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Section – 0222
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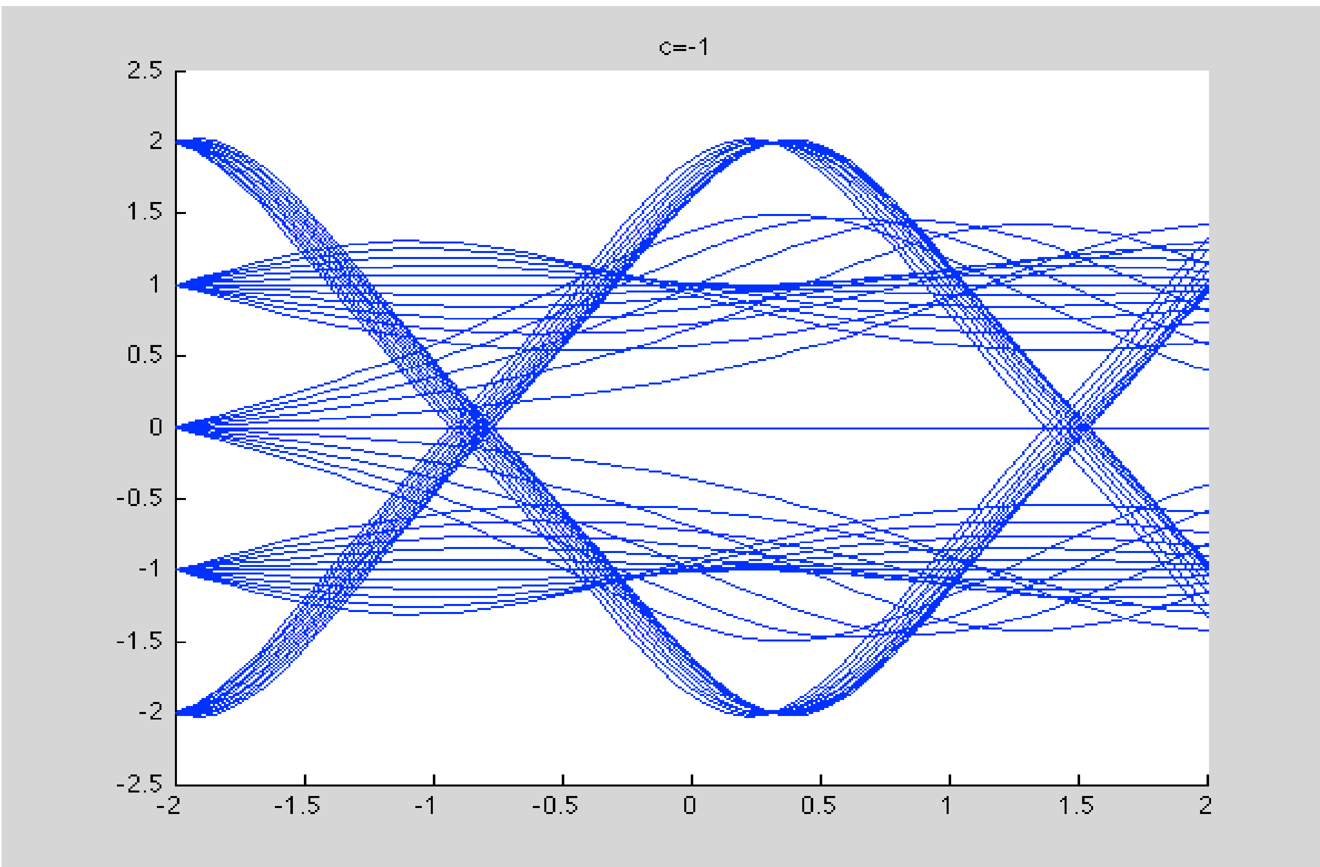
5/11/09

MATH 246
EXTRA CREDIT
MATLAB Assignment

Eq - Dx^2/Dt^2 + x^3 + c*x = 0
from c=-1 to c=1

```
syms c
figure
c = -1
```

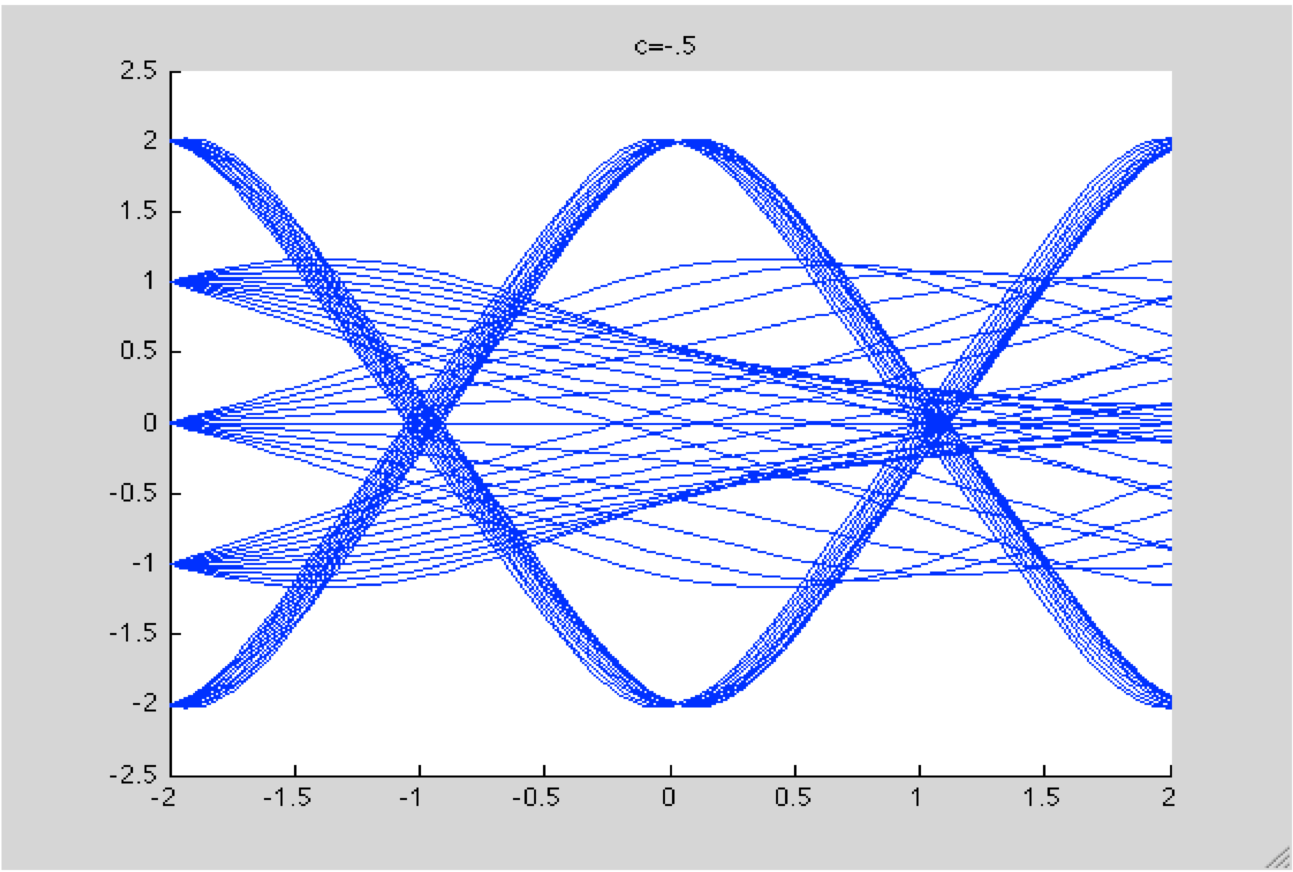
```
rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
[xa, ya] = ode45(rhs, [0 2], [-1 1]);
hold on
for x0 = -2:2
    for xp0 = -.5:0.1:.5
      [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
        [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
        plot(tfor, xfor(:,1))
        plot(tbak, xbak(:,1))
    end
end
hold off
title 'c=-1';
```



For c= -1, the curves from y=2 & y=-2 have an anti-node at x=-1 and then the next one at x= 1.5, reaching max amplitude of 2 at x=0.4. The curves from y-1 &y=1 curve across horizontally almost linearly. The curve from y=0 opens up conically, is at its widest position at x=0.5 with an amplitude of 1.5, and then starts converging.

```
figure
c = -.5
rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
[xa, ya] = ode45(rhs, [0 2], [-1 1]);
hold on
```

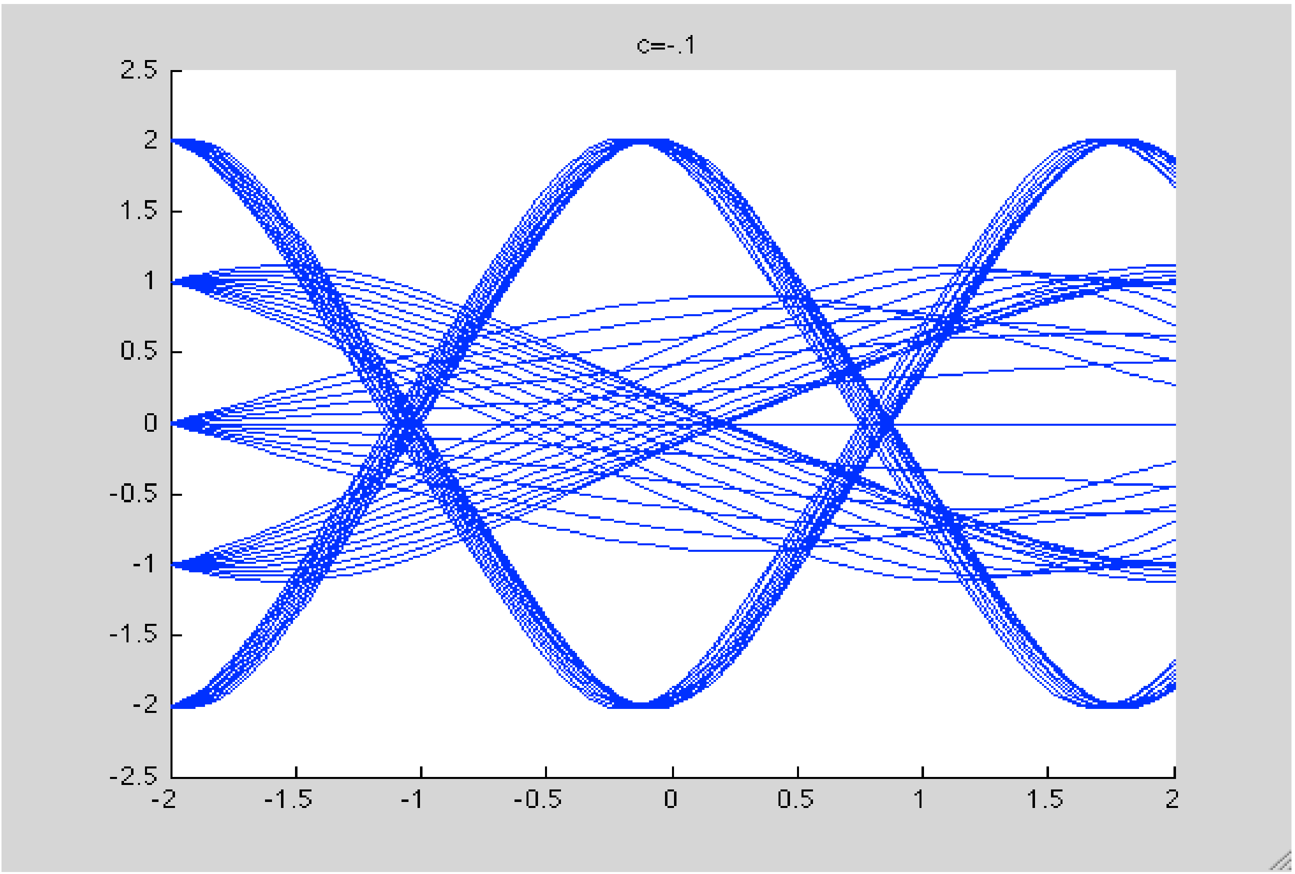
```
for x0 = -2:2
    for xp0 = -.5:0.1:.5
        [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
        [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
        plot(tfor, xfor(:,1))
        plot(tbak, xbak(:,1))
    end
end
hold off
title 'c=-.5';
```



For c= -0.5, the curves from y=2 & y=-2 have the second anti-node a little earlier at x=1.1. The curves from y-1 &y=1 start converging and almost cross at x=2. The curve from y=0 opens up conically, and is at its widest a little earlier at x=0.4 with a decreased amplitude of 1.4, before starting to converge.

```
figure
c = -.1
rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
[xa, ya] = ode45(rhs, [0 2], [-1 1]);
hold on
for x0 = -2:2
    for xp0 = -.5:0.1:.5
```

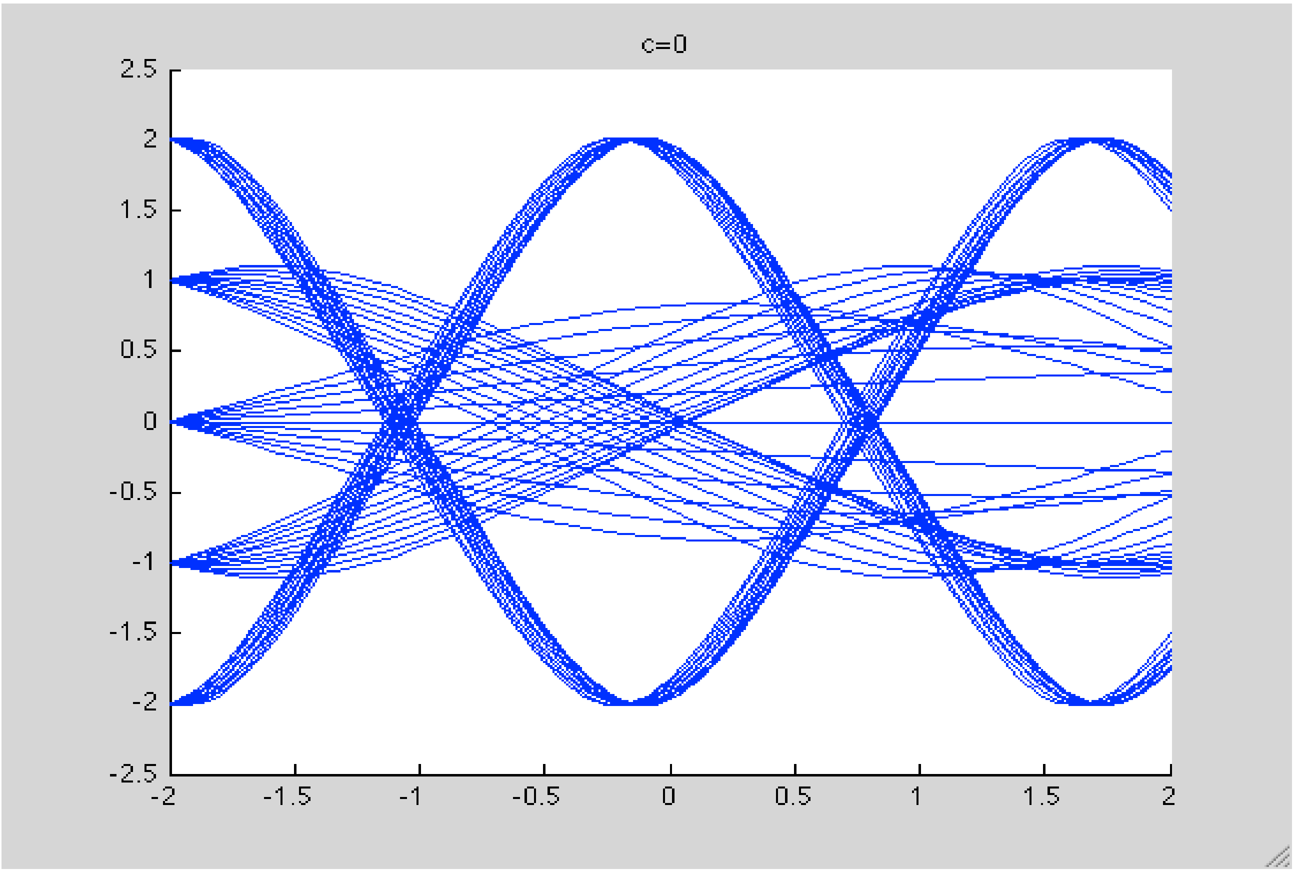
```
            [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
            [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
           plot(tfor, xfor(:,1))
           plot(tbak, xbak(:,1))
       end
   end
   hold off
   title 'c=-.1';
```



For c= -0.1, the curves from y=2 & y=-2 have the second anti-node much earlier at x=0.9. The curves from y-1 &y=1 start converging much faster and cross at x=0. The curve from y=0 opens up conically, is at its widest even earlier at x=0.3 with a decreased amplitude of 1.

```
   figure
   c = 0
   rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
   [xa, ya] = ode45(rhs, [0 2], [-1 1]);
   hold on
   for x0 = -2:2
       for xp0 = -.5:0.1:.5
            [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
            [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
```

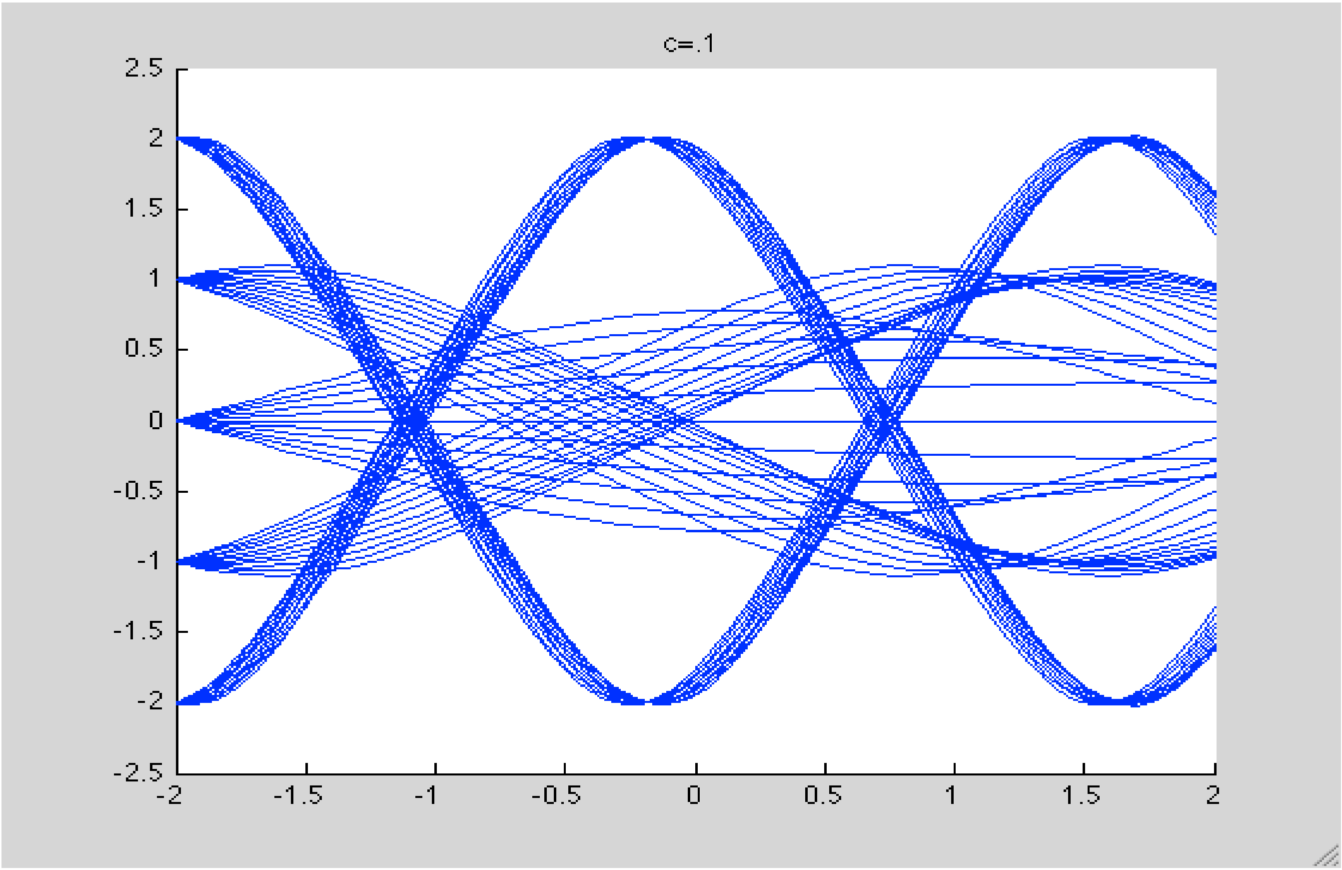
```
            plot(tfor, xfor(:,1))
            plot(tbak, xbak(:,1))
        end
    end
    hold off
    title 'c=0';
```



For c= 0.0, the curves from y=2 & y=-2 have the second anti-node just a little before x=0.9. The curves from y-1 &y=1 start converging a little faster and cross right before x=0. The curve from y=0 opens up conically, is at its widest even earlier at x=0.3 with a decreased amplitude of 0.9.

```
    figure
    c = .1
    rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
    [xa, ya] = ode45(rhs, [0 2], [-1 1]);
    hold on
    for x0 = -2:2
        for xp0 = -.5:0.1:.5
            [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
            [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
            plot(tfor, xfor(:,1))
            plot(tbak, xbak(:,1))
```

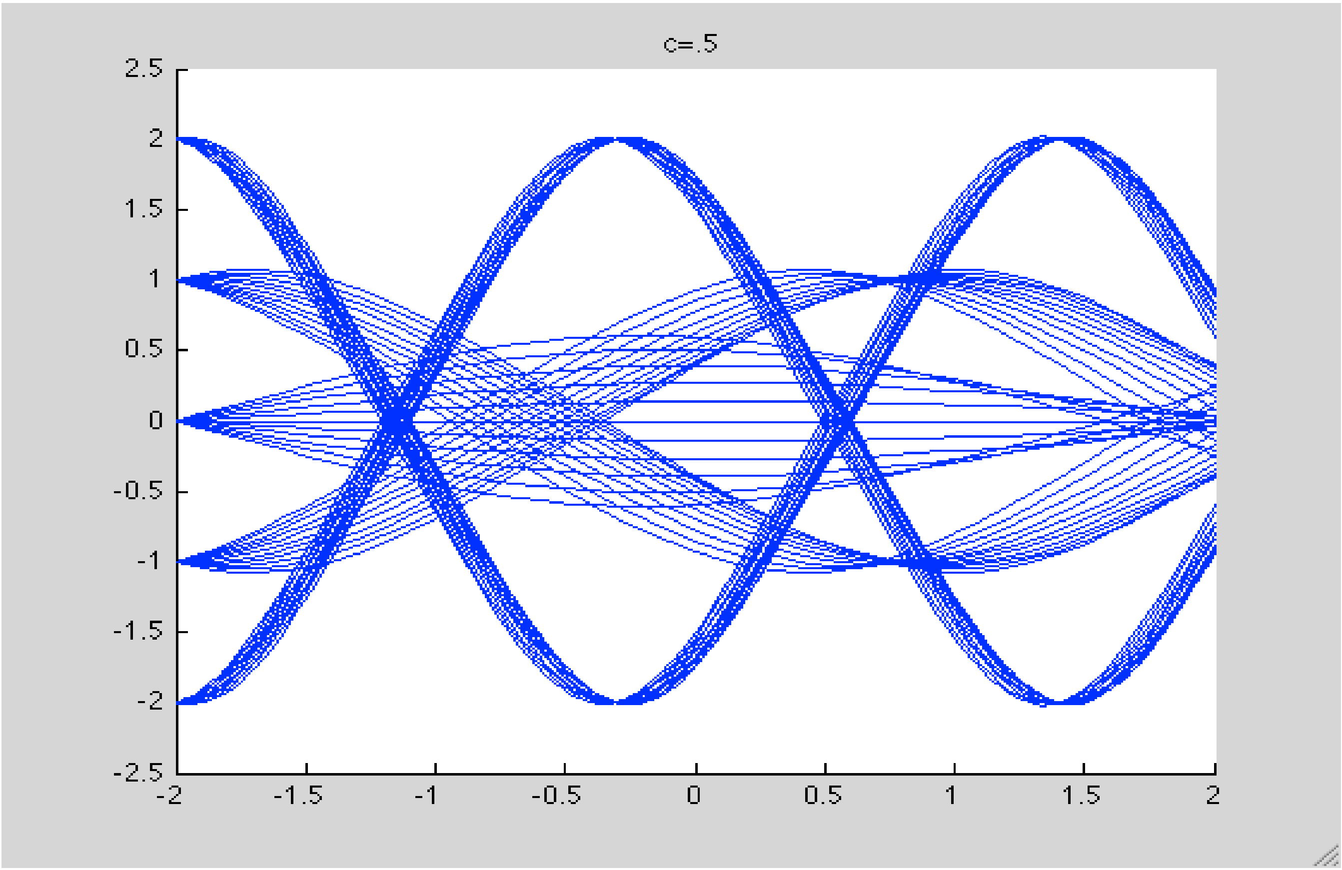
```
    end
end
hold off
title 'c=.1';
```



For c= 0.1, the curves from y=2 & y=-2 have the second anti-node just a little before at x=0.8. The curves from y-1 &y=1 start converging a little faster and cross right before x=-0.2. The curve from y=0 opens up conically, even more narrowly, being at its widest even earlier at x=0.1 with an amplitude of only 0.7, and almost has an anti-node at x=2.

