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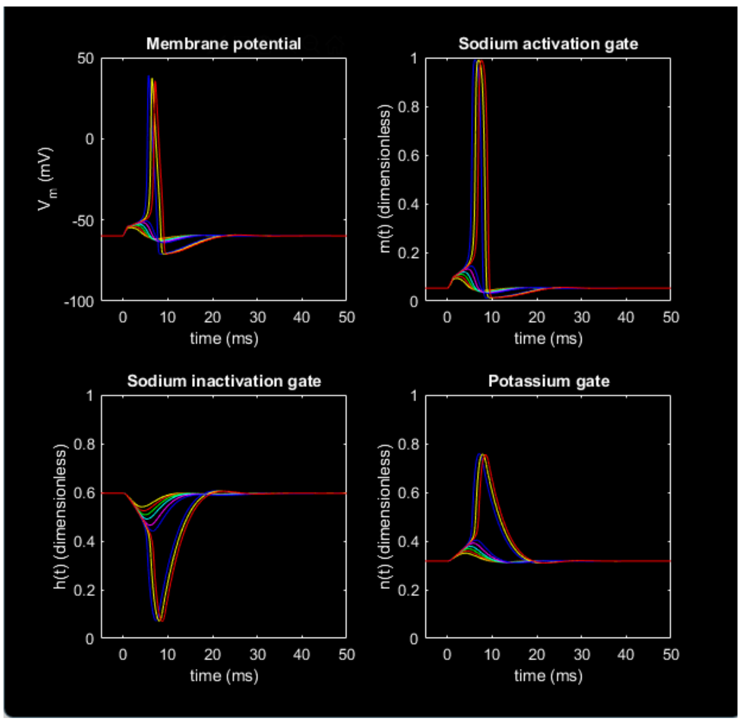
BM2101 - Analysis of Physiological Systems – Assignment 03

GitHub Repo: [Click here]

<u>Explanations of the results</u>

Question 01

- The first step was to identify a suitable sub-threshold and a supra threshold.
- After choosing 6 and 7 as the sub-threshold and the supra-threshold respectively, using the bisection method I got this result. (Check bisec.m MATLAB file as well)



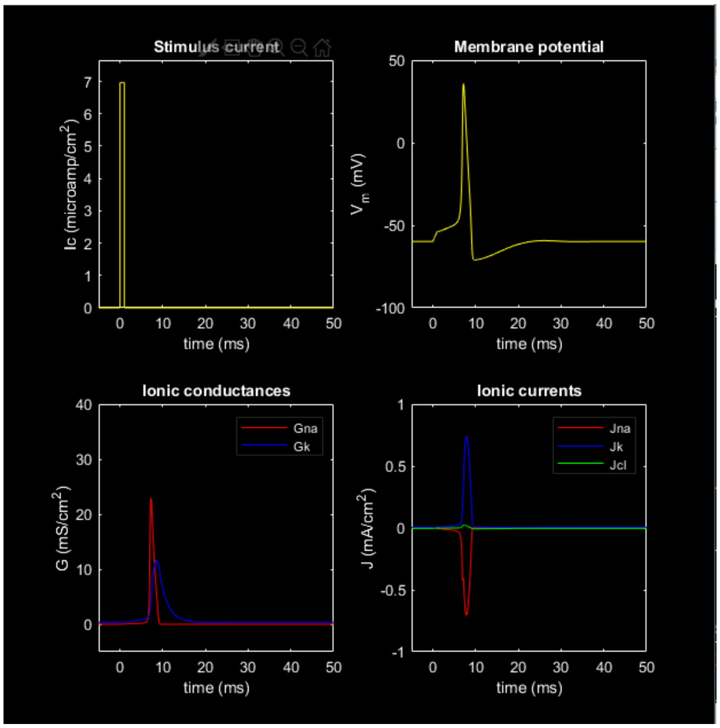

```
When ampliude = 6.5-->-53.9948
When ampliude = 6.75-->-53.262
When ampliude = 6.875-->-52.5262
When ampliude = 6.9375-->-51.562
When ampliude = 6.9688-->37.4533
When ampliude = 6.9531-->-50.7059
When ampliude = 6.9609-->35.8031
```

```
disp("Estimated Threshold is "+round(amp1,2)+" micro Ampere per square centimetres")
```

```
Estimated Threshold is 6.96 micro Ampere per square centimetres
```

- Hence the estimated threshold that meets the accuracy is 6.96 micro-Amperes per square centimeters.

Question 02




```
disp("qna + qk + ql = "+ (qna+qk+ql));
```

```
qna + qk + ql = 6.9617
```

```
disp("qei = "+ (amp1*width1))
```

```
qei = 6.9609
```

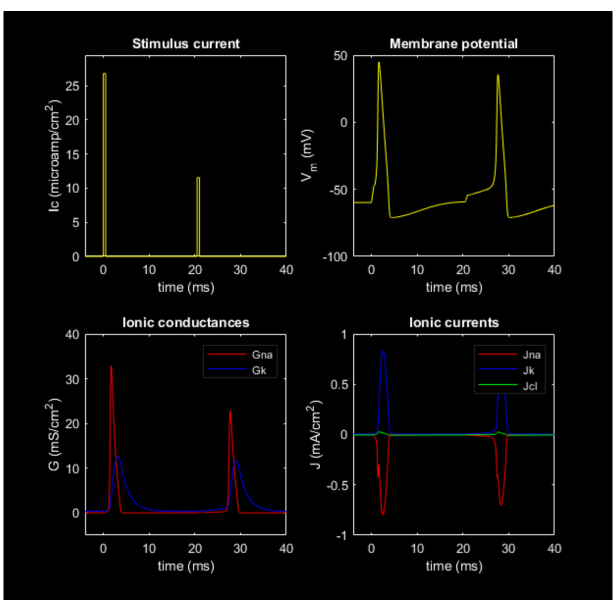
Now we can see that the summation of ionic chargers in K, Na and leak channels is nearly equal to the summation of stimulating chargers.

That is,

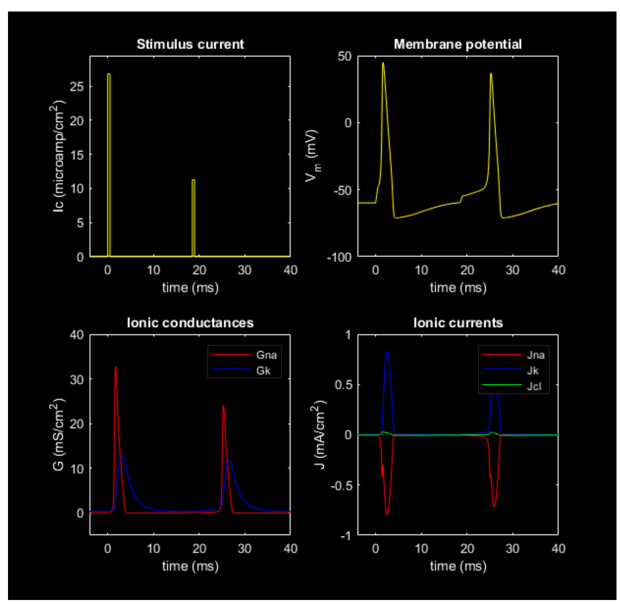
$$\int_{t0}^{tf} \sum_{k} Jk\, dt \approx \int_{t0}^{tf} Jei\, dt$$

Question 03

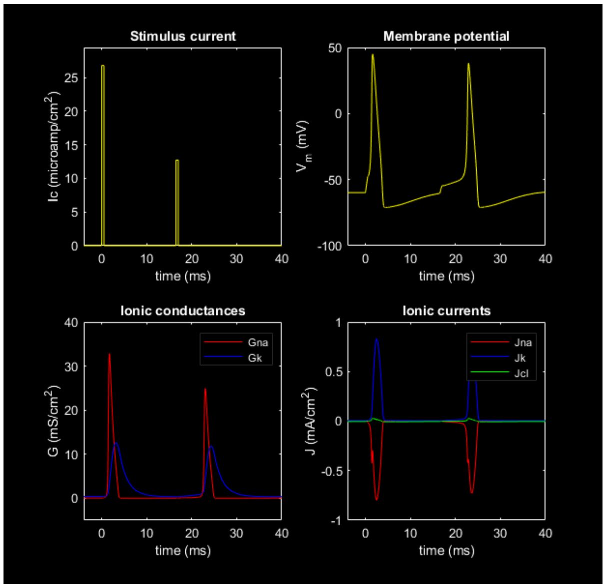
When delay2 = 20 ms,



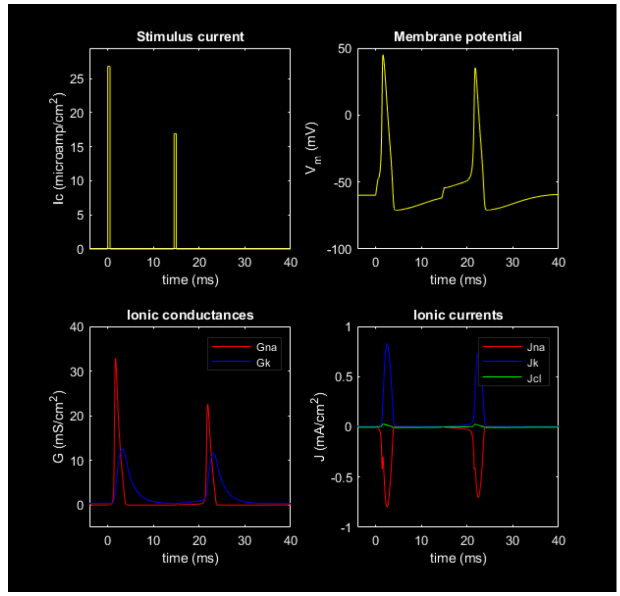
When delay2 = 18 ms,



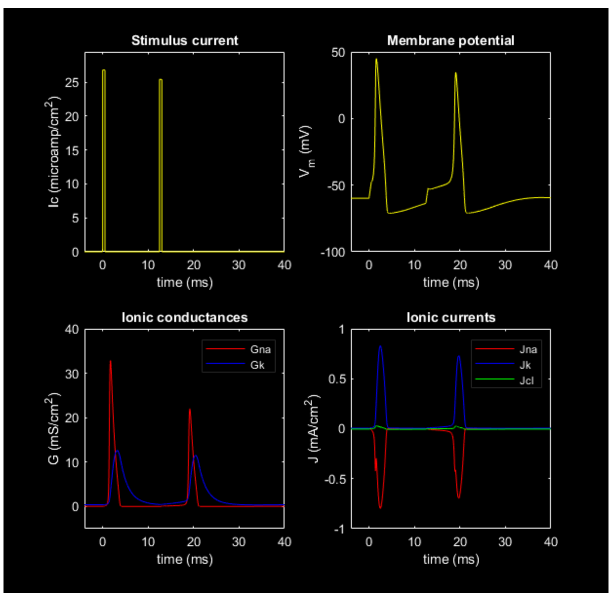
When delay2 = 16 ms,



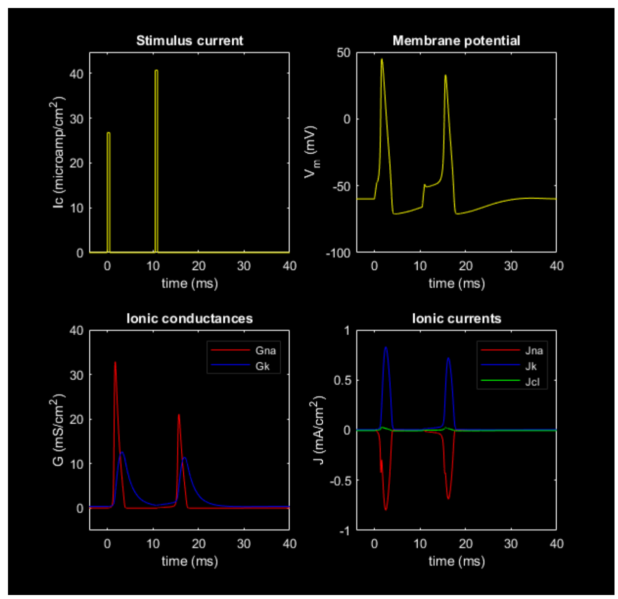
When delay2 = 14 ms,



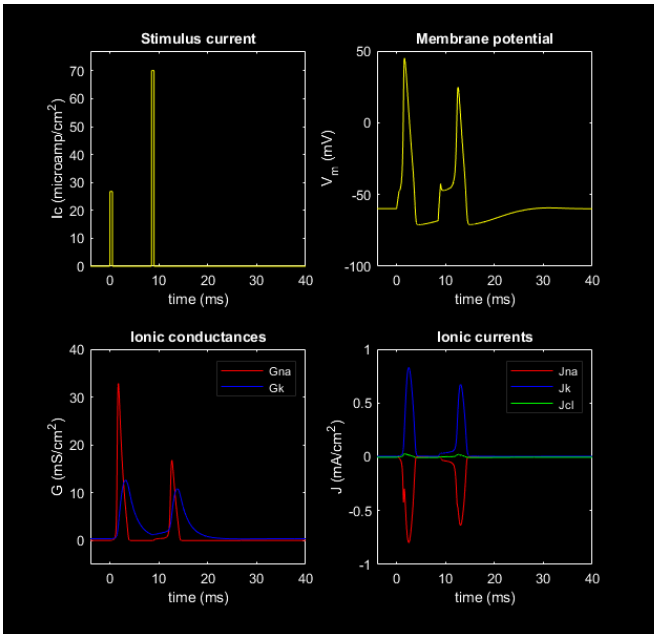
When delay2 = 12 ms,



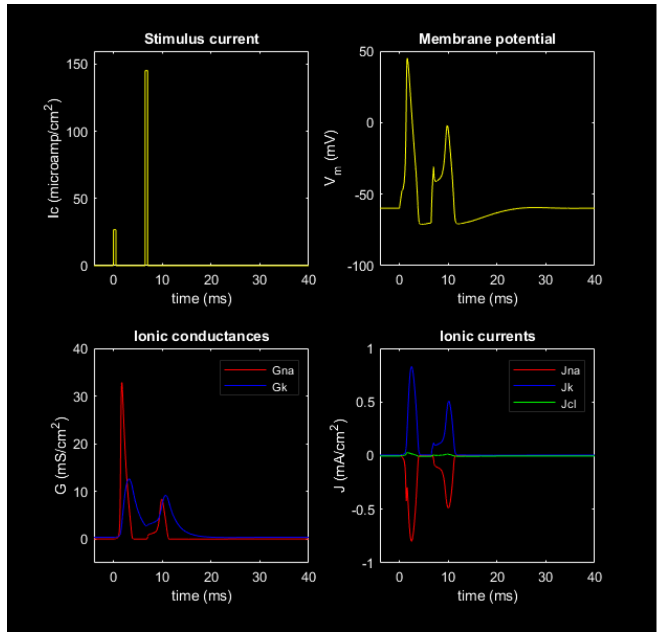
When delay2 = 10 ms,



When delay2 = 8 ms,

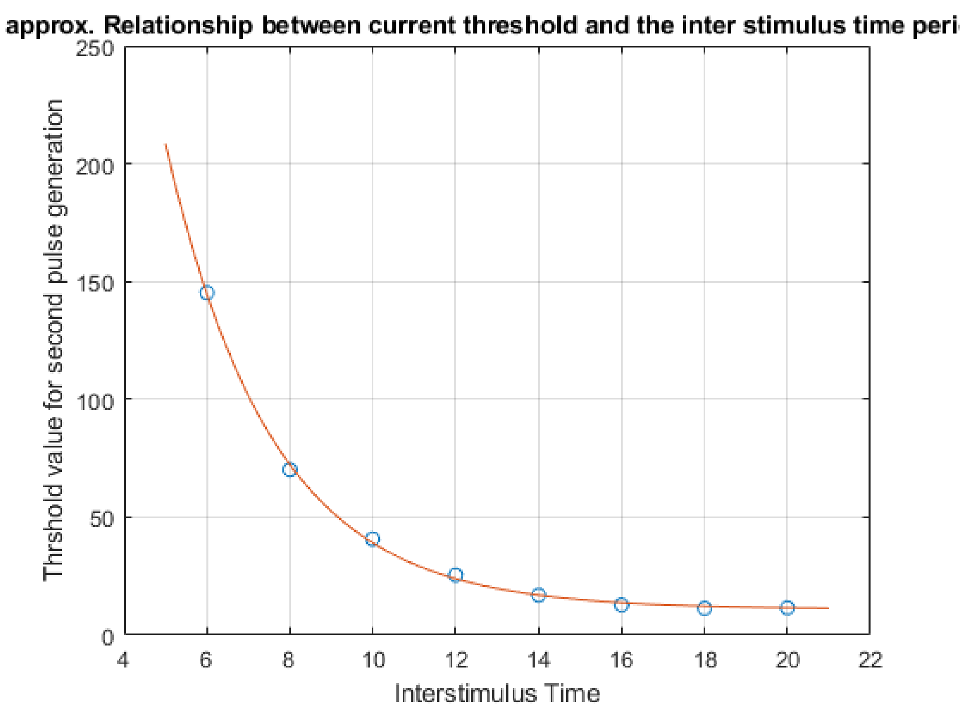


When delay2 = 6 ms,

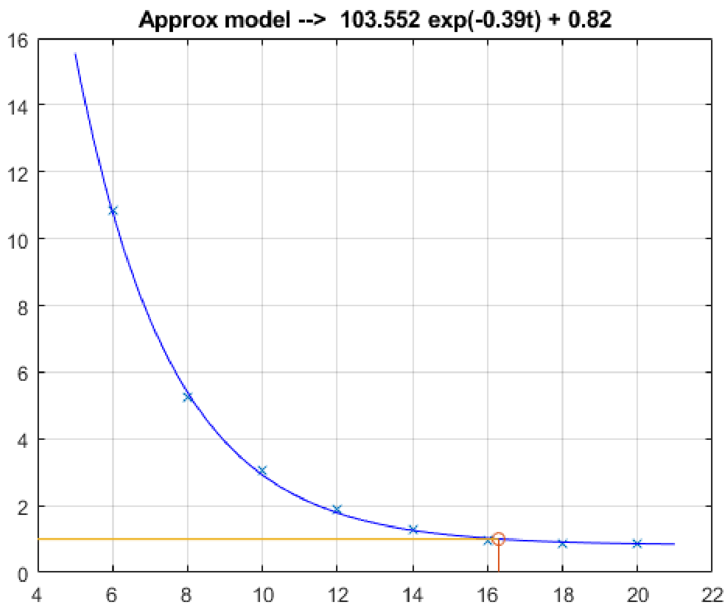


When we reduce the delay2, the stimulus current we need tends to increase a lot.

Please see ***fitModel.ipynb*** file to see how I derived an approximate model to the relationship between current threshold and the inter stimulus time period.



Question 04



Here we plot the ratio between the second threshold and the first threshold in front of the inter stimulus time.

The sodium gates are opened with the start of first action potential and then start to close during the repolarization. When the potassium channels fully opened, the Na gates are almost closed, and the time is around 3.188 ms. Therefore, the absolute refractory period is nearly 0ms - 3.188ms. From the above plot, we can see that the threshold is more than 15 times the initial threshold.

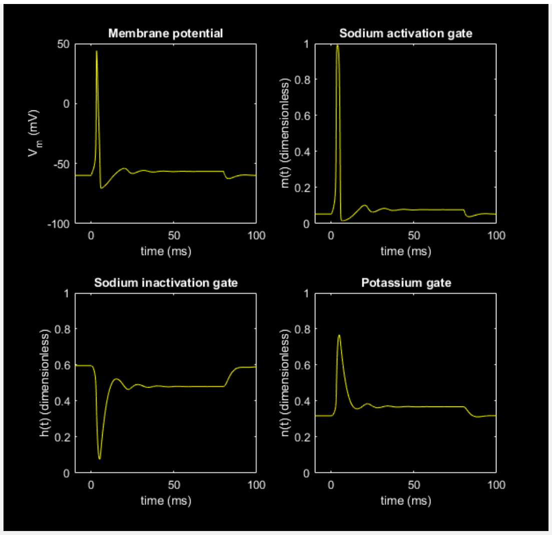
Then starts the relative refractory period. There we can initiate a second action potential with the expense of a high stimulus current. The stimulus current we need becomes equal to the first stimulus current value, when the time is around, 16.946 ms according to the above calculations and the plot. Therefore, the relative refractory period is nearly from 3.188ms to 16.946 ms.

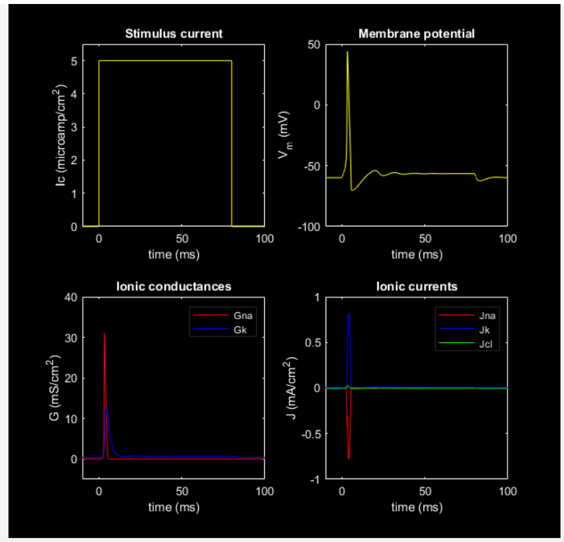
Absolute refractory period ---> nearly 0 ms to 3.188 ms

