UNIVERSITY OF MORATUWA, SRI LANKA

Faculty of Engineering

Department of Electronic and Telecommunication Engineering

Semester 4 (Intake 2020)

BM2102 Analysis of physiological systems

Assignment 2

Branched Cylinders: Dendritic Tree Approximations

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200664P

Assignment 2. 200664P

Q1) From (1)

$$\frac{d^2V}{dx^2} = V$$

$$V = e^{mx}$$

$$\frac{dV}{dx} = me^{mx} \qquad \frac{d^2V}{dx^2} = m^2e^{mx}$$

$$(m^2-1) = 0$$

$$m = \pm 1$$

$$V = A_1e^{-x} + A_2e^{x}$$

From (2)

$$V_1(x) = A_1e^{-x} + B_1e^{x} \quad \text{—— (A)}$$

$$V_{21}(x) = A_{21}e^{-x} + B_{21}e^{x} \quad \text{—— (B)}$$

$$V_{22}(x) = A_{22}e^{-x} + B_{22}e^{x} \quad \text{—— (C)}$$

(A) →

$$\frac{dV_1}{dx} = A_1(-1)e^{-x} + B_1e^{x}$$

at $x = 0$,

$$B_1 - A_1 = -(r_i\lambda_c)_1 I_{app}$$

$$A_1 - B_1 = (r_i\lambda_c)_1 I_{app} \quad \text{—— (i)}$$

$V_{21}(L_{21}) = V_{22}(L_{22}) = 0$

When $X = L_{21}$

$\rightarrow B$

$$\underbrace{V_{21}(L_{21})}_{0} = A_{21} e^{-L_{21}} + B_{21} e^{L_{21}}$$

$$A_{21} e^{-L_{21}} + B_{21} e^{L_{21}} = 0 \quad \text{— (ii)}$$

At $X = L_{22}$,

$$\underbrace{V_{22}(L_{22})}_{0} = A_{22} e^{-L_{22}} + B_{22} e^{L_{22}}$$

$$A_{22} e^{-L_{22}} + B_{22} e^{L_{22}} = 0 \quad \text{— (iii)}$$

Using nodal conditions,

$$\underbrace{V_1(L_1) = V_{21}(L_1)}_{} = V_{22}(L_1)$$

$$V_1(L_1) = A_1 e^{-L_1} + B_1 e^{L_1} \quad \text{— (D)}$$

$$V_{21}(L_1) = A_{21} e^{-L_1} + B_{21} e^{L_1} \quad \text{— (E)}$$

$$V_{22}(L_1) = A_{22} e^{-L_1} + B_{22} e^{L_1} \quad \text{— (F)}$$

D = E $\Rightarrow$

$$A_1 e^{-L_1} + B_1 e^{L_1} - A_{21} e^{-L_1} - B_{21} e^{L_1} = 0 \quad \text{— (iv)}$$

E = F $\Rightarrow$

$$A_{21} e^{-L_1} + B_{21} e^{L_1} - A_{22} e^{-L_1} - B_{22} e^{L_1} = 0 \quad \text{— (v)}$$

$$\frac{dV_1}{dx} = -A_1 e^{-x} + B_1 e^{x}$$

$$\left.\frac{dV_1}{dx}\right|_{x=L_1} = -A_1 e^{-L_1} + B_1 e^{L_1} \quad \text{— G}$$

$$\frac{dV_{21}}{dx} = -A_{21} e^{-x} + B_{21} e^{x}$$

$$\left.\frac{dV_{21}}{dx}\right|_{x=L_1} = -A_{21} e^{-L_1} + B_{21} e^{L} \quad \text{— H}$$

$$\frac{dV_{22}}{dx} = -A_{22} e^{-x} + B_{22} e^{x}$$

$$\left.\frac{dV_{22}}{dx}\right|_{x=L_1} = -A_{22} e^{-L_1} + B_{22} e^{L_1} \quad \text{— I}$$

