solving a second order ode

the Van der Pol oscillator Matlab can only solve first order ODEs, or systems of first order ODES. To solve a second order ODE, we must convert it by changes of variables to a system of first order ODES. We consider the Van der Pol oscillator here:

$$\frac{d^2x}{dt^2} - \mu(1 - x^2)\frac{dx}{dt} + x = 0$$

μ is a constant. If we let $y = x - x^3/3$ http://en.wikipedia.org/wiki/Van_der_Pol_oscillator, then we arrive at this set of equations:

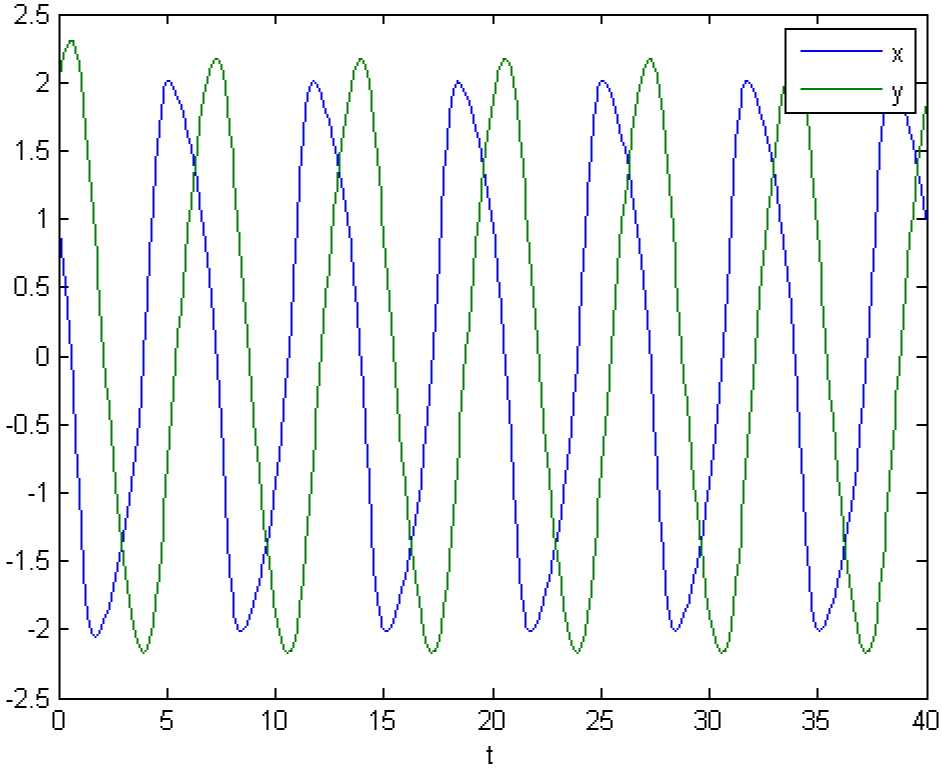
$$\frac{dx}{dt} = \mu(x - 1/3x^3 - y)$$

$$\frac{dy}{dt} = 1/\mu(x)$$

here is how we solve this set of equations. Let $\mu = 1$.

```
function main

X0 = [1;2];
tspan = [0 40];
[t,X] = ode45(@VanderPol, tspan, X0);

x = X(:,1);
y = X(:,2);

h = figure
plot(t,x,t,y)
xlabel('t')
legend 'x' 'y'
saveas(h, 'fig1.png')
```

```
h =

     1
```

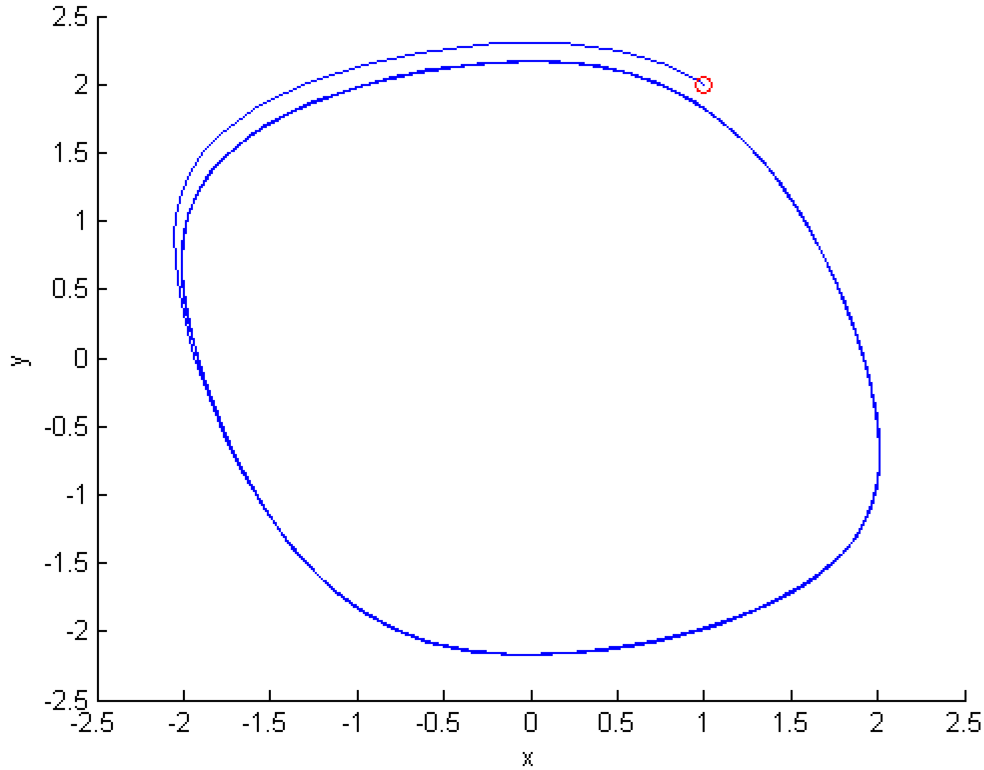


phase portrait

it is common to create a phase portrait. Although the solution appears periodic above, here you can see a limit cycle is definitely approached after the initial transient behavior. We mark the starting point with a red circle.

```
h = figure
hold on
plot(x,y)
plot(x(1),y(1),'ro') % starting point for reference
xlabel('x')
ylabel('y')
saveas(h, 'fig2.png')
```

```
h =

     2
```




```
'done'
```

ans =

done

```
function dXdt = VanderPol(t,X)
x = X(1);
y = X(2);
mu = 1;
dxdt = mu*(x-1/3*x^3-y);
dydt = x/mu;
dXdt = [dxdt; dydt];
```

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