ELEC 341 – Graded Assignments

Assignment A3
Mechanical Circuits

10 Marks

Learning Objectives

Mechanical Circuits
Electrical Equivalents
Mixed Electro-Mech Systems
Nodal Analysis
UnLoaded Electric Motors

Matlab
- tf(‘s’)
- dcgain()

*Transform "**Mechanical Circuit #1**" into its equivalent electrical circuit.*
Annotate it with corresponding component labels (R1, L1, C1, etc.)

Q1 2 mark(s) Mass Distance

Use nodal analysis to compute the transfer function G.

Output = d3 Distance of mass M3
Input = F0 Applied Force

Use **minreal()** to cancel any common factors.

- Q1.G (m/N) LTI

Q2 2 mark(s) Spring Force

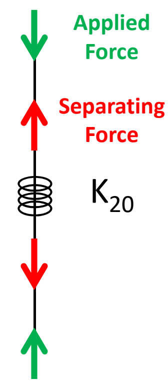
Use nodal analysis to compute the transfer function G.

Output = fK20 **Separating** force exerted by spring K20
Input = F0 Applied Force

Use **minreal()** to cancel any common factors.

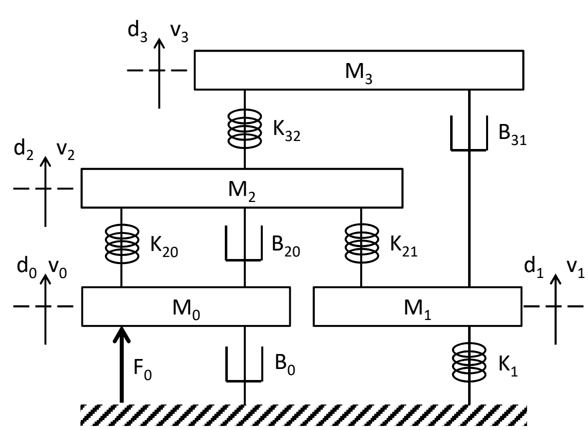
- Q2.G (N/N) LTI

*The command **s=tf('s')** defines the Complex Frequency variable.*
Once defined, you can use it just like a constant in your equations.



Mechanical Circuit #1

- M0 = M3 = #A (Kg)
- M1 = M2 = #B (Kg)
- B0 = #C (Ns/m)
- B20 = #E (Ns/m)
- B31 = #F (Ns/m)
- K1 = K32 = #G (N/m)
- K20 = K21 = #H (N/m)
- F0 = 300 (N)



***COW**: Plot the Impulse (Natural) Response.*
Is the Final Value 0 ??? Should it be ????
What should the final values of the electric circuit be if you applied a jolt of current ???
*If it doesn't agree, **check your circuit analysis**.*
What should the final values of the mechanism be if you gave the motor a nudge ???
*If it doesn't agree, **check your e-mech transformation**.*
What is the electrical equivalent of angle ??? Can you measure it on a scope ???

*Replace Spring K1 with Damper B1 to get "**Mechanical Circuit #2**".*

Q3 2 mark(s) Mass Distance

Use nodal analysis to compute the transfer function G.

Output = d3 Distance of mass M3
Input = F0 Applied Force

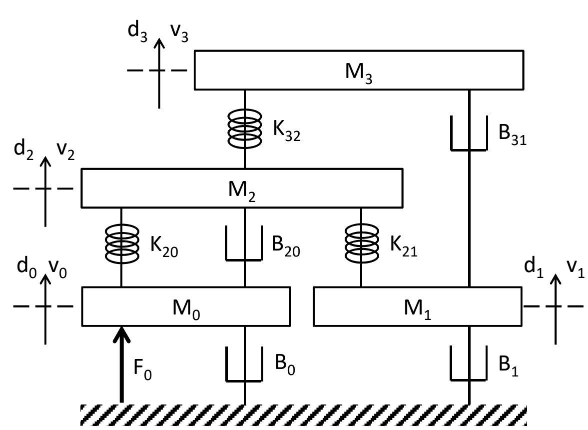
Use **minreal()** to cancel any common factors.

- Q3.G (rad/Nm) LTI

***COW:** Do the exact same thing again. What changed ???*
*Does this make **practical sense** ??? B1 doesn't even touch M3, after all.*

Mechanical Circuit #2

- B1 = #D (Ns/m)



An electric motor combines an electrical system with a mechanical system with two dependent sources. Rotor torque is determined by winding current, and back-EMF is determined by rotor speed. This looks like a tricky problem until you convert the mechanical system into its electrical equivalent. Then it's no big deal.

*Transform "**Motor Model**" into its equivalent electrical circuit.*

Q4 2 mark(s) Rotor Speed

Use nodal analysis to compute the transfer function G.

Output = ω Rotor speed

Input = Vin Applied voltage

Use **minreal()** to cancel any common factors.

- Q4.G (rad/Vs) LTI

Q5 2 mark(s) Winding Current

Use nodal analysis to compute the transfer function G.

Output = Iw Winding current

Input = Vin Applied voltage

Use **minreal()** to cancel any common factors.

- Q5.G (A/V) LTI

COW: *Plot the Step Response.*

What is the Final Value ??? What should it be ????

What does an electric motor do when you apply a voltage ???

*This assignment has parameters **similar** to the following commercial motor:*

Maxon DC-max 26 S – 12V Program

Notice that Km and K'm have the same value but different physical units ???

Is this a coincidence ??? Does this agree with the data-sheet ???

Plot speed in (RPM) and current in (mA) so the data-sheet values correspond.

*Refer to the data-sheet for ball-park values. Use the **dcgain()** function.*

The parameters aren't identical so don't expect identical performance.

What do you expect the current to do when you first apply the voltage ???

Since the motor isn't moving yet, what is the back-EMF ???

Motor Model

- Rw = 1 + #A/10 (Ω)
- Lw = 100 + 10 x #B (μH)

- Jr = #C/10 (μNms²)
- Br = (#D + #E + #F) (μNms)

- K_M = 10 + #G (mVs)
- K'_M = 10 + #G (mNm/A)

- V_{in} = 12 (V)