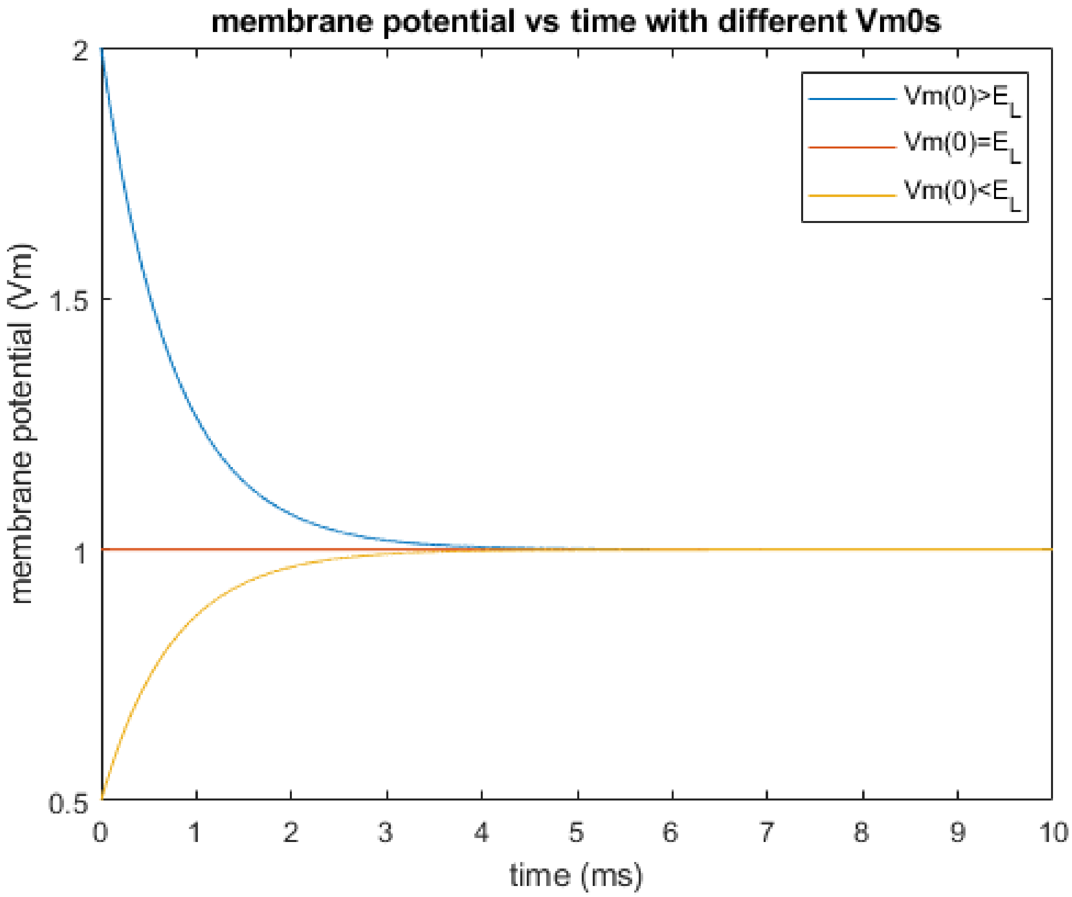
Contents

[Part 1] Simulate the dynamics of the passive membrane model with different Vm(0)

```
%Declare constants
C_m = 3; % Membrane capacitance = 3
G_L = 4; % Leaky conductance = 4
E_L = 1; % Resting membrane potential = 1mV

%time conditions and steps (range from 0~10 seconds)
t0 = 0;
tf = 10;
dt = 0.001; %step size 1ms

%time vector and voltage Vector
tvec = t0:dt:tf;
vvec = zeros(size(tvec));

%declare initial voltage vector
Vm0_initial = zeros(3);
Vm0_initial(1) = 2; % Vm0>EL
Vm0_initial(2) = 1; % Vm0=EL
Vm0_initial(3) = 0.5; % Vm0<EL

% Implementing Euler Methods
for j = 1:3
    %implementing different Vm0 initial conditions
    vvec(1) = Vm0_initial(j);
    %Euler Methods
    for i = 2:length(tvec)
    %dvm/dt = Gl/Cm*(E_L-Vm)
    dVm_over_dt =  G_L / C_m *(E_L - vvec(i-1));
    % Vm(i) = Vm(i-1) + dt*f(t(i-1),Vm(i-1))
    vvec(i) = vvec(i-1) + dt * dVm_over_dt;
    end
    figure(1)
    plot(tvec, vvec)
    hold on
end
%labels, legends and axis
title('membrane potential vs time with different Vm0s')
xlabel('time (ms)')
ylabel('membrane potential (Vm)')
legend({'Vm(0)>E_L','Vm(0)=E_L','Vm(0)<E_L'})
```



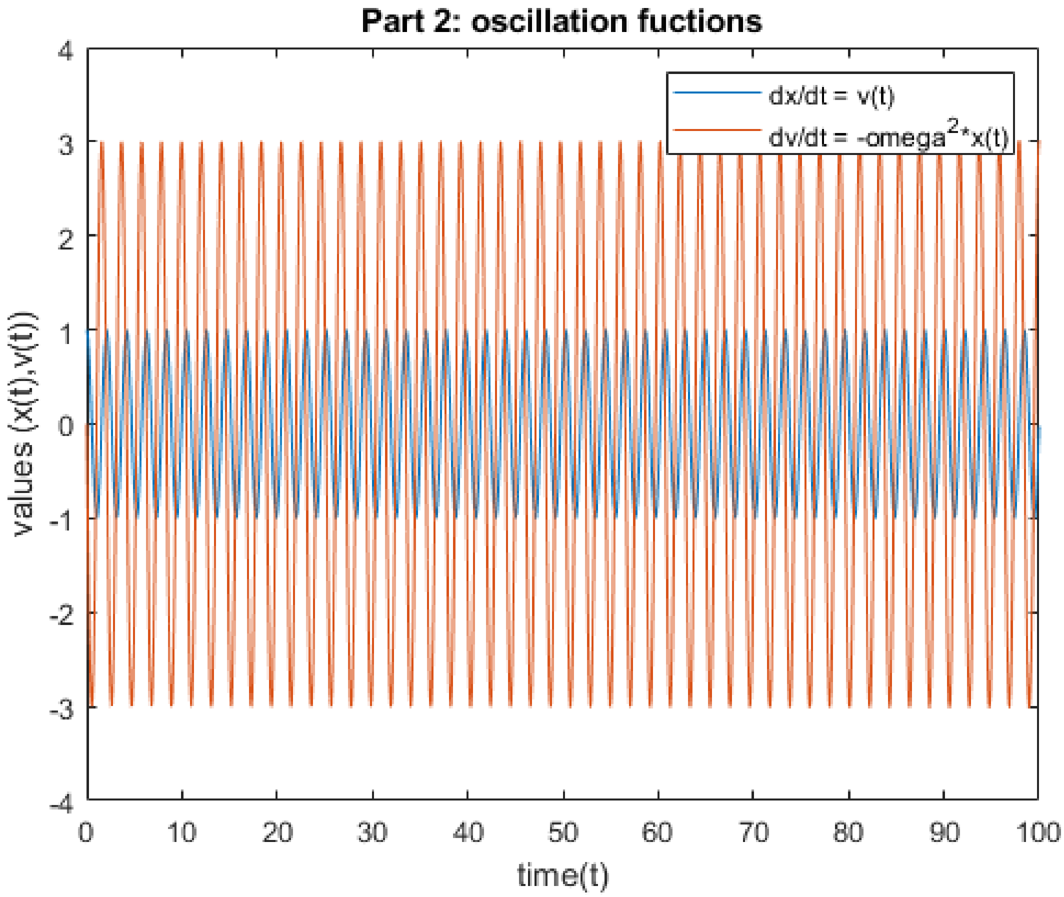
What can you say about the dynamics of this model behavior?

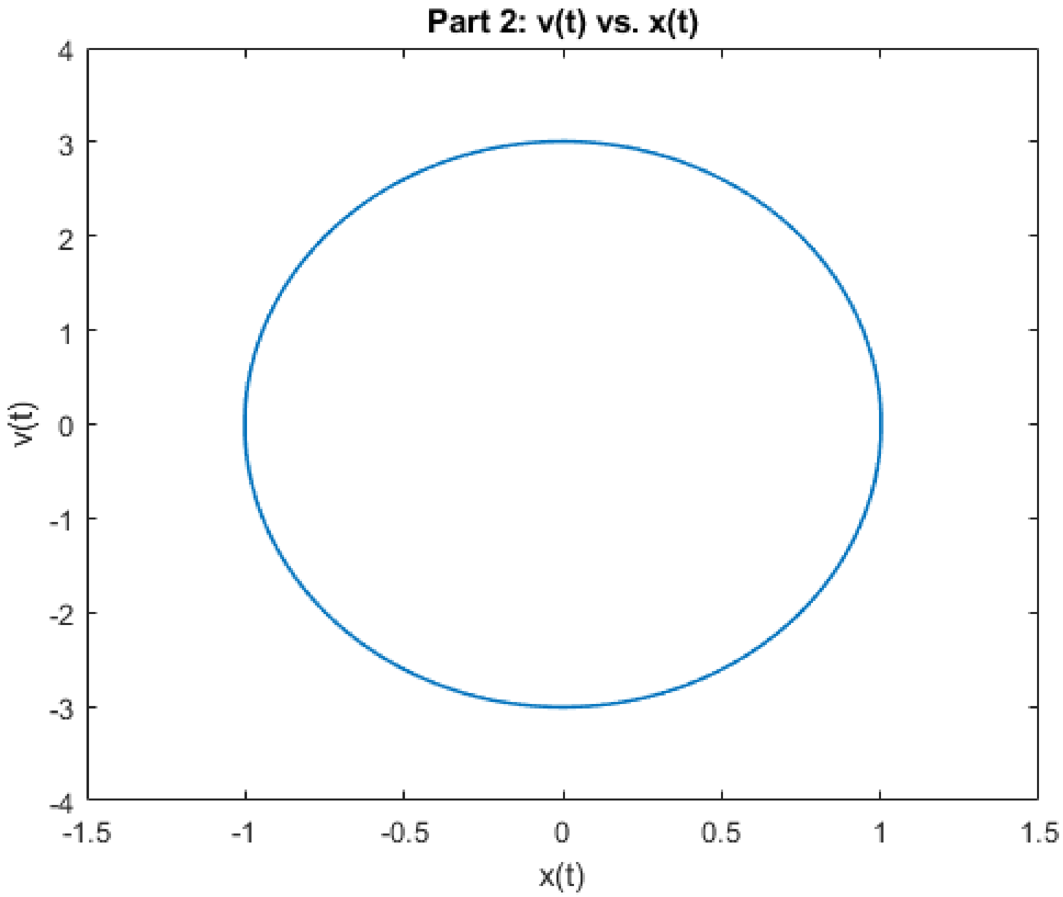
```
% When the initial Vm(0) equal to Equilibrium potential, dVm/dt = 0.
% Therefore, we can see a constant line parallel to the x axis. However,
% when Vm(0) is greater than EL, dVm/dt turns negative, which can
% be seen a negative exponential graph Vm approaching EL as time goes on.
% On the other hand, when Vm(0) is less than EL, dVm/dt is positive, which
% translates to a postive exponential graph which Vm approaches to EL over
% time.
```

[Part 2] Simulate the coupled two variable system of equations on Slide 9

```
% define initial constants
x0 = 1.0; % x(0)=1m
v0 = 0.0; % v(0)=0m/s
omega = 3; % omega = 3
omega_sqr = omega * omega; % omega^2 = 9

%time vector from 0s to 100s
t0 = 0;
tf = 100;
dt = 0.00001;
tvec = t0:dt:tf;

%define the velocity and position vector
vvec = zeros(size(tvec));
xvec = zeros(size(tvec));
```

```
%implement initials from the velocity and position vector
vvec(1) = v0;
xvec(1) = x0;

%Euler's Method implementation.
for i = 2:length(tvec)
   %dx(t)/dt = v(t)
   dx_over_dt = vvec(i-1);
   %dv(t)/dt = -omega^2*x(t)
   dv_over_dt = -1 * omega_sqr * xvec(i-1);
   %yi = yi-1 + dx*f(xi-1,yi-1)
   xvec(i) = xvec(i-1) + dx_over_dt *dt;
   vvec(i) = vvec(i-1) + dv_over_dt *dt;
end

%plot the solutions
%plot 1
figure(2)
plot(tvec, xvec)
hold on
plot(tvec, vvec)
title('Part 2: oscillation fuctions')
xlabel('time(t)')
ylabel('values (x(t),v(t))')
legend({'dx/dt = v(t)','dv/dt = -omega^2*x(t)'})
%plot 2
figure(3)
plot(xvec,vvec)
title('Part 2: v(t) vs. x(t)')
xlabel('x(t)')
ylabel('v(t)')
```





What can you say about the model behavior?

we can see that both graphs are sinusoidal. These two models affect each other, as can be seen in the circle in the graph. In polar coordinates coupled oscillators represent a sine cosine relationship.

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