XMUT315 Control Systems Engineering

Assignment 1: System Modelling and Feedback Systems

Due Date: Monday, 18th May 2026 (Online submission to XMUT315 wiki website at VUW)

A. Laplace Transforms

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

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

   a. Find the expression for the transfer-function equation of the system, $P(s)/Q(s)$. [5 marks]

   b. Determine the transfer-function equation of the system in the time domain, $p(t)/q(t)$. Hint: use table of Laplace transform and partial-fraction expansion. [15 marks]

   c. Predict the characteristics of the system as per results in part (b) in terms of its transient response and stability of the system. [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]

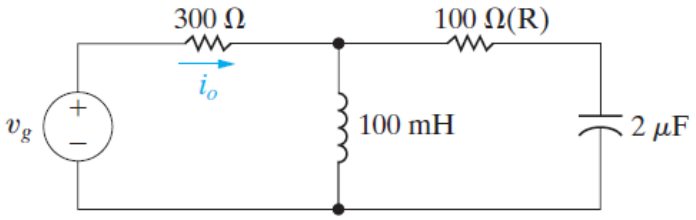
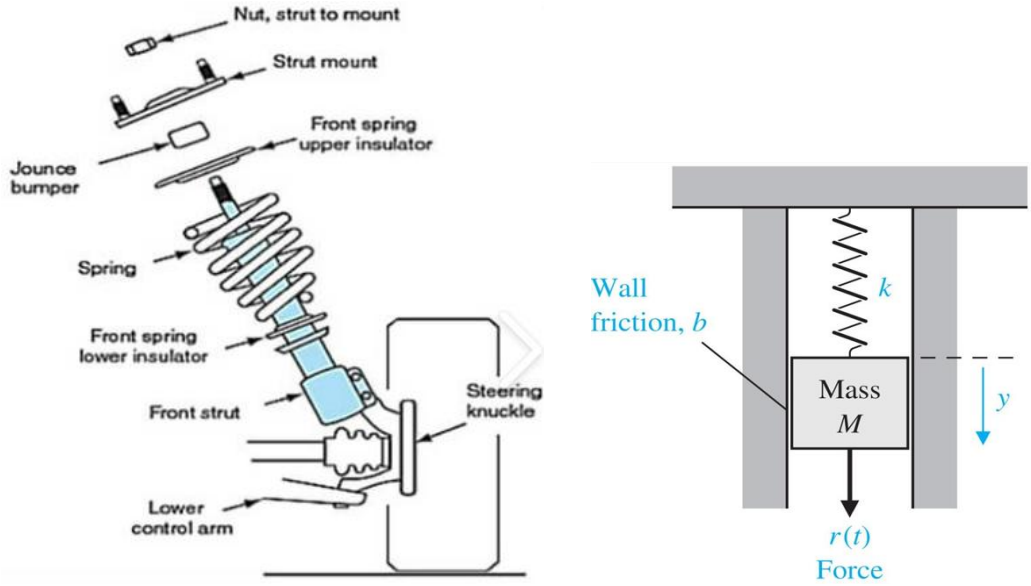


Figure 1: Electrical network system

3. For a shock absorber system as shown in figure (a) below, it can be modelled as in figure (b).



(a) (b)

Figure 2: Shock absorber system

Note that the wall friction, $f_{friction} = b\ dy/dt$ and the force on the spring, $f_{spring} = kx$, with b is the friction constant, k is the spring constant, and y is the displacement. Draw a free-body diagram showing all forces and their directions and derive the transfer-function equation of the system in terms of $Y(s)/R(s)$. [15 marks]

C. Block Diagrams

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

   a. Block reduction method. [7.5 marks]

   b. MATLAB. [7.5 marks]

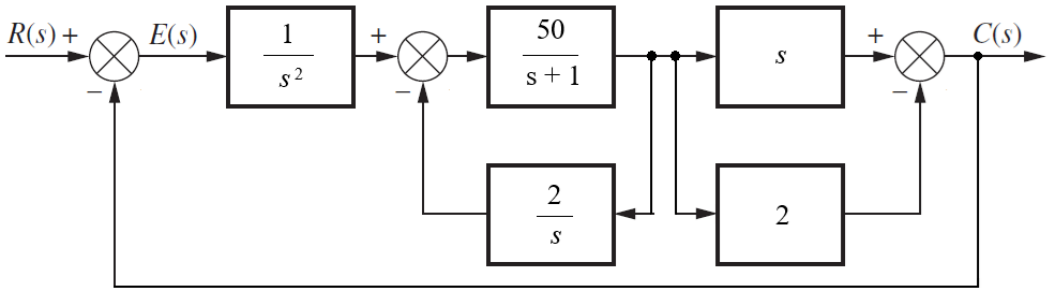


Figure 3: Block diagram of an electrical system

5. For a mechanical system shown in the figure below, reduce it to a single block to find its overall transfer-function equation, $G(s) = C(s)/R(s)$. [15 marks]

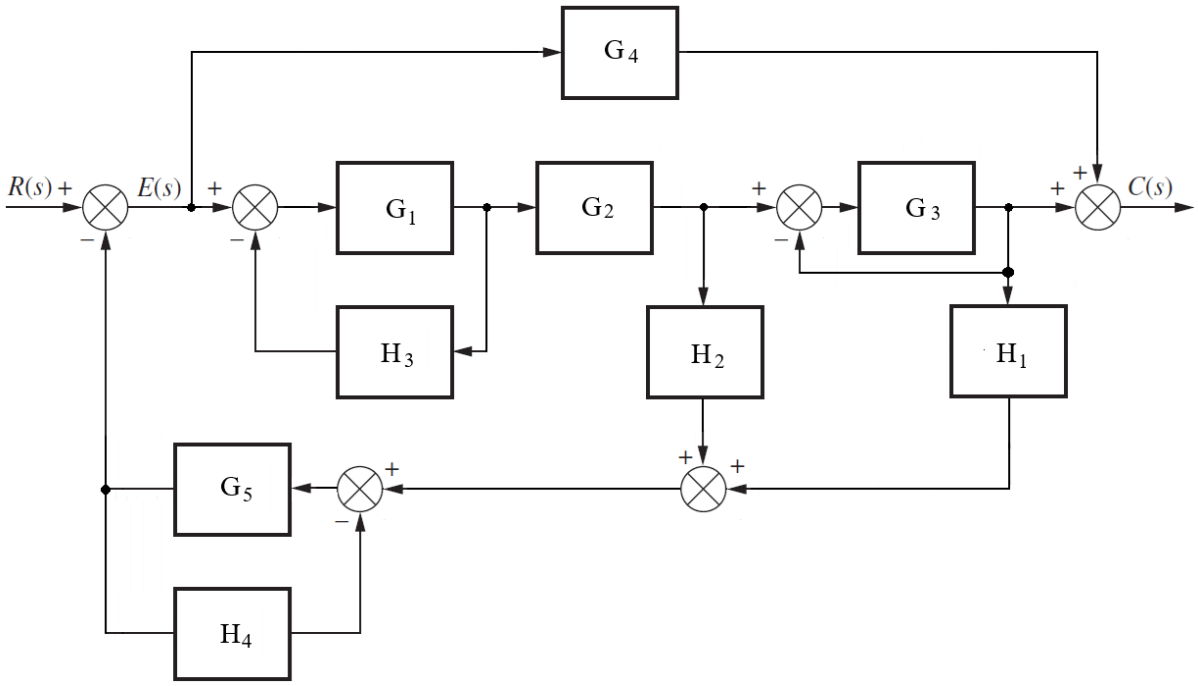


Figure 4: Block diagram of a mechanical system

D. Feedback Systems

6. Compare the differences between the open-loop control system and closed-loop system given below in terms of their characteristics and performance:

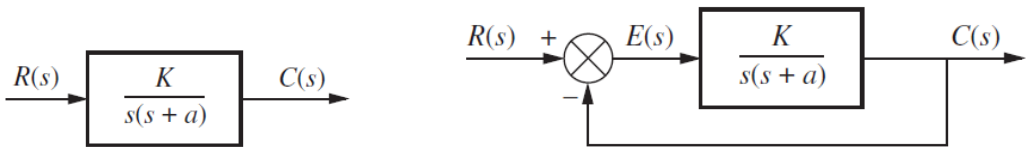


Figure 5: Open-loop (left) and closed-loop (right) systems.

a. When there is 50% change in parameters K and a against the output of the system. [5 marks]

b. In term of sensitivity of the forward gain K of the system against the output of the system. [10 marks]

Marking Schedule

Student ID : _____

Student Name : _____

No	Description	Mark	Your Mark	Remarks
A	**Laplace Transforms**			
1a	Expression for the transfer-function equation of the system.	5		
1b	Time-domain response of the system.	15		
1c	Comment on results 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.	7.5		
4b	Overall transfer function of the electrical system using MATLAB.	7.5		
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.	5		
6b	Comparison in term of sensitivity of the forward gain of the system.	10		
	Total	100		

Comment: