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COLLEGE OF ENGINEERING

DEPARTMENT OF CHEMICAL AND PETROLEUM ENGINEERING

PROCESS DYNAMICS & CONTROL II

CHE 532 ASSIGNMENT I

BY

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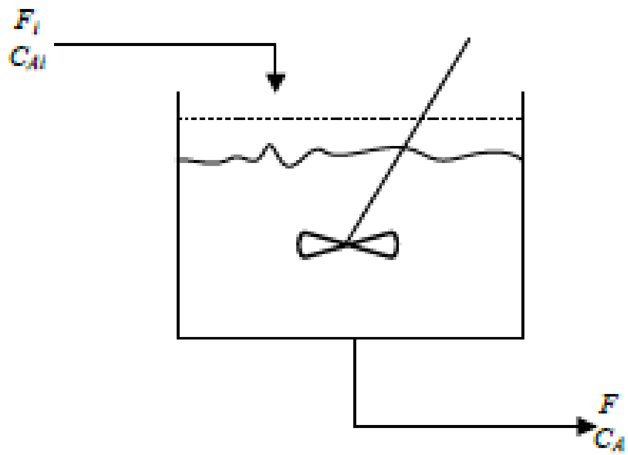
14/ENG01/016



Overall material balance:

$$\{\text{Accumulation of mass}\} = \{\text{mass in}\} - \{\text{mass out}\}$$

$$\frac{d(\rho V)}{dt} = \rho F_i - \rho F \qquad (1a)$$

$$\frac{dV}{dt} = F_i - F \qquad (1b)$$

Component balance of A

$$\{Accumulation\ of\ component\ mass\} = \{component\ mass\ in\} - \{component\ mass\ out\} + \{generation\ of\ component\ mass\}$$

$$\frac{d(C_A V)}{dt} = F_i C_{Ai} - F C_A + V r_A$$

But:

$$r_A = -K C_A$$

$$\frac{d(C_A V)}{dt} = V\frac{dC_A}{dt} + C_A\frac{dV}{dt}$$

Therefore:

$$V\frac{dC_A}{dt} + C_A\frac{dV}{dt} = F_iC_{Ai} - FC_A - VKC_A$$

$$V\frac{d(C_A)}{dt} = F_iC_{Ai} - FC_A - VKC_A - C_A\frac{dV}{dt} \qquad (2)$$

Recall:

$$\frac{dV}{dt} = F_i - F$$

Therefore:

$$V\frac{d(C_A)}{dt} = F_iC_{Ai} - FC_A - VKC_A - C_A(F_i - F)$$

$$V\frac{d(C_A)}{dt} = F_iC_{Ai} - FC_A - VKC_A - F_iC_A + FC_A$$

$$V\frac{d(C_A)}{dt} = F_iC_{Ai} - VKC_A - F_iC_A$$

$$V\frac{d(C_A)}{dt} = F_iC_{Ai} - C_A(F_i + VK)$$

$$V\frac{d(C_A)}{dt} + C_A(F_i + VK) = F_iC_{Ai}$$

$$F_i = F$$

$$\frac{d(C_A)}{dt} + \left(\frac{F + VK}{V}\right)C_A = \frac{F}{V}C_{Ai}$$

$$\frac{d(C_A)}{dt} + \frac{1}{\tau_p}C_A = \frac{F}{V}C_{Ai} \qquad (3)$$

$$\tau_p\frac{d(C_A)}{dt} + C_A = \frac{F\tau}{V}C_{Ai}$$

$$\tau_p\frac{d(C_A)}{dt} + C_A = \frac{F}{V} * \frac{V}{F + VK}C_{Ai}$$

$$\tau_p\frac{d(C_A)}{dt} + C_A = \frac{F}{F + VK}C_{Ai}$$

$$\tau_p \frac{d(C_A)}{dt} + C_A = K_p C_{Ai}$$

$$\tau_p \frac{d(C_{As})}{dt} + C_{As} = K_p C_{Ais}$$

With time constant $\tau_p = \frac{V}{F + VK}$ *

$where\ the\ steady\ state\ gain,\ K_p = \frac{F}{F + Vk}$ **

Equation 3 is the dynamic equation. To find the transfer function, we'll have to get the Laplace of the system:

