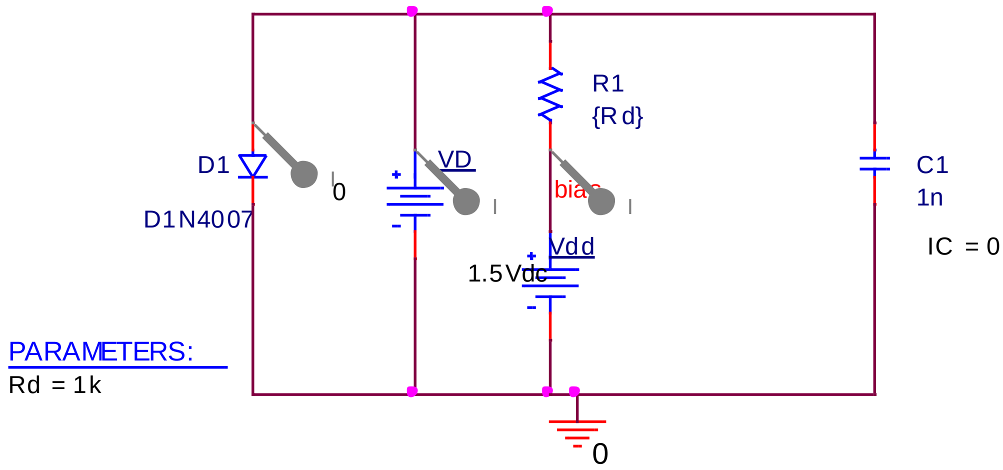
Homework 1

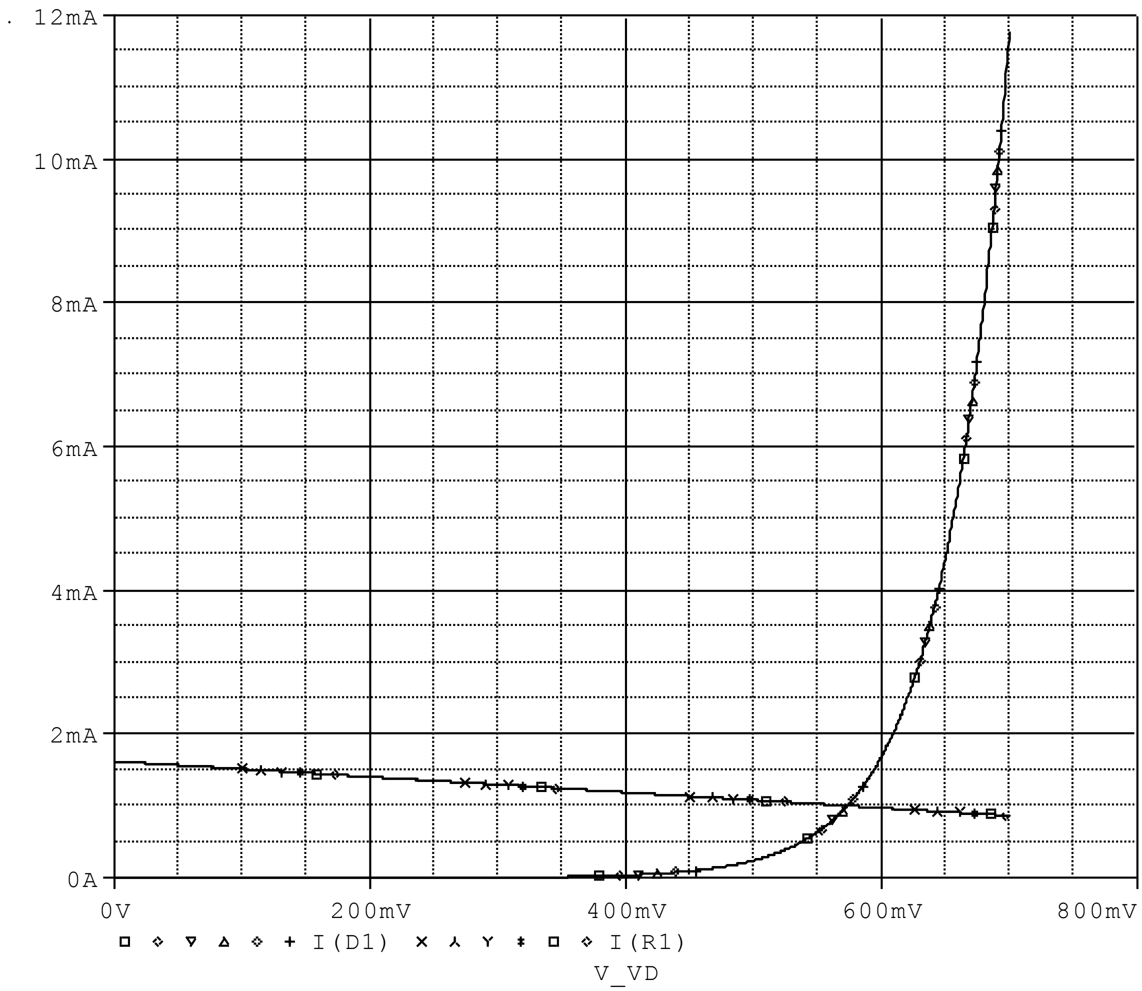
Question 1

a)

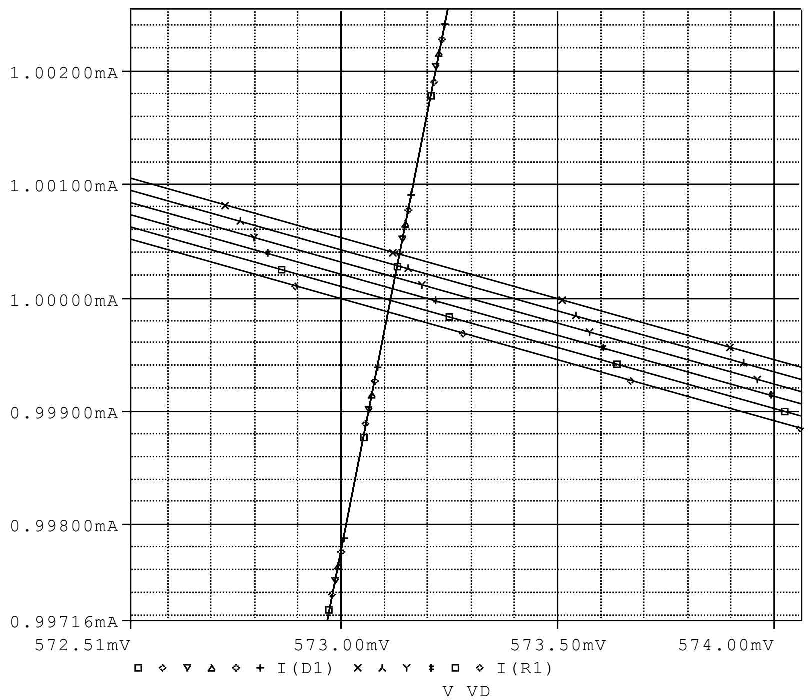
PSpice Schematic



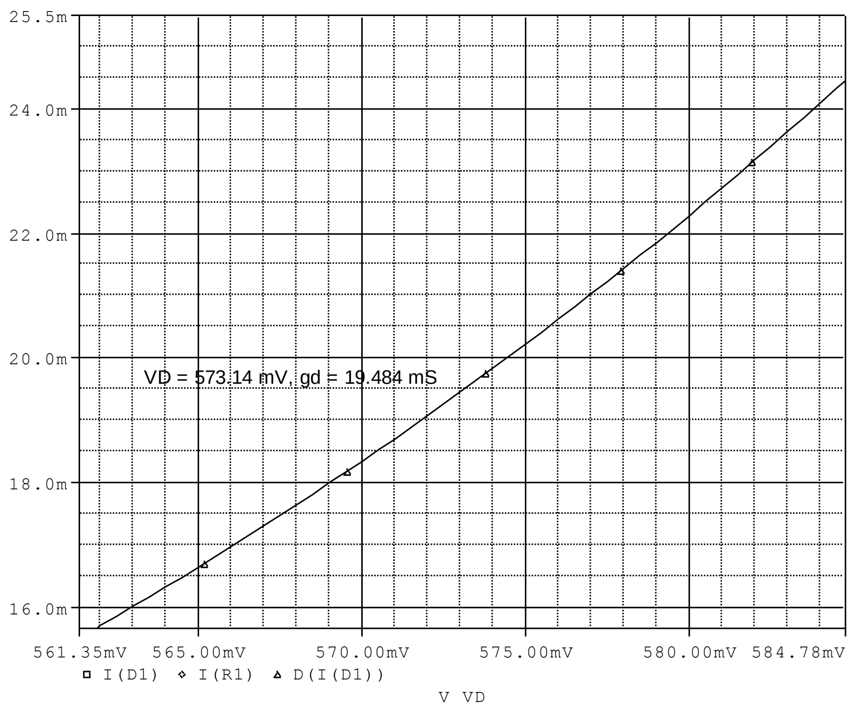
Plot of diode current and load line



Zooming in to find R_D and Q-point