Relative refractory period ----> nearly 3.188 ms to 16.946 ms

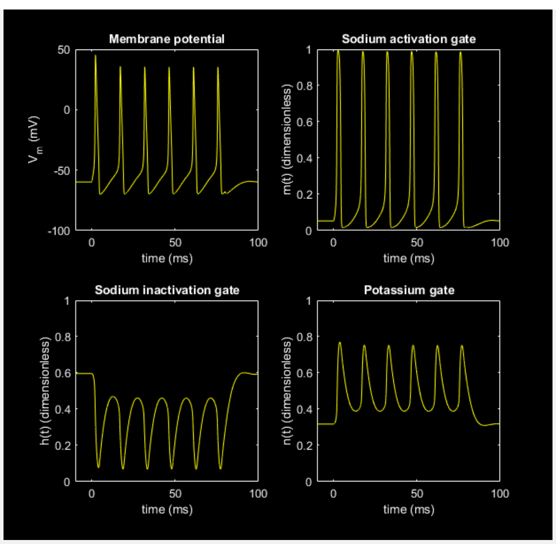
Question 05

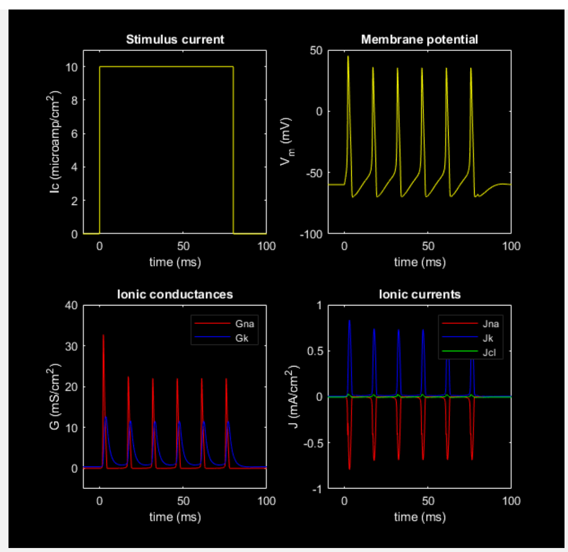
When amplitude = 5 μAcm^{-2}



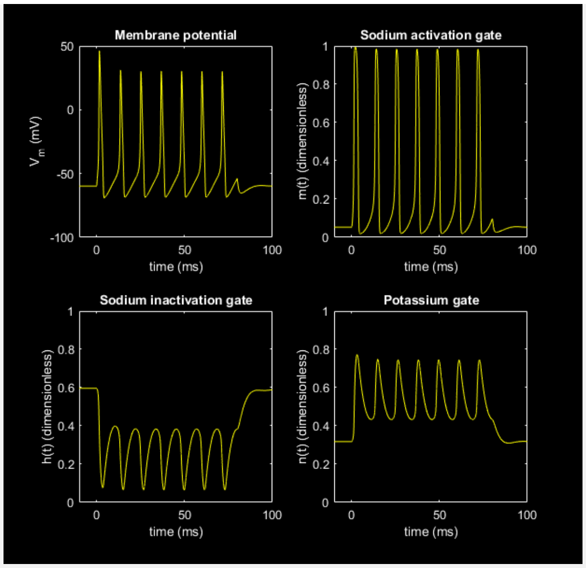


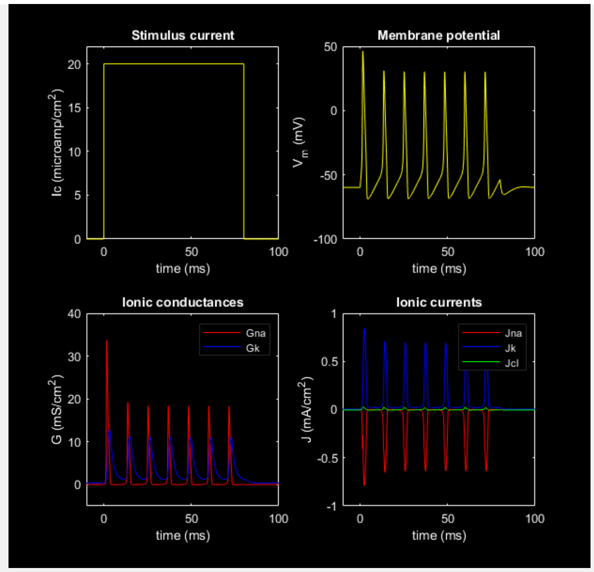
When amplitude = 10 μAcm^{-2}



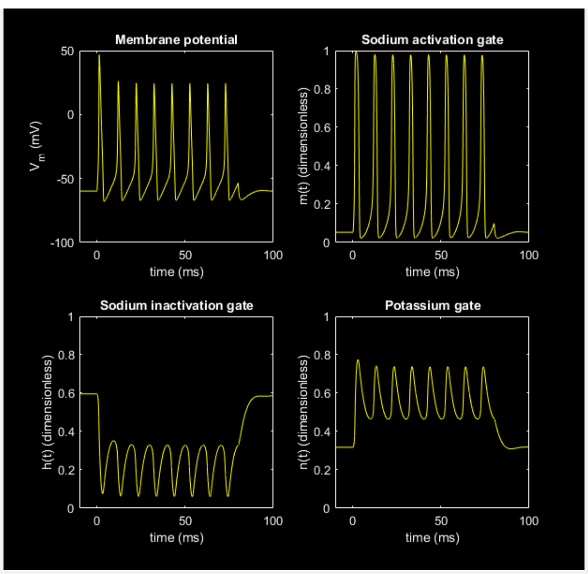


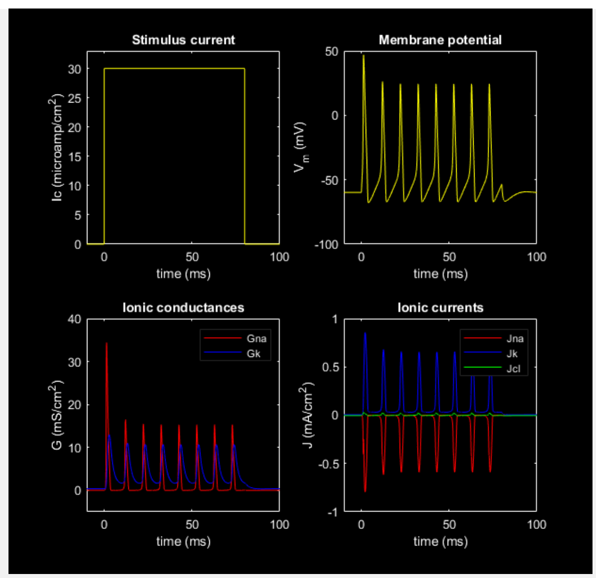
When amplitude = 20 μAcm^{-2}



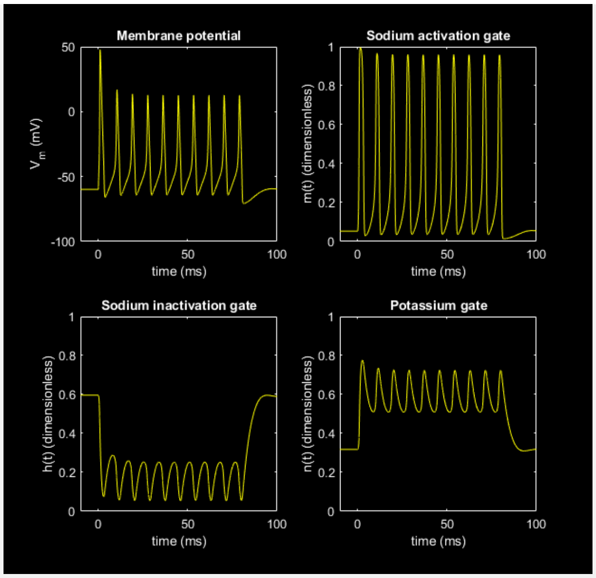


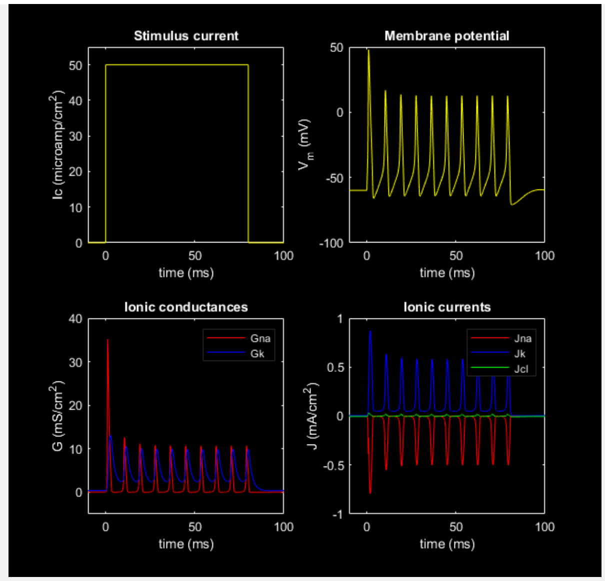
When amplitude = 30 μAcm^{-2}



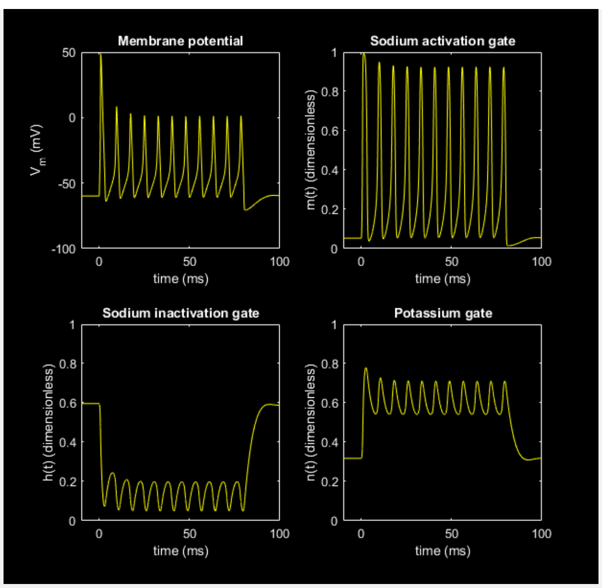


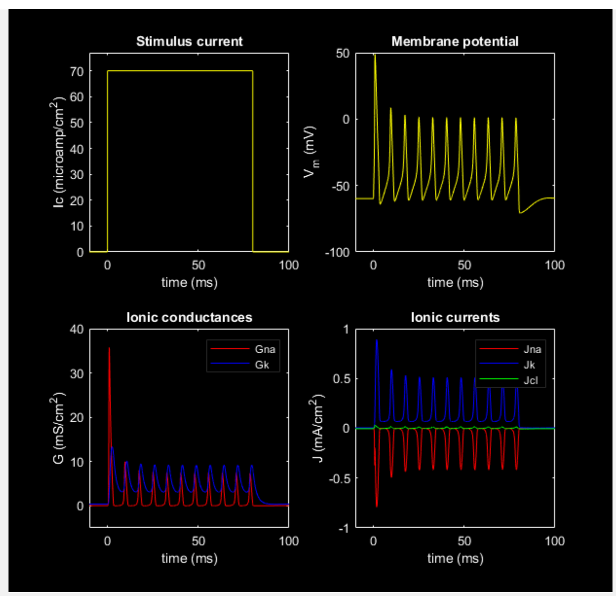