$$\overline{C_A} = C_A(s)$$

$$\overline{C_{Ai}} = C_{Ai}(s)$$

$$\overline{C_A'}(t) = sC_A(s) - C_A(0)$$

$$\tau_p \frac{d(C_A - C_{As})}{dt} + (C_A - C_{As}) = K_p(C_{Ai} - C_{Ais})$$

$$\tau_p \frac{d(\overline{C_A})}{dt} + \overline{C_A} = K_p \overline{C_{Ai}}$$

$$\tau_p[S\overline{C_A}(s) - \overline{C_A}(0)] + \overline{C_A}(s) = K_p \overline{C_{Ai}}(s)$$

$$\tau_p S\overline{C_A}(s) + \overline{C_A}(s) = K_p \overline{C_{Ai}}(s)$$

$$\overline{C_A}(s)(\tau_p S + 1) = K_p \overline{C_{Ai}}(s)$$

$$\frac{\overline{C_A}(s)}{\overline{C_{Ai}}(s)} = \frac{K_p}{(\tau_p S + 1)}$$

$$G(s) = \frac{\overline{C_A}(s)}{\overline{C_{Ai}}(s)} = \frac{K_p}{(\tau_p S + 1)}$$

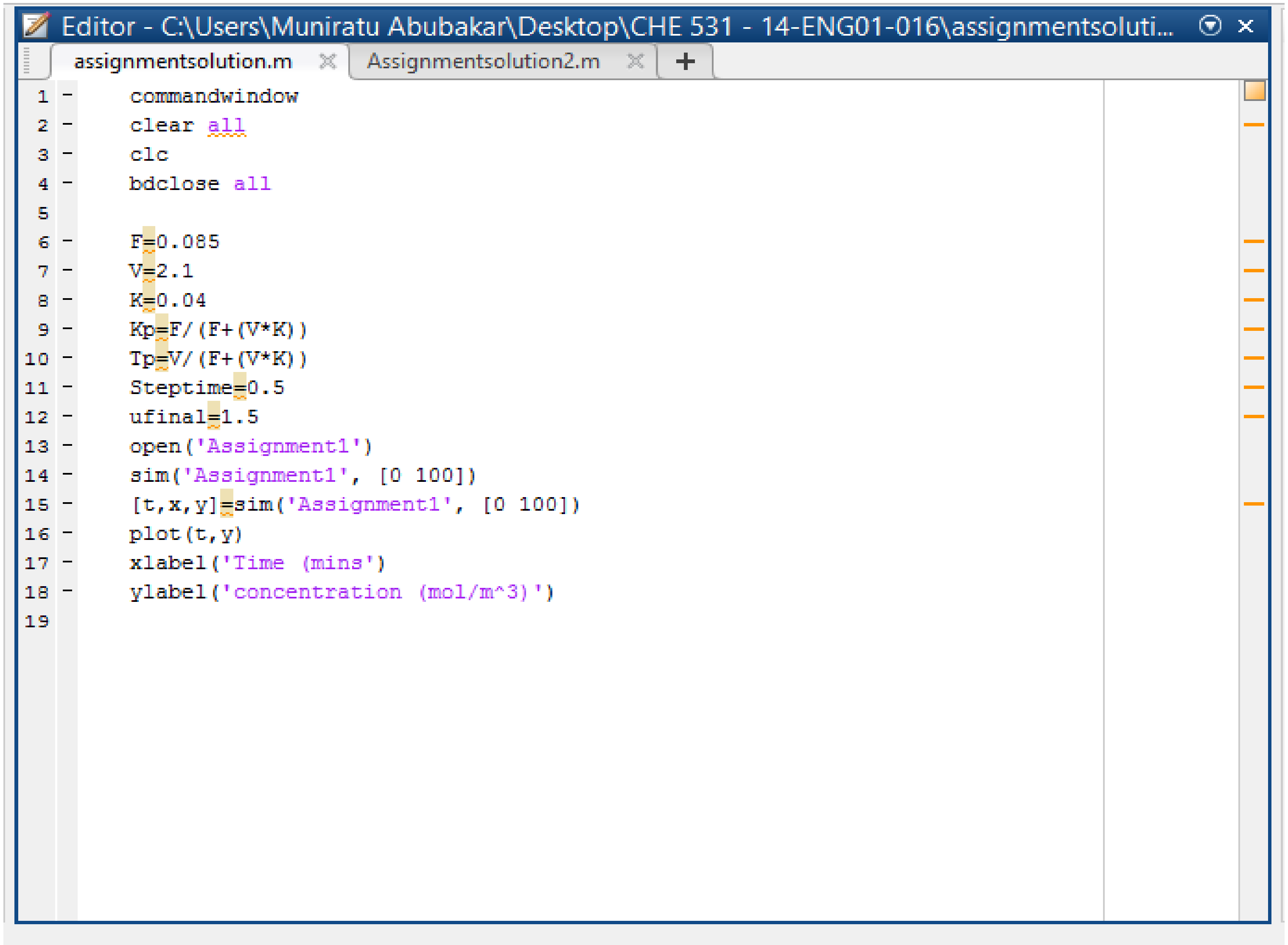


Figure 1. 1. open loop dynamic model simulation

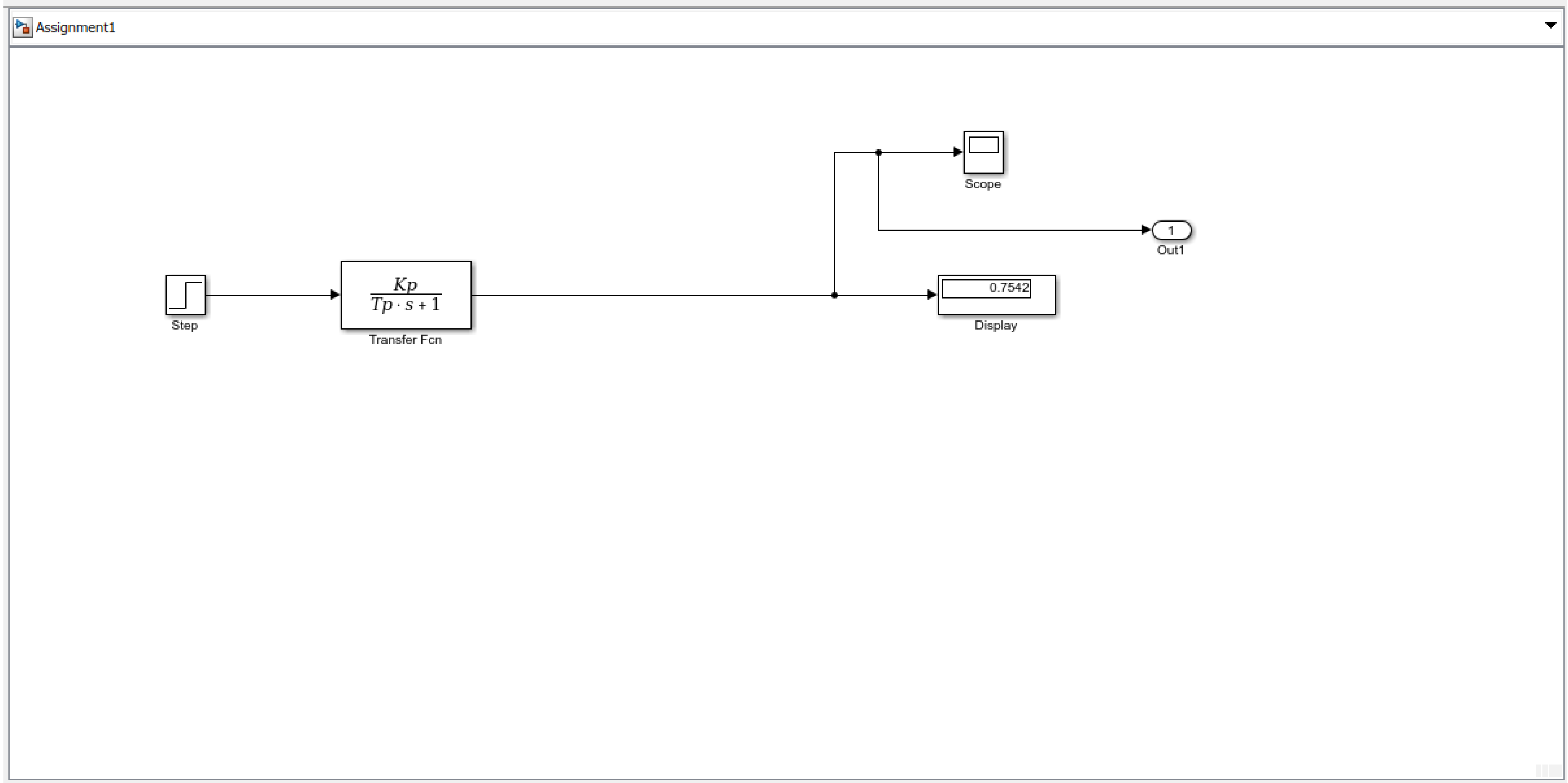


Figure 1. 2. Open loop dynamic model

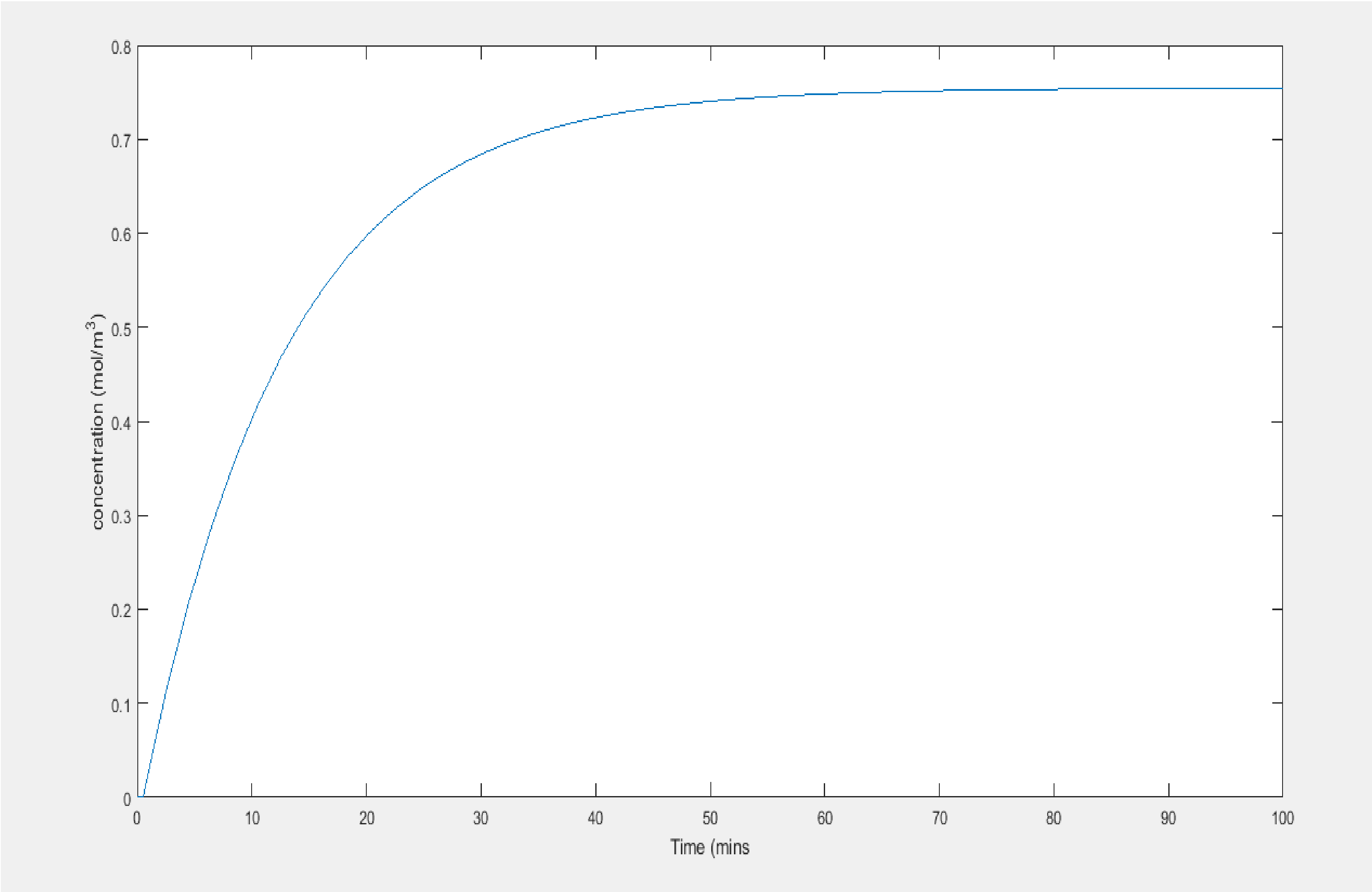
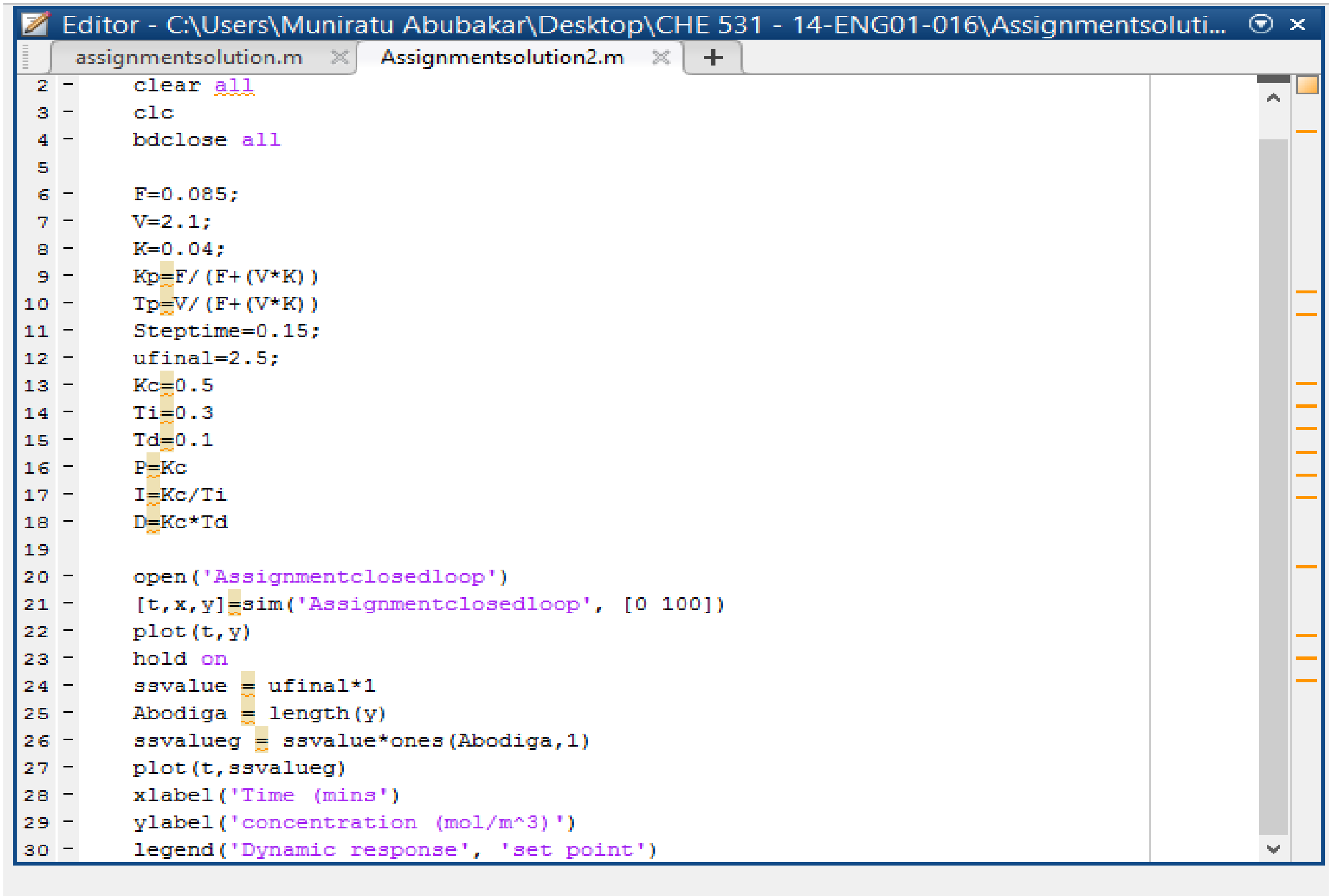


Figure 1. 3. Open loop dynamic model plot




```
clear all
clc
bdclose all

F=0.085;
V=2.1;
K=0.04;
Kp=F/(F+(V*K))
Tp=V/(F+(V*K))
Steptime=0.15;
ufinal=2.5;
Kc=0.5
Ti=0.3
Td=0.1
P=Kc
I=Kc/Ti
D=Kc*Td

open('Assignmentclosedloop')
[t,x,y]=sim('Assignmentclosedloop', [0 100])
plot(t,y)
hold on
ssvalue = ufinal*1
Abodiga = length(y)
ssvalueg = ssvalue*ones(Abodiga,1)
plot(t,ssvalueg)
xlabel('Time (mins')
ylabel('concentration (mol/m^3)')
legend('Dynamic response', 'set point')
```

Figure 1. 4. closed loop dynamic model simulation

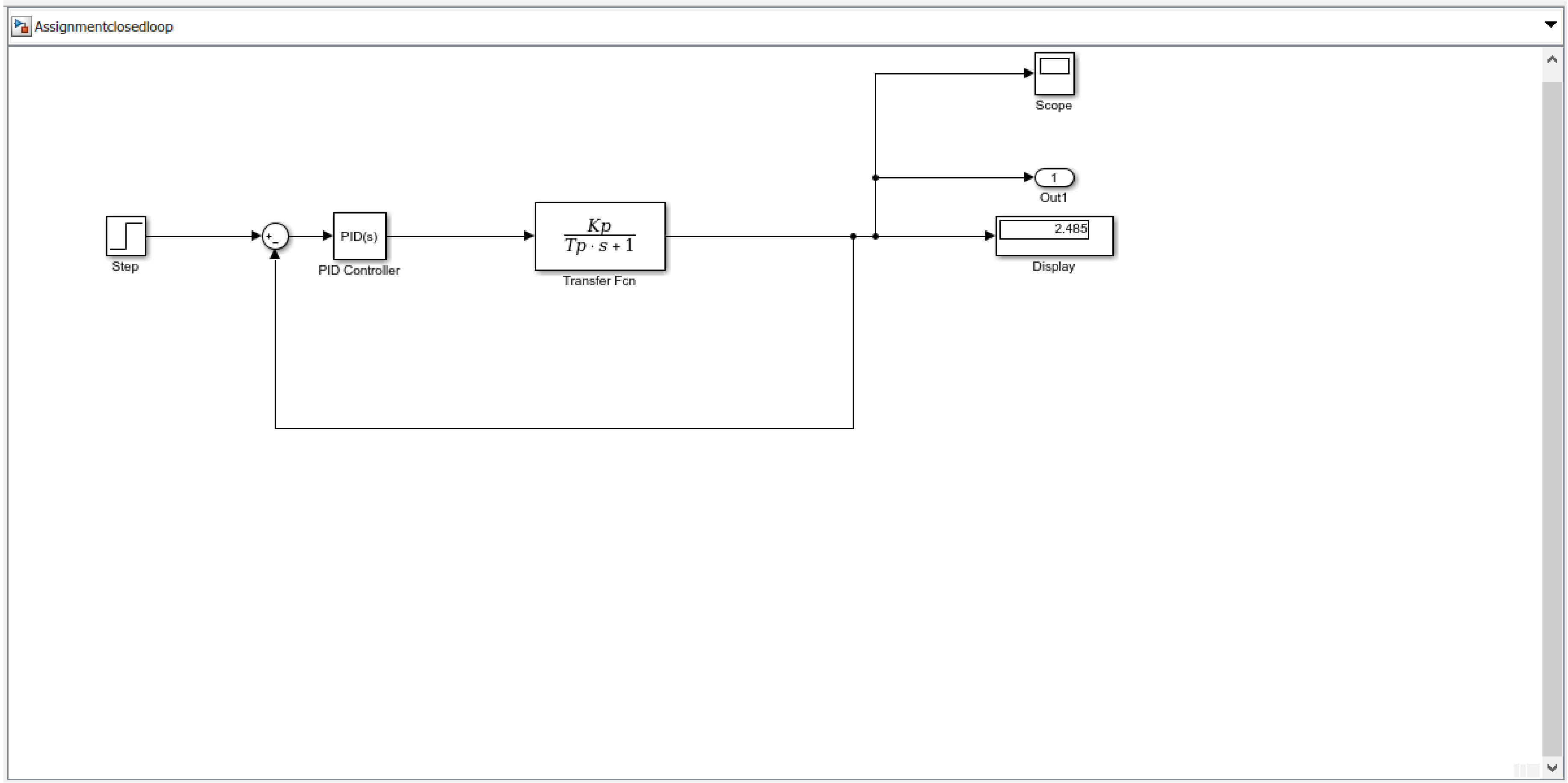


Figure 1. 5. Closed loop dynamic model

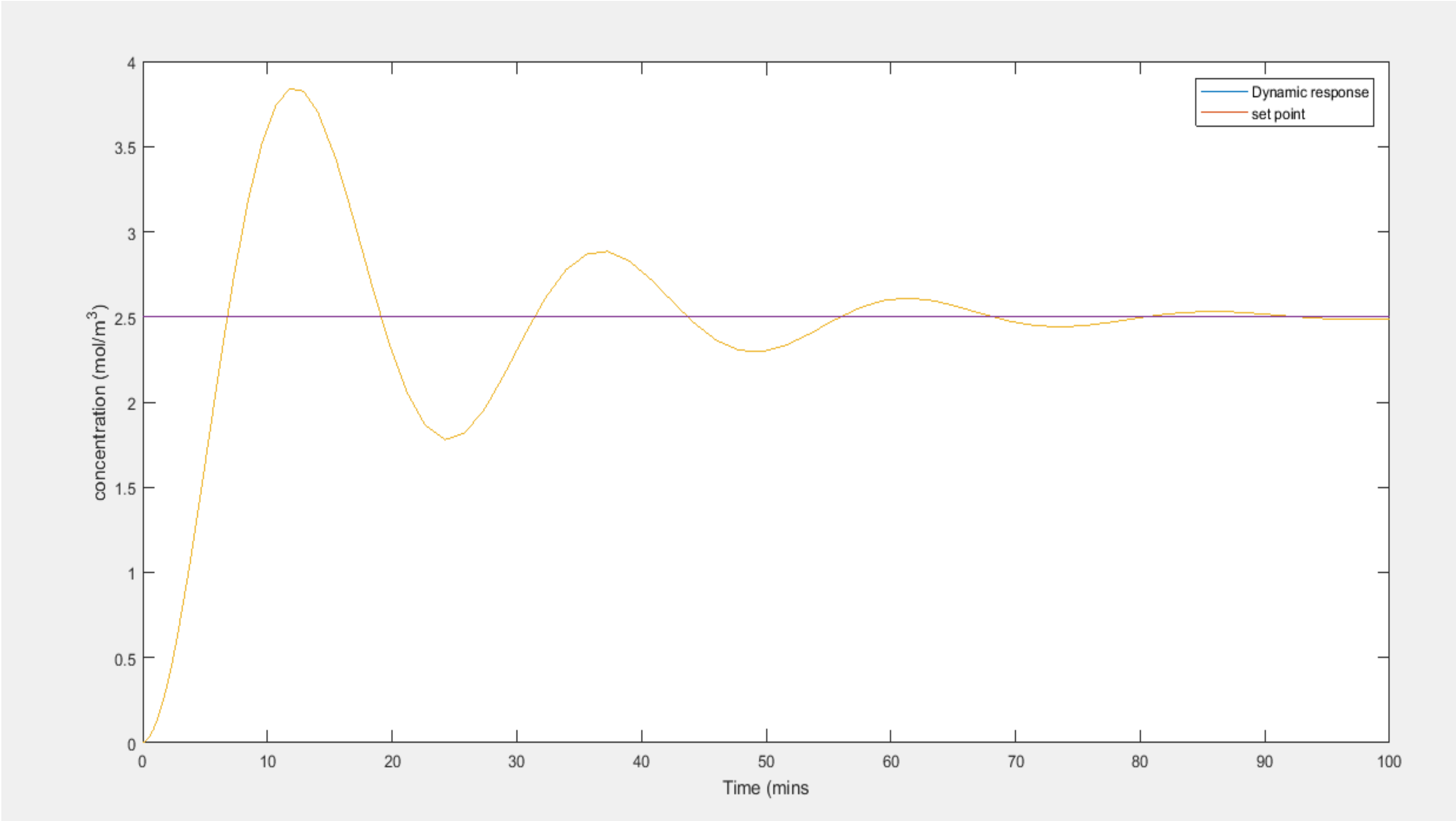


Figure 1. 6. Closed loop dynamic model plot