Problem 1.

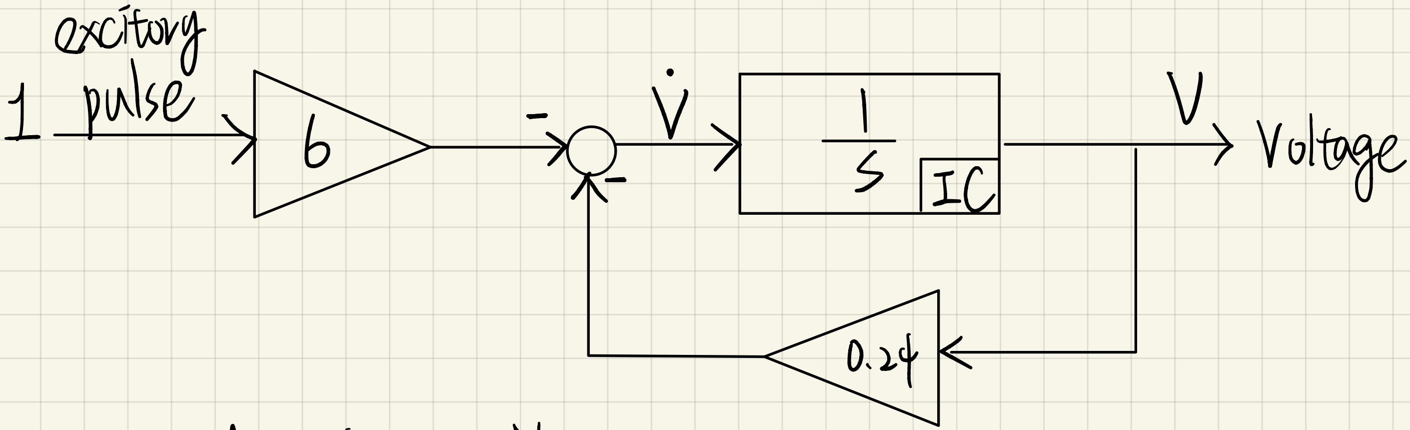
1-1. ODE , $t \leq 1ms$

$$12.5\frac{dV}{dt} = -75 - V - \frac{g_e}{g_l}V + \frac{g_i}{g_l}(75 - V)$$, where $g_i = 0$, $g_e/g_l = 2$

$$\Rightarrow 12.5\dot{V} = -75 - V - 2V + \frac{0}{g_l}(75 - V)$$

$$\Rightarrow \dot{V} = -0.24V - 6 \quad \#$$

1-2. Block Diagram.



1-3 Initial value problem

$$\dot{V} = -0.24V - 6 , \quad V(0) = -75$$

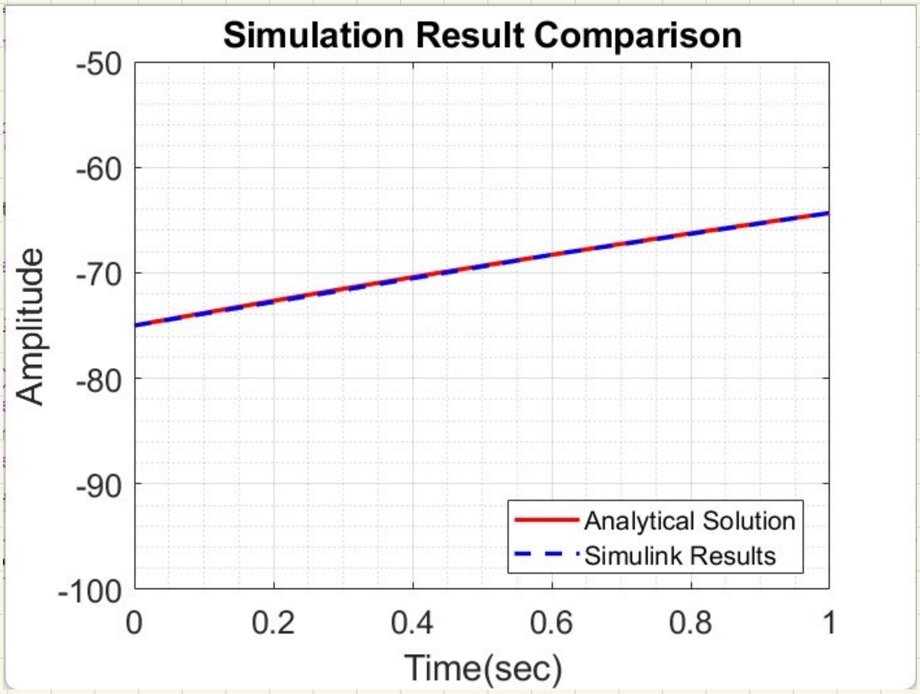
$$\dot{V} = -0.24V_p - 6$$

$$\Rightarrow e^{0.24t}V = -6\int_0^1 e^{0.24t}dt + C_1$$

$$\Rightarrow V = -6e^{-0.24t}\int_0^1 e^{0.24t}dt + C_1 e^{-0.24t}$$

$$\Rightarrow \underline{V = 25(e^{-0.24t} - 1) - 75e^{-0.24t}} \quad \#$$

1-4 Simulation $t \le 1\,ms$



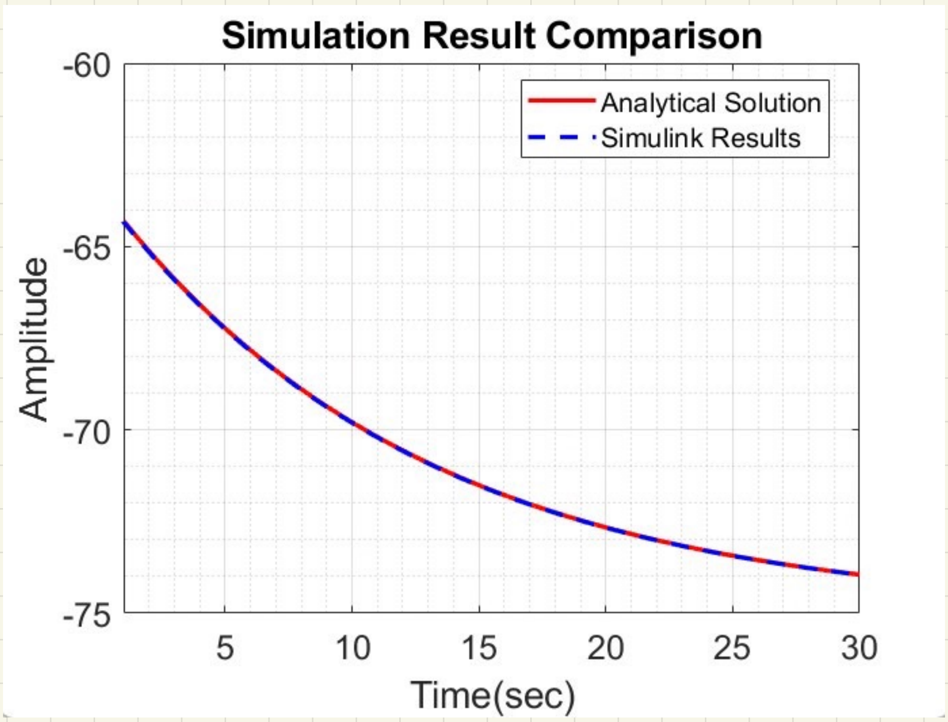
1-5 ODE, $t > 1ms$

$$12.5\frac{dV}{dt} = -75 - V - \frac{g_e}{g_\ell}V + \frac{g_i}{g_\ell}(75 - V)$$, where $g_i = 0$, $g_e/g_\ell = 0$

$$\Rightarrow 12.5\dot{V} = -75 - V - 0V + \frac{0}{g_\ell}(75 - V)$$

$$\Rightarrow \dot{V} = -0.0\ V - 6$$ #

1-6 Simulation $t > 1ms$



Problem 2.

2-1 Find $\bar{R}_f$

$$R_f = \frac{\sqrt{\Delta P}}{Q_{out}}$$

$$\Rightarrow \Delta P = R_f^2 Q_{out}^2$$

$$\Rightarrow \frac{d\Delta P}{dQ_{out}} = 2R_f^2 Q_{out}$$

$$= 2R_f(R_f Q_{out})$$

$$= 2R_f\sqrt{\rho g h(t)}$$

operation point is (Q_0, h_0)

$$\Rightarrow \bar{R}_f = 2R_f\sqrt{\rho g h_0} \ \#$$

2-2 Substitude $\bar{R}_f$

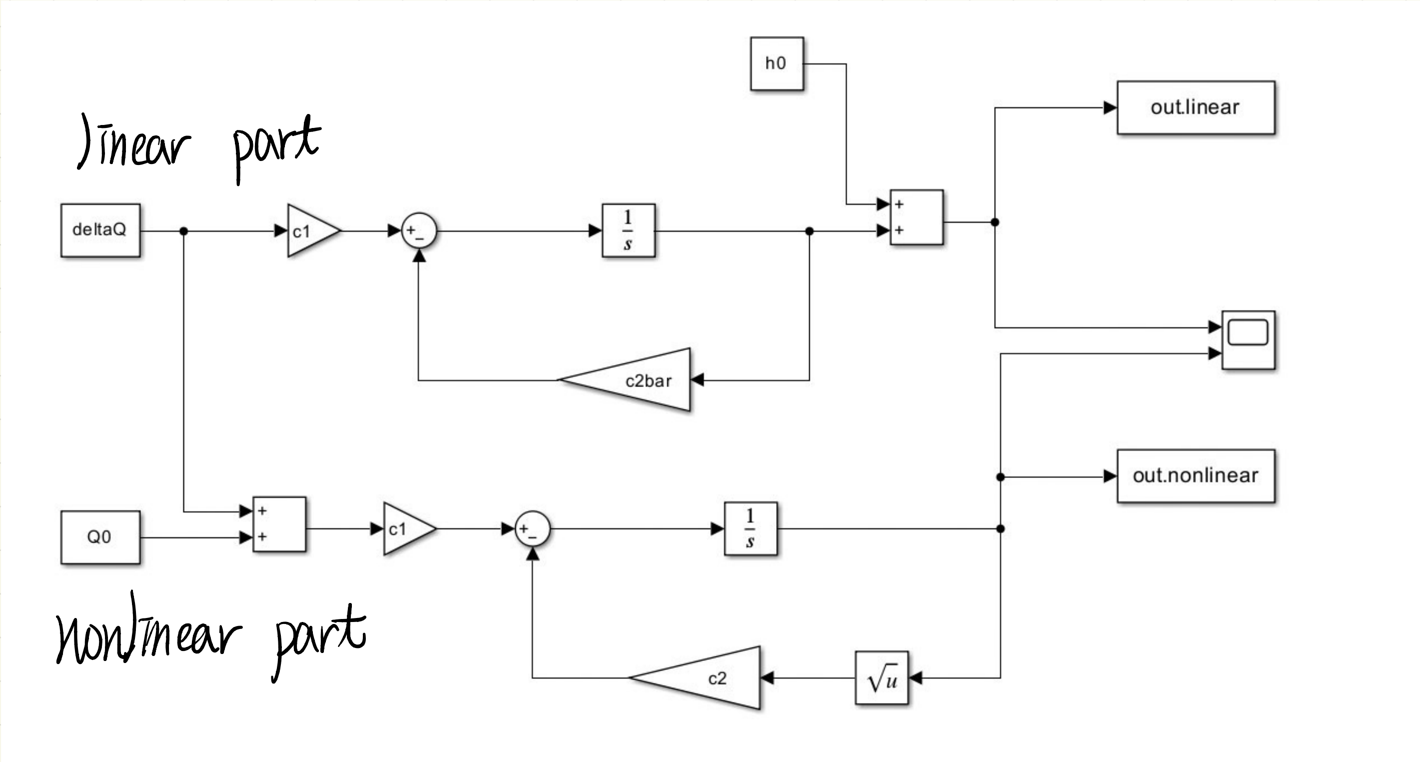
Eqn(7), $\frac{\pi D^2}{4}\delta\dot{h}(t) = \delta Q(t) - \frac{1}{\bar{R}_f}\rho g \delta h(t)$

$$\Rightarrow \frac{\pi D^2}{4}\delta\dot{h}(t) = \delta Q(t) - \frac{1}{2R_f\sqrt{\rho g h_0}}\rho g \delta h(t)$$

$$\Rightarrow \delta\dot{h}(t) = \frac{4}{\pi D^2}\delta Q(t) - \frac{2\sqrt{\rho g}}{\pi D^2 R_f\sqrt{h_0}}\delta h(t) \ \#$$

the equation is identical to the results obtained in class.

2-3 Block Diagram



Follow the equations we can build up the linear and nonlinear models respectively, and the block diagrams are showed above.

deltaQ: δQ $\quad$ $C_2: \frac{4\sqrt{\rho g}}{R_f \pi D^2}$

$C_1: 4/\pi D^2$ $\quad$ $C_2\text{bar}: \frac{C_2}{2\sqrt{h_0}}$

$\frac{1}{s}$: Integrator $\quad$ $\sqrt{u}$: square root

2-4 Show the Result