Plot of diode current derivative

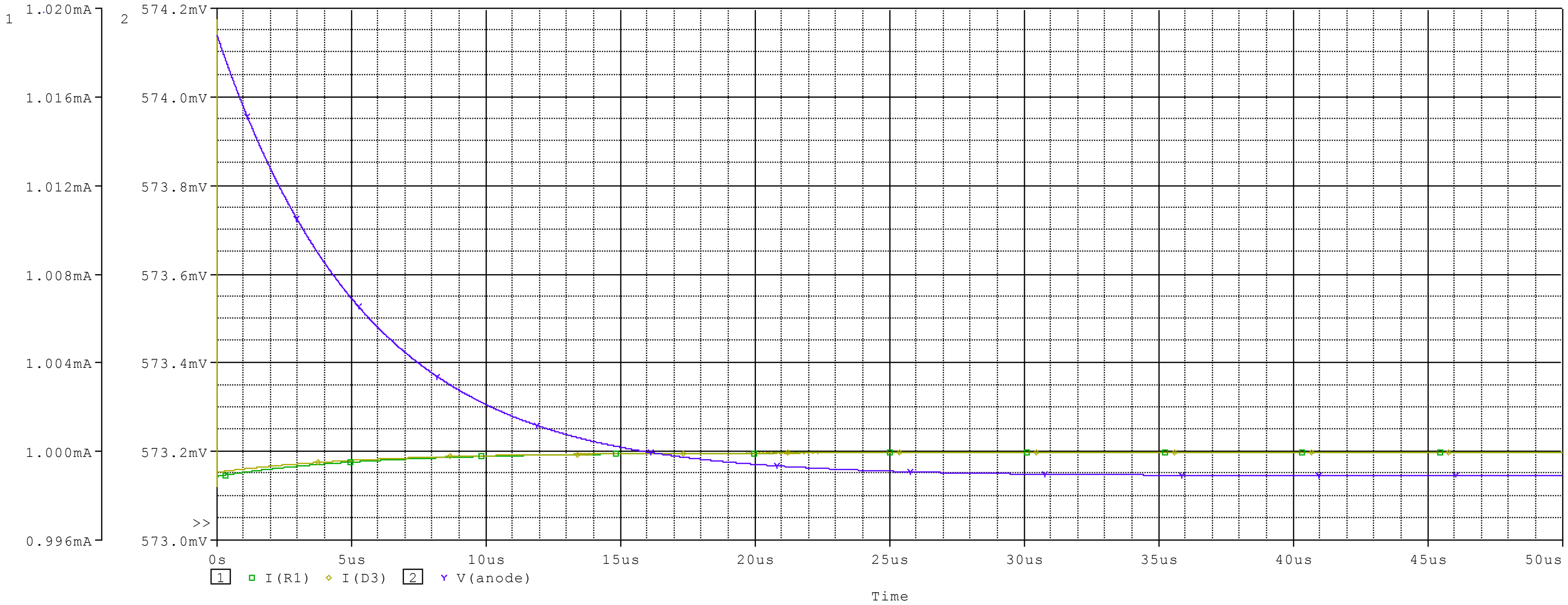


Summary of values

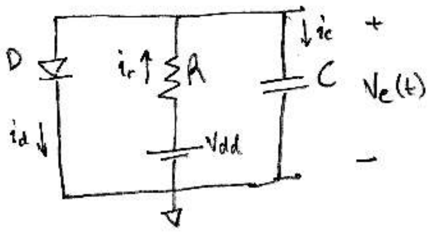
$R_D = 926.9\ \Omega$
$V_D = 526.14$ mV
$g_d = 19.484$ mA/V

b)

Transient Run



1b)



<u>Small signal Differential Equation</u>

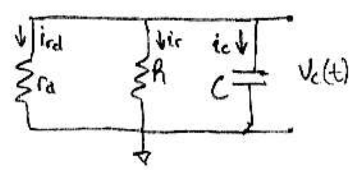
$$i_r = i_c + i_d$$

$$\frac{V_{dd} - V_c(t)}{R} = C\frac{dV_c(t)}{dt} + \frac{V_c(t)}{r_d}$$

$$\frac{dV_c(t)}{dt} + \frac{V_c(t)}{C}\left[\frac{1}{R}+\frac{1}{r_d}\right] - \frac{V_{dd}}{RC} = 0$$

<u>Question 2</u>

a)



$V_c(0^-) = V_c(0) = V_c(0) = 1\,mV$ (small-signal component)

b) $i_c + i_{rd} + i_r = 0$

$$C\frac{dV_c(t)}{dt} + V_c(t)\left(\frac{1}{R}+\frac{1}{r_d}\right) = 0$$

$$\int \frac{1}{V_c(t)}\,dV_c = \frac{-1}{C}\left(\frac{1}{R}+\frac{1}{r_d}\right)\int dt$$

$$\ln|V_c(t)| = \frac{-1}{C}\left(\frac{1}{R}+\frac{1}{r_d}\right)t + K_1$$

$$V_c(t) = K_2 \exp\left(\frac{-t}{C R_{eq}}\right) \quad \text{Where } R_{eq} = r_d \,//\, R$$

$$K_2 = V_c(0) = 1\,mV$$

$$CR_{eq} = (1\times10^{-9}\,F)\left(926.9\,\Omega \,//\, \left(\frac{1}{19.484\,mS}\right)\right) = 4.86\times10^{-8}\,s$$

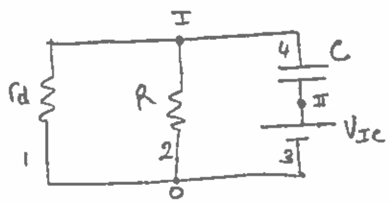
⇒ Superimposing the steady-state response $V_Q = 573.14\,mV$

$$\therefore \quad V_c(t) = 0.57314 + 0.001\exp\left(\frac{-t}{4.86\times10^{-8}}\right)$$

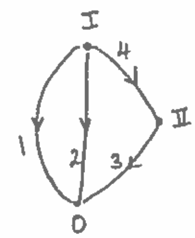
c) Attached

d) The response of the analytical solution is much faster than the PSpice run. The Spice model is more accurate and includes parasitic capacitances (junction + diffusion caps) that act to increase the the decay time constant which means the response is slower.

Question 3



schematic



graph

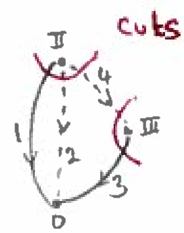
$b = 4$

$n = 3$

$t = n - 1 = 2$

$l = b - t = 2$

Choose branches 1 and 3 as tree branches.



$$0 = i_{b1} + i_{b2} + i_{b4}$$

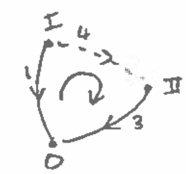
$$0 = i_{b3} - i_{b4}$$

$$\therefore \quad C = \begin{bmatrix} 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

cut-set

Loop 1

Loop 2



$$0 = -V_{b1} + V_{b2}$$

$$0 = -V_{b1} + V_{b3} + V_{b4}$$

$$T = \begin{bmatrix} -1 & 1 & 0 & 0 \\ -1 & 0 & 1 & 1 \end{bmatrix}$$

tie-set