

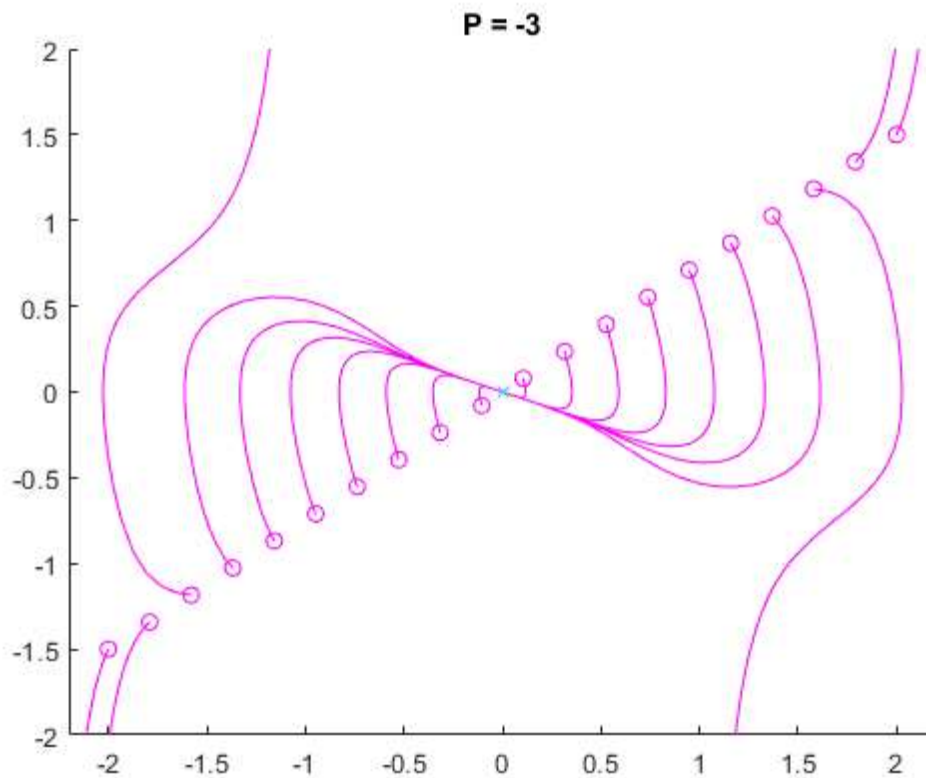
Contents

- [p = -3](#)
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- [p = 3](#)

```
clear all;  
close all;  
clc;
```

p = -3

```
x1 = linspace(-2,2,20);  
x2 = linspace(-1.5,1.5,20);  
  
for a = 1:length(x1)  
    for b = 1:length(x2)  
        A(:,a) = [x1(a) ; x2(b)];  
    end  
end  
  
figure  
  
for a = 1:length(x1)  
    x = [x1(a);x2(a)];  
    [T,X] = ode45(@odefcn1, [0 10], x);  
    hold on  
    plot(X(:,1), X(:,2), '-m', x(1), x(2), '-mo');  
    grid;  
    drawnow;  
end  
  
hold on  
plot (0, 0, 'X');  
axis ([-2.2 2.2 -2 2]);  
title ('P = -3');
```



p = -1

```

for a = 1 : length(x1)
    for b = 1:length(x2)
        A(:,a) = [x1(a) ; x2(b)];
    end
end
figure
for a = 1:length(x1)
    x = [x1(a);x2(a)];
    [T,X] = ode45(@odefcn2, [0 10], x);
    hold on
    plot(X(:,1), X(:,2), '-r', x(1), x(2), '-ro');
    grid;
    drawnow;
end

plot (0, 0, 'X');
axis ([-2.8 2.8 -3 3]);
title ('P = -1');

