**Chapter 3 – Solutions to Instructor Reserve Problems**

**I-1 Instructor**

Add branch currents and node voltages to the schematic and obtain,

**3**

**2**

**3**

**3**



Write the differential equation for each energy storage element.



Therefore the state vector is 

Now obtain  and , in terms of the state variables,





Also, the output is



Hence,



**I-2 Instructor**

Writing the differential equations,





Defining the state variables to be x1, v1, x2, v2, where v's are velocities,

1 = v1

2 = v2

1 = -2v1-2x12+2v2

2 = v1-v2+0.5f(t)

Around x1 = 1, x1 = 1+x1, and 1 =  1 . Also,



Therefore, the state and output equations are,

1 = v1

2 = v2

1 = -2v1-2(1+2x1)+2v2

2 = v1-v2+0.5f(t)

y = x­2

In vector-matrix form,

; 

where *f(t) = 2 + f(t)*, since force in the nonlinear spring is 2 N and must be balanced by 2 N force on the damper.

**I-3 Instructor**

**a.**  We begin by calculating



and

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where

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**b.**

>> A=[-0.435 0.209 0.02; 0.268 -0.394 0; 0.227 0 -0.02]

A =

-0.4350 0.2090 0.0200

0.2680 -0.3940 0

0.2270 0 -0.0200

>> B = [1;0;0]

B =

1

0

0

>> C = [0.0003 0 0]

C =

1.0e-003 \*

0.3000 0 0

>> [n,d]=ss2tf(A,B,C,0)

n =

1.0e-003 \*

0 0.3000 0.1242 0.0024

d =

1.0000 0.8490 0.1274 0.0005

>> roots(n)

ans =

-0.3940

-0.0200

>> roots(d)

ans =

-0.6560

-0.1889

-0.0042

**I-4 Instructor**

By direct observation



**24. 20**

**a.**

>> A=[-0.038 0.896 0 0.0015; 0.0017 -0.092 0 -0.0056; 1 0 0 -3.086; 0 1 0 0]

A =

-0.0380 0.8960 0 0.0015

0.0017 -0.0920 0 -0.0056

1.0000 0 0 -3.0860

0 1.0000 0 0

>> B = [-0.0075 -0.023; 0.0017 -0.0022; 0 0; 0 0]

B =

-0.0075 -0.0230

0.0017 -0.0022

0 0

0 0

>> C = [0 0 1 0; 0 0 0 1]

C =

0 0 1 0

0 0 0 1

>> [num,den] = ss2tf(A,B,C,zeros(2),1)

num =

0 0.0000 -0.0075 -0.0044 -0.0002

0 0 0.0017 0.0001 0

den =

1.0000 0.1300 0.0076 0.0002 0

>> [num,den] = ss2tf(A,B,C,zeros(2),2)

num =

0 -0.0000 -0.0230 0.0027 0.0002

0 -0.0000 -0.0022 -0.0001 0

den =

1.0000 0.1300 0.0076 0.0002 0

**b.**

From the MATLAB results

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**I-5 Instructor**

The transfer function is divided into two parts:



So we have

 and 

In time domain

 and 

Define the state variables as



So we can write

 and 

In matrix form these equations are:



