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MAT NO: 18/ENG04/021

Question 2
Tank holds 1200 gal of water with 15 lb of salt dissolved in it

- input rate => 50 gal of brine/min [1 gal has (1+sin t) lb of salt]
- Output rate => 30 gal of brine/min
  m => Amount of salt at any time t
  Using the balance law
  $\frac{dm}{dt} = m_{in} - m_{out}$

1) 50 gal of water per minute and a gallon has (1+sin t) lb of salt
   $\therefore M_{in} = 50 \text{ gal/min} \times (1+\sin t) = 50(1+\sin t)$ lb/min
   if the tank contains 1200 gal of water and 30 gal of water leaves per minute. That is $\frac{30}{1200} = \frac{1}{40} = 0.025$

=> 2.5% of water in the tank leaves per minute. This also must that 2.5% of salt will also leave the tank per minute

m_{out} => 2.5% of m

$\frac{dm}{dt} = 50(1+\sin t) - 0.025m$ ----(i)

differentiating using integration factor method

$\frac{dm}{dt} + 0.025m = 50(\sin t + 1)$ ---(ii)

$\frac{dy}{dx} + Py = Q\left(\frac{dm}{dt} + P_m = Q\right)$

$P = 0.025$, $Q = 50(\sin t + 1)$

$e^{\int P dt}$ = integrating factor

$\int P dt = \int 0.025\, dt = 0.025t$

If => $e^{0.025t}$

From $y \cdot IF = \int Q \cdot IF\, dx$

$m \cdot IF = \int Q \cdot IF\, dt$

$m \cdot e^{0.025t} = \int 50(\sin t + 1) \cdot e^{0.025t}\, dt$

$= 50 \int e^{t/40} (\sin t + 1) dt$

let $v = \frac{t}{40} \rightarrow \frac{dv}{dt} = \frac{1}{40}$, $dt = 40\, dv$

$= 40 \int e^v (\sin 40v + 1) dv$

$\int e^v (\sin 40v + 1) dv$

Let $q = \sin 40v + 1$, $dp = e^v dv$

$\frac{dq}{dv} = 40 \cos 40v$ $\int dp = \int e^v dv$

$dq = 40(\cos 40v) dv$ $p = e^v$

From $\int q\, dp = qp - \int p\, dq$

$\int 40e^v (\cos 40v) dv \Rightarrow 40 \int e^v (\cos 40v) dv$

$\int e^v \cos 40v\, dv \Rightarrow$ Let $q = \cos 40v$ $dp = e^v dv$

Integrating

$\int e^v \cos 40v\, dv = e^v \cos 40v - \int -40e^v (\sin 40v) dv$ — (iii)

integration by part

$q = -40 \sin 40v$ $dp = e^v$

$dq = -1600(\cos 40v) dv$ $p = e^v$

$\int e^v \cos 40v\, dv = e^v \cos 40v - C - 40e^v \sin 40v - \int -1600 e^v \cos 40v\, dv$

$1601 \int e^v \cos 40v\, dv = e^v \cos 40 + 40e^v \sin 40v$

$\int e^v \cos 40v\, dv = \frac{e^v \cos 40 + 40e^v \sin 40v}{1601}$

$40 \int e^v \cos 40v\, dv = 40(40e^v \sin 40v + e^v \cos 40v)$ — (iv)

From (iii)

$\Rightarrow \int e^v (\sin 40v + 1) dv = e^v \sin 40v + 1 - \int 40e^v \cos 40v\, dv$

$\int e^v (\sin 40v + 1) \Rightarrow e^v \sin 40v + 1 - \frac{40(40e^v \sin 40v + e^v \cos 40v)}{1601}$

$$\int 40e^{u}\sin 40u + 1\,du = 40e^{u}(\sin 40u + 1) - 1600\,\frac{(40e^{u}\sin 40u + e^{u}\cos 40u)}{1601}$$

put $u = t/40$

$$40e^{t/40}(\sin t + 1) - \frac{1600\,(40e^{t/40} + e^{t/40}\cos(t))}{1601}$$

$$50\int e^{t/40}(\sin t + 1)\,dt$$

$$50\int e^{t/40}(\sin t + 1)\,dt \Rightarrow \frac{2000e^{t/40}(\sin t - 40\cos t + 1601)}{1601} + C \quad -(V)$$

Recall the original integration factor

$$m.IF = \int Q.IF\,dt$$

$$m\cdot e^{0.025} = \int 150(\sin t + 1)\cdot e^{0.025t}\,dt$$

put eqn (V)

$$m\cdot e^{0.025t} = 2000e^{0.025}\,\frac{(\sin t - 40\cos t + 1601)}{1601} + C$$

$$m = \frac{2000(\sin t - 40\cos t + 1601)}{1601} + m_0\cdot e^{-0.025t} \quad -(VI)$$

at $t = 0$ min and $m = 150$ lb of salt

$$150 = \frac{2000(\sin 0 - 40\cos(0) + 1601)}{1601} + m_0\cdot 1$$

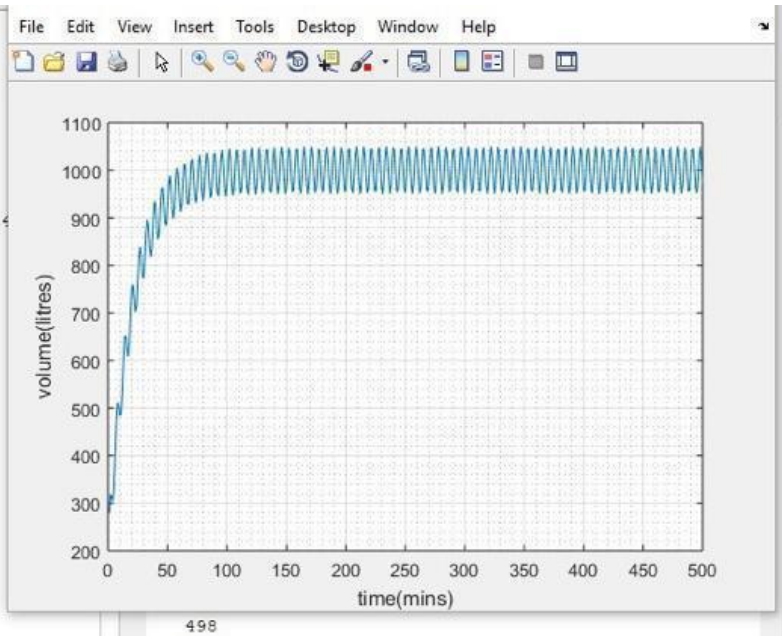
$$150 = 1950.03 + m_0$$

$$m_0 = -1800.03$$

put m_0 in eqn (VI)

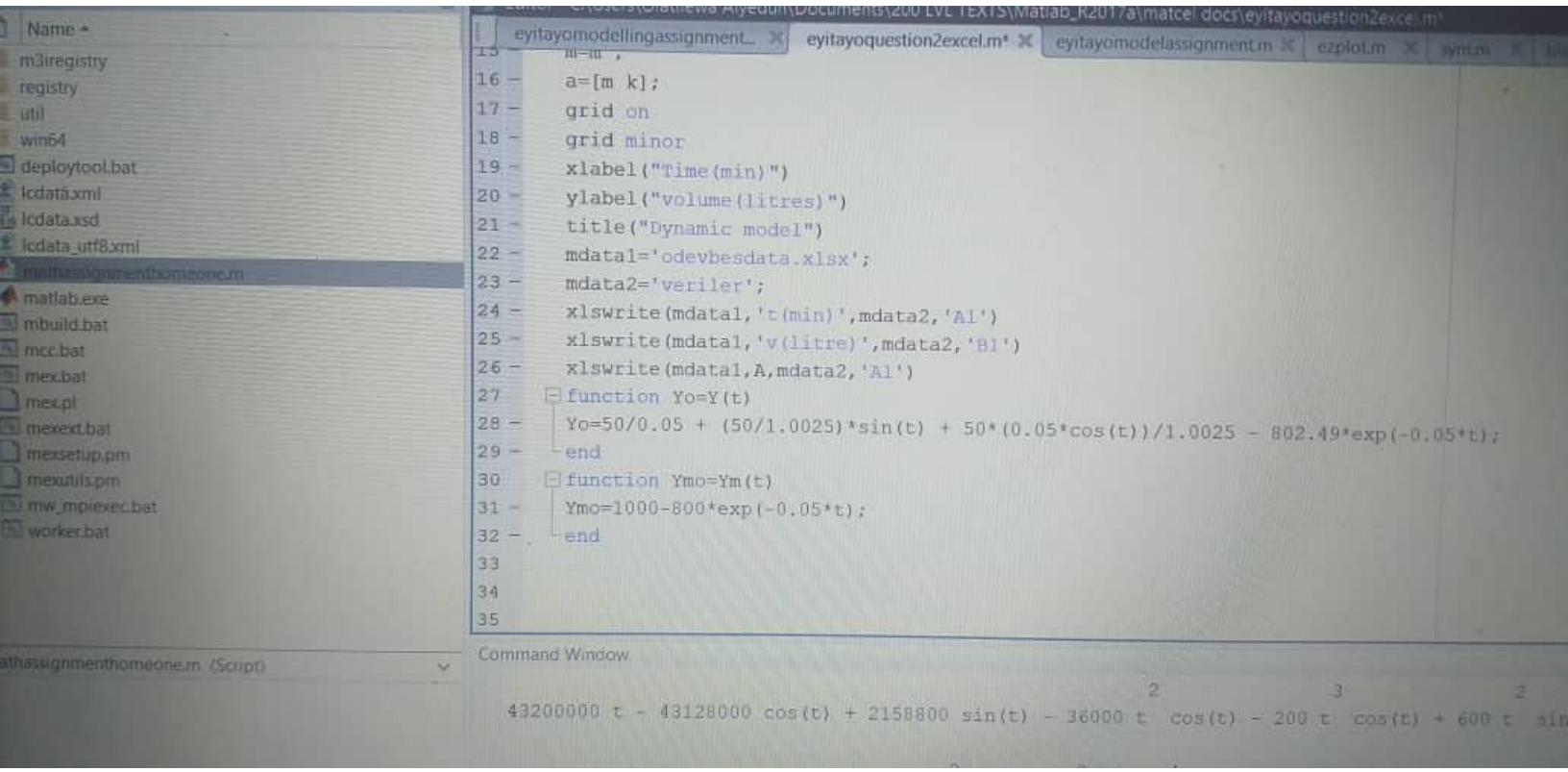
$$m = \frac{2000(\sin t - 40\cos t + 1601)}{1601} - \frac{1800.03}{e^{0.025t}}$$

```
commandwindow
clear
clc
close all
syms t
values=[]
t=1:1:500
mean=1000-((exp(-0.05*t))*800)
y=1000+(50/1.0025)*sin(t)+(2.5/1.0025)*cos(t)-((exp(-0.05*t))*802.4

if rem(t,2) ==0
    values=[values,mean]
else
    values=[values,y]
end
excelvalues=transpose(values)
mins=transpose(t)
plot(t,values)
grid on
grid minor
xlabel ('time(mins)')
ylabel('volume(litres)')
xlswrite('odevbesdata.xlsx',{'t(min)'},'veriler','A1')
xlswrite('odevbesdata.xlsx',mins,'veriler','A2')
xlswrite('odevbesdata.xlsx',{'V(Litre)'},'veriler','B1')
xlswrite('odevbesdata.xlsx',excelvalues,'veriler','B2')

```




```
498
499
500
```

fx >>


Name
m3iregistry
registry
util
win64
deploytool.bat
lcdata.xml
lcdata.xsd
lcdata_utf8.xml
matlab.exe
mbuild.bat
mcc.bat
mex.bat
mex.pl
mexext.bat
mexsetup.pm
mexutils.pm
mw_mpiexec.bat
worker.bat
eyitayomodellingassignment_
eyitayoquestion2excel.m*
eyitayomodelassignment.m
ezplot.m
a=[m k];
grid on
grid minor
xlabel("Time(min)")
ylabel("volume(litres)")
title("Dynamic model")
mdata1='odevbesdata.xlsx';
mdata2='veriler';
xlswrite(mdata1,'t(min)',mdata2,'A1')
xlswrite(mdata1,'v(litre)',mdata2,'B1')
xlswrite(mdata1,A,mdata2,'A1')
function Yo=Y(t)
Yo=50/0.05 + (50/1.0025)*sin(t) + 50*(0.05*cos(t))/1.0025 - 802.49*exp(-0.05*t);
end
function Ymo=Ym(t)
Ymo=1000-800*exp(-0.05*t);
end
Command Window
43200000 t - 43128000 cos(t) + 2158800 sin(t) - 36000 t^2 cos(t) - 200 t^3 cos(t) + 600 t^2 sin