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18/Eng 03/011

Civil engineering

1) Applying the balance law

Accumulation rate of  $\equiv$  Input rate of salt - Output rate of salt

Salt within a system into a system from the system denoting the amount of salt present in the tank of any-time  $t$  as  $y$ , its time rate of change is given as,

$$\frac{dy}{dt} = y_{in} - y_{out}$$

Since 5 gal of brine enter the tank per minute and one gallon contains [1 + 0.02] lb of salt;

1) at  $t = 1$ ; [1 + 0.02] = [1 + 0.02] = 1.02 lb of salt;  $\therefore$  It means that the amount of salt entering the tank is  $y_{in} = 5 \text{ gal/min} \times 1.02 \text{ lb/gal} = 5.16 \text{ lb/min}$

The tank contains 200 gal of water with the dissolved salt, & 30 gallons of the solution leaves the tank per minute. That is  $30 \text{ gal} / 200 \text{ gal} = 0.15 = 15\%$  of the content of the tank. ~~contains~~ If that's the case; 15% of the salt present in the tank will also leave the tank per minute (in other words);

a) Therefore;  $\frac{dy}{dt} \stackrel{2.5\% \text{ of } y}{15/\text{min}} = 51 \text{ lb/min} - 2.5\% \text{ of } y \text{ lb/min}$

b)  $\frac{dy}{dt} = 51 - 0.025y$ ;  $\frac{dy}{dt} = 0.025y + 51$   
 $\frac{dy}{dt} = 0.025 \left[ \frac{-0.025y + 51}{-0.025y} + \frac{51}{-0.02} \right]$ ;  $\frac{dy}{dt} = \frac{-0.025}{(y-2040)}$

$$\frac{dy}{(y-2040)} = -0.0254; \int \frac{dy}{(y-2040)} = \int -0.025 dt;$$
$$\ln(y-2040) = 0.025 \int dt; \ln(y-2040) = -0.025t + C;$$

$$y - 2040 = e^{-0.025t} C; \quad y - 2040 = e^{-0.025t} C;$$

$$y = y_0 \cdot e^{-0.025t} + 2040; \quad \text{Given that when } t=1$$

Initially  $y = 150 \text{ lb}$

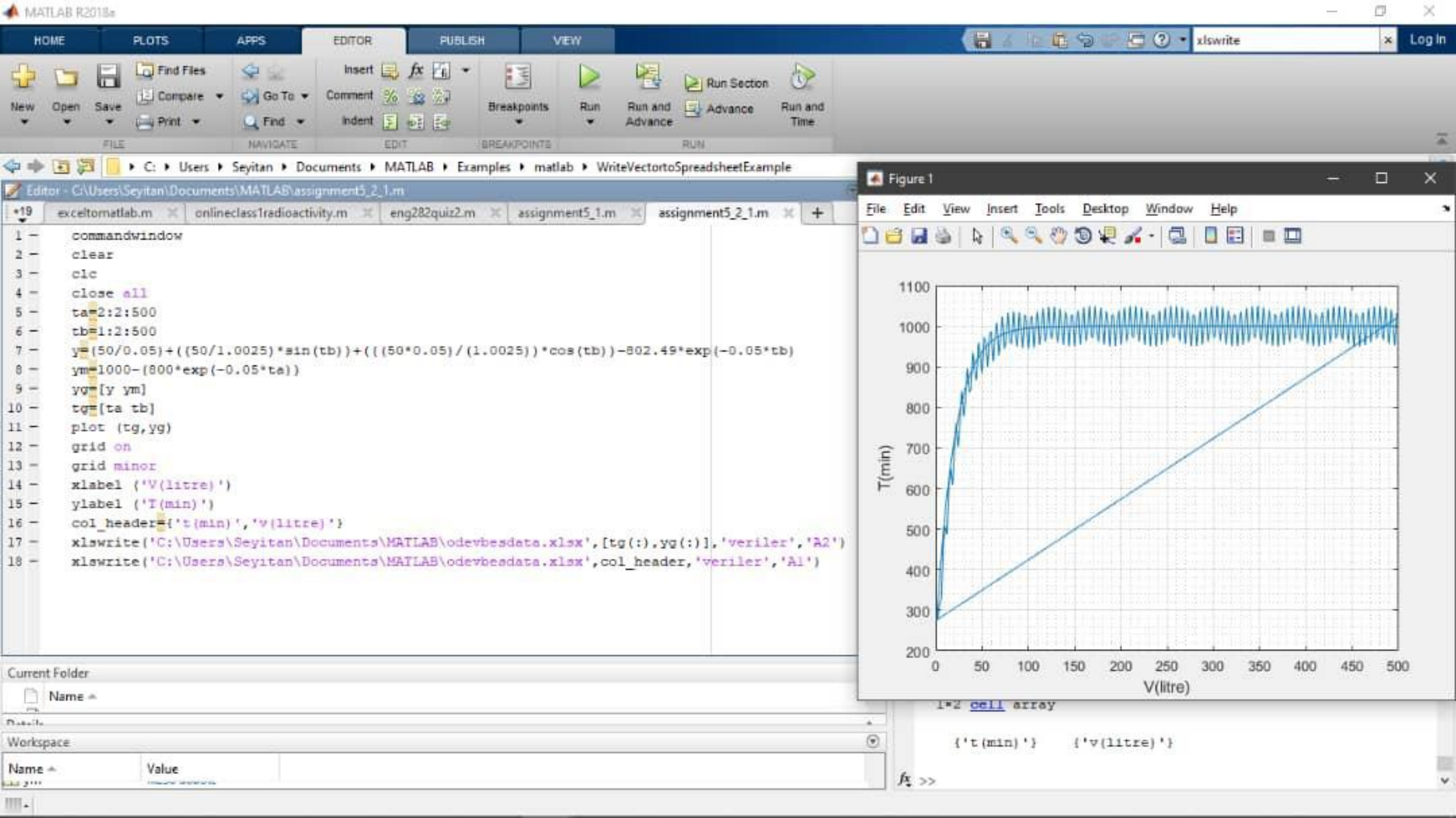
$$150 = y_0 e^{-0.025 \times 1} + 2040; \quad 150 - 2040 = y_0 \times 1;$$

$$y_0 = -1890$$

50;

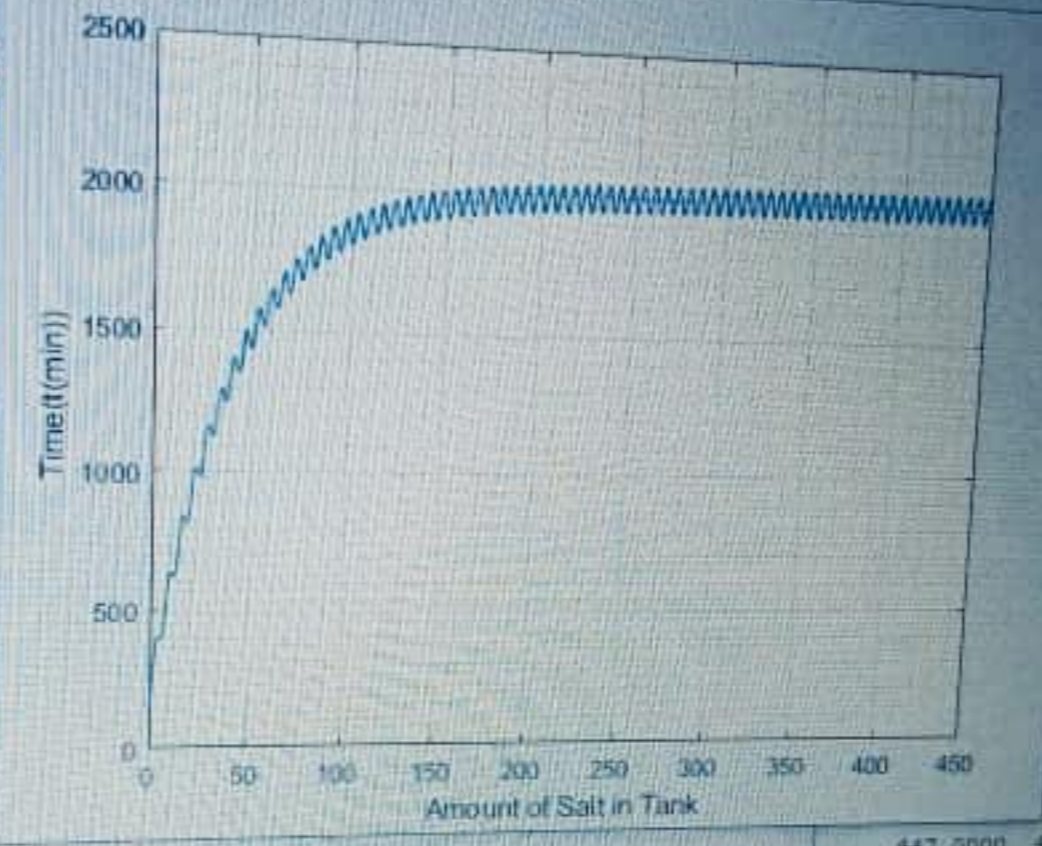
$$y = -1890 e^{-0.025t}$$

$$y = \underline{\underline{2040 - 1890 e^{-0.025t}}}$$



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1 - commandwindow
2 - clear
3 - clc
4 - close all
5 - syms m t
6 - s=dsolve('Dm+(0.025*m) = 50*(1+sin(t))', 'm(0)=0')
7 - tn=0:0.5:450
8 - sn=subs(s,tn)
9 - plot(tn,sn)
10 - grid on
11 - grid minor
12 - xlabel('Amount of Salt in Tank')
13 - ylabel('Time t (min)')
14
15
16
    
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through 876  
 25.5000 436.0000 436.5000 437.0000 437.5000  
 through 882  
 38.5000 438.0000 438.5000 439.0000 439.5000  
 through 888  
 41.5000 442.0000 442.5000 443.0000 443.5000  
 through 894  
 44.5000 445.0000 445.5000 446.0000 446.5000  
 through 900

447.0000 447.5000 448.0000 448.5000 449.0000 449.5000  
 Column 901  
 450.0000

sn =  
 [ 150, 2000 - (2000\*1492^(11/21)\*exp(atanh(13/45)) + 1/21)\*1492