2:
  x:=array(0..iMax):
  x[0]:=0.1:

>
  for i from 0 to iMax-1 do

> x[i+1]:=evalf(mu*x[i]*(1-x[i])):
  end do:
>  L:=0:
> for i from 1 to iMax do
  L:=L+ln(abs(mu*(1-2*x[i]))):
  end do:
>
  Lya:=L/iMax;
```

$$Lya := 0.69276921000448614582 \tag{4}$$

```
> restart:
> mu:='mu':
> iMax:=500:jMax:=4*10^2: step:=1*10^(-2):
> ll:=array(0..jMax):
  xx:=array(0..jMax,0..iMax):
  for j from 0 to jMax-1 do
  xx[j,0]:=0.1:
    for i from 0 to iMax-1 do
       xx[j,i+1]:=evalf((step*j)*xx[j,i]*(1-xx[j,i])):
    end do:
  L:=0:
    for i from 1 to iMax do
  L:=L+ln(abs((step*j)*(1-2*xx[j,i]))):
    end do:
  ll[j]:=[(step*j),L/iMax]:
  end do:

> Ly:=[seq(ll[j],j=3*100..jMax-1)]:
> with(plots):#listplot([Ly[n]$n=3*100..jMax],color="SteelBlue")
> plot(Ly)
```


0.5
0
-0.5
-1
-1.5
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9

```
> # Bifurcation diagram of the logistic map
  restart:
> mu:='mu':
> Imax:=80:
  Jmax:=400:
  step:=0.01:
> LL:=array(0..10^4):
  XX:=array(0..10^4,0..10^4):
> for j from 0 to Jmax do
  XX[j,0]:=0.5:
  for i from 0 to Imax do
  XX[j,i+1]:=(step*j)*XX[j,i]*(1-XX[j,i]):
  end do:
> LL[j]:=[[(step*j),XX[j,n]]$n=40..Imax]:
  end do:
> L:=[seq(LL[j],j=0..Jmax)]:
> plot(L,x=0..4,y=-0.1..1,style=point,symbol=solidcircle,
  symbolsize=4,tickmarks=[2,2],labels=['mu','x'],font=[TIMES,ROMAN,
  15],color=blue);
```