```

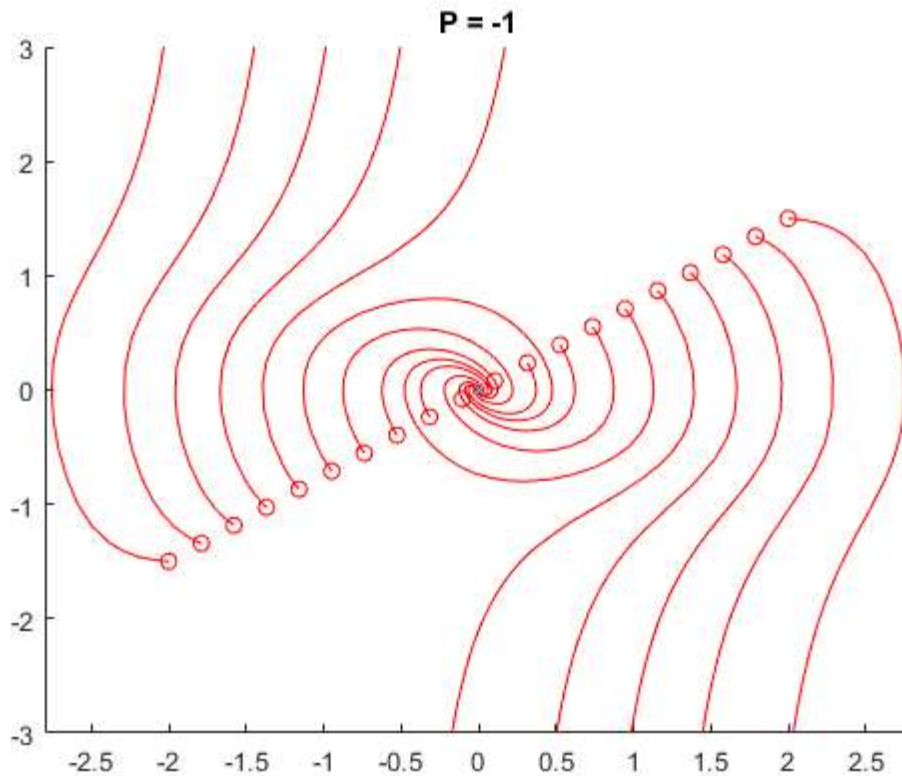
Warning: Failure at t=1.558644e+00. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (3.552714e-15) at time t.

Warning: Failure at t=1.587483e+00. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (3.552714e-15) at time t.

Warning: Failure at t=1.700546e+00. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (3.552714e-15) at time t.

Warning: Failure at t=1.905644e+00. Unable to meet integration tolerances

without reducing the step size below the smallest value allowed (3.552714e-15)
at time t.
Warning: Failure at t=2.348998e+00. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (7.105427e-15)
at time t.
Warning: Failure at t=2.348998e+00. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (7.105427e-15)
at time t.
Warning: Failure at t=1.905644e+00. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (3.552714e-15)
at time t.
Warning: Failure at t=1.700546e+00. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (3.552714e-15)
at time t.
Warning: Failure at t=1.587483e+00. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (3.552714e-15)
at time t.
Warning: Failure at t=1.558644e+00. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (3.552714e-15)
at time t.



p = 0.5

```
for a = 1:length(x1)
    for b = 1:length(x2)
        A(:,a) = [x1(a) ; x2(b)];
    end
end

figure
for a = 1:length(x1)
    x = [x1(a);x2(a)]
```

```

[T,X] = ode45(@odefcn3, [0 10], x);
hold on
plot(X(:,1), X(:,2), '-k', x(1), x(2), '-ko');
grid;
drawnow;
end

hold on
plot (0, 0, 'x');
axis ([-2.5 2.5 -1.7 1.7]);
title ('P = 0.5');

