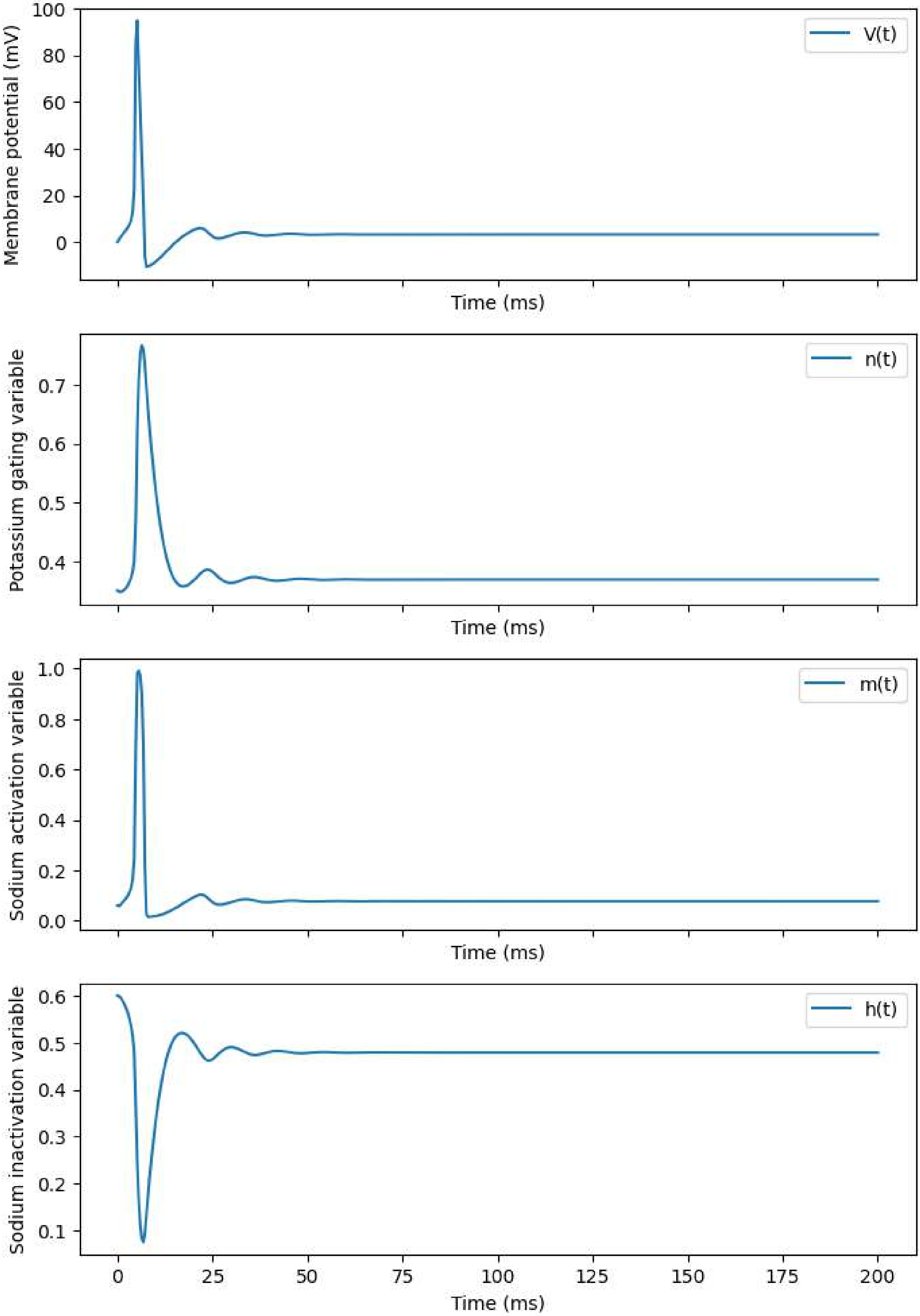
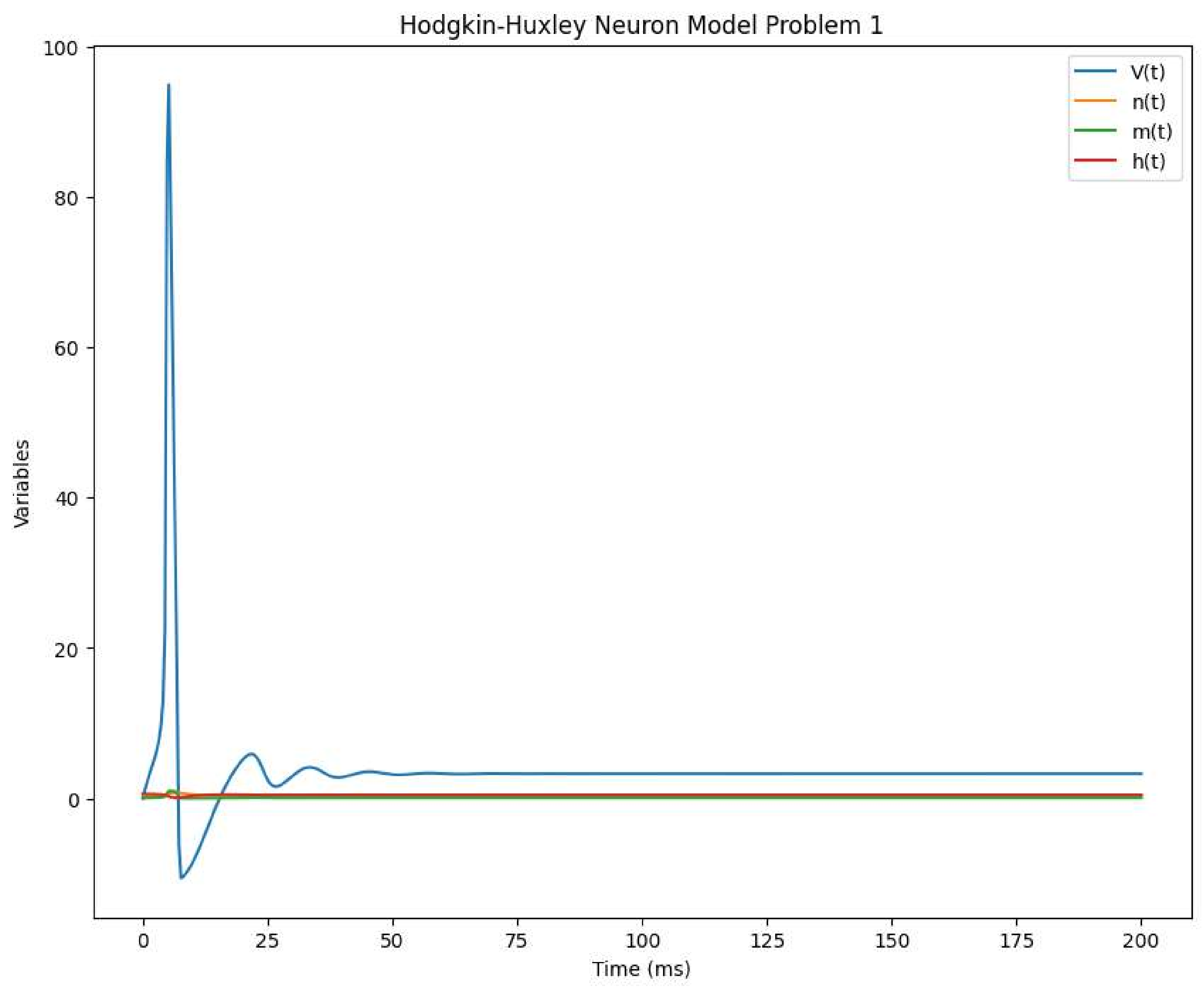
Part 1

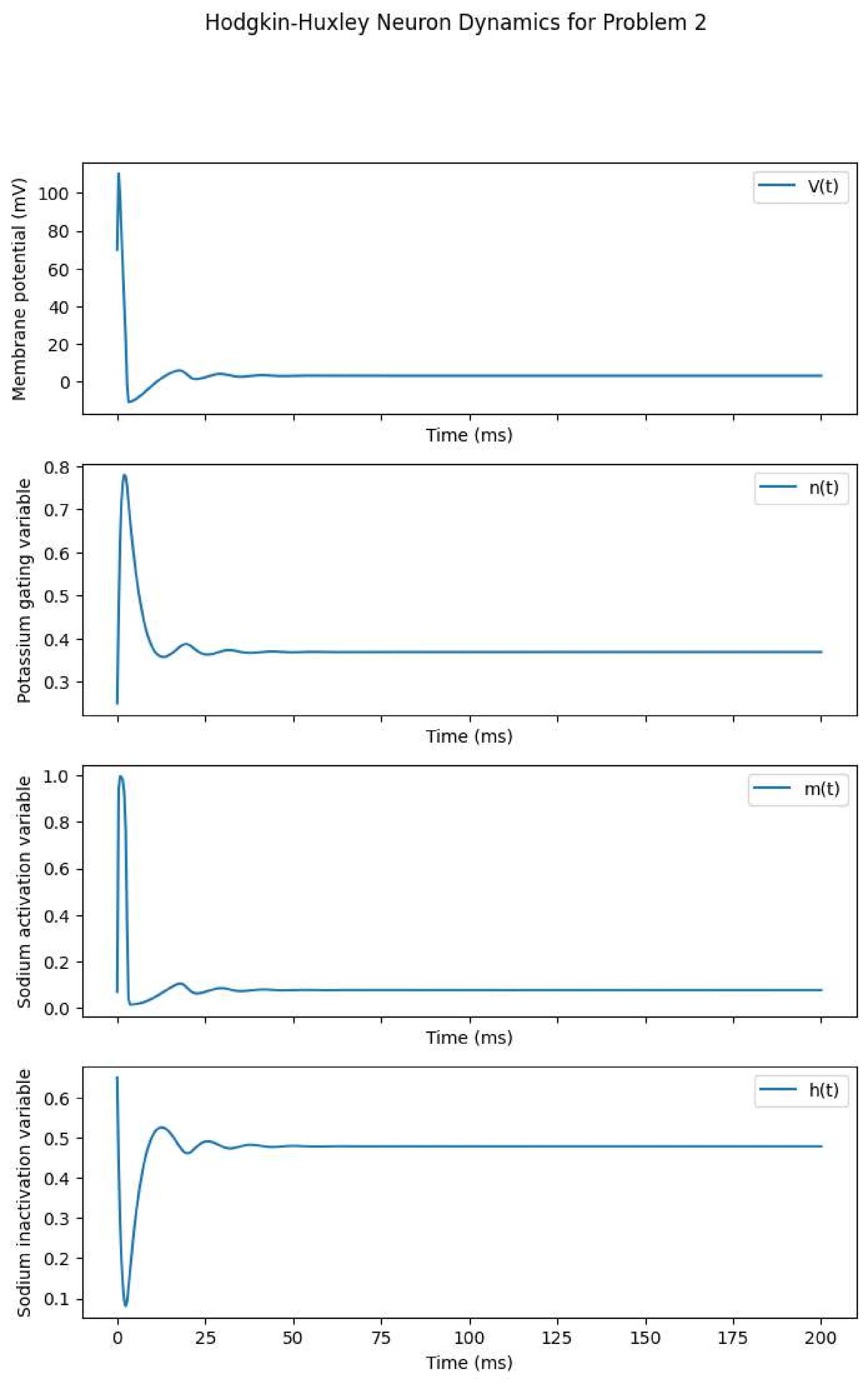
Hodgkin-Huxley Neuron Dynamics for Problem 1

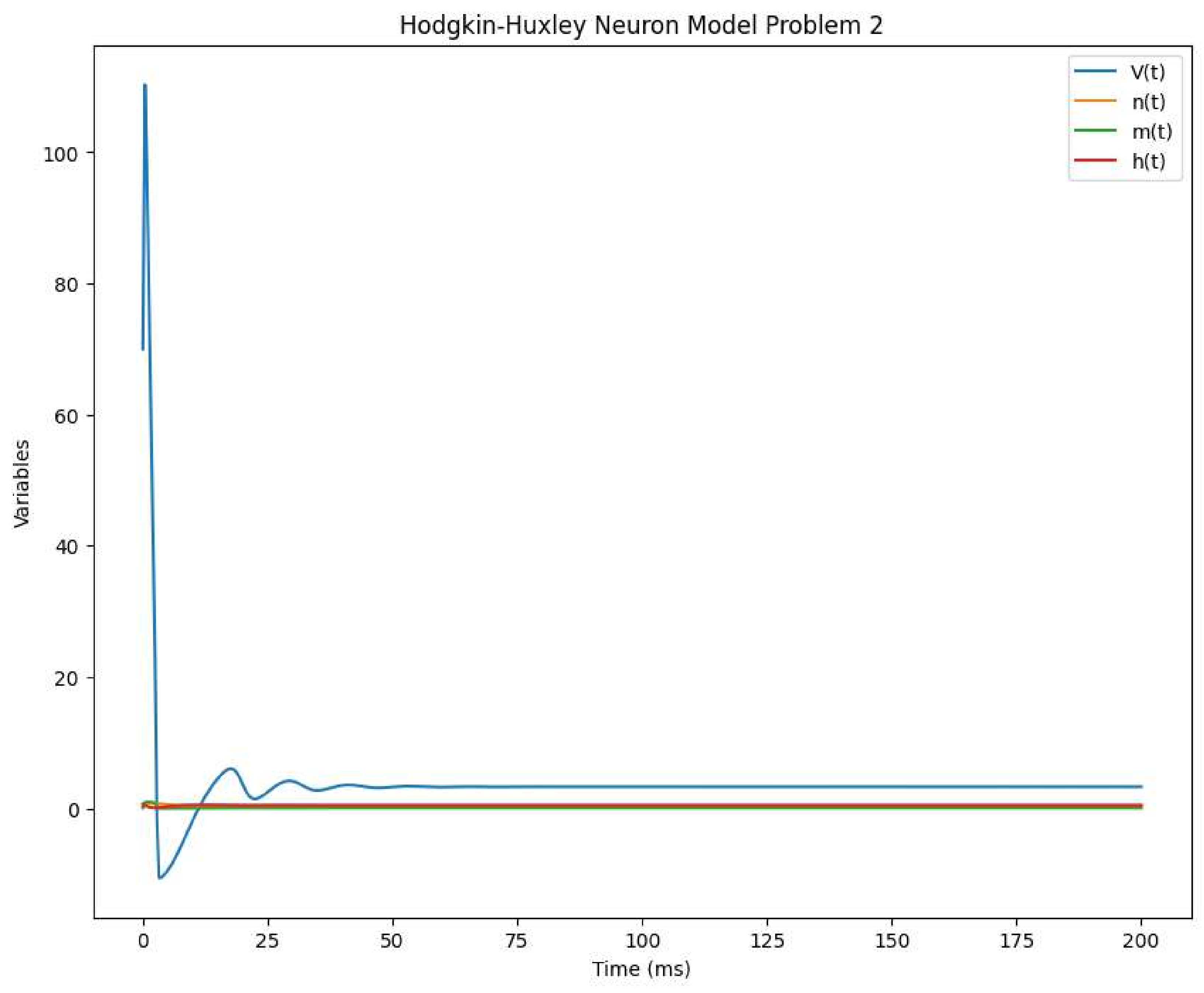
Mirza Shaheen Iqubal (22998316)

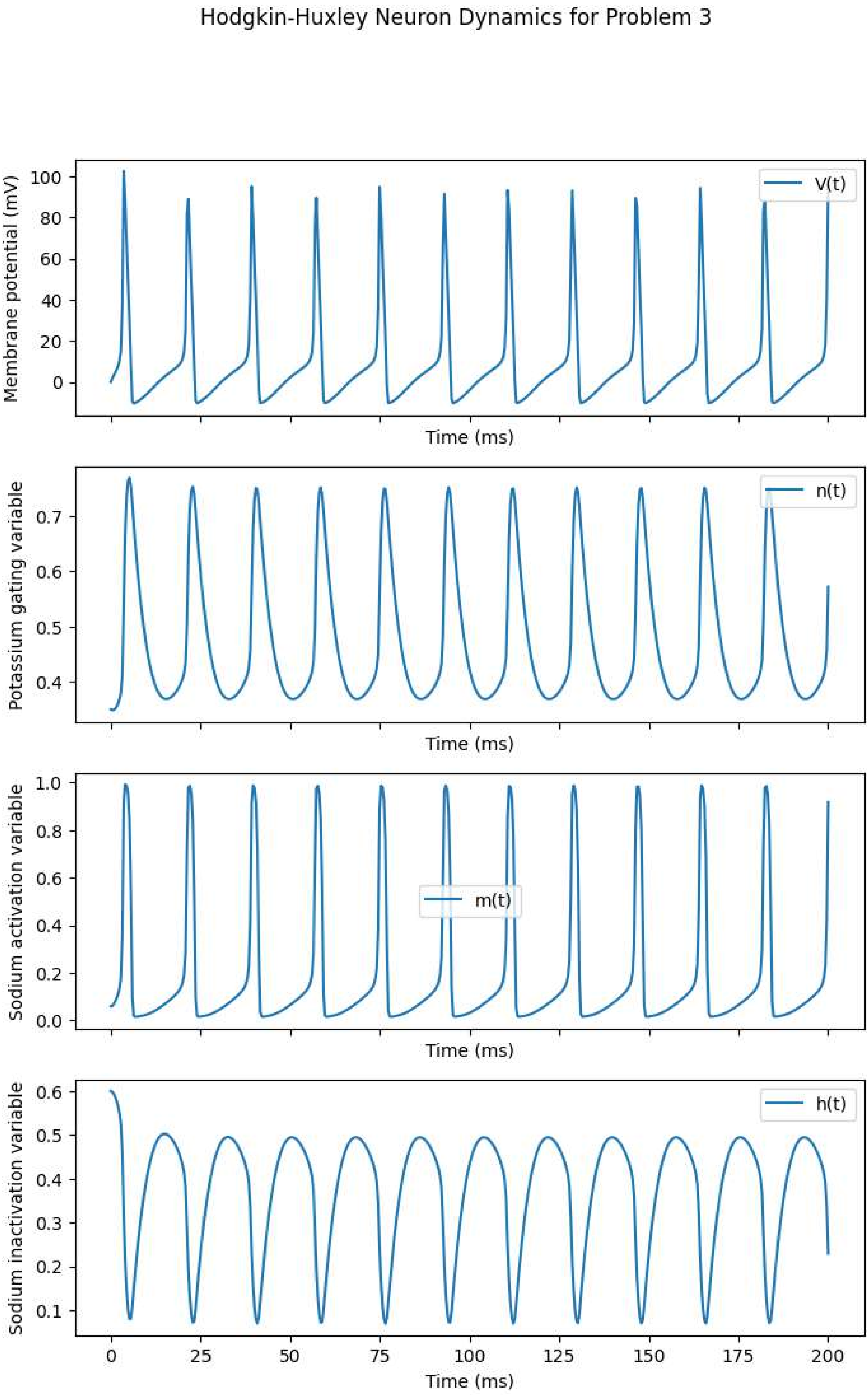


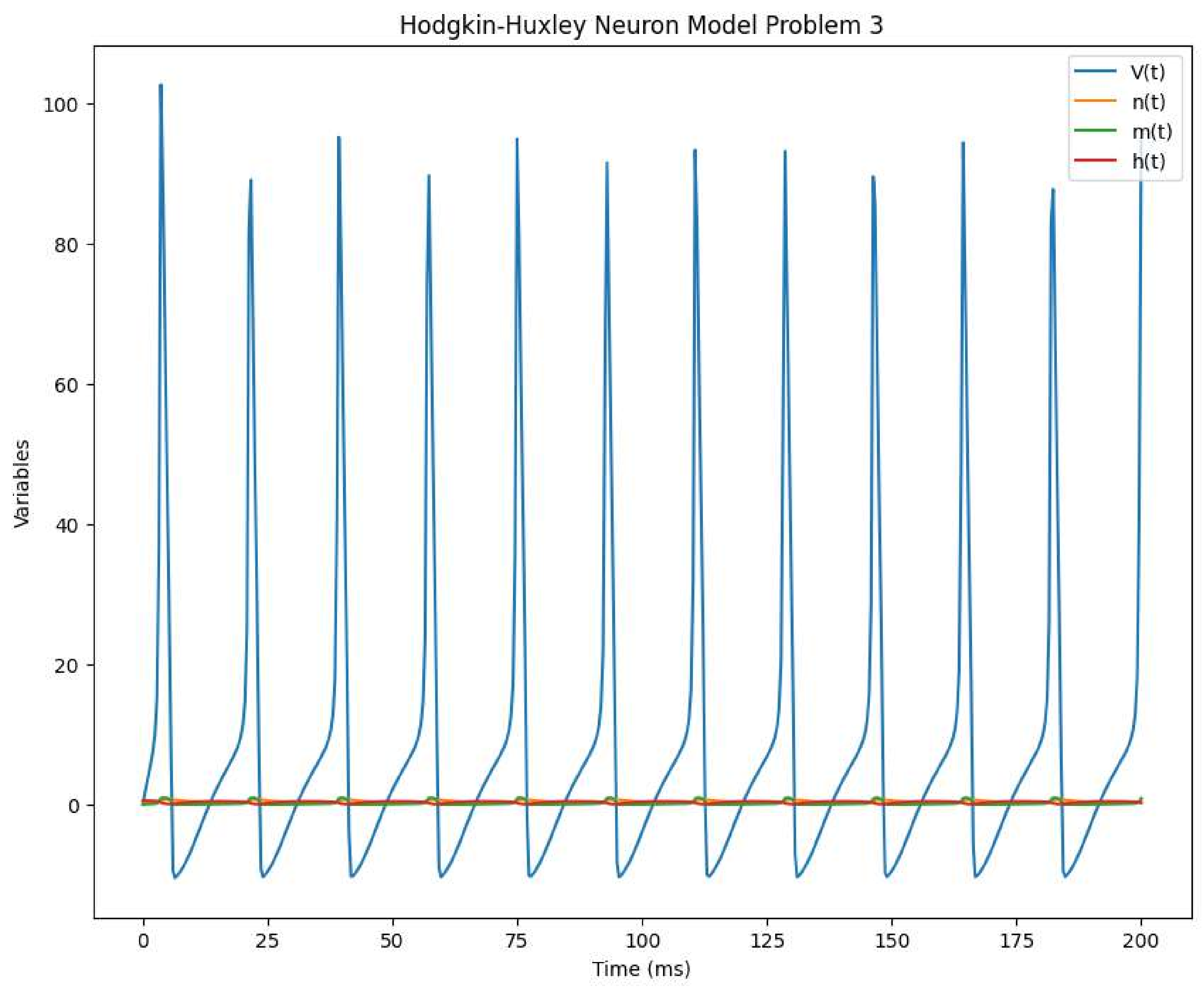


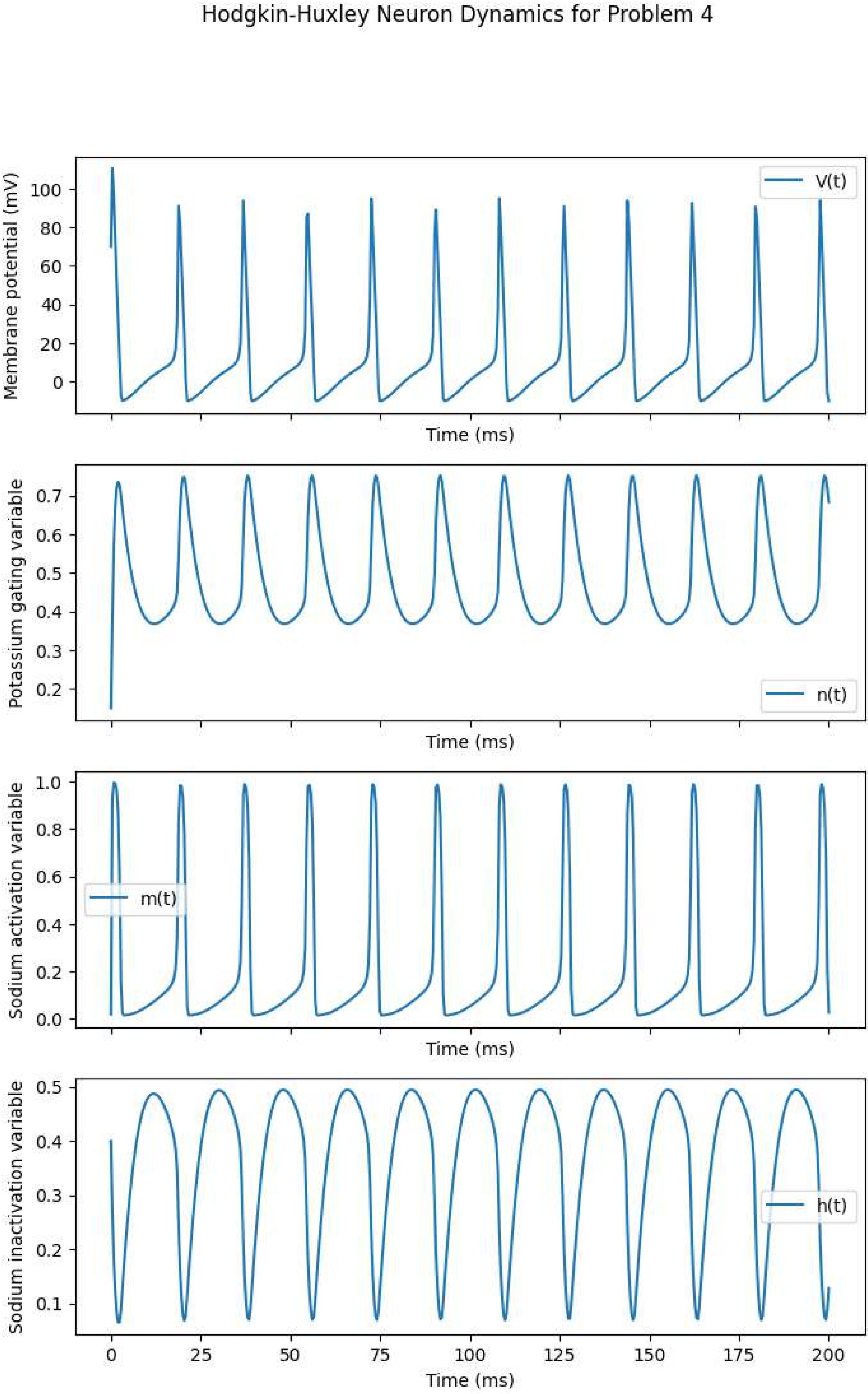
Hodgkin-Huxley Neuron Model Problem 1
V(t)
n(t)
m(t)
h(t)
Variables
Time (ms)
0
20
40
60
80
100
0
25
50
75
100
125
150
175
200

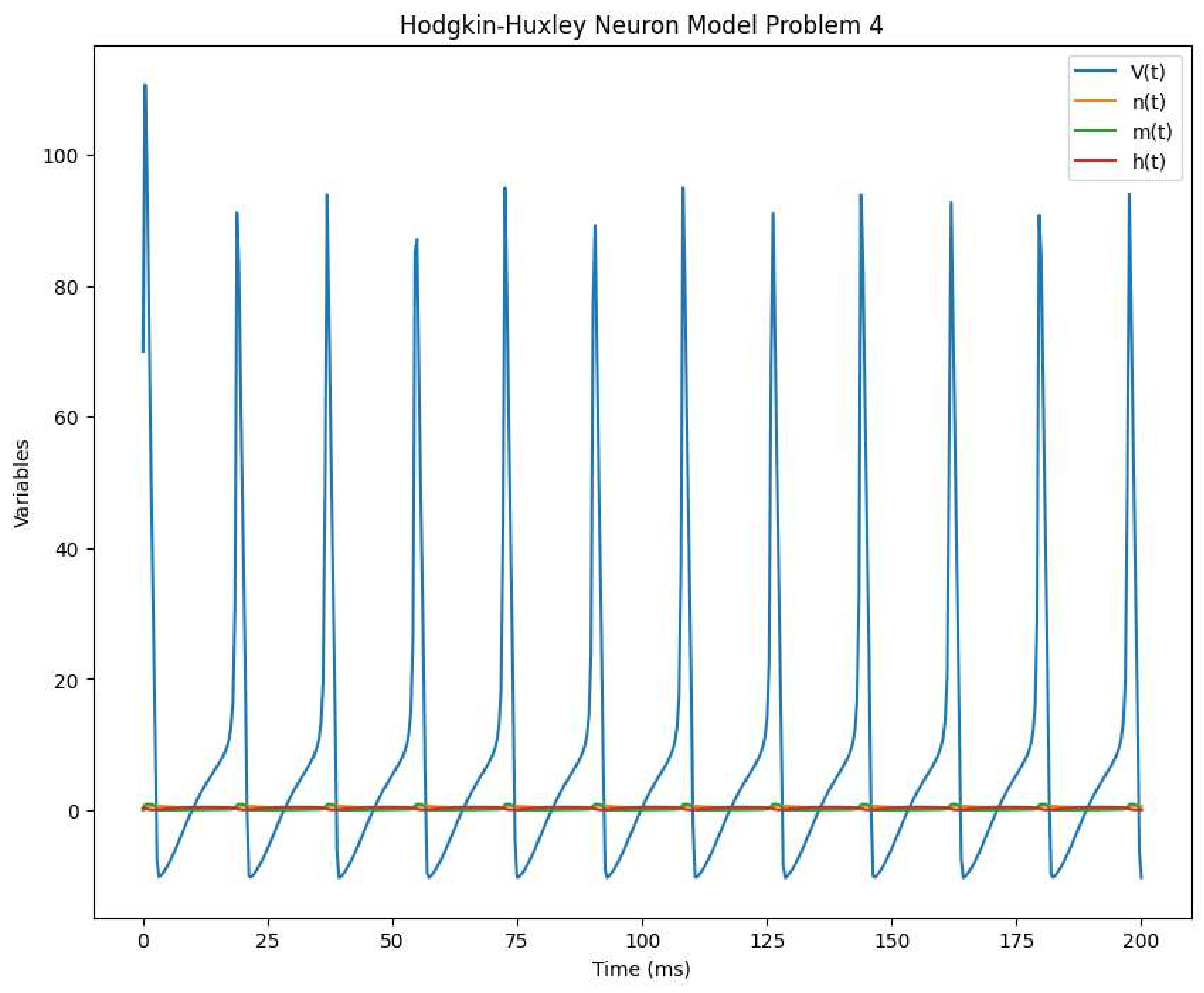

Hodgkin-Huxley Neuron Dynamics for Problem 2
V(t)
Membrane potential (mV)
Time (ms)
n(t)
Potassium gating variable
Time (ms)
m(t)
Sodium activation variable
Time (ms)
h(t)
Sodium inactivation variable
Time (ms)


Hodgkin-Huxley Neuron Model Problem 2
V(t)
n(t)
m(t)
h(t)
Variables
Time (ms)
0
20
40
60
80
100
0
25
50
75
100
125
150
175
200


Hodgkin-Huxley Neuron Dynamics for Problem 3
Membrane potential (mV)
V(t)
Time (ms)
Potassium gating variable
n(t)
Time (ms)
Sodium activation variable
m(t)
Time (ms)
Sodium inactivation variable
h(t)
Time (ms)
0
25
50
75
100
125
150
175
200


Hodgkin-Huxley Neuron Model Problem 3
V(t)
n(t)
m(t)
h(t)
Variables
Time (ms)
0
20
40
60
80
100
0
25
50
75
100
125
150
175
200


Hodgkin-Huxley Neuron Dynamics for Problem 4
Membrane potential (mV)
V(t)
Time (ms)
Potassium gating variable
n(t)
Time (ms)
Sodium activation variable
m(t)
Time (ms)
Sodium inactivation variable
h(t)
Time (ms)
0
25
50
75
100
125
150
175
200



Hodgkin-Huxley Neuron Model Problem 4
V(t)
n(t)
m(t)
h(t)
Variables
Time (ms)
0
20
40
60
80
100
0
25
50
75
100
125
150
175
200

Part 2: Timescale separation and dimension reduction

Problem 1

Consider the following set of coupled ODEs, each characterized by the timescales ε_1 and ε_2,

$$\begin{cases} \frac{dx}{dt} &= \varepsilon_1^{-1}\big[-x(t)+y(t)+I(t)\big] \\ \frac{dy}{dt} &= \big[-y(t)+x(t)^2+A\big]/\varepsilon_2 \end{cases} \tag{3}$$

(a) If ε_1 << ε_2, then the system can be reduced to:

$$\varepsilon_1\frac{dx}{dt} = -x(t)+x(t)^2+I(t)+A \tag{4}$$

(b) If ε_2 << ε_1, then the system can be reduced to:

$$\frac{dy}{dt} = \frac{1}{\varepsilon_2}\big[-y(t)+\big[y(t)+I(t)\big]^2+A\big] \tag{5}$$

(c) If ε_1 = ε_2, then none of the ODEs in (a) and (b) above can be correct.

Problem 2

A channel with gating variable $R(t)$, given by $\frac{dR}{dt} = \varepsilon_1^{-1}\big[-R(t)+R_0(V)\big]$ influences the voltage $V(t)$ given by $\varepsilon_2\frac{dV}{dt} = -\big[V(t)-V_0\big]+R(t)^2A$.

A reduction of dimension

(a) is possible, and the result is $\varepsilon_1\frac{dR}{dt} = -R(t)+R_0\big[V_0+R(t)^2A\big]$ if ε_2 << ε_1.

(b) is impossible if ε_1 = ε_2.

(c) is possible, and the result is $\varepsilon_2\frac{dV}{dt} = -V(t)+V_0+R_0(V)^2A$ if ε_2 >> ε_1.