When amplitude = 50 μAcm^{-2}



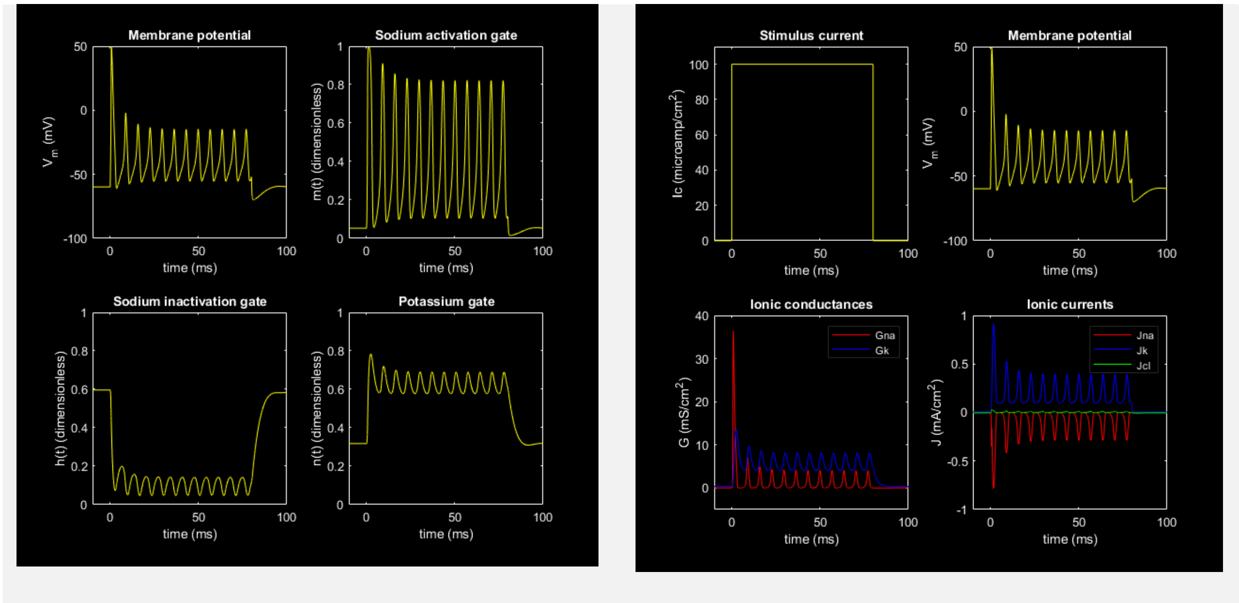


When amplitude = 70 μAcm^{-2}

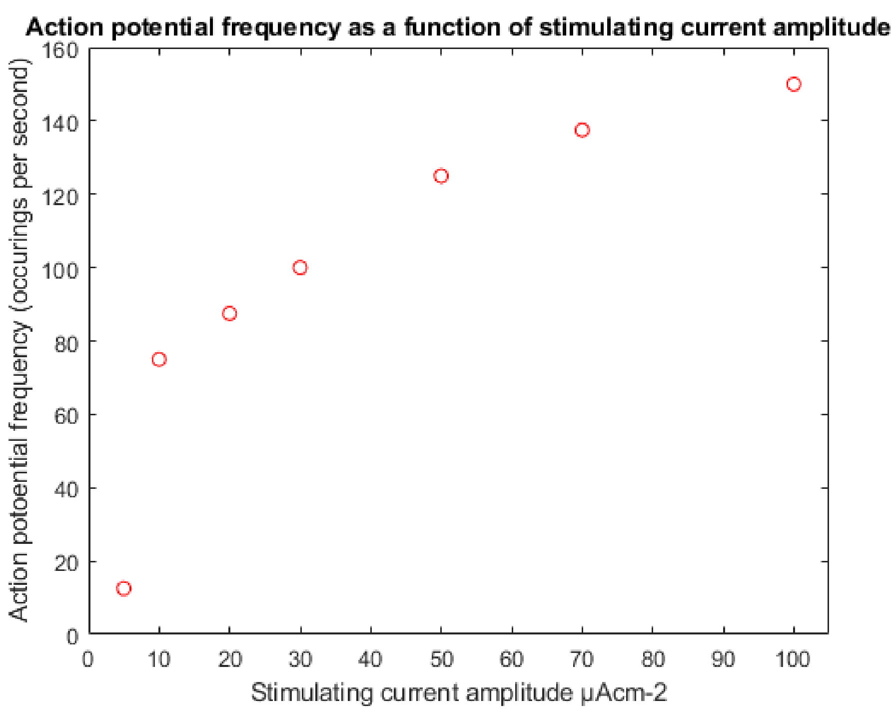




When amplitude = 100 μAcm^{-2}

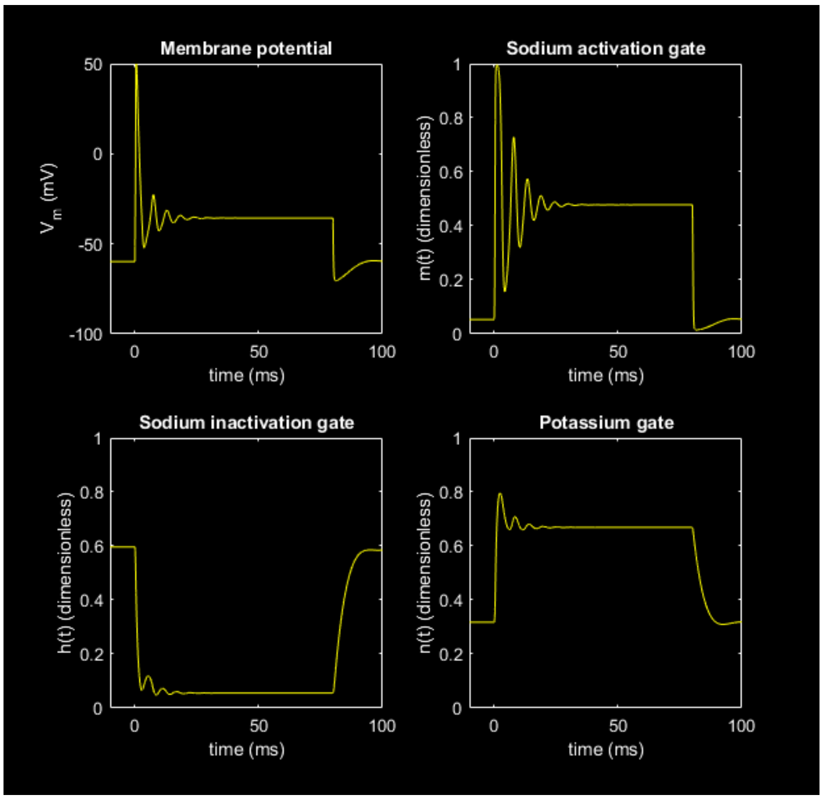



```
When amplitude = 5, action potential frequency = 12.5
When amplitude = 10, action potential frequency = 75
When amplitude = 20, action potential frequency = 87.5
When amplitude = 30, action potential frequency = 100
When amplitude = 50, action potential frequency = 125
When amplitude = 70, action potential frequency = 137.5
When amplitude = 100, action potential frequency = 150
```



