

XMUT315 Control Systems Engineering

Assignment 1: System Modelling and Feedback Systems

Due Date: Friday, 2nd May 2025 (Online submission to XMUT315 wiki website at VUW)

A. Laplace Transforms

1. A system is described by the following differential equation:

$$2 \frac{dp(t)}{dt} - 5p = 3 \frac{d^2p(t)}{dt^2} - q(t)$$

- Find the expression for the transfer function of the system, $P(s)/Q(s)$. [5 marks]
- Work out the response of the system in the time domain (hint: use table of Laplace transform and partial fraction expansion). [15 marks]
- Comment on the response of the system as per part (b). [5 marks]

B. System Modelling

2. Given in the figure below is an electrical network system, determine the transfer function equation of the system, $I_o(s)/V_g(s)$. [15 marks]

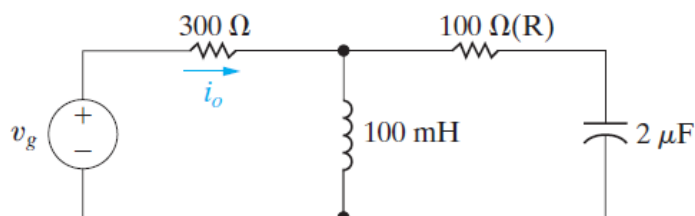


Figure 1: Electrical network system

3. For a shock absorber system as shown in the figure (a) below, it can be modelled as in the figure (b). Note that the wall friction, f can be approximated as $f = b \, dy/dt$, with b is the friction

constant and y is the displacement. Draw a free-body diagram showing all forces and their directions and derive the transfer function in terms of $R(s)/Y(s)$. [15 marks]

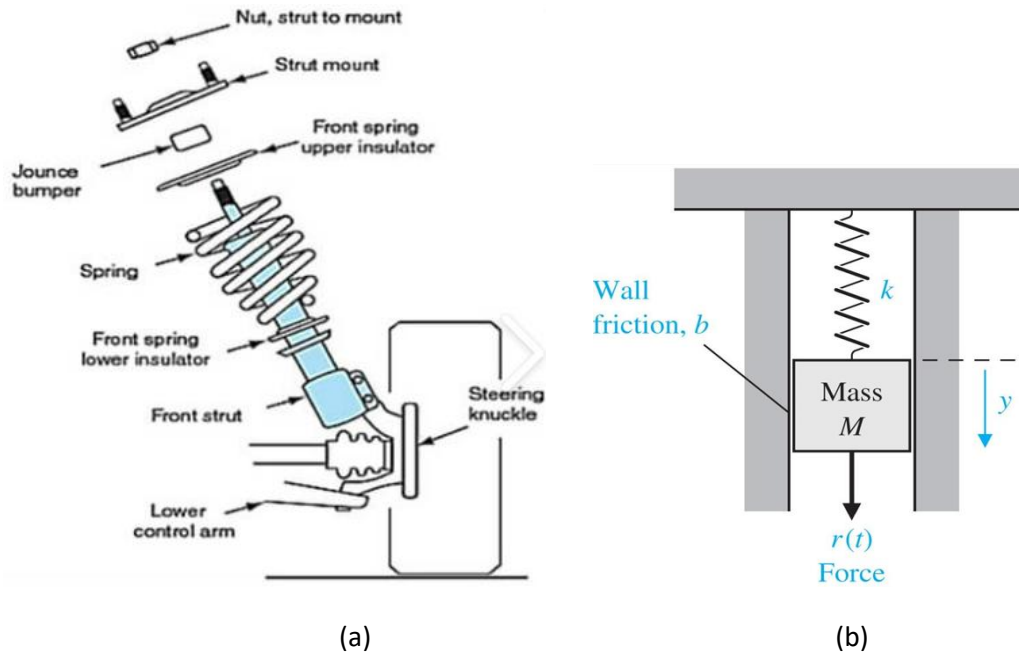


Figure 2: Shock absorber system

C. Block Diagrams

4. Reduce the block diagram of an electrical system as shown in the figure below to a single transfer function, $T(s) = C(s)/R(s)$. Use the following methods:

- Block reduction method. [5 marks]
- MATLAB. [10 marks]

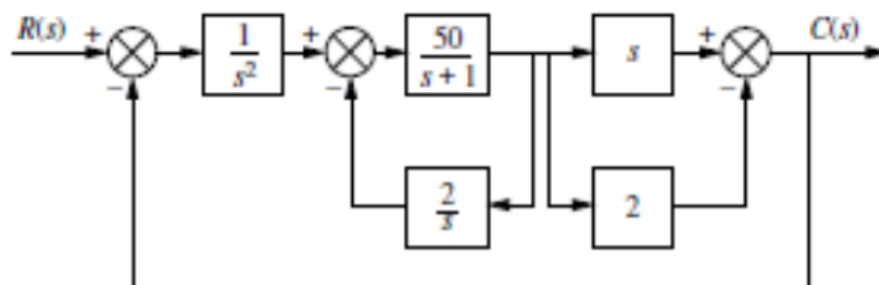


Figure 3: Block diagram of an electrical system

5. For a mechanical system shown in the figures below, reduce it to a single block to find the transfer functions of the systems, $G(s) = C(s)/R(s)$. [15 marks]

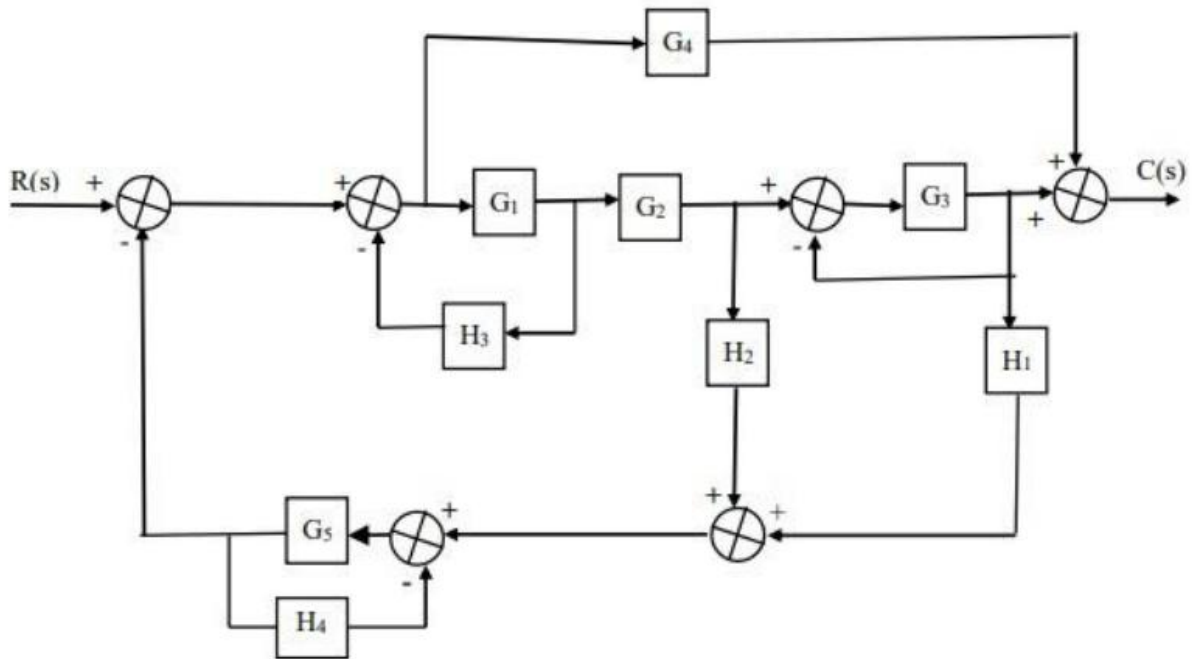


Figure 4: Block diagram of a mechanical system

D. Feedback Systems

6. Compare the differences between the open-loop control system and closed-loop system given below:

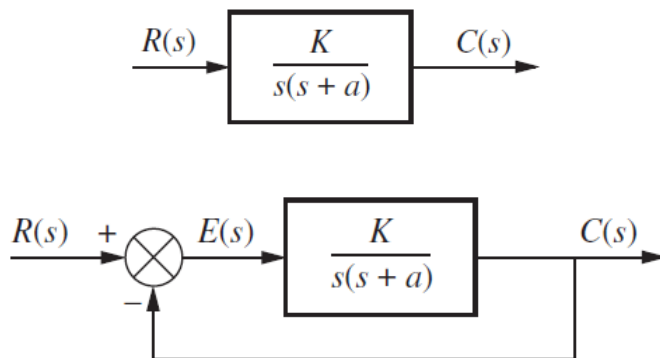


Figure 5: Open-loop (top) and closed-loop (bottom) systems.

- When there is 50% change in parameters K and a against the output of the system. [10 marks]
- In term of sensitivity of the forward gain K of the system against the output of the system. [5 marks]

Marking Schedule

Student ID : _____

Student Name : _____

No	Description	Mark	Your Mark	Remarks
A	Laplace Transforms			
1a	Expression for the transfer function of the system.	5		
1b	Time domain response of the system.	15		
1c	Comment on result of part (b).	5		
B	System Modelling			
2	Transfer function of the electrical network system.	15		
3	Transfer function of the mechanical system.	15		
C	Block Diagrams			
4a	Overall transfer function of the electrical system using the block reduction method.	5		
4b	Overall transfer function of the electrical system using MATLAB.	10		
5	Overall transfer function of the mechanical system using the block reduction method.	15		
D	Feedback Systems			
6a	Comparison in term of parameter changes in the system.	10		
6b	Comparison in term of sensitivity of the forward gain of the system.	5		
	Total	100		

Comment: