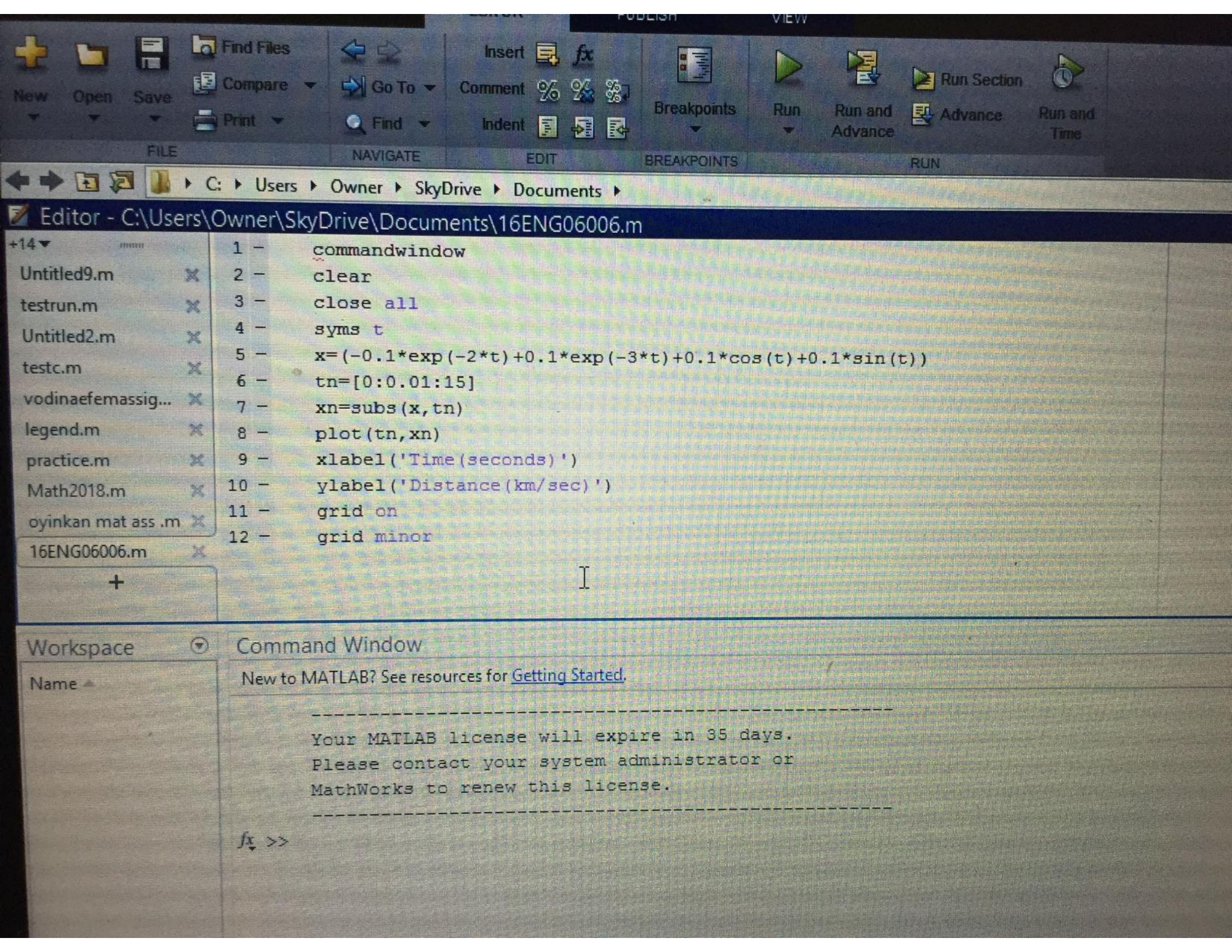
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2 - clear
3 - close all
4 - syms t
5 - x=(-0.1*exp(-2*t)+0.1*exp(-3*t)+0.1*cos(t)+0.1*sin(t))
6 - tn=[0:0.01:15]
7 - xn=subs(x,tn)
8 - plot(tn,xn)
9 - xlabel('Time(seconds)')
10 - ylabel('Distance(km/sec)')
11 - grid on
12 - grid minor
Workspace
Name
Command Window
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TLAB? See resources for Getting St