- In every case, the first action potential has a significantly higher amplitude than the next set of action potentials.
- When the stimulus intensity amplitude increases, the action potential amplitude decreases.
- But the first action potential has only a little deviation compared to the other action potentials after it, in every case.

Question 06



Explanation for Question 5:

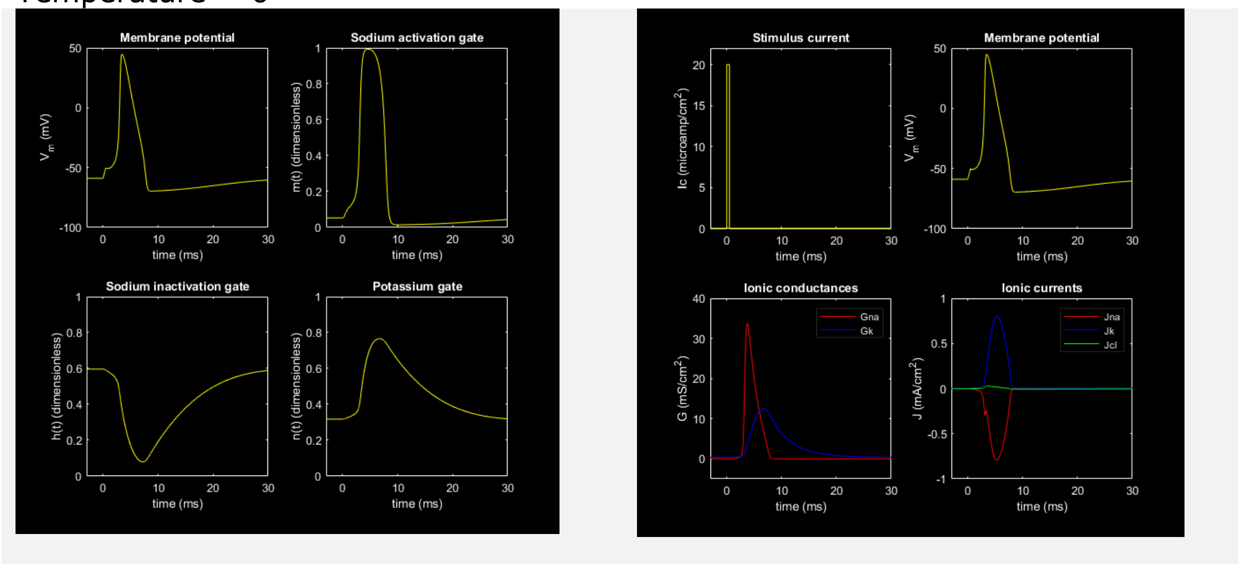
The h and n factors in the Hodgkin-Huxley equations are depends on Vm. From the results we got, we can clearly see that the Na+ and K+ gates have switched more faster. That is due to the effect of Vm on "h and n" as reducing "h" and increasing "n" values. Hence the frequency of switching is increased with the stimulus intensity.

Explanation for Question 6:

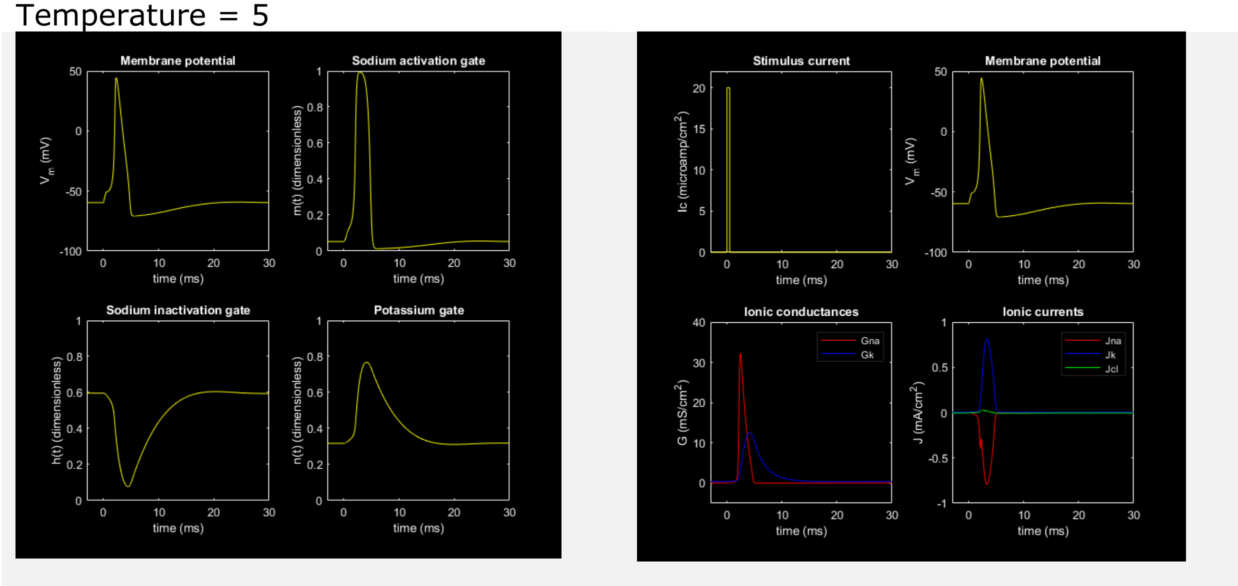
The voltage gated switches require a charge gradient across the cell membrane to function properly. But when we switch more faster, the time that the cell has to develop such charge gradient across the cell membrane is not enough. Therefore, voltage gated channels can’t function properly. We have a damped situation.

Question 07

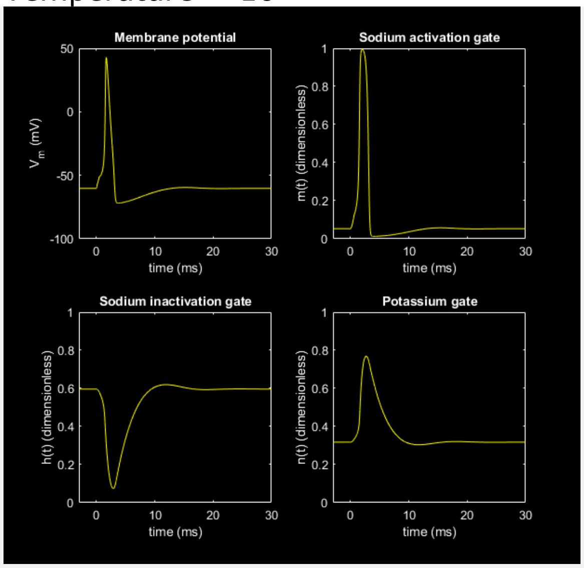
Temperature = 0

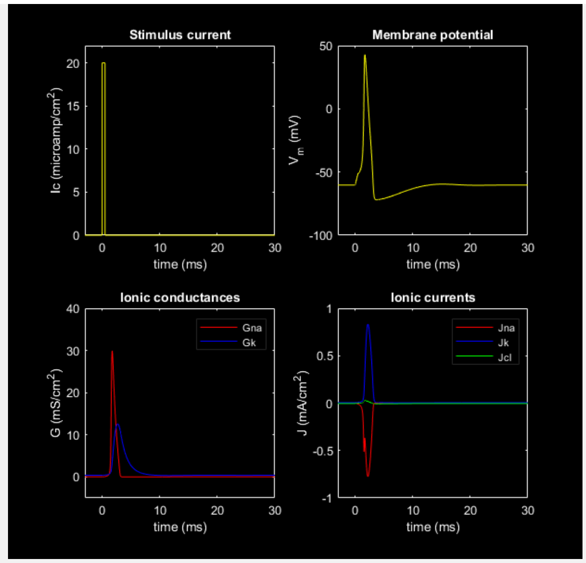


Temperature = 5

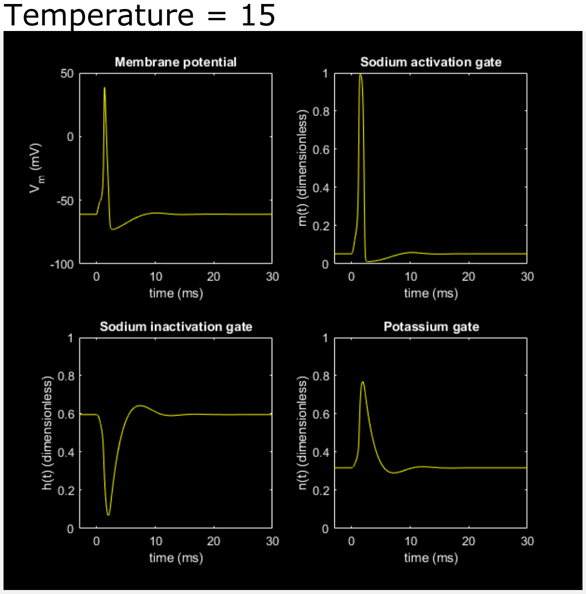


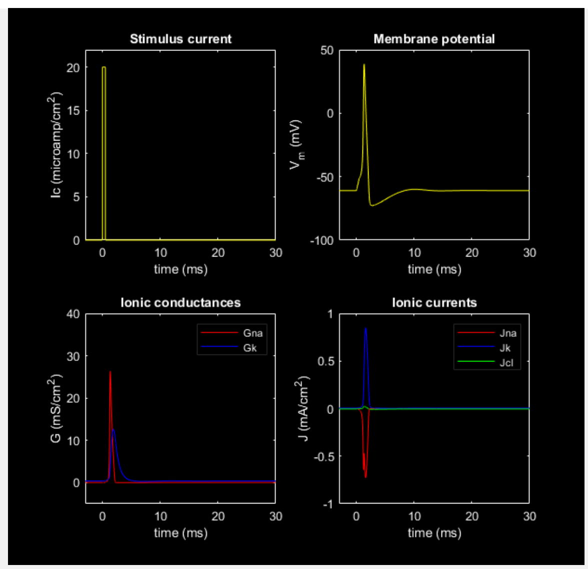
Temperature = 10



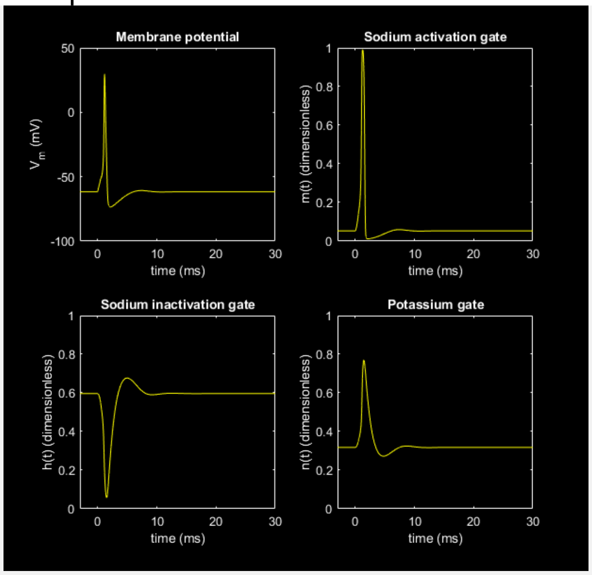


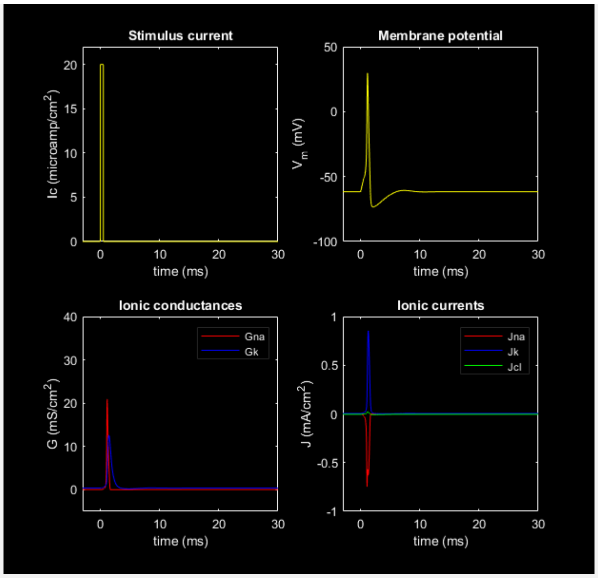
Temperature = 15



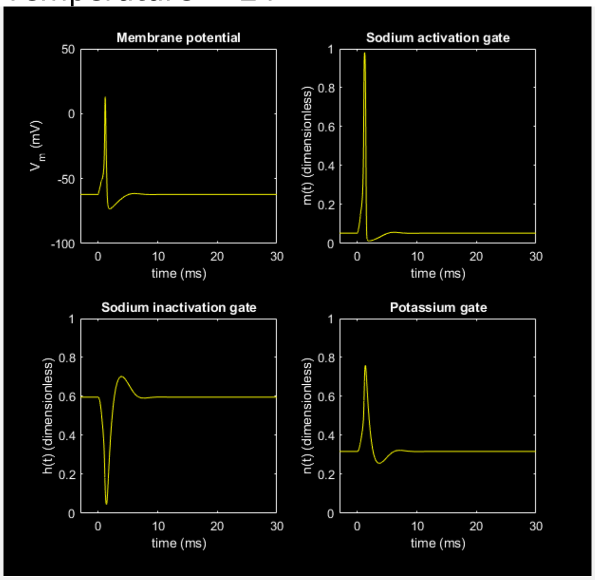


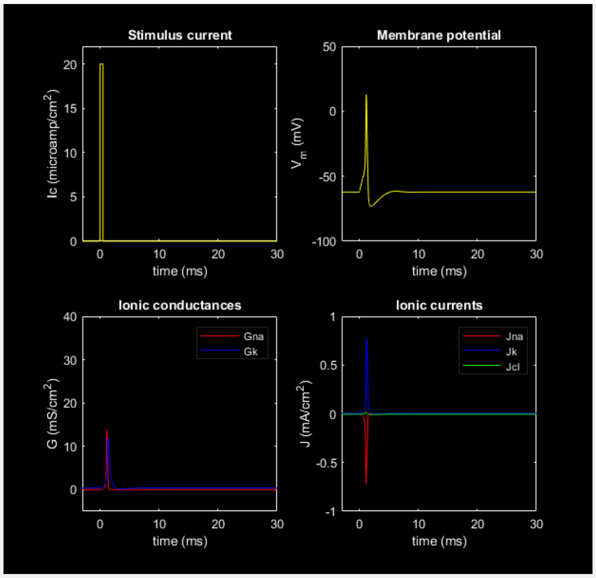
Temperature = 20



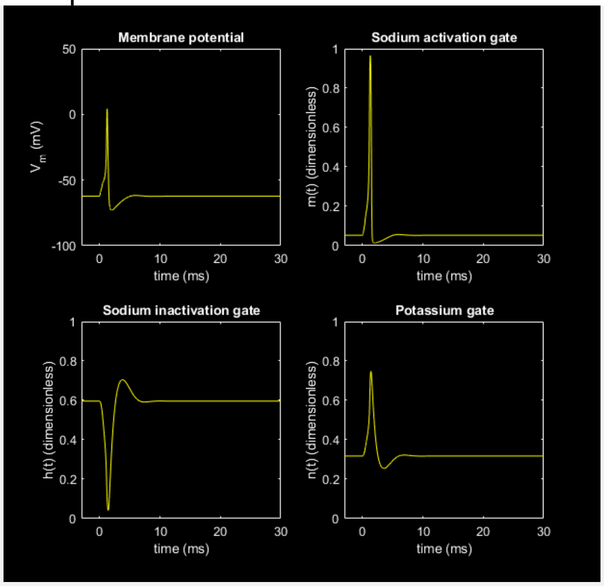


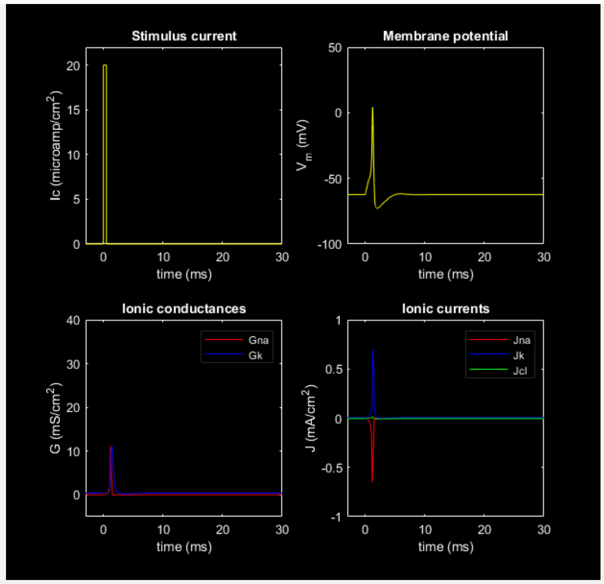
Temperature = 24



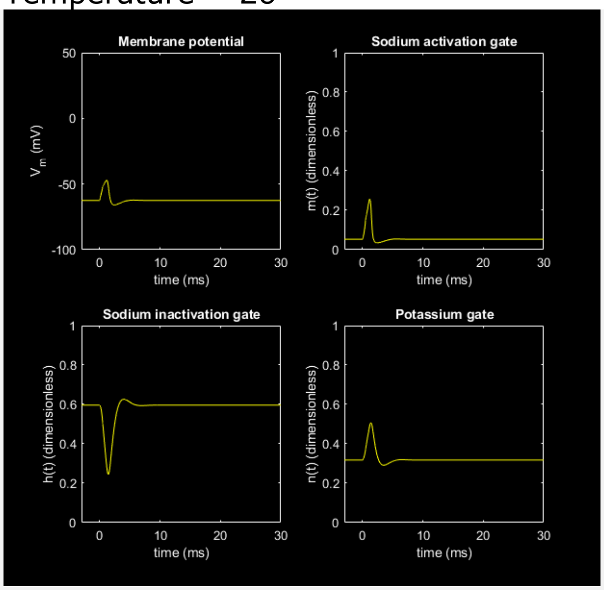


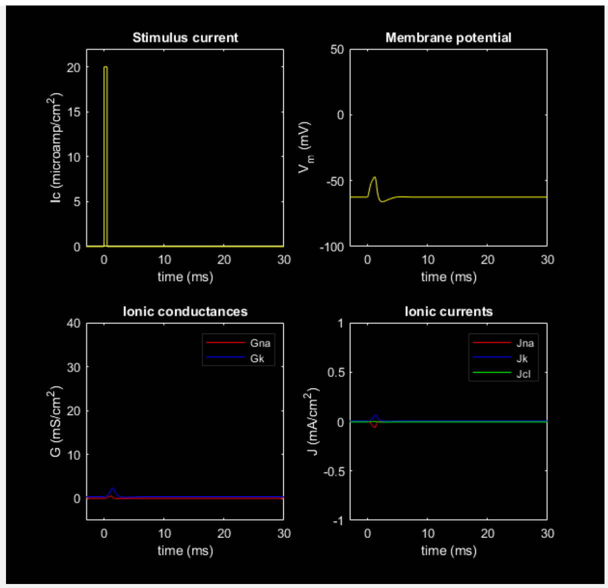
Temperature = 25



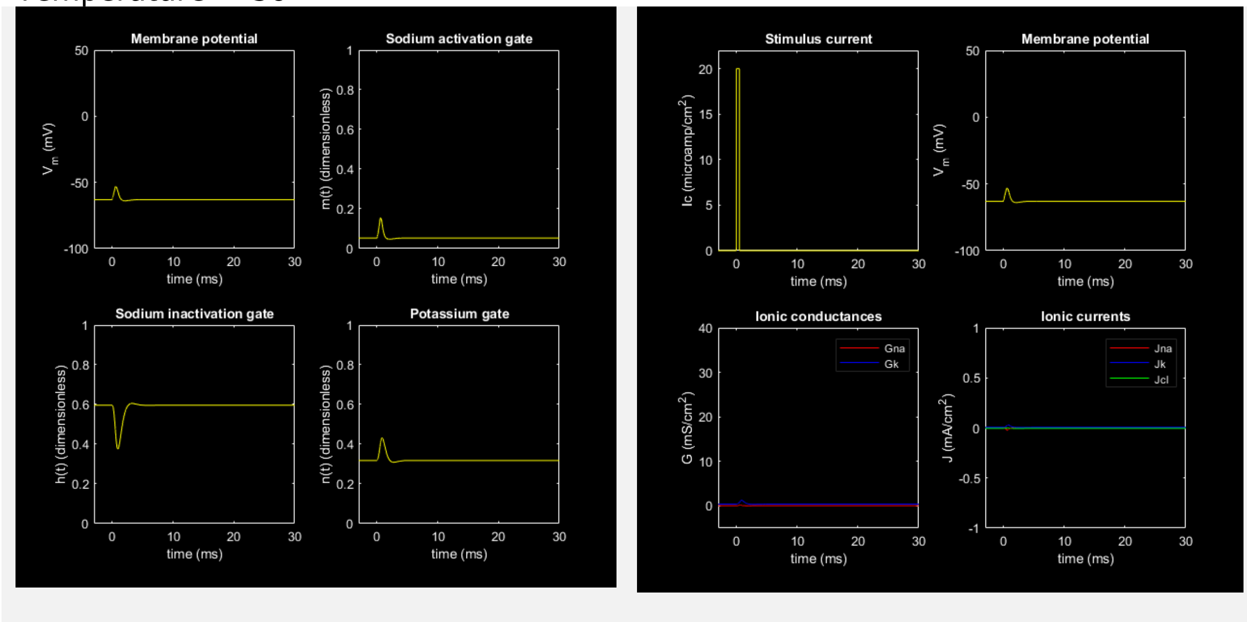


Temperature = 26





Temperature = 30



- Effect of temperature on the amplitude – When the temperature increases the amplitude reduces
- Effect of temperature on the duration – When the temperature increases the duration of the action potential also reduces.
- Explanation – When the temperature is increased the opening of Potassium gates happen early than before. Hence the cell loose much more potassium ions. Therefore, the amplitude of the action potential is lower than before. Also, the duration is shortened.
- In generally the amplitude, duration and the occurrence of action potential is effected by the temperature.