From G, H, I and 6,

$$\frac{1}{(r_i \lambda_c)_1}\left(-A_1 e^{-L_1} + B_1 e^{L_1}\right) = \frac{1}{(r_i \lambda_c)_{21}}\left(-A_{21} e^{-L_1} + B_{21} e^{L_1}\right)$$

$$+\frac{1}{(r_i;\lambda_c)_{22}}\left(-A_{22}e^{-L_1}+B_{22}e^{L_1}\right)$$

$$-\frac{A_1 e^{-L_1}}{(r_i;\lambda_c)_1}+\frac{B_1 e^{L_1}}{(r_i;\lambda_c)_1}+\frac{A_{21}e^{-L_1}}{(r_i;\lambda_c)_{21}}-\frac{B_{21}e^{L_1}}{(r_i;\lambda_c)_{21}}$$

$$+\frac{A_{22}e^{-L_1}}{(r_i;\lambda_c)_{22}}-\frac{B_{22}e^{L_1}}{(r_i;\lambda_c)_{22}}=0 \quad \text{—— (vi)}$$

$$(vi)\equiv 7$$

2 $Ax=b$

$Ax=$

$$\begin{bmatrix} 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & e^{-L_{21}} & e^{L_{21}} & 0 & 0 \\ 0 & 0 & 0 & 0 & e^{-L_{22}} & e^{L_{22}} \\ e^{-L_1} & e^{L_1} & -e^{-L_1} & -e^{L_1} & 0 & 0 \\ 0 & 0 & e^{-L_1} & e^{L_1} & -e^{-L_1} & -e^{L_1} \\ \frac{-e^{-L_1}}{(r_i;\lambda_c)_1} & \frac{e^{L_1}}{(r_i;\lambda_c)_1} & \frac{e^{-L_1}}{(r_i;\lambda_c)_{21}} & \frac{-e^{L_1}}{(r_i;\lambda_c)_{21}} & \frac{e^{-L_1}}{(r_i;\lambda_c)_{22}} & \frac{-e^{L_1}}{(r_i;\lambda_c)_{22}} \end{bmatrix} \begin{bmatrix} A_1 \\ B_1 \\ A_{21} \\ B_{21} \\ A_{22} \\ B_{22} \end{bmatrix}$$

$$
= \begin{pmatrix}
A_1 - B_1 \\
A_{21} e^{-L_{21}} + B_{21} e^{L_{21}} \\
A_{22} e^{-L_{22}} + B_{22} e^{L_{22}} \\
A_1 e^{-L_1} + B_1 e^{L_1} - A_{21} e^{-L_1} - B_{21} e^{L_1} \\
A_{21} e^{-L_1} + B_{21} e^{L_1} - A_{22} e^{-L_1} - B_{22} e^{L_1} \\
-\frac{e^{-L_1} A_1}{(\gamma_i \lambda_c)_1} + \frac{B_1 e^{L_1}}{(\gamma_i \lambda_c)_1} + \frac{A_{21} e^{-L_1}}{(\gamma_1 \lambda_c)_{21}} - \frac{B_{21} e^{-L_1}}{(\gamma_1 \lambda_c)_{21}} \\
+ \frac{e^{-L_1} A_{22}}{(\gamma_i \lambda_c)_{22}} - \frac{e^{-L_1} B_{22}}{(\gamma_1 \lambda_c)_{22}}
\end{pmatrix}
$$

from equations i, ii, iii, iV, v, vi

$$
Ax = \begin{pmatrix}
(\gamma_i \lambda_c)_1 I_{app} \\
0 \\
0 \\
0 \\
0 \\
0
\end{pmatrix} = b
$$

Assignment2

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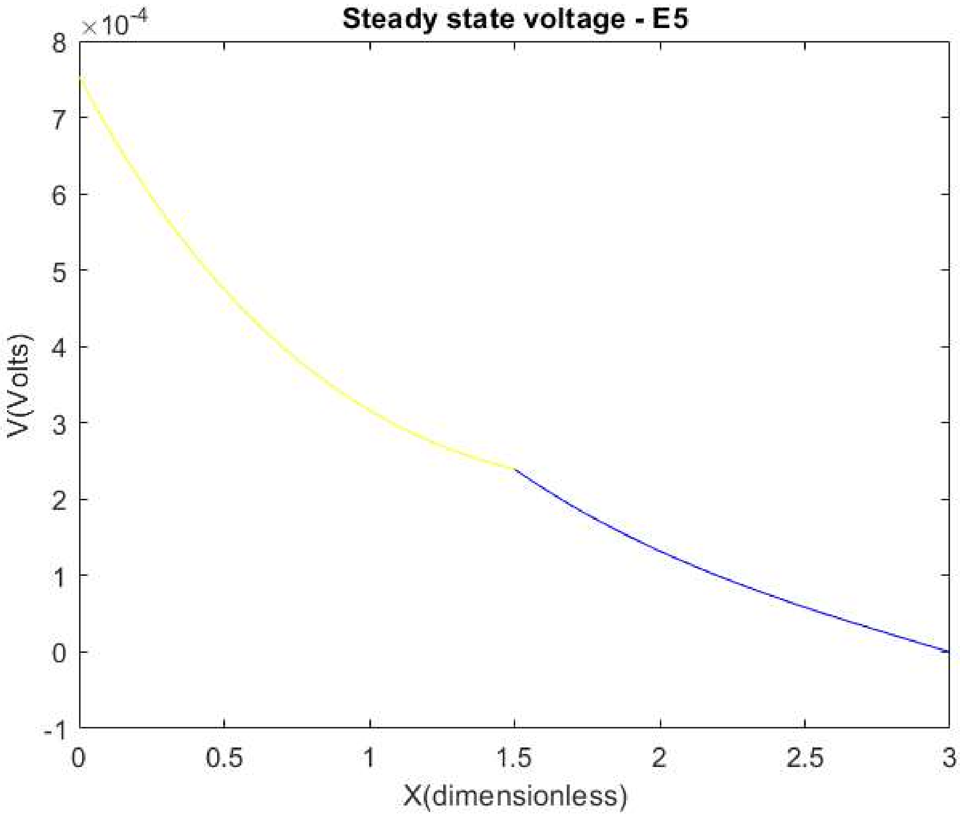
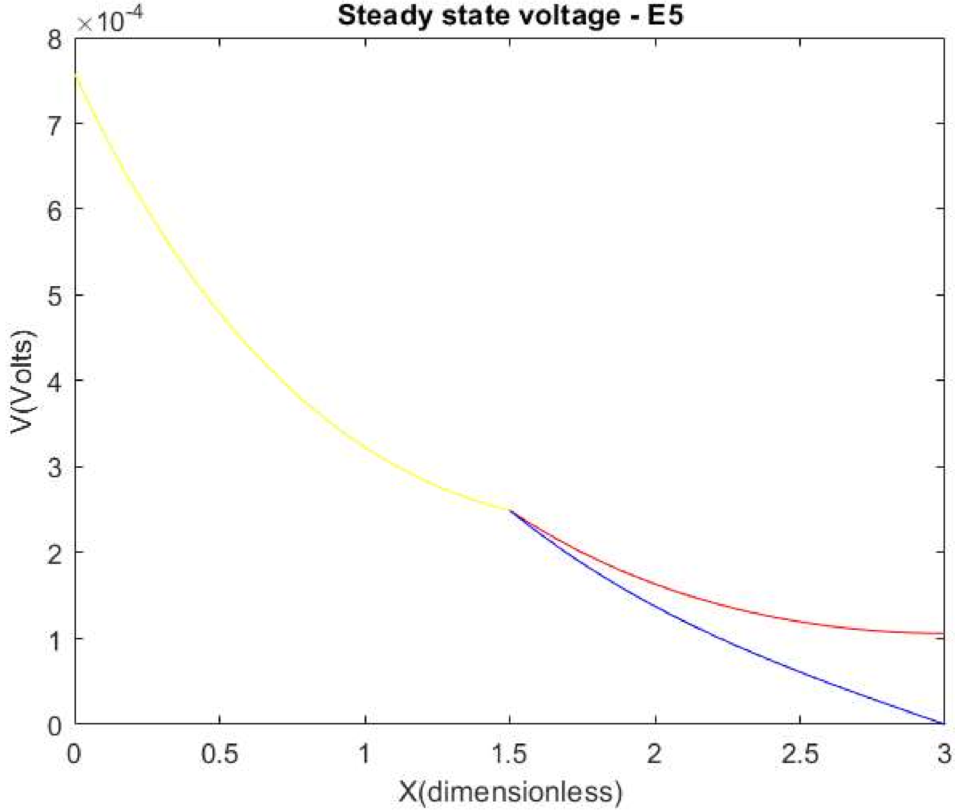
Q3

```
x = 6×1
    0.0007
    0.0000
    0.0011
   -0.0000
    0.0011
   -0.0000
```

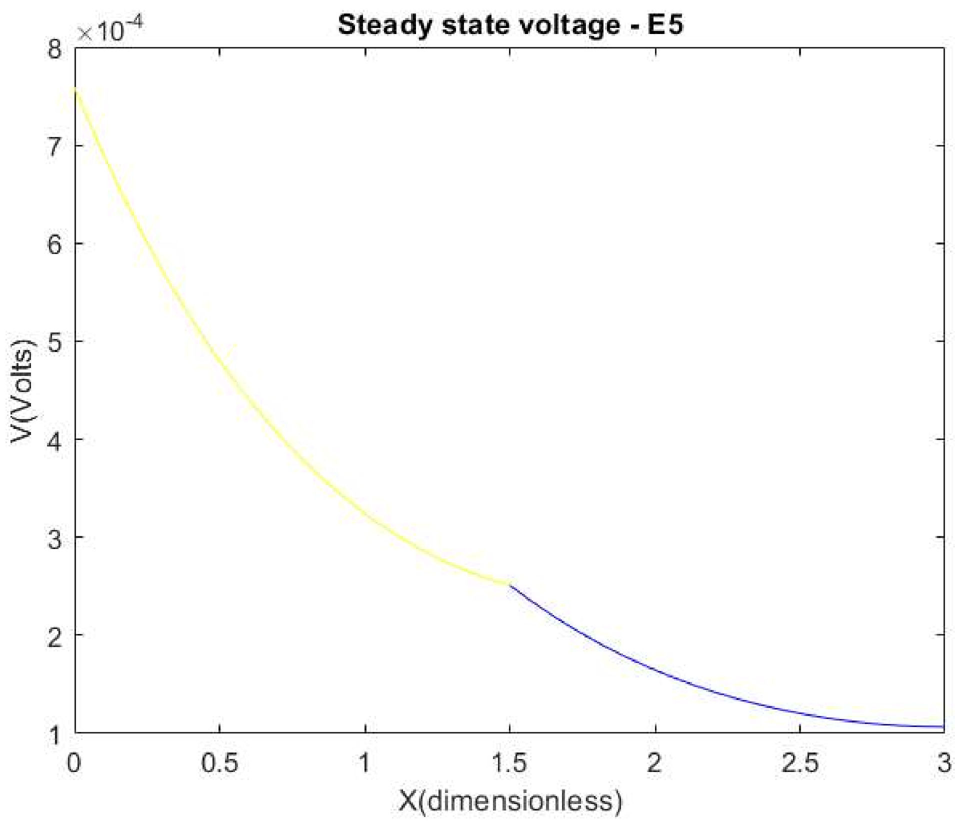
Q4



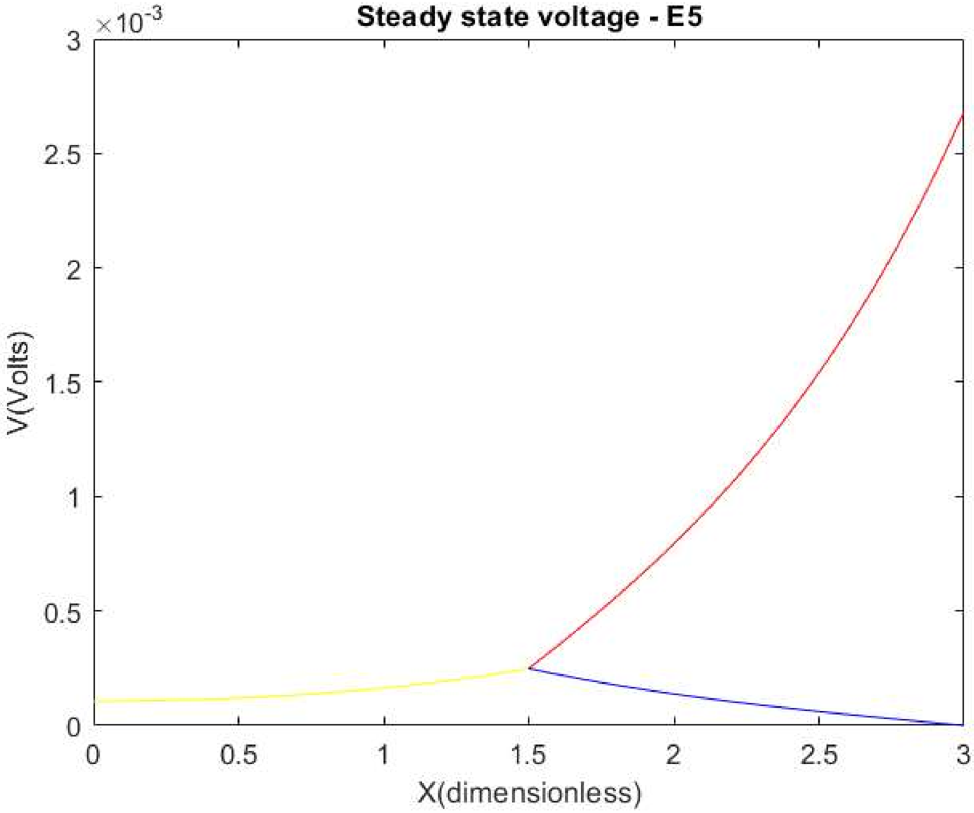
Part a


Steady state voltage - E5
×10^-4
8
7
6
5
4
3
2
1
0
V(Volts)
0
0.5
1
1.5
2
2.5
3
X(dimensionless)

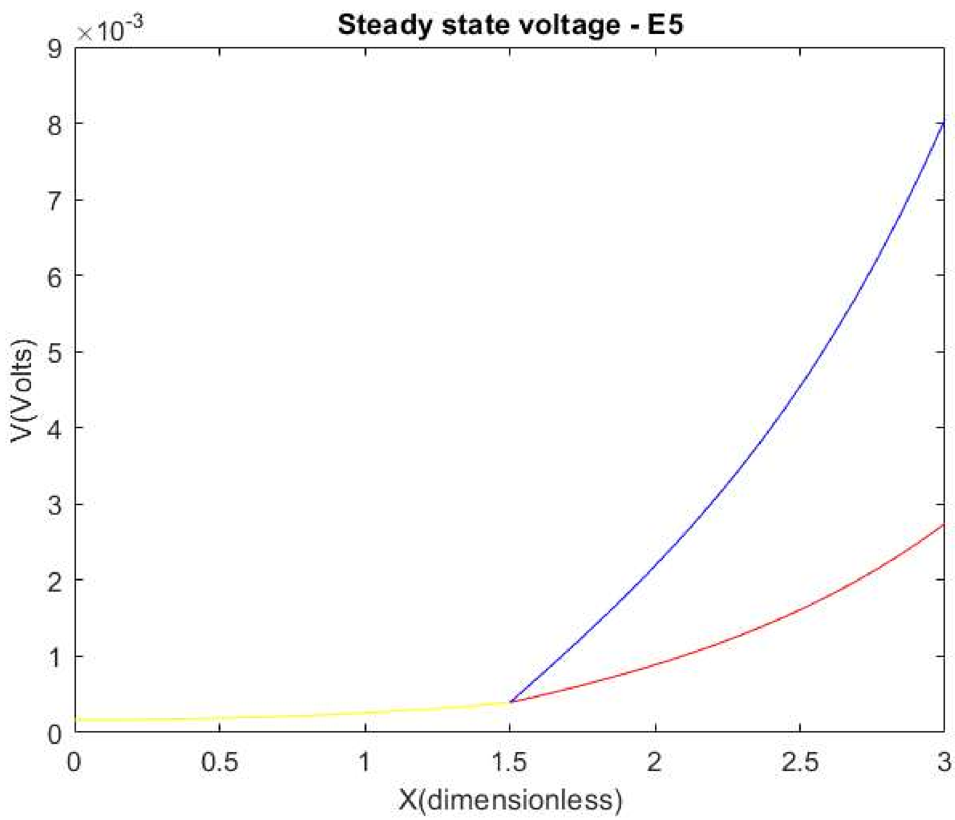
Part b


Steady state voltage - E5
×10^-4
8
7
6
5
4
3
2
1
V(Volts)
0
0.5
1
1.5
2
2.5
3
X(dimensionless)

Part c



Part d

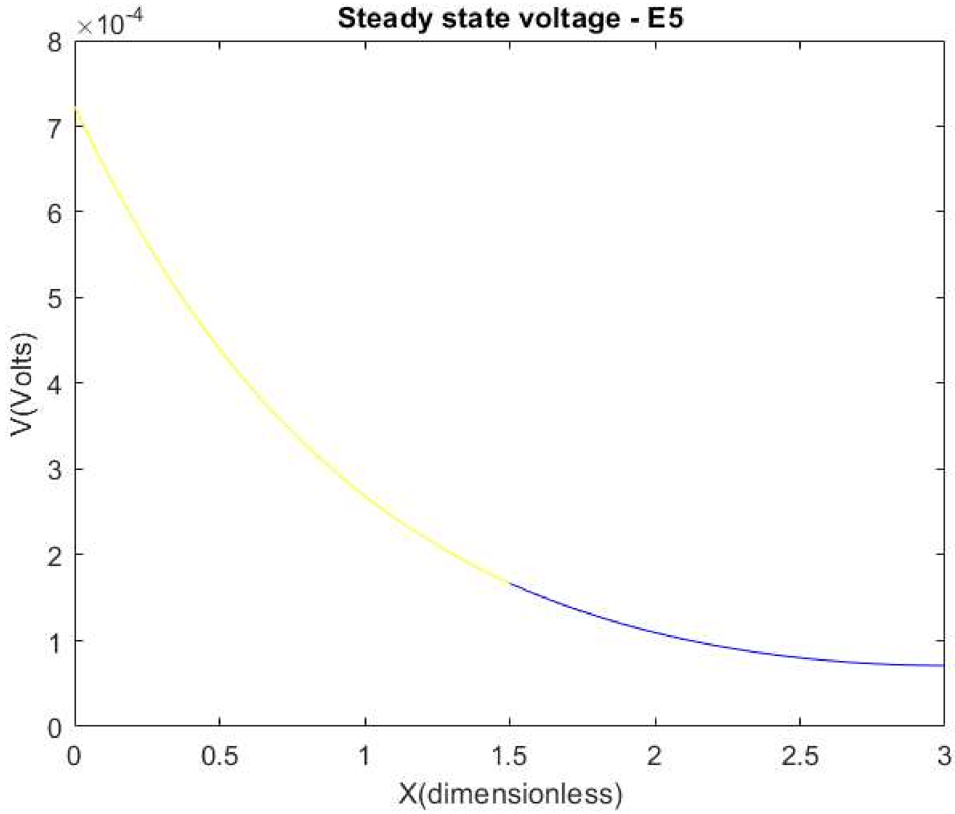


Question 5

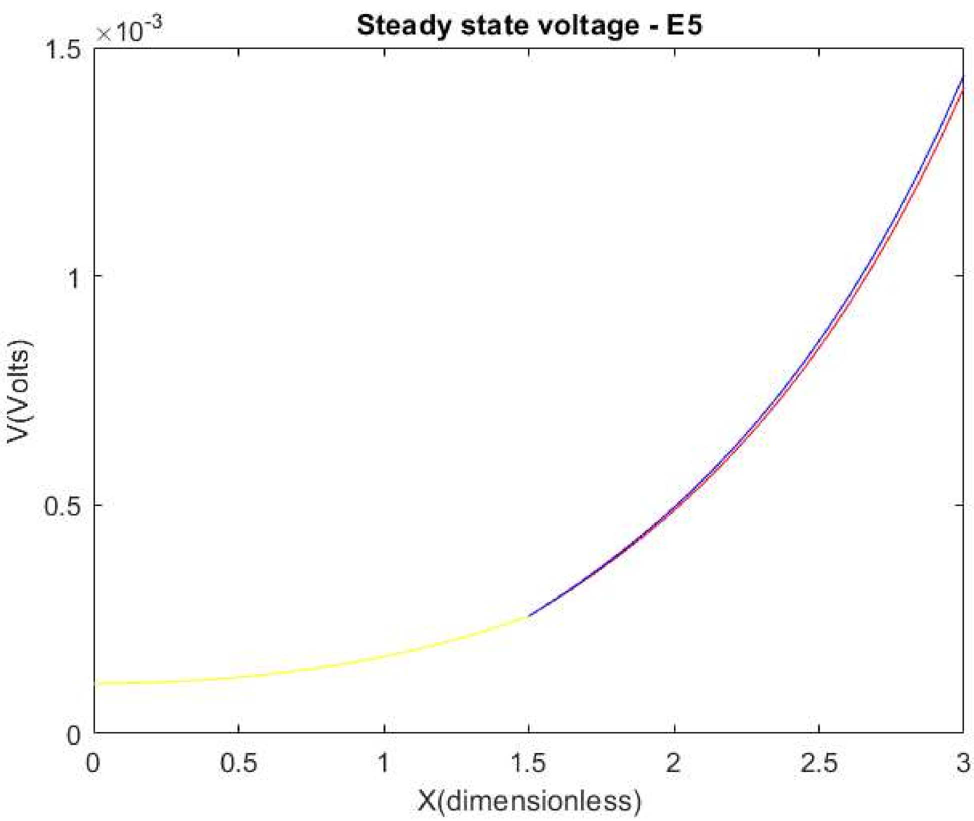
Because, the current is received through that end of the daughter branches. The potential of that end is higher. Therefore, potential increases as X increases from 0, resulting in a positive gradient.

Question 6

Q6 - b



Q6 - d



Here, the resistive forces of daughter branches are equal as the diameters are now similar. Therefore, when providing a current from the end of the daughter branches, the drop of action potential with the distance is similar.