ms 1499 through 1501

Figure 1

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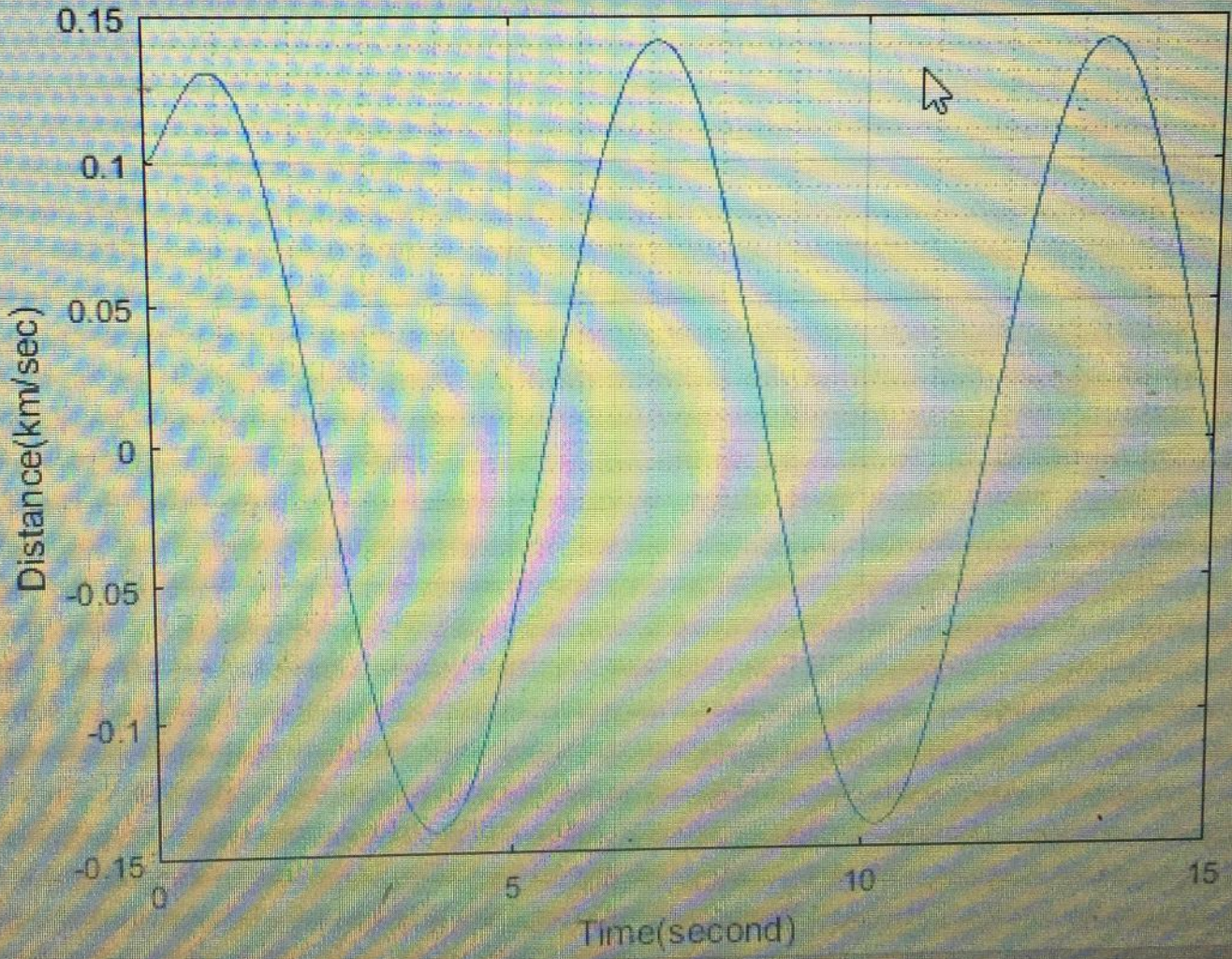

Ajayeoba Oyinkan Ekoko
16/ENG06/006
Mechanical Engineering
EMG 381 Assignment

$$\frac{d^2x}{dt^2} + 5\frac{dx}{dt} + 6x = \cos t$$

when $t=0$, $x=0.1$ and $dx/dt = 0$

solution

$m^2 + 5m + 6 = 0$

$m^2 + 3m + 2m + 6 = 0$

$m(m+3) + 2(m+3) = 0$

$(m+2)(m+3) = 0$

$m = -2$ or $m = -3$

$X = Ae^{m_1 x} + Be^{m_2 x}$

$X = Ae^{-2t} + Be^{-3t}$ ... (CF)

PI: $f(t) = \cos t$ $\quad X = C\cos t + D\sin t$

$\frac{dx}{dt} = -C\sin t + D\cos t$

$\frac{d^2x}{dt^2} = -C\cos t - D\sin t$

substitute back into general question

$-C\cos t - D\sin t + 5(-C\sin t + D\cos t) + 6(C\cos t + D\sin t) = \cos t$

$-C\cos t - D\sin t - 5C\sin t + 5D\cos t + 6C\cos t + 6D\sin t = \cos t$

$-C\cos t + 6C\cos t - D\sin t + 6D\sin t - 5C\sin t + 5D\cos t = \cos t$

$-C\cos t + 6C\cos t + 5D\cos t - D\sin t + 6D\sin t - 5C\sin t = \cos t$

$5C\cos t - 5D\cos t + 5D\sin t - 5C\sin t = \cos t$

$(5C - 5D)\cos t + (5D - 5C)\sin t = \cos t$

$5C + 5D = 1$ ... (1)

$5D - 5C = 0$ ... (2)

$5D = 5C$

$D = 5/5C$

$D = C$ ... (3)

sub eqn (3) into (1)

$5C + 5D = 1$

$5C + 5C = 1$

$10C = 1$

$C = 1/10$

From eqn (3)

$D = 1/10 = C$

Substitute c into (x)

$X = C\cos t + D\sin t$

$X = \frac{1}{10}\cos t + D\sin t \quad \ldots PI$

from $X = CF + PI$

$X = Ae^{-2t} + Be^{-3t} + \frac{1}{10}\cos t + \frac{1}{10}\sin t$

at $x = 0.1 \quad t = 0 \quad dx/dt = 0$

$0.1 = Ae^{-2(0)} + Be^{-3(0)} + \frac{1}{10}\cos(0) + \frac{1}{10}\sin(0)$

$0.1 = A + B + 0.1 + 0$

$0.1 = A + B + 0.1$

$0.1 - 0.1 = A + B$

$0 = A + B \quad \ldots (4)$

$\frac{dx}{dt} = \frac{d}{dt}\left[Ae^{-2t}\right] + \frac{d}{dt}\left[Be^{-3t}\right] + \frac{d}{dt}\left[\frac{1}{10}\cos t\right] + \frac{d}{dt}\left[\frac{1}{10}\sin t\right]$

$\frac{dx}{dt} = A(-2e^{-2t}) + B(-3e^{-3t}) - \frac{1}{10}\sin t + \frac{1}{10}\cos t$

$\frac{dx}{dt} = -2Ae^{-2t} - 3Be^{-3t} - \frac{1}{10}\sin t + \frac{1}{10}\cos t$

sub $t = 0$ and $dx/dt = 0$

$0 = -2Ae^{-2(0)} - 3B^{-3(0)} - \frac{1}{10}\sin(0) + \frac{1}{10}\cos(0)$

$0 = -2A - 3B + 0 + \frac{1}{10}$

$0 = -2A - 3B + \frac{1}{10}$

$-\frac{1}{10} = -2A - 3B \quad \ldots (5)$

$0 = A + B \quad \ldots (4)$

$-\frac{1}{10} = -2A - 3B \quad \ldots (5)$

$-B = A$ from eqn (4) $\ldots (6)$

$\frac{-1}{10} = -2(-B) - 3B$

$\frac{-1}{10} = 2B - 3B$

$\frac{-1}{10} = -B$

$B = \frac{1}{10}$

sub $B = \frac{1}{10}$ into eqn (6)

$A = -B$

$A = -1/10$

$$X = \frac{-1}{10}e^{-2t} + \frac{1}{10}e^{-3t} + \frac{1}{10}\cos t + \frac{1}{10}\sin t$$

$$X = -0.1e^{-2t} + 0.1e^{-3t} + 0.1\cos t + 0.1\sin t.$$

iii Steady state solution in form of $x = K\sin(t+a)$

Solution

$$X = \frac{1}{10}\left[e^{-3t} - e^{-2t} + \sin t + \cos t + \sin t\right]$$

at $\frac{dx}{dt} = 0$

$$\frac{dx}{dt} = \frac{1}{10}\left[-3e^{-3t} + 2e^{-2t} + \cos - \sin t\right]$$

From the exponentials resulting to zero

$0 = \cos t - \sin t$

$\sin t = \cos t$

$t = 45°$

$x = 1/10\,(\cos 45 + \sin 45)$

$x = \frac{\sqrt{2}}{10}$

But from the sinusoidal expression in matlab graph,

$A\cos\omega t + r\sin\omega t = K\cos(\omega t - \theta)$

$\cos(\omega t - \theta) = \sin(\omega t - \theta + 90°)$

$K = \sqrt{A^2 + B^2} = \sqrt{(1/10)^2 + (1/10)^2} = \frac{\sqrt{2}}{10}$

$\theta = 0^\circ$ (From the same phase)

in the form $x = k\sin(t + a)$

$$\frac{\sqrt{2}}{10} = \frac{\sqrt{2}}{10}\sin(45 + a)$$

$$1 = \sin(45 + a)$$

$$45 + a = \sin^{-1}(1)$$

$$45 + a = 90$$

$$a = 90 - 45^\circ = 45^\circ \simeq \frac{\pi}{4}$$

The steady state solution is

$$x = \frac{\sqrt{2}}{10}\sin\left(1t + \frac{\pi}{4}\right)$$

Matlab Code

```
Command window
clear
close all
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x = (-0.1*exp(-2*t) + 0.1*exp(-3*t) + 0.1*cos(t) + 0.1*sin(t))
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ylabel('Displacement (km/sec)')
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grid minor
```