HOMEWORK - 01
Computational Neuroscience

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Ques 1.

$S.A = 0.025\, mm^2$

$cm = 10\, nF/\, mm^2$

$rm = 1\, M\Omega - mm^2$

$E = -\ 70\, mV$

(a) **Cm** = cm * S.A = 10 * 0.025 = **0.25 nF**
(b) **Rm** = rm * 1/S.A = 1/0.025 = **40 MΩ**
(c) τm = Rm * Cm = 40 * 10^6 * 0.25 * 10^{-9} = **10 ms**
(d) **Ie** = (V-E) / Rm = -65 + 75 / 40 * 10^6 = **0.125 nA**
(e) V(t) = E + (V_0 - E) $e^{-t/\tau}$

Since, Ie is being held constantly, V at E would be -65 and the -70 becomes the V0

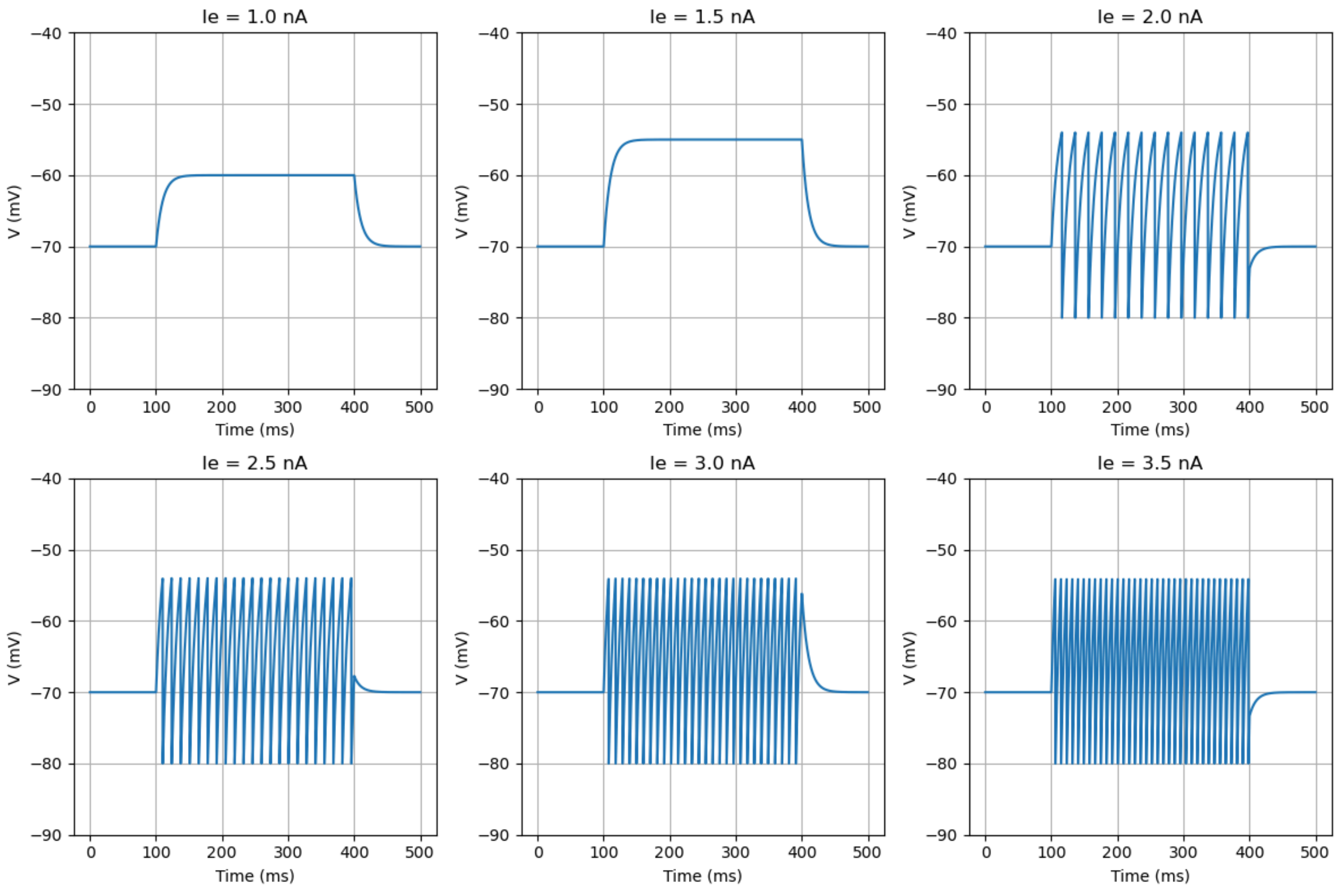
-67 = -65 + (-70 - (-65))$e^{-t/0.01}$ ⇒ 2 = 5 $e^{-t/0.01}$ ⇒ ⅖ = $e^{-t/0.01}$