```

x =

```

-2.0000
-1.5000

```

x =

```

-1.7895
-1.3421

```

x =

```

-1.5789
-1.1842

```

x =

```

-1.3684
-1.0263

```

x =

```

-1.1579
-0.8684

```

x =

```

-0.9474
-0.7105

```

x =

```

-0.7368
-0.5526

```

x =

```

-0.5263
-0.3947

```

x =

-0.3158

-0.2368

x =

-0.1053

-0.0789

x =

0.1053

0.0789

x =

0.3158

0.2368

x =

0.5263

0.3947

x =

0.7368

0.5526

x =

0.9474

0.7105

x =

1.1579

0.8684

x =

1.3684

1.0263

x =

1.5789

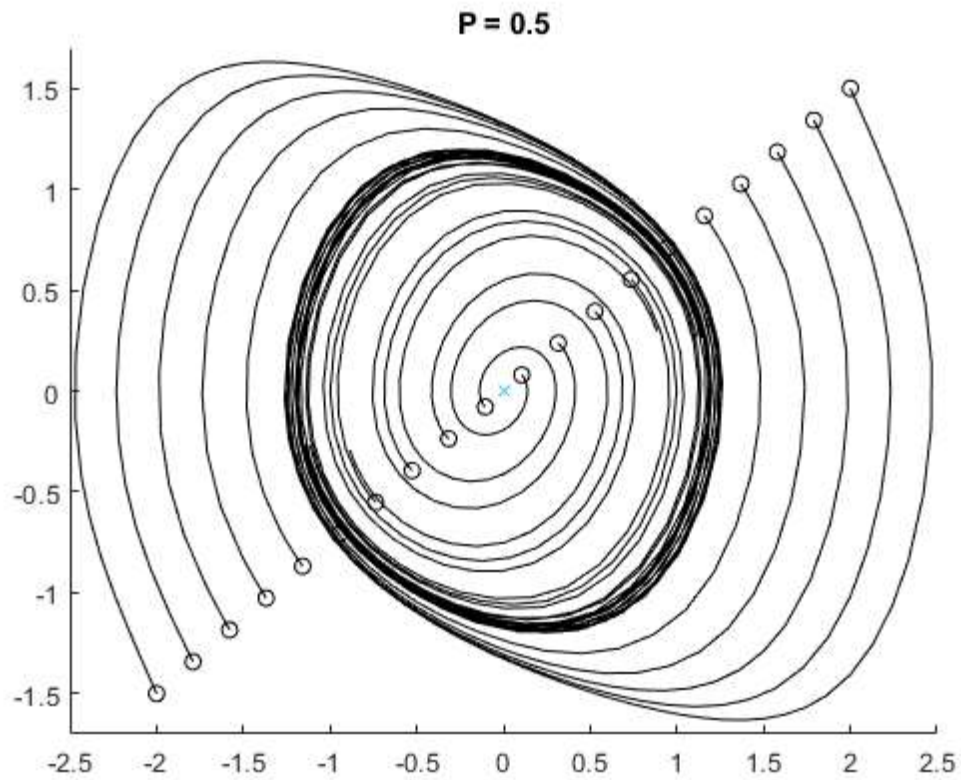
1.1842

x =

1.7895
1.3421

x =

2.0000
1.5000



p = 3

```
for a = 1 : length(x1)
    for b = 1:length(x2)
        A(:,a) = [x1(a) ; x2(b)];
    end
end
figure
for a = 1:length(x1)
    x = [x1(a);x2(a)]
    [T,X] = ode45(@odefcn4, [0 10], x);
    hold on
    plot(X(:,1), X(:,2), '-g', x(1), x(2), '-go');
    grid;
    drawnow;
end

plot (0, 0, 'x');
```

```
axis ([-2.5 2.5 -1.5 1.5]);  
title ('P = 3');
```

x =

```
-2.0000  
-1.5000
```

Warning: Failure at t=1.156944e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (2.220446e-16) at time t.

x =

```
-1.7895  
-1.3421
```

Warning: Failure at t=1.816278e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (4.440892e-16) at time t.

x =

```
-1.5789  
-1.1842
```

Warning: Failure at t=1.897826e+00. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (3.552714e-15) at time t.

x =

```
-1.3684  
-1.0263
```

x =

```
-1.1579  
-0.8684
```

x =

```
-0.9474  
-0.7105
```

x =

```
-0.7368  
-0.5526
```

x =

```
-0.5263  
-0.3947
```

x =

-0.3158
-0.2368

x =

-0.1053
-0.0789

x =

0.1053
0.0789

x =

0.3158
0.2368

x =

0.5263
0.3947

x =

0.7368
0.5526

x =

0.9474
0.7105

x =

1.1579
0.8684

x =

1.3684
1.0263

x =

1.5789
1.1842

Warning: Failure at t=1.897826e+00. Unable to meet integration tolerances

without reducing the step size below the smallest value allowed (3.552714e-15)
at time t.

x =

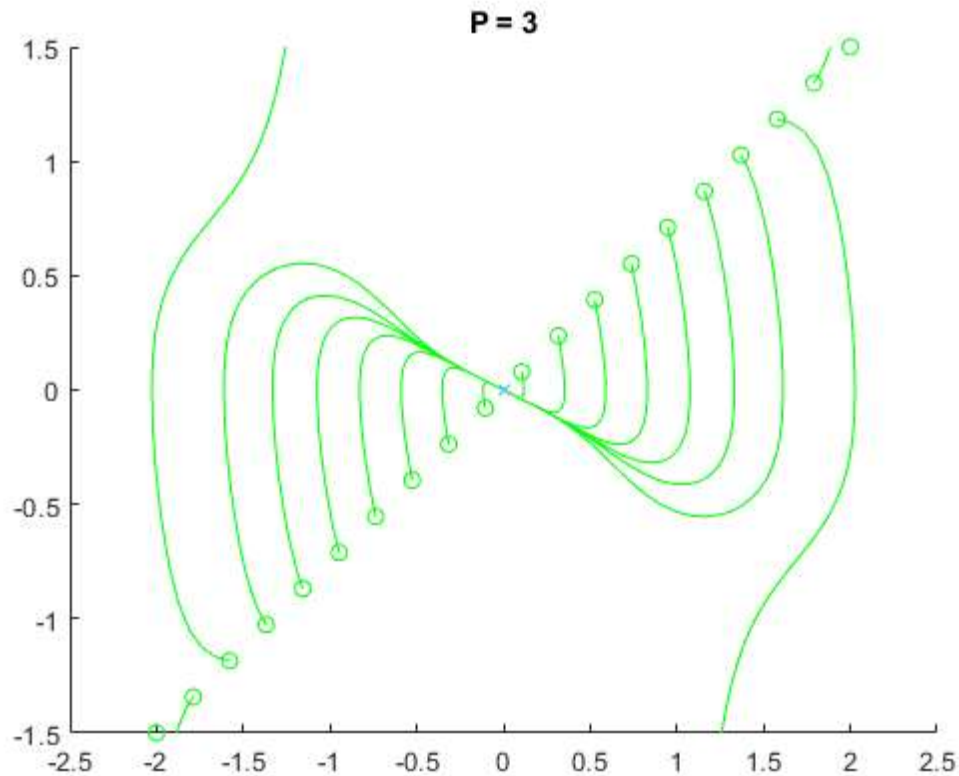
```
1.7895  
1.3421
```

Warning: Failure at t=1.816278e-01. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (4.440892e-16)
at time t.

x =

```
2.0000  
1.5000
```

Warning: Failure at t=1.156944e-01. Unable to meet integration tolerances
without reducing the step size below the smallest value allowed (2.220446e-16)
at time t.



function definitions

```
function dxdt = odefcn1(t, x)  
    dxdt = zeros(2,1);  
    dxdt(1)= x(2);  
    dxdt(2)=-x(1) + (-3).*(1-(x(2)^2))*x(2);  
end  
function dxdt = odefcn2(t, x)  
    dxdt = zeros(2,1);  
    dxdt(1)= x(2);  
    dxdt(2)=-x(1) + (-1).*(1-(x(2)^2))*x(2);
```

```

end
function dxdt = odefcn3(t, x)
    dxdt = zeros(2,1);
    dxdt(1)= x(2);
    dxdt(2)=-x(1) + (0.5).*(1-(x(2)^2))*x(2);
end
function dxdt = odefcn4(t,x)
    dxdt = zeros(2,1);
    dxdt(1)= x(2);
    dxdt(2)=-x(1) + (-3).*(1-(x(2)^2))*x(2);
end

```

Warning: Failure at t=1.156944e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (2.220446e-16) at time t.

Warning: Failure at t=1.816278e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (4.440892e-16) at time t.

Warning: Failure at t=1.897826e+00. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (3.552714e-15) at time t.

Warning: Failure at t=1.897826e+00. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (3.552714e-15) at time t.

Warning: Failure at t=1.816278e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (4.440892e-16) at time t.

Warning: Failure at t=1.156944e-01. Unable to meet integration tolerances without reducing the step size below the smallest value allowed (2.220446e-16) at time t.

```

%c
% Hopf Bifurcation because we have two eigenvalues cross the imaginary axis
% because of a variation of the system parameters

```