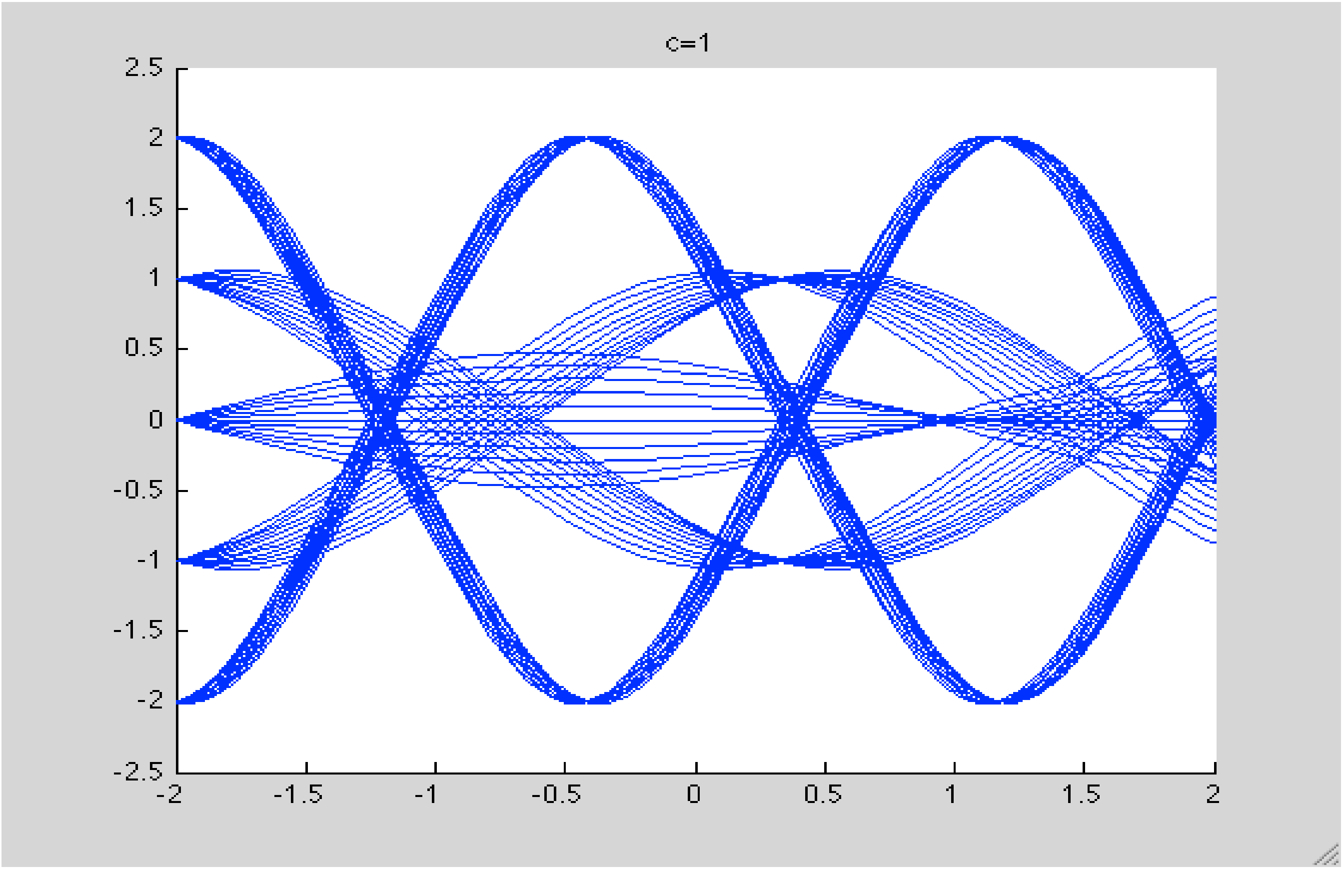
```
figure
c = .5
rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
[xa, ya] = ode45(rhs, [0 2], [-1 1]);
hold on
for x0 = -2:2
    for xp0 = -.5:0.1:.5
        [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
        [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
        plot(tfor, xfor(:,1))
        plot(tbak, xbak(:,1))
    end
end
```

```
hold off
title 'c=.5';
```



For c= 0.5, the curves from y=2 & y=-2 have the second anti-node even earlier at x=0.5. The first anti-node also came earlier at x=-1.2 but the wavelength is still smaller than when c < 0.5. The curves from y-1 &y=1 start converging way faster and cross at x=-0.6. The curve from y=0 opens up conically, very narrowly, being at its widest even earlier at x=-0.2, with an amplitude of 0.5, and has an anti-node at x=2.0

```
figure
c = 1
rhs = @(t, x) [x(2); -x(1)^3 - c*x(1)];
[xa, ya] = ode45(rhs, [0 2], [-1 1]);
hold on
for x0 = -2:2
    for xp0 = -.5:0.1:.5
        [tfor, xfor] = ode45(rhs, [-2 2], [x0 xp0]);
        [tbak, xbak] = ode45(rhs, [-2 2], [x0 xp0]);
        plot(tfor, xfor(:,1))
        plot(tbak, xbak(:,1))
    end
end
hold off
title 'c=1';
```



For c= 1.0, the curves from y=2 & y=-2 create the first and the second anti-node at the earliest yet at x=-1.3 and x=0.4 respectively. Both the curves have the smallest wavelength also. The curves from y-1 &y=1 start converge the fast yet also, crossing each other at x=-0.8. The curve from y=0 opens up conically, most narrowly, being at its widest even earlier at x=-0.5, with an amplitude of lower than 0.5. It has an anti-node even before x=1, therefore having the smallest wavelength yet.