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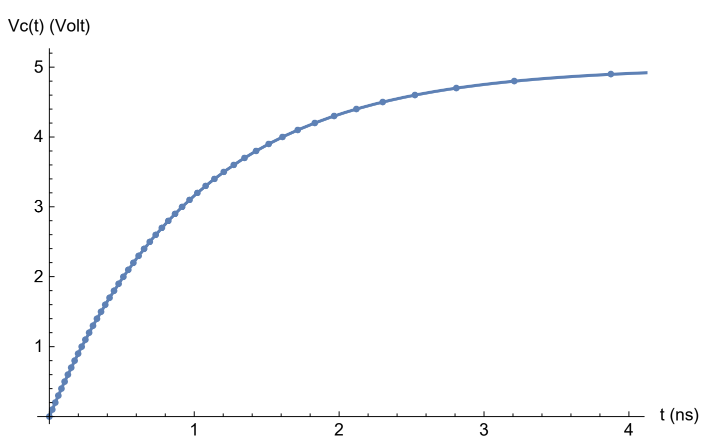
Mathematica HW 2
Due Friday Week 9 5pm

Consider charging an RC (form simplicity use R = 1kΩ, C = 1pF) circuit with Vs(t) = 5 u(t) (a step function). The capacitor is initially uncharged, i.e. Vc(0) = 0V. The analytic waveform for Vc(t) is known to be Vc(t) = $5\left(1-e^{-t/(RC)}\right)$ by solving the differential equation. We want to plot the waveform by estimating the time for Vc to rise from 0 to 1V, from 1 to 2V and so on until Vc reaches 5V using the technique we discussed for CMOS inverter, i.e. estimating $\Delta\tau = \frac{\Delta Qc}{\langle I_c \rangle}$.

(a) Write a computer program (***Mathematica*** or **otherwise, Matlab, Python, C++ etc.**) that will plot your estimated discrete waveform for Vc(t) together with the analytic solution for Vc(t).
(b) If your program work for grids {0,1,2,3,4,5}, repeat your calculation for finer grids of {0,0.5,1,1.5,2,2.5 ....)

Your result will look something like this. You should reproduce one similar to this with calculated value (dots) and analytical solution (continuous form) :



In[190]:=

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Clear["Global`*"]
c = 1;
r = 1;
ΔV = 0.5;
Vs = 5;
Vcrange = Range[0, 5, ΔV];
ic = (Vs - Slot[1])/r & /@ Vcrange;
ic1 = Range[5, 0, -ΔV];
Avic = Table[(ic[[i]] + ic[[i + 1]])/2, {i, 1, Vs/ΔV}] // N;
ΔQ = Table[c * ΔV, {i, 1, Vs/ΔV + 1}];
Δτ = Table[ΔQ[[i]]/Avic[[i]], {i, 1, Vs/ΔV}];
t = Table[Sum[Δτ[[i]], {j, i}], {i, 1, Vs/ΔV}];
t = Prepend[t, 0];
handcl = Thread[{t, Vcrange}];
lp = ListPlot[handcl, Joined → True, Mesh → All, AxesLabel → {"time (ns)", "Vc (Volt)"}]
Plot[5 * (1 - (Exp[-x / (r * c)])), {x, 0, 20},
 PlotRange → {{0, 20}, {0, 5}}, AxesLabel → {"time (ns)", "Vc (Volt)"}]
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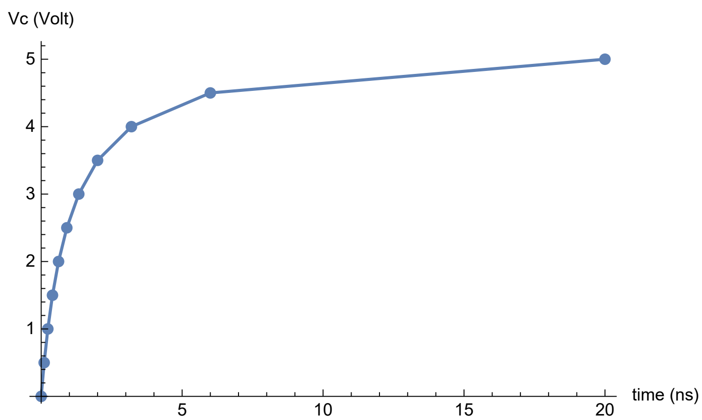
Out[204]=



Out[205]=