Introduction to neural networks – Assignment 1 – RC circuits

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In this page I will write the final answers, in the next pages the calculations and code are added.

Question 1

The voltage on each pair of capacitor is the same because they all carry a total of $6\mu F$:

$$V_1 = V_2 = V_3 = 4[v]$$

The charge:

$$Q_1 = 4\mu F \,, Q_2 = 20\mu F, Q_3 = 8\mu F, Q_4 = 16\mu F, Q_5 = Q_6 = 12\mu F$$

Question 2

a. While charging:

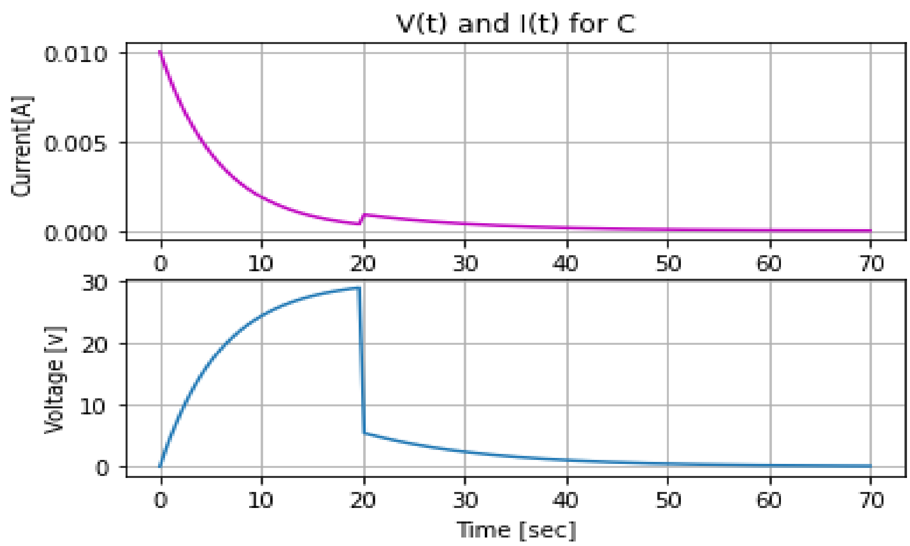
$$I_c = \frac{dq}{dt} = \frac{\epsilon}{R} e^{-\frac{t}{RC}} \,, V = \frac{q}{c} = \epsilon(1 - e^{-\frac{t}{RC}})$$

b. From the graph:

$$V_0 = \epsilon \cong 11.94[v] \,, R \cong 3[k\Omega]$$
$$I(0) \cong 4[milA], I(20) \cong 1.05[milA]$$

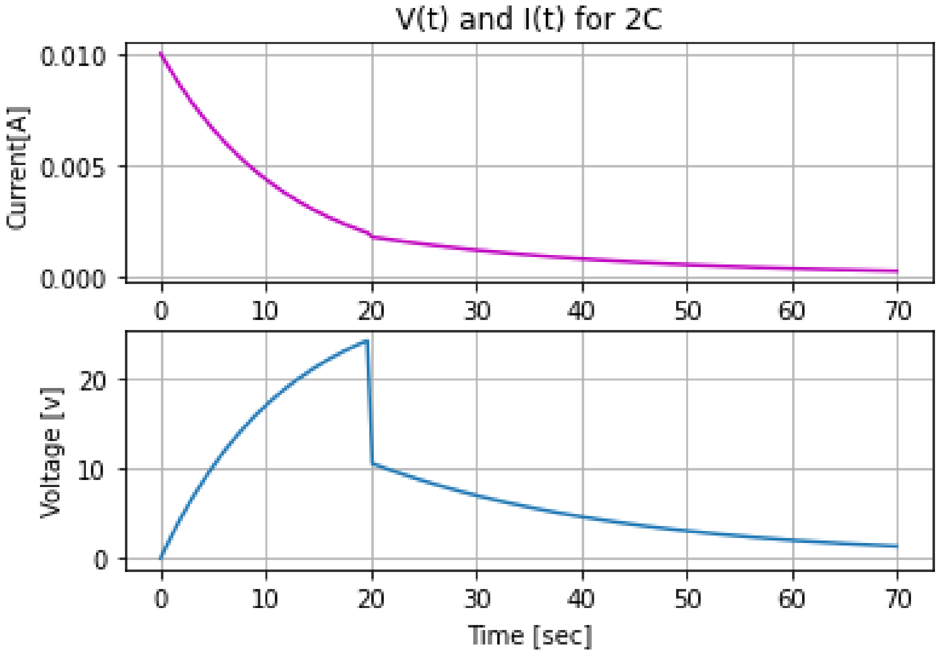
Question 3

a.



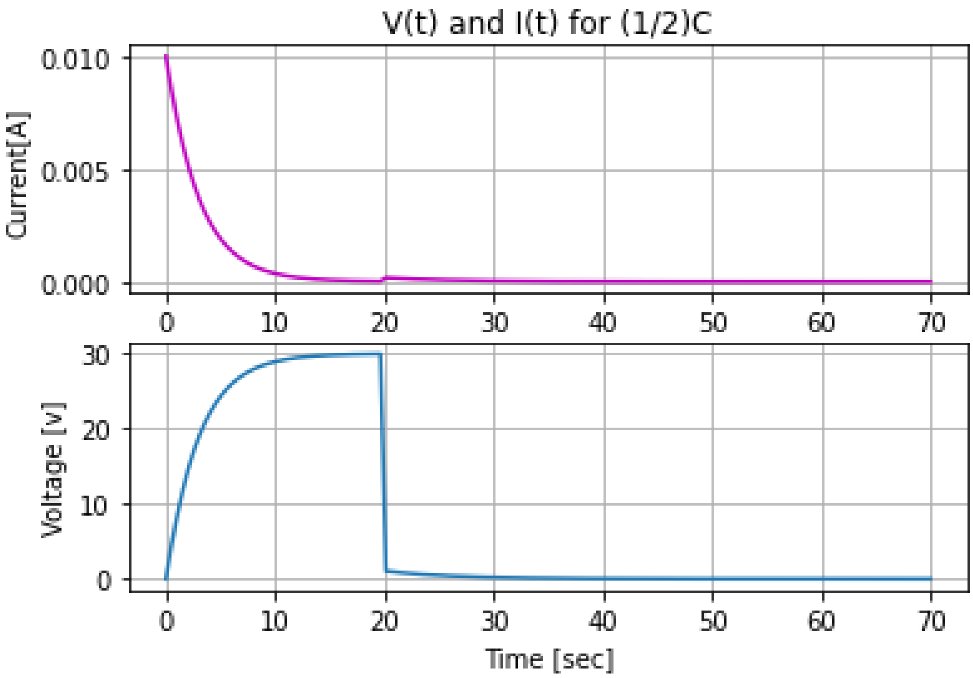
b1.

$$c_{eq} = C + C = 2C$$



b2.

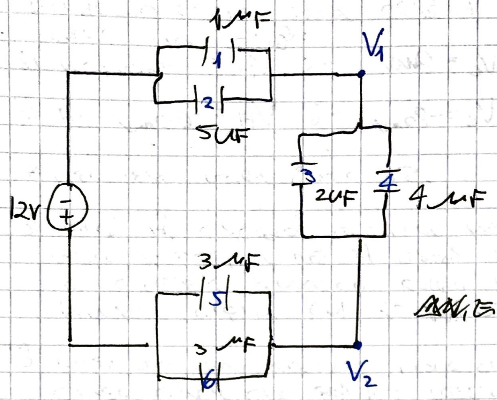
$$c_{eq} = \left(\frac{1}{C} + \frac{1}{C}\right)^{-1} = \frac{C}{2}$$



מאיש: נפב פנרת
ת.ז: 207825506

מבוא לרשתות נוירונים - עבודה 1

שאלה 1

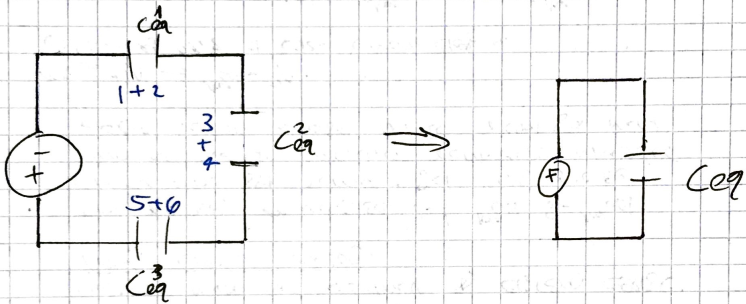


אנו מניחים שהמעגל במצב יציב ולכן כל הקבלים טעונים במלואם.

$$Q_1 = C_1 \Delta V_1 \ , \ Q_2 = C_2 \Delta V_1$$
$$Q_3 = C_3 \Delta V_2 \ , \ Q_4 = C_4 \Delta V_2$$
$$Q_5 = C_5 \Delta V_3 \ , \ Q_6 = C_6 \Delta V_3$$

~~כאשר~~

כעת נמצא קבלים שקולים:



כעת, חיבור קבלים בסדרה נותן:

$$\frac{1}{C_{eq}} = \frac{1}{C_{eq}^{(1)}} + \frac{1}{C_{eq}^{(2)}} + \frac{1}{C_{eq}^{(3)}} \Rightarrow C_{eq} = \left(\sum \frac{1}{C_{eq}^{(i)}} \right)^{-1}$$

וחיבור קבלים במקביל נותן:

$$C_{eq}^{(1)} = C_1 + C_2 \ , \ C_{eq}^{(2)} = C_3 + C_4 \ , \ C_{eq}^{(3)} = C_5 + C_6$$

לבסוף נזדקק לשתי עובדות נוספות: המטען של קבלים בסדרה שווה והמטען של הקבל השקול של הקבלים בסדרה שווה להם. כלומר:

$$Q_{eq} = Q_{eq}(1) = Q_{eq}(2) = Q_{eq}(3)$$

כעת חישובים:

$$Q_{eq} = C_{eq} V_{tot} = 12 C_{eq}$$

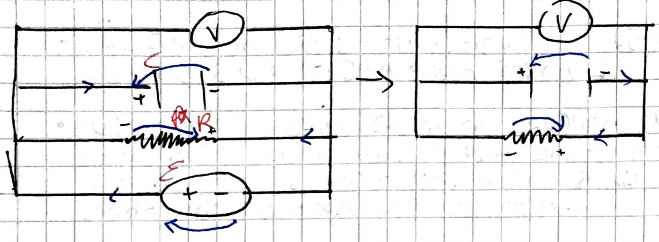
$$C_{eq}(1) = C_{eq}(2) = C_{eq}(3) = 6\mu F \Rightarrow C_{eq} = \frac{6}{3}\mu F$$

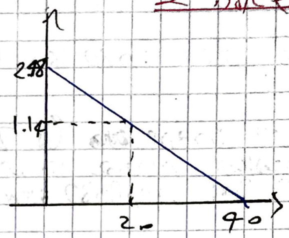
$$\Rightarrow Q_{eq} = Q_{eq}(1) = Q_{eq}(2) = Q_{eq}(3) = 12 C_{eq} = 24[\mu C]$$

$$\Rightarrow V_1 = V_2 = V_3 = \frac{Q_{eq}(1)}{C_{eq}(1)} = \frac{24\mu C}{6\mu F} = 4V$$

$$\Rightarrow Q_1 = 4\mu C \ , \ Q_2 = 20\mu C \ , \ Q_3 = 8\cancel{10}\mu C \ , \ Q_4 = 16\mu C$$
$$Q_5 = 12\mu C \ , \ Q_6 = 12\mu C$$

<u>שאלה 2</u>





א) במהלך הטעינה:

$$q(t)=\varepsilon C\left(1-e^{-t/RC}\right) \Rightarrow I_c=\frac{dq}{dt}=\frac{\varepsilon}{R}e^{-t/RC}$$

$$Q=VC \Rightarrow V=\frac{Q}{C} \quad \forall \quad V(t)=\varepsilon\left(1-e^{-t/RC}\right)$$

ב) כעת אנו מדברים על מעגל RC פשוט, סגור ~~עם~~ ונקבל מ- KVL:

$$V_c=Q/C \Rightarrow I=C\frac{dV}{dt}, \quad V_c+V_R=V_c+IR=V_c+\frac{dV}{dt}CR=0$$

$$\Rightarrow \frac{dV_c}{dt}=-\frac{V_c}{RC} \Rightarrow V_c=V_0e^{-t/RC}$$

מהגרף נראה כי:

$$\Rightarrow \ln(V_c(0))=2.48 \Rightarrow \underline{V_0=\varepsilon\cong 11.94V}$$

ג) נמצא את R:

$$V_c(t)=\varepsilon e^{-t/RC} \Rightarrow \ln\left(\frac{V}{\varepsilon}\right)=-\frac{t}{RC}, \quad V_c(20)=\exp(1.14)=3.13V$$

$$\Rightarrow R=\frac{t}{C}\left(\ln\left(\frac{\varepsilon}{V}\right)\right)^{-1} \Rightarrow R=\frac{20s}{500\mu F}\left(\ln\left(\frac{11.94}{3.13}\right)\right)\cong 3\times10^{-3}[M\Omega]$$

מצאנו:

$$\underline{R\simeq 3K\Omega}$$

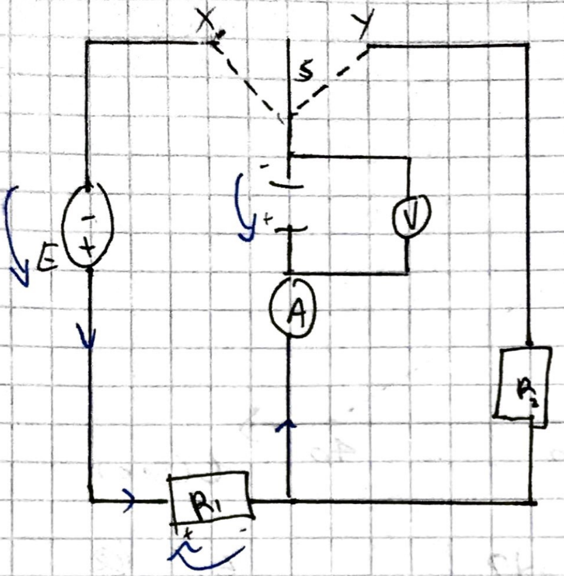
ג) נכתוב לפי חוק אוהם:

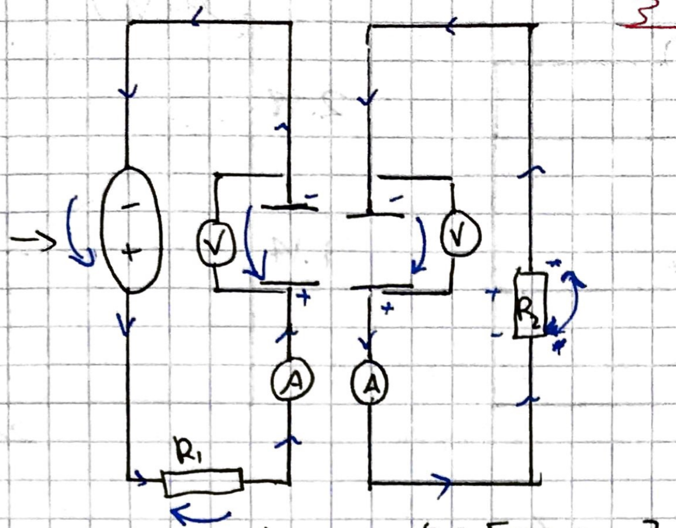
$$I=\frac{V}{R}=\frac{\varepsilon}{R}e^{-t/RC}$$

נותר רק לחשב:

$$I(0)=\frac{\varepsilon}{R}\cong 4[mA], \quad I(20)=\frac{\varepsilon}{R}e^{-20/RC}\cong 1.05[mA]$$

שאלה 3





$t=0 \Rightarrow t=20_s$, $t\in[20_s, 70_s]$

עבור ה-20 שניות הראשונות, טעינה:

$$V_\varepsilon - V_R - V_c = 0 \Rightarrow \varepsilon - \frac{dV_c}{dt} CR - V_c = 0 \qquad t\in[0,20_s]$$

$$\Rightarrow \frac{dV_c}{dt} = -\frac{V_c}{RC} + \frac{\varepsilon}{RC} \Rightarrow \frac{dV_c}{dt} + \frac{V_c}{RC} = \frac{\varepsilon}{RC}$$

$$\Rightarrow V_h = V_0 e^{-t/RC}, \quad V_0 = const = \varepsilon$$

$$\Rightarrow \underline{V_c = \varepsilon(1 - e^{-t/R_1C})}, \quad \underline{I_c = \frac{dQ}{dt} = \frac{d(VC)}{dt} = \frac{\varepsilon}{R_1} e^{-t/R_1C}}$$

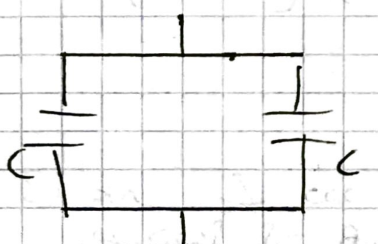
עבור הפריקה:

$$V_c^{new} + R_2C\frac{dV}{dt} = 0 \Rightarrow \underline{V_c^{new} = V_0 e^{-\frac{t}{R_2C}}} \quad \underline{I_c = \frac{V_0}{R_2} e^{-t/R_2C}} \qquad t\in[20_s,70_s]$$

$$\underline{V_c^{new}(0) = V_0 = V_c^{old}(20)}$$

(b

(i



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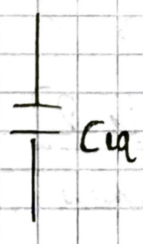
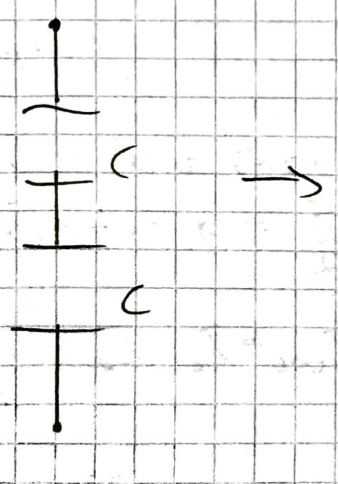


$C_{eq} = 2C$

(ii



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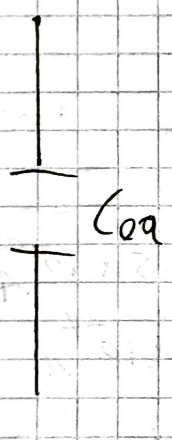

$C_{eq} = \left(\frac{2}{C}\right)^{-1} = \frac{C}{2}$

```
[27] # Author Nadav Porat
     import numpy as np
     import matplotlib.pyplot as plt

     emf = 30 # This is Epsilon, the battary.
     R1 = 3000
     R2 = 6000
     c = 0.002
     c *= 2
     tau1 = (R1*c)
     tau2 = (R2*c)
```

```
[30]
     test = lambda t: emf*(-1*np.expm1(-t/tau1)) # expm1(x) is a function that returns [e^x -1]
     v0 = test(20) # Setting the intial charge for discharge function.
     voltage_fun = lambda t: emf*(-1*np.expm1(-t/tau1)) if t<20 else v0*np.exp(-t/tau2) # This function returns the voltage for 0<t<70
     current_fun = lambda t: (emf/R1)*np.exp(-t/tau1) if t<20 else (v0/R2)*np.exp(-t/tau2)

     time = np.linspace(0,70,140)
     voltage = np.array(list(map(voltage_fun,time))) # Apllying the functions to the Time domain.
     current = np.array(list(map(current_fun,time)))
```

```
plt.figure() # Creating graphs

plt.subplot(211)
plt.title("V(t) and I(t) for 2C")
plt.ylabel("Current[A]")
plt.grid(True)
plt.plot(time,current,color="m")

plt.subplot(212)
plt.ylabel("Voltage [v]")
plt.xlabel("Time [sec]")
plt.grid(True)
plt.plot(time,voltage)
```