⇒ $ln\,(2/5) = -\ t/0.01$ ⇒ $ln\, 2 - ln\, 5 = -\ t/0.01$

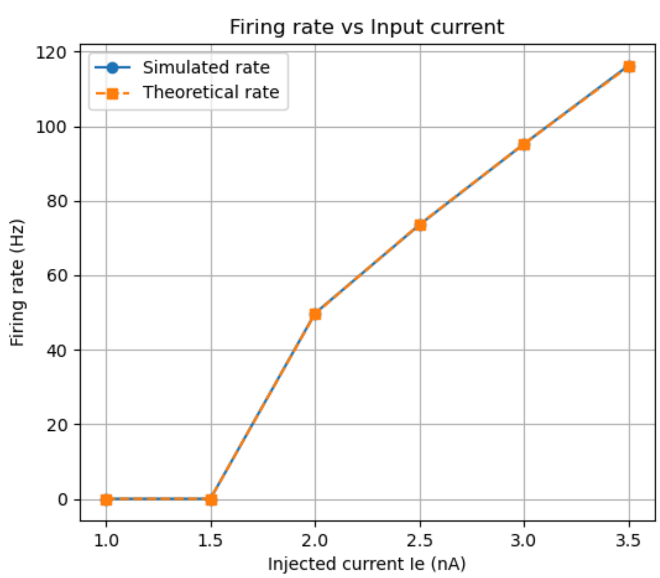
-0.916 = -t/0.01

t = 9.16 ms

Ques 2.

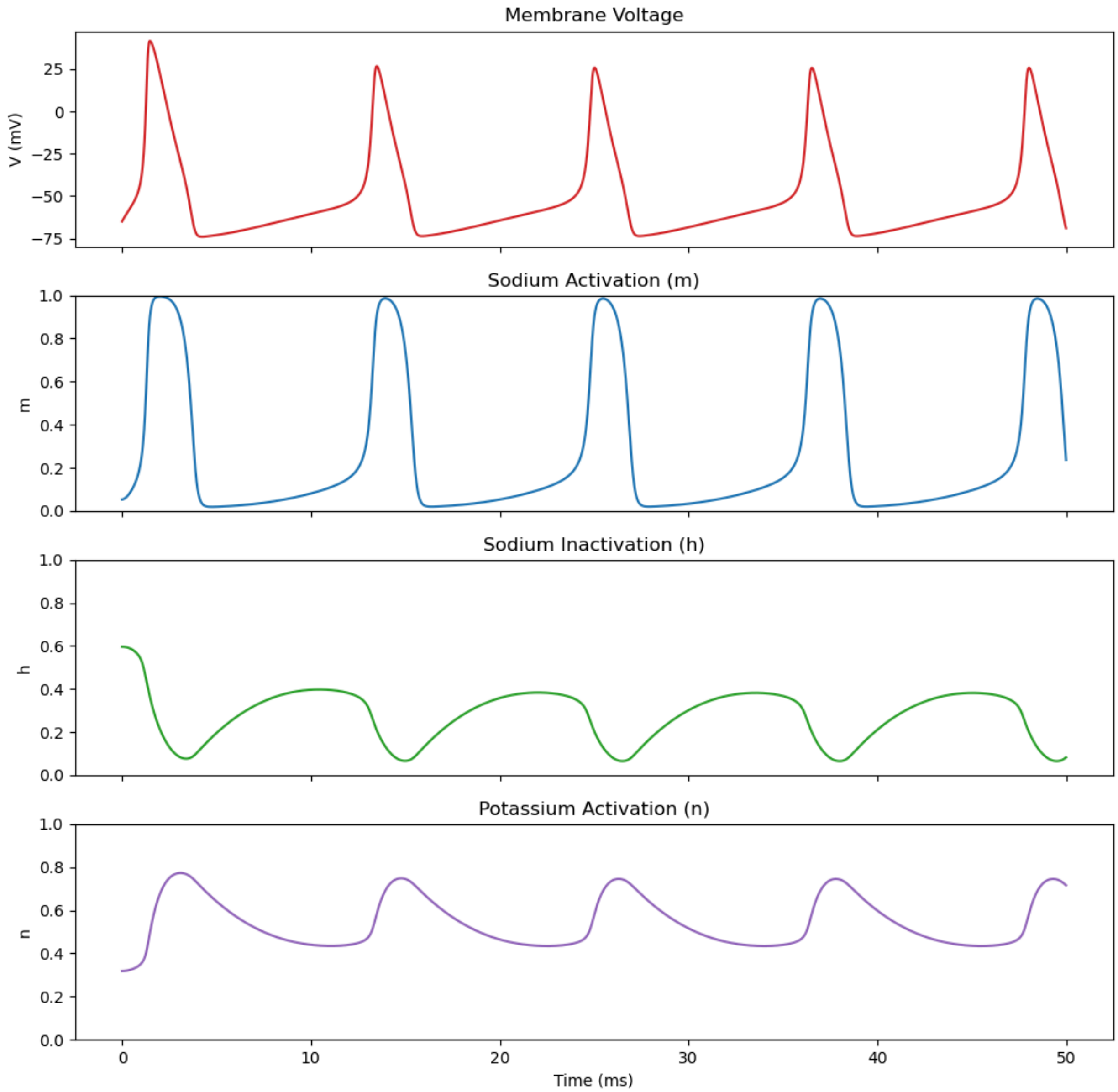


The firing rate using the integrate and fire model and the equation are the same.

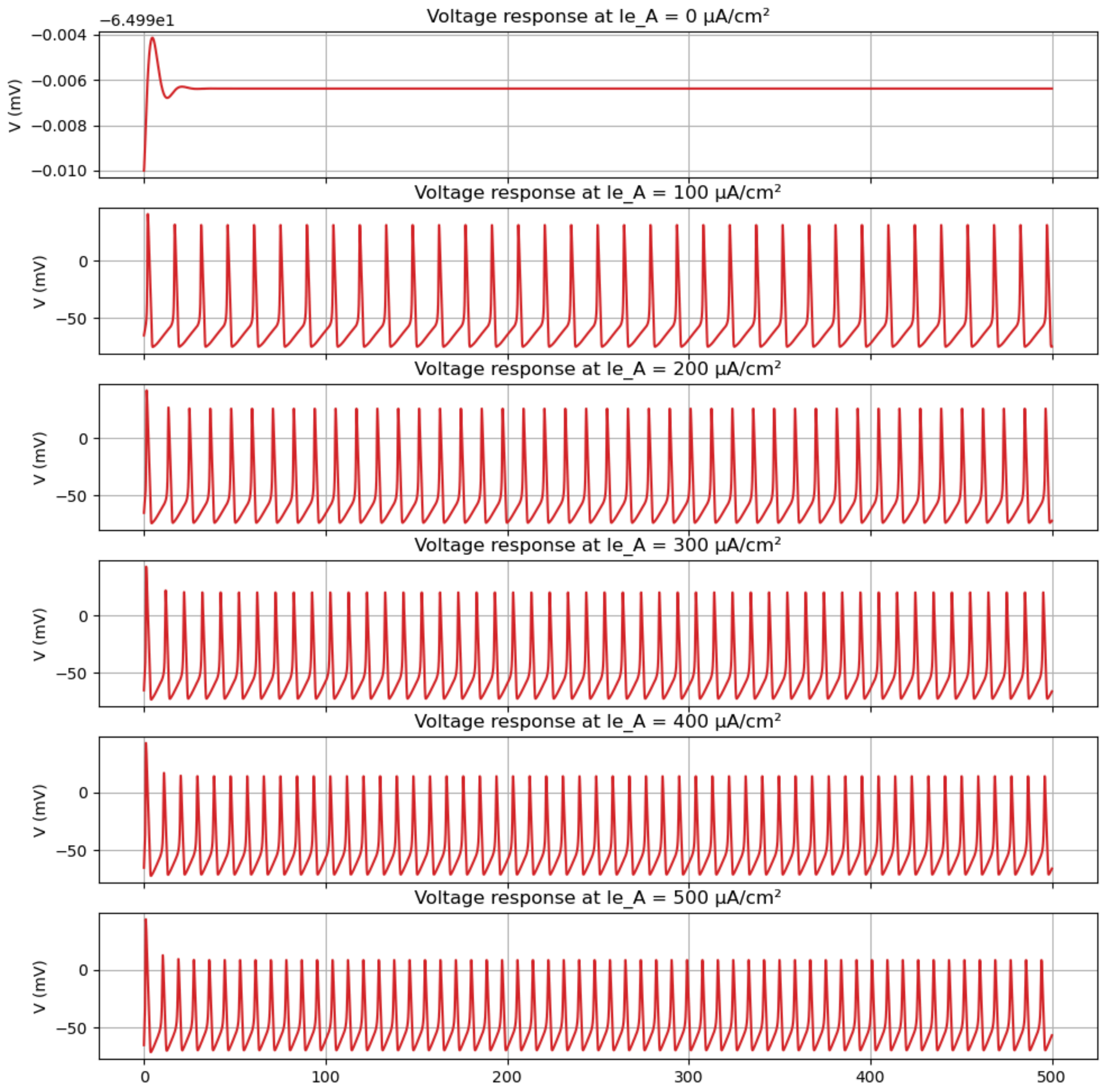


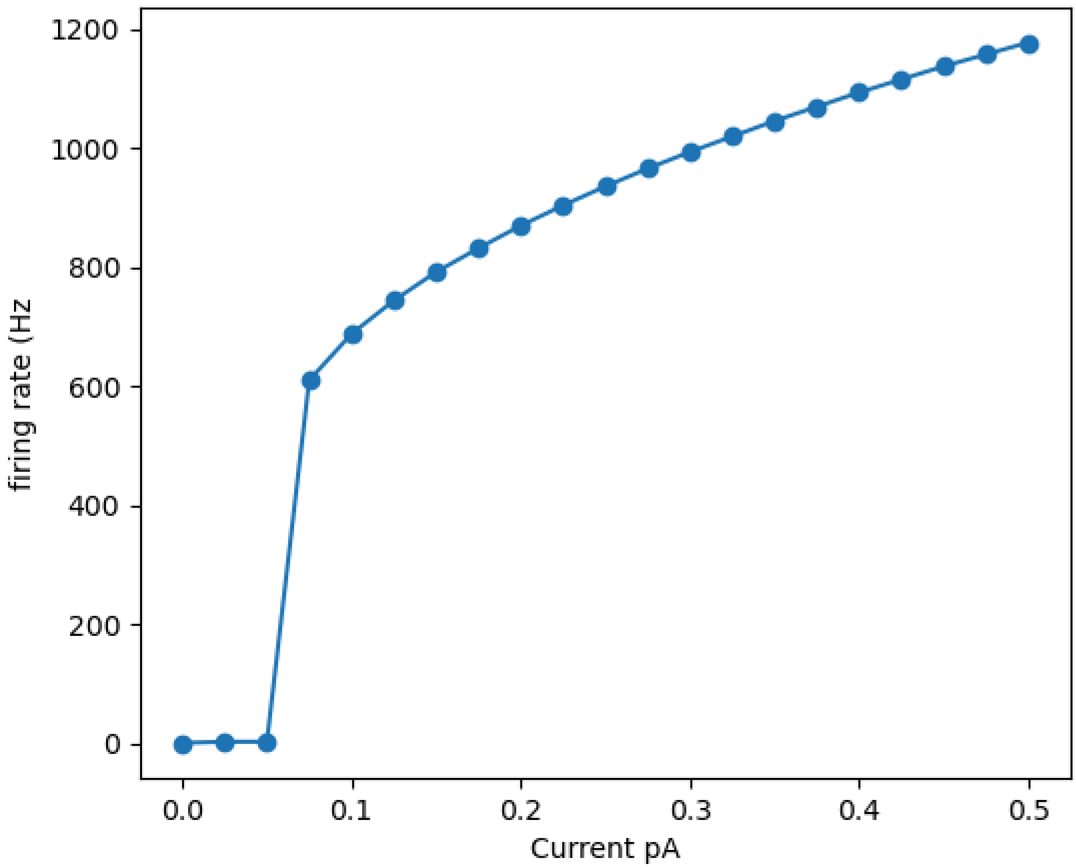
Ques 3.

(a) As expected, we see that the membrane voltage is being driven by the sodium gates being activated and the depolarisation is marked by sodium inactivation and potassium channels being activated.



(b)


−6.499e1
Voltage response at Ie_A = 0 μA/cm²
V (mV)
−0.004
−0.006
−0.008
−0.010
Voltage response at Ie_A = 100 μA/cm²
Voltage response at Ie_A = 200 μA/cm²
Voltage response at Ie_A = 300 μA/cm²
Voltage response at Ie_A = 400 μA/cm²
Voltage response at Ie_A = 500 μA/cm²
0
−50
0
100
200
300
400
500
Time (ms)



The Hodgkin-Huxley model reaches the spiking threshold sharply and is non-linear in its increase post the achievement of threshold V, as compared to the integrate and fire model.

(c)

Neuron spikes after hyperpolarizing current (a.k.a. Rebound spike) due to re-activation of inactivated Ca+2 channels, HCN and Na+2 channels. This rebound spiking or excitation had been proposed as a mechanism to encode and process inhibitory signals.