**LAB # 6**

**OBJECTIVE**

Generate a MatLab Code to find the transfer function of the Mechanical and Electromechanical Systems.

**THEORY**

**Mechanical Systems**

A **mechanical system** manages power to accomplish a task that involves forces and movement.

**Electromechanical Systems**

**Electromechanical systems** or devices convert electrical energy into mechanical movement and sometimes vice versa. Most of the common electromechanical components, such as electric motors and solenoids are used in combination with mechanical parts to provide actuation or movement.

There are two types of mechanical systems: i) Mechanical Translational Systems ii) mechanical Rotational Systems.

There are two common electromechanical systems: i) DC Generator ii) DC Servo Motor

**Mechanical Translational Systems**

The model of mechanical translational systems can obtain by using three basic elements mass or inertia (M), spring or elasticity (K) and damper or friction (B). When a force is applied to a translational mechanical system, it is opposed by opposing forces due to mass, friction and elasticity of the system.

**Mechanical Rotational Systems**

The model of rotational mechanical systems can be obtained by using three elements, moment of inertia [J] of mass, rotational friction or damper [B] and rotational or torsional spring (K) with stiffness. When a torque is applied to a rotational mechanical system, it is opposed by opposing torques due to moment of inertia, friction and elasticity of the system.

The difference in both systems is after applying force the displacement is straight in mechanical translational system but in mechanical rotational system the displacement is angular after applying torque.

The force or torque acting on a mechanical body is governed by Newton’s second law of motion. For translational and rotational systems it states that the sum of forces or torques acting on a body is zero.

To perform this lab we need the following commands:

* Solve
* Syms
* Pretty
* Simplify

**EXERCISE**

**Task 1:** Find the transfer function X1/F of the given mechanical translational system by using solve command.

**Coding:**

syms x m s b k f

t=solve(**'f=((m\*s^2\*x)+(b\*s\*x)+(k\*x))'**,f,x)

F=t.f

X=t.x

g=X/F

a=simplify(g)

pretty(a)

**Result:**

g =

1/(m\*s^2 + b\*s + k)

a =

1/(m\*s^2 + b\*s + k)

1

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m s ^2 + b s + k

**Task 2:** Find the transfer function X1/F and X2/F of the given mechanical translational system by using solve command.

**Coding:**

syms **k1 k2 b m1 m2 x1 x2 s f**

t=solve(**'f=((m2\*(s^2)\*x2)+(k2\*x2)+(b\*s\*(x2-x1))+(k1\*(x2-x1)))','((m1\*(s^2)\*x1)+(k1\*(x1-x2))+(b\*s\*(x1-x2))=0)',f,x1,x2**)

F=t.f

X1=t.x1

X2=t.x2

g1=X1/F

a1=simplify(g1)

pretty(a1)

g2=X2/F

a2=simplify(g2)

pretty(a2)

**Result:**

g1 =

(k1 + b\*s)/(k1\*k2 + b\*m1\*s^3 + b\*m2\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + k2\*m1\*s^2 + m1\*m2\*s^4 + b\*k2\*s)

a1 =

(k1 + b\*s)/(k2\*(m1\*s^2 + b\*s + k1) + b\*m1\*s^3 + b\*m2\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + m1\*m2\*s^4)

k1 + b s

--------------------------------------------------------------------------

2 3 3 2 2 4

k2 (m1 s + b s + k1) + b m1 s + b m2 s + k1 m1 s + k1 m2 s + m1 m2 s

g2 =

(m1\*s^2 + b\*s + k1)/(k1\*k2 + b\*m1\*s^3 + b\*m2\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + k2\*m1\*s^2 + m1\*m2\*s^4 + b\*k2\*s)

a2 =

(m1\*s^2 + b\*s + k1)/(k2\*(m1\*s^2 + b\*s + k1) + b\*m1\*s^3 + b\*m2\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + m1\*m2\*s^4)

2

m1 s + b s + k1

--------------------------------------------------------------------------

2 3 3 2 2 4

k2 (m1 s + b s + k1) + b m1 s + b m2 s + k1 m1 s + k1 m2 s + m1 m2 s

**Task 3:** Find the transfer function X1/F of the given mechanical translational system by using solve command.

**Coding:**

syms **k b m x1 x2 s f**

t=solve(**'f=((m1\*(s^2)\*x2)+(b\*s\*(x2-x1)))','((b\*s\*(x1-x2))+(k\*x2)=0)',f,x1,x2**)

F=t.f

X1=t.x1

X2=t.x2

g1=X1/F

a1=simplify(g1)

pretty(a1)

g2=X2/F

a2=simplify(g2)

pretty(a2)

**Result:**

g1 =

-(z\*(k - b\*s))/(b\*s\*(m1\*z\*s^2 + k\*z))

a1 =

-(k - b\*s)/(b\*s\*(m1\*s^2 + k))

k - b s

- ---------------

2

b s (m1 s + k)

g2 =

z/(m1\*z\*s^2 + k\*z)

a2 =

1/(m1\*s^2 + k)

1

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2

m1 s + k

**Task 4:** Find the transfer function X1/F and X2/F of the given mechanical translational system by using solve command.

**Coding:**

syms **k1 k2 b1 b2 m1 m2 x1 x2 s f**

t=solve(**'f=((m1\*(s^2)\*x1)+(k1\*(x1-x2))+(b1\*s\*(x1-x2)))','((m2\*(s^2)\*x2)+(b2\*s\*x2)+(k2\*x2)+(k1\*(x2-x1))+(b1\*s\*(x2-x1))=0)',f,x1,x2**)

F=t.f

X1=t.x1

X2=t.x2

g1=X1/F

a1=simplify(g1)

pretty(a1)

g2=X2/F

a2=simplify(g2)

pretty(a2)

**Result:**

g1 =

(k1 + k2 + b1\*s + b2\*s + m2\*s^2)/(k1\*k2 + b1\*m1\*s^3 + b1\*m2\*s^3 + b2\*m1\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + k2\*m1\*s^2 + m1\*m2\*s^4 + b1\*k2\*s + b2\*k1\*s + b1\*b2\*s^2)

a1 =

(m2\*s^2 + (b1 + b2)\*s + k1 + k2)/(k1\*k2 + b1\*m1\*s^3 + b1\*m2\*s^3 + b2\*m1\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + k2\*m1\*s^2 + m1\*m2\*s^4 + b1\*k2\*s + b2\*k1\*s + b1\*b2\*s^2)

2

m2 s + (b1 + b2) s + k1 + k2

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3 3 3 2 2 2 4 2

k1 k2 + b1 m1 s + b1 m2 s + b2 m1 s + k1 m1 s + k1 m2 s + k2 m1 s + m1 m2 s + b1 k2 s + b2 k1 s + b1 b2 s

g2 =

(k1 + b1\*s)/(k1\*k2 + b1\*m1\*s^3 + b1\*m2\*s^3 + b2\*m1\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + k2\*m1\*s^2 + m1\*m2\*s^4 + b1\*k2\*s + b2\*k1\*s + b1\*b2\*s^2)

a2 =

(k1 + b1\*s)/(k1\*k2 + b1\*m1\*s^3 + b1\*m2\*s^3 + b2\*m1\*s^3 + k1\*m1\*s^2 + k1\*m2\*s^2 + k2\*m1\*s^2 + m1\*m2\*s^4 + b1\*k2\*s + b2\*k1\*s + b1\*b2\*s^2)

k1 + b1 s

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3 3 3 2 2 2 4 2

k1 k2 + b1 m1 s + b1 m2 s + b2 m1 s + k1 m1 s + k1 m2 s + k2 m1 s + m1 m2 s + b1 k2 s + b2 k1 s + b1 b2 s

**CONCLUSION:**

In this lab we find the transfer function of the **Mechanical & Electromechanical Systems.** By using **Syms, Solve, Pretty & Simplify.**