# Biol635/Math635/Biol432/Math430
# Fall 2023
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# Assignment 1

**Answer the following questions.**

- Justify your answers.
- Explain your results.
- Provide the necessary calculations in a clear way.
- Provide the codes you used (if any).

**Question 1**

Calculate the equilibrium (reversal) potentials for the following ions at a temperature of 20° C.

**(a)** $K^+$, $[K^+]_{out}$= 5 mmol/L, $[K^+]_{in}$= 150 mmol/L.
**(b)** $Na^+$, $[Na^+]_{out}$= 150 mmol/L, $[Na^+]_{in}$= 15 mmol/L.
**(c)** $Cl^-$, $[Cl^-]_{out}$= 125 mmol/L, $[Cl^-]_{in}$= 10 mmol/L.
**(d)** $Ca^{2+}$, $[Ca^{2+}]_{out}$= 2 mmol/L, $[Ca^{2+}]_{in}$= 0.0002 mmol/L.
**(e)** What is the effect of increasing the temperature to 25° C on these equilibrium potentials.
**(f)** Plot graphs of $E_{Na}$, $E_K$, $E_{Ca}$ and $E_{Cl}$ as a function of temperature in the range 10° C to 40° C.

Note: Mind the units and the signs.

**Question 2**

**(a)** Consider an ion $X^+$ at 20° C. What is the concentration relation $[X^+]_{out}/\ [X^+]_{in}$ necessary to maintain a resting membrane potential V = -60 mV?
**(b)** How is this value affected when the temperature is increased to 25° C?

**(c)** Plot a graph of the concentration relation $[X^+]_{out}/\,[X^+]_{in}$ necessary to maintain a resting membrane potential V = -60 mV as a function of the temperature in the range 10° C to 40° C.

## Question 3

Consider the following passive membrane equation

$$\tau \frac{dV}{dt} = -(V - E_L) + R\, I_{app} \tag{1}$$

with $V(0) = E_L$, $R = 100\, M\Omega$, $C = 100\, pF$, $I_{app} = 0.25\, nA$ and $E_L = -60mV$.

**(a)** Calculate the value of $\tau$.

**(b)** Calculate the value of the term $R\, I_{app}$.

**(c)** Calculate, if possible, the time it takes the voltage to reach $V = -50\, mV$.

**(d)** Calculate, if possible, the time it takes the voltage to reach $V = -30\, mV$.

Note: Mind the units and the signs.

## Question 4

Write a code to solve numerically eq. (1) or adapt the template code provided in the course website. Simulate eq. (1) for the parameter values provided in Question 3. Repeat the process for $I_{app} = 0.5\, nA$

Note: The axis should be labeled correctly and the fonts should be large enough (suggested: "fontsize" = 24).