Question 1:

See code in Appendix 1

Question 2: I\_stim = 275 µA

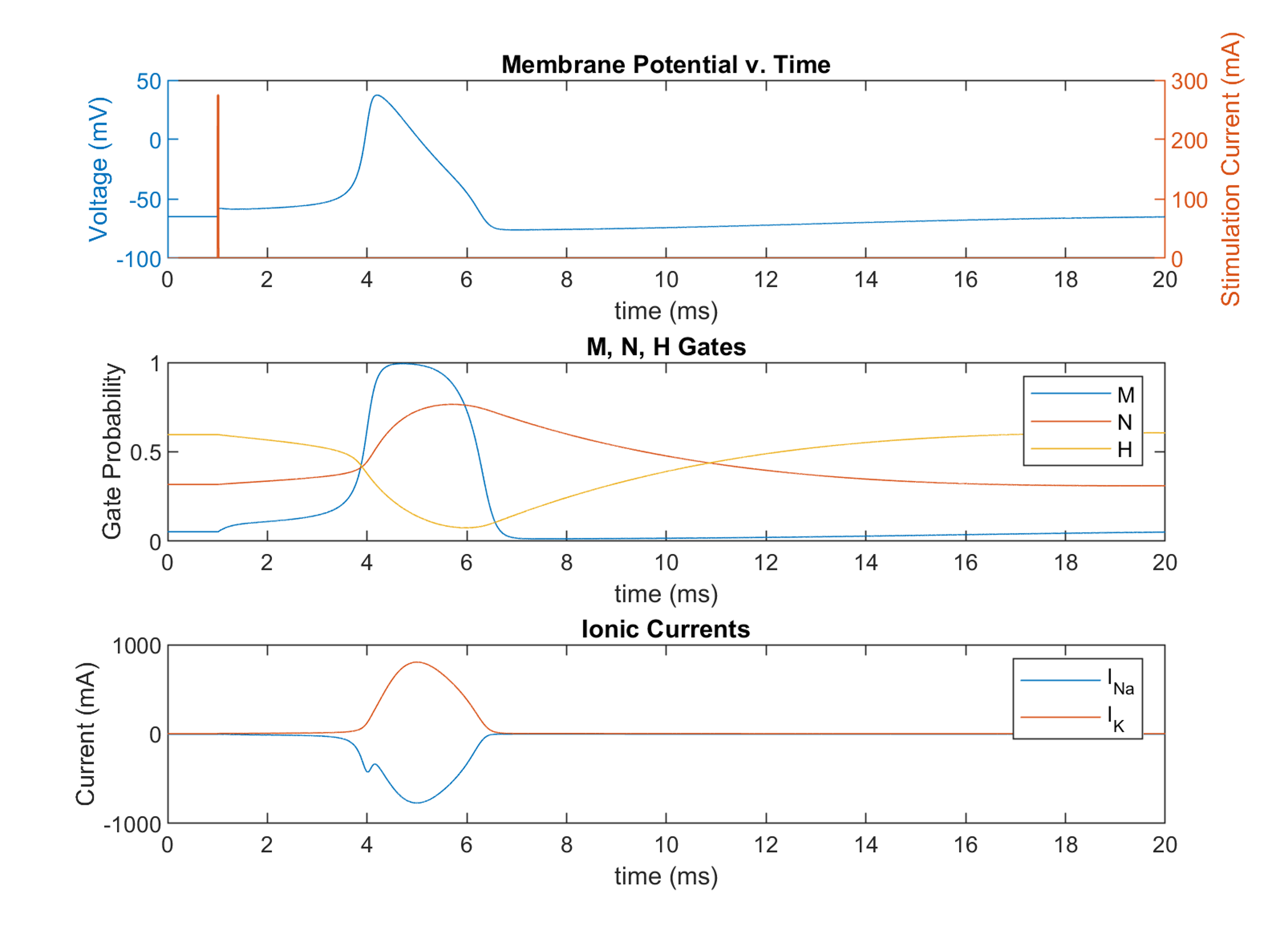


Figure 1: Membrane voltage, stimulation currents, ionic currents and M, N, H gate values for a .25ms stimulation of 275 µA.

Question 3A: I\_stim = 275 µA, Refractory Period = 17.2ms

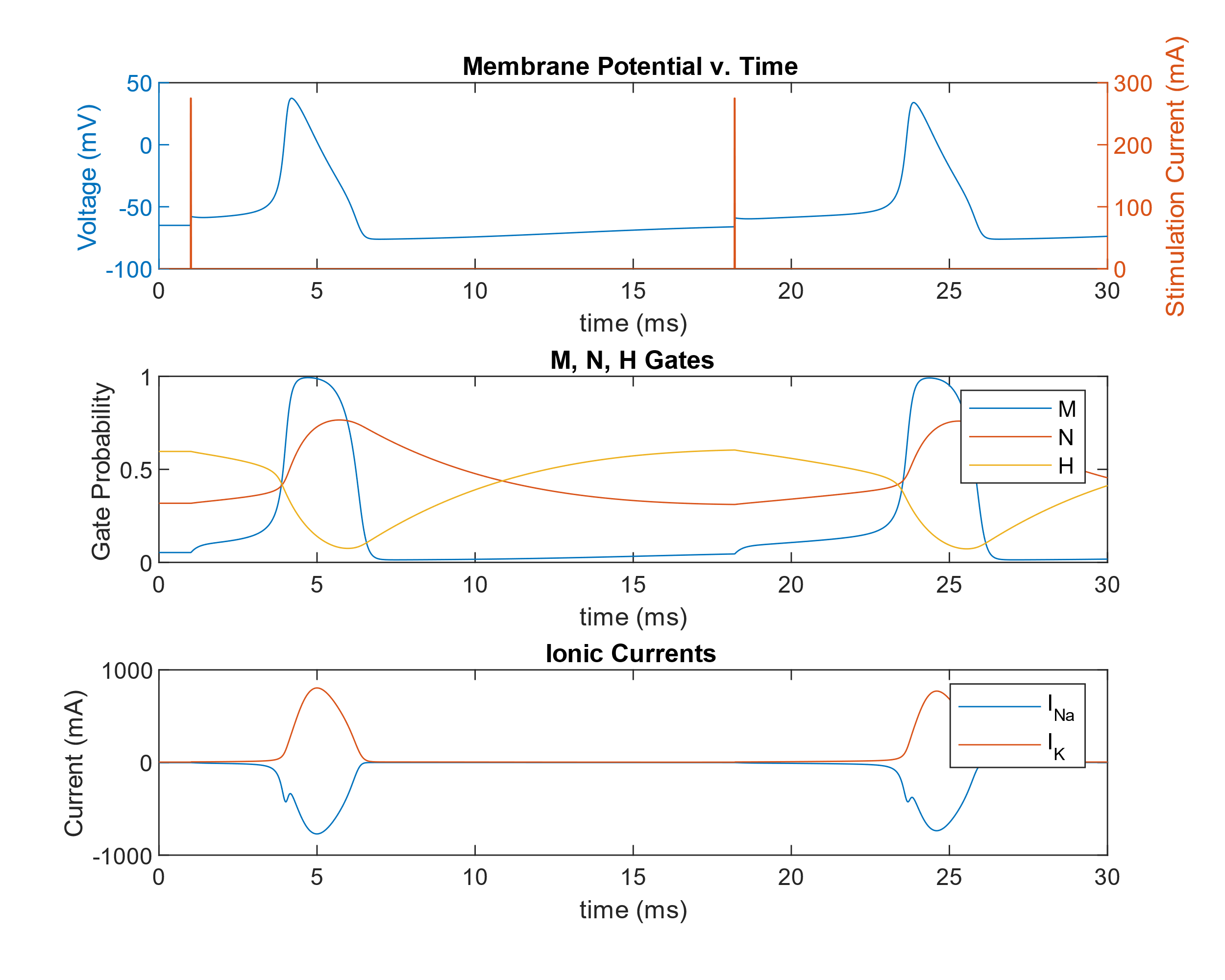


Figure 2: Membrane voltage, stimulation currents, ionic currents and M, N, H gate values for two .25ms stimulation of 275 µA. The minimum refractory period (relative) is 17.2 milliseconds.

Question 3B: I\_stim = 275 µA and 825 µA, Refractory Period = 11.8 ms

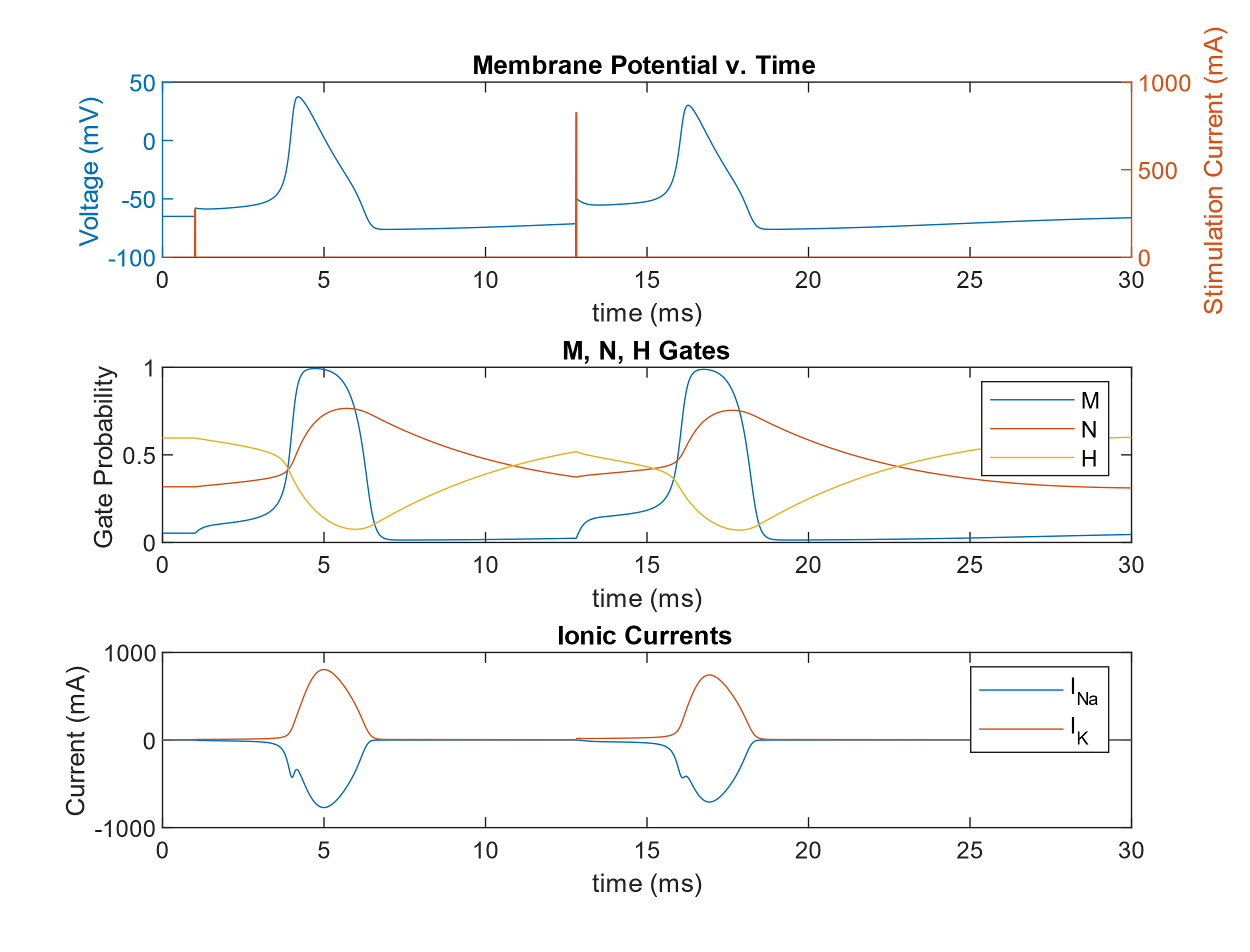
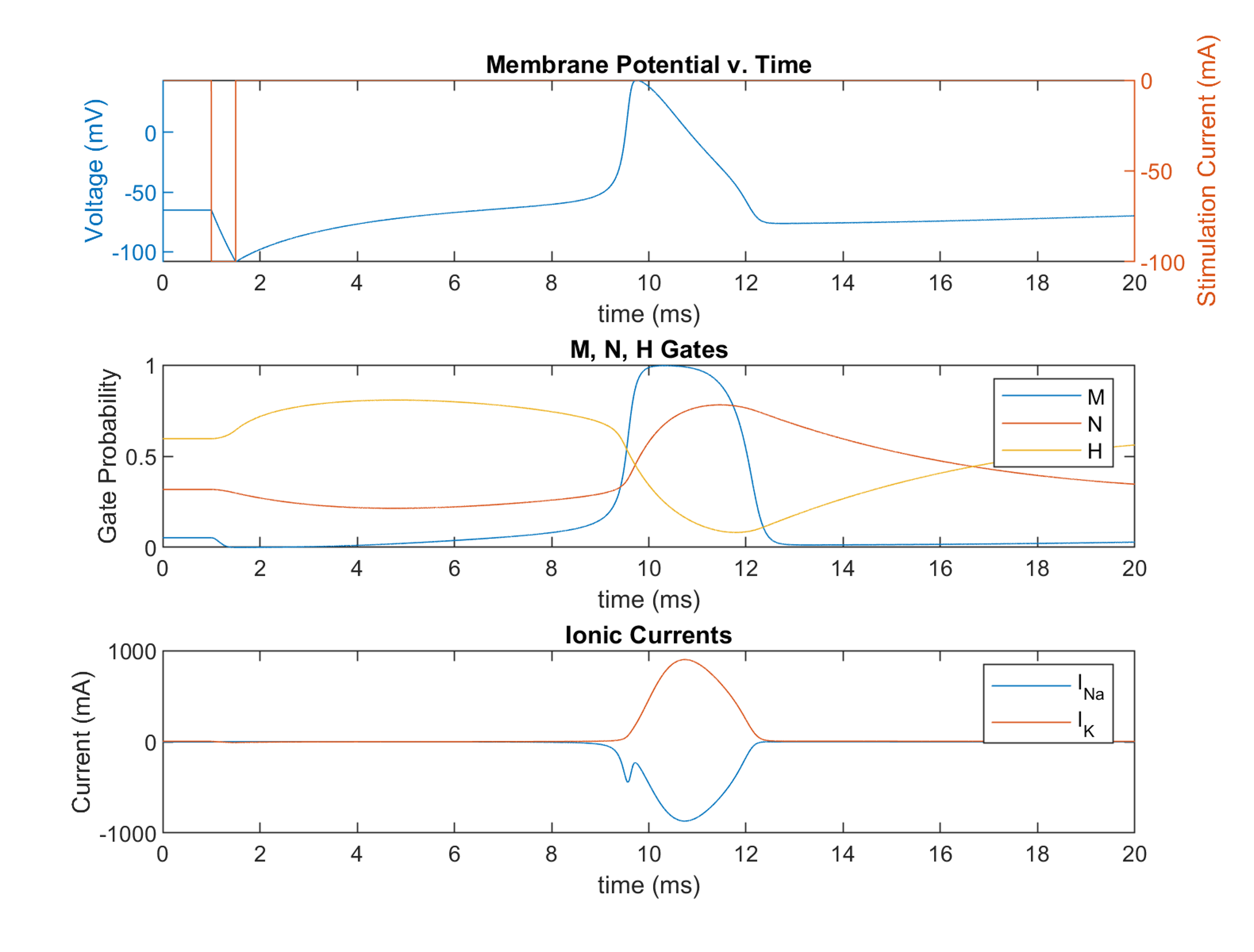


Figure 3: Membrane voltage, stimulation currents, ionic currents and M, N, H gate values for two .25ms stimulation, first of 275 µA, and second of 825 µA. The minimum refractory period (relative) is 11.8 milliseconds.

Question 4: : I\_stim = -100 µA for .5ms

 Figure 4: Membrane voltage, stimulation currents, ionic currents, and M, N, H gate values a .5 millisecond long hyperpolarizing pulse of -100 µA to trigger an anode break excitation.

**Appendix 1:**

HH\_Run

close all; clear all; clc;

T = 6.3;

gNa = 120;

gK = 36;

Na\_Out = 490;

Na\_in = 50;

K\_out = 20;

K\_in = 400;

R = 8.314;

F = 9.6485\*10^4;

E\_Na = 1000\*(R\*T/F)\*log(Na\_Out/Na\_in);

E\_K = 1000\*(R\*T/F)\*log(K\_out/K\_in);

V\_rest = -60.34;

m\_0 = 0.05;

n\_0 = 0.32;

h\_0 = 0.6;

y\_0 = [V\_rest; m\_0; n\_0; h\_0];

dt = [0,20];

options = odeset('RelTol',1e-4,'AbsTol',[1e-8,1e-8,1e-8,1e-8],'MaxStep',0.01);

[t,y] = ode45(@(t,y) HH(I),dt,y\_0,options);

V = y(:,1);

M = y(:,2);

N = y(:,3);

H = y(:,4);

figure;

plot(t,V); title('Voltage'); xlabel('Time (ms)'); ylabel('Voltage (mV)');

figure

plot(t,M);

hold on; plot(t,H);

hold on; plot(t,N);

title('M, N, H Gates');

xlabel('Time (ms)');

ylabel('Probability Open');

legend('M','N','H');

I\_K = gK.\*N.^4.\*(V-E\_K);

I\_Na = gK.\*M.^3.\*H.\*(V-E\_Na);

figure;

plot(t,I\_K);

hold on; plot(t,I\_Na);

title('Ionic Currents'); xlabel('Time (ms)'); ylabel('Current (mA)');

legend('I\_{Na}','I\_{K}');

ODE

function Dydt = HH(t,y)

I\_s = 0

V\_rest = -65 ;

T = 6.3;

T\_k = 273.15+T;

V = y(1,1);

m = y(2,1);

n = y(3,1);

h = y(4,1);

v\_m = V-V\_rest;

gNa = 120;

gK = 36;

gL = 0.3;

Na\_out = 490;

Na\_in = 50;

K\_out = 20;

K\_in = 400;

R = 8.314;

F = 9.6485\*10^4;

E\_Na = 1000\*(R\*T\_k/F)\*log(Na\_out/Na\_in);

E\_K = 1000\*(R\*T\_k/F)\*log(K\_out/K\_in);

E\_L = -50;

C = 1.0;

k = 3^(0.1\*T-0.63);

alpha\_m = .1\*(25-v\_m)./(exp((25-v\_m)/10)-1);

alpha\_h = .07\*exp(-v\_m/20);

alpha\_n = .01\*(10-v\_m)./(exp((10-v\_m)/10)-1);

beta\_m = 4\*exp(-v\_m/18);

beta\_h = 1/(exp((30-v\_m)/10)+1);

beta\_n = .125\*exp(-v\_m/80);

dVdt = (1/C).\*(I\_s-gNa\*m^3\*h\*(V-E\_Na)-gK\*n^4\*(V-E\_K)-gL\*(V-E\_L));

dmdt = (-(alpha\_m+beta\_m)\*m+alpha\_m)\*k;

dndt = (-(alpha\_n+beta\_n)\*n+alpha\_n)\*k;

dhdt = (-(alpha\_h+beta\_h)\*h+alpha\_h)\*k;

Dydt = zeros(4,1);

Dydt(:,1) = [dVdt; dmdt; dndt; dhdt];

end