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CMSC 491: Neural Eng Assignment 2

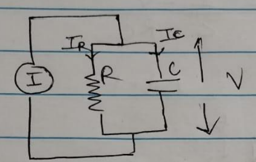
HW2 MATLAB Simulation:

1.

HW2.

Assignment 2

Q.1. Write down a differential eq^n that describes the behaviour of RC circuit shown.



By Kirchoff's current law,

$$I = I_R + I_C$$

$$\therefore I = \frac{V}{R} + C \cdot \frac{dv}{dt} \quad \ldots \text{Resistor} \left(V = IR \therefore I = \frac{V}{R} \right)$$

$$\ldots \text{Capacitor} \left(I = C \cdot \frac{dv}{dt} \right)$$

$$\therefore I = \frac{v}{R} + C \frac{dv}{dt}$$

$$\therefore C \frac{dv}{dt} = \frac{-V}{R} + I$$

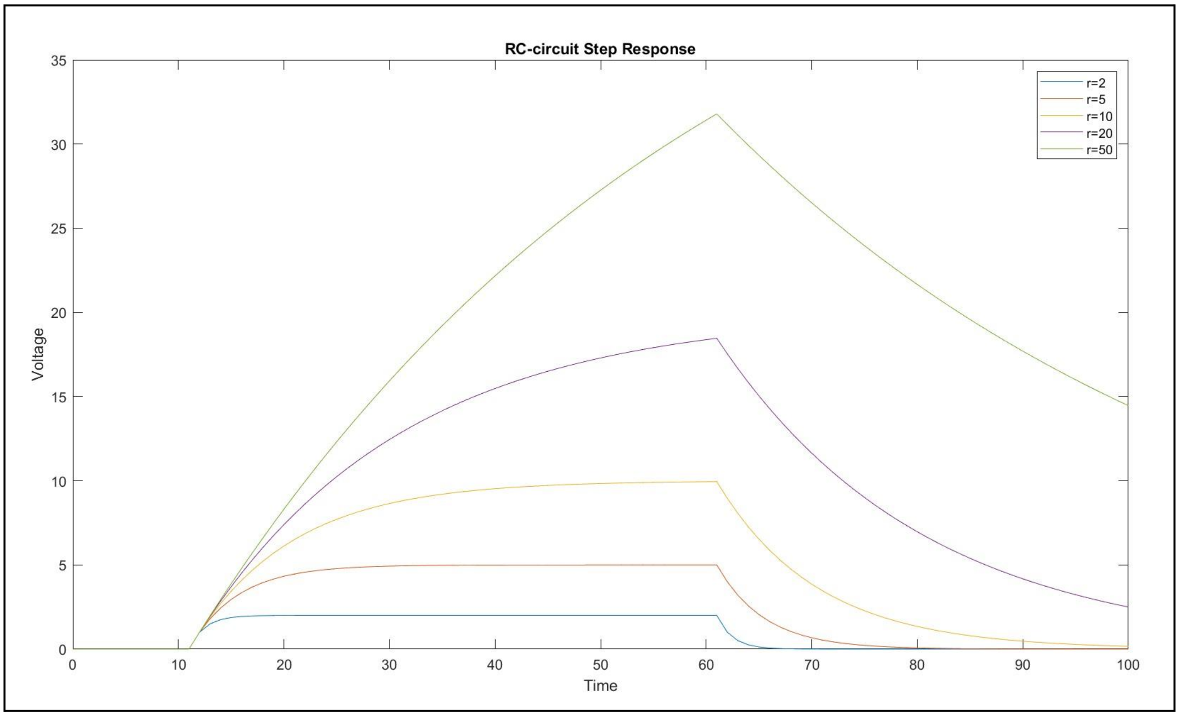
$$\therefore C \frac{dv}{dt} = I - \frac{V}{R}$$

$$\therefore \boxed{\frac{dv}{dt} = \frac{I}{C} - \frac{V}{RC}}$$

Q2 Apply the Euler Integration technique.
Code:

```
delta_t=1;
n=100;
resistors=[2,5,10,20,50];
time=uint32(0):uint32(100);
for r=1:5
   voltage=[];
   v=0;
   for t=0:n
       voltage=[voltage,v];
       if t>10 && t<=60
           I=1;
       else
           I=0;
       end
       v=v+delta_t*voltage_fun(I,v,resistors(r));
   end
   disp(length(voltage))
   disp(length(time))
   plot(time,voltage)
   hold on
end
hold off
title('RC-circuit Step Response')
xlabel('Time')
ylabel('Voltage')
legend('r=2','r=5','r=10','r=20','r=50')
function diff_eqn_val=voltage_fun(I,v,R)
   C=1;
   diff_eqn_val=(I/C)-(v/R*C);
end
```

Output:


RC-circuit Step Response
Voltage
Time
r=2
r=5
r=10
r=20
r=50
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
70
80
90
100

Q3a. Write a set of six subroutines…..

L'Hopital's rule:

★ **Hodgkin - Huxley Model**

i) $$\alpha_n = \frac{0.01(10-V)}{\exp\left(\frac{-V+10}{10}\right)-1}$$

$\alpha_n \Rightarrow$ becomes $\frac{0}{0}$ when $V = 10$

$\therefore$ when $V = 10$,

L'Hopital's Rule:-

$$\alpha_n = \lim_{V \to 10} \frac{f(V)}{g(V)} = \lim_{V \to 10} \frac{f'(V)}{g'(V)}$$

$$= \frac{\frac{d}{dV}\left[0.01(10-V)\right]}{\frac{d}{dV}\left[\exp\left(\frac{10-V}{10}\right)-1\right]}$$

$$= \frac{0 - 0.01}{\exp\left(\frac{10-V}{10}\right)\cdot\left(\frac{-1}{10}\right) - 0}$$

$$\alpha_n = \frac{-0.01}{\exp\left(\frac{10-V}{10}\right)\left(\frac{-1}{10}\right)}$$

$$\therefore \alpha_n \text{ at } V=10 \Rightarrow \frac{-0.01}{\exp(0)\left(\frac{-1}{10}\right)} = \frac{-0.01}{\left(\frac{-1}{10}\right)}$$

$$= 0.1$$

2) $\alpha_m = \dfrac{0.1(25-V)}{\exp\left(\frac{25-V}{10}\right)-1}$

$\alpha_m \Rightarrow$ becomes $\frac{0}{0}$ when $V = 25$.

$\therefore \alpha_m = \lim\limits_{V \to 25} \dfrac{f(V)}{g(V)} = \lim\limits_{V \to 25} \dfrac{f'(V)}{g'(V)}$

$= \dfrac{\frac{d}{dV}\left[0.1(25-V)\right]}{\frac{d}{dV}\left[\exp\left(\frac{25-V}{10}\right)-1\right]}$

$\therefore \alpha_m = \dfrac{-0.1}{\frac{-1}{10}\exp\left(\frac{25-V}{10}\right)}$

$\therefore \alpha_m$ at $(V=25) = \dfrac{-0.1}{\frac{-1}{10}} = \underline{\underline{1}}$

a. Six subroutines:

Code:

```
function alpha_n=alphan(v)
   if v==10
       alpha_n=0.1;
   else
       alpha_n=0.01*(10-v)/(exp((10-v)/10)-1);
   end
end
----------------------------------------------
function beta_n=betan(v)
   beta_n=0.125*exp(-v/80);
end
----------------------------------------------
function alpha_m=alpham(v)
   if v==25
       alpha_m=1;
   else
       alpha_m=0.1*(25-v)/(exp((25-v)/10)-1);
   end
end
----------------------------------------------
function beta_m=betam(v)
   beta_m=4*exp(-v/18);
end
----------------------------------------------
function alpha_h=alphah(v)
   alpha_h=0.07*exp(-v/20);
end
----------------------------------------------
function beta_h=betah(v)
   beta_h=1/(exp((30-v)/10)+1);
end
```

----

b. Generate and turn in plots…

Code: (Uses the above subroutines in Q3.a)

```
volt=-50:150;
tau_m=[];
tau_h=[];
tau_n=[];
m_inf=[];
h_inf=[];
n_inf=[];
for v=-50:150
       tau_m=[tau_m,tau(alpham(v),betam(v))];
       tau_h=[tau_h,tau(alphah(v),betah(v))];
       tau_n=[tau_n,tau(alphan(v),betan(v))];
       m_inf=[m_inf,inf(alpham(v),betam(v))];
       h_inf=[h_inf,inf(alphah(v),betah(v))];
       n_inf=[n_inf,inf(alphan(v),betan(v))];
end

subplot(2,3,1)
plot(volt,tau_m)
title('Tau_m')
xlabel('v(mV)');
ylabel('tau(msec)')

subplot(2,3,2)
plot(volt,tau_h)
title('Tau_h')
xlabel('v(mV)');
ylabel('tau(msec)')

subplot(2,3,3)
plot(volt,tau_n)
title('Tau_n')
xlabel('v(mV)');
ylabel('tau(msec)')

subplot(2,3,4)
plot(volt,m_inf)
title('m_i_n_f')
xlabel('v(mV)');

subplot(2,3,5)
plot(volt,h_inf)
title('h_i_n_f')
xlabel('v(mV)');
```

```
subplot(2,3,6)
plot(volt,n_inf)
title('n_i_n_f')
xlabel('v(mV)');

function tau=tau(alpha,beta)
   tau=1/(alpha+beta);
end

function inf=inf(alpha,beta)
   inf=alpha/(alpha+beta);
end
```

Output: