بسم الله الرحمن الرحيم

Mechanical Vibrations	Closed Book Exam
MENG366	Time: 1 ½ hrs
First Exam	Mon: 19/8/1424 H

Name:	Number: ....
Q1: ...., Q2: ...., Q3: ...., Q4: ....,	Total:: ..../40

1. Pick an example of a closed-loop system that you are familiar with (e.g. temperature control system in an office, liquid-level control system). Draw a simple block diagram of that system, similar to the one shown in Figure 1. For the system you choose, specify the physical input, the physical output, and a possible source of disturbance and noise. Also write down the physical devices that constitute the "controller", the "plant", and the "sensor", but don't worry about writing any transfer functions! Discuss briefly (in one paragraph) how effective or ineffective the control system would be without feedback.

2. The following block diagram represents a generic closed-loop linear system consisting of a reference input $R(s)$, a disturbance $D(s)$, and sensor noise $N(s)$ and output $C(s)$.

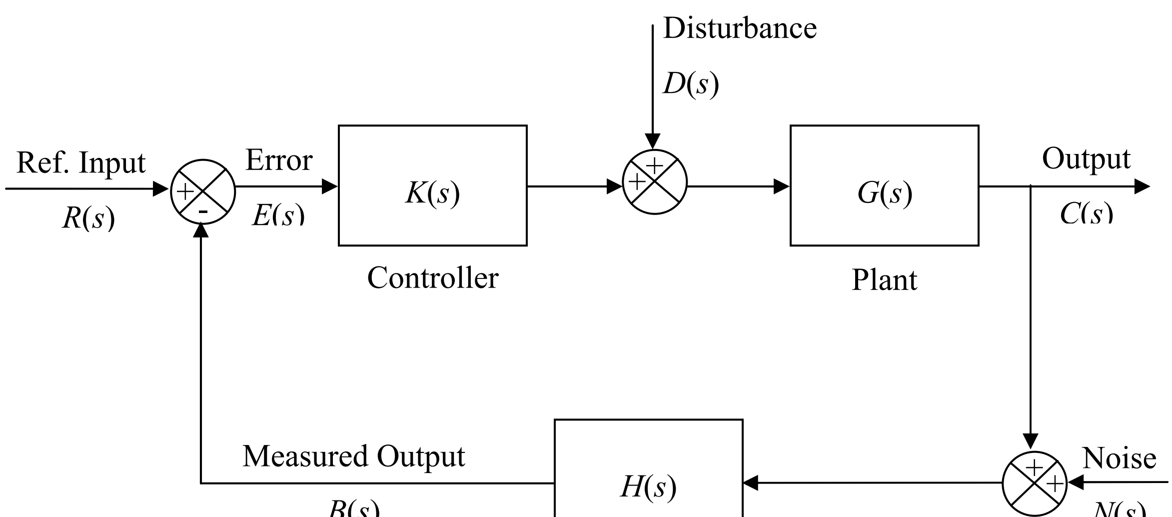

Figure 1: Feedback Loop

a) Evaluate the transfer functions relating the output $C(s)$ to each of the inputs $R(s)$, $D(s)$, and $N(s)$.
Hint: since the system is linear use the property of superposition. For example, to calculate the transfer function C(s)/R(s), set D(s) and N(s) to zero.

b) Assume that $H(s) = 1$ (i.e. unity feedback) and $K(s) = K$ (i.e. the controller is a simple amplifier).
Assume also that there is no noise or disturbance (i.e. N(s) = 0 and D(s) = 0).
Derive a simple expression for the error $E(s) = R(s)\text{-}B(s)$, in terms of $R(s)$, $G(s)$, and K.

c) Consider the following plant: $G(s) = \dfrac{1}{s^2 + 2}$ and take $R(s)$ as a unit step input.
Assume $H(s) = 1$, $K(s) = K$, $N(s) = 0$, and $D(s) = 0$. Use the Final Value Theorem to find the steady state error, (i.e. $e(t)$ as t goes to infinity).

3. Find the closed-loop transfer function $C(s)/R(s)$ for each one of the block diagrams shown in Figure 2 and Figure 3.

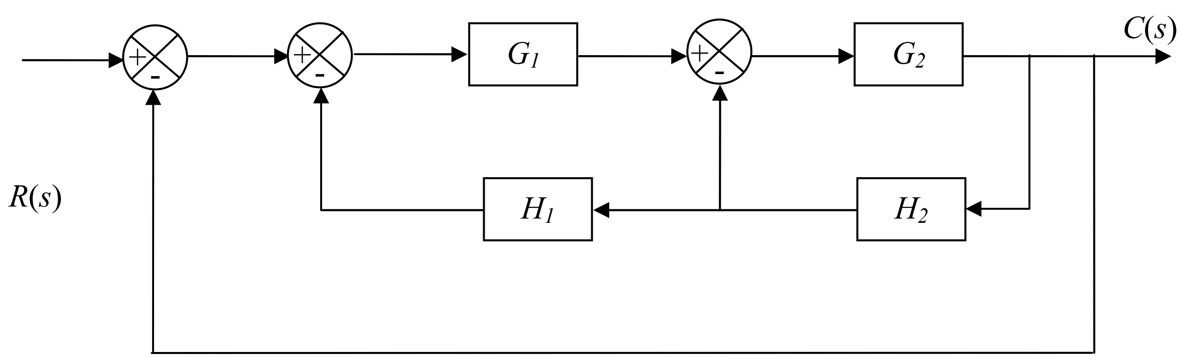

Figure 2: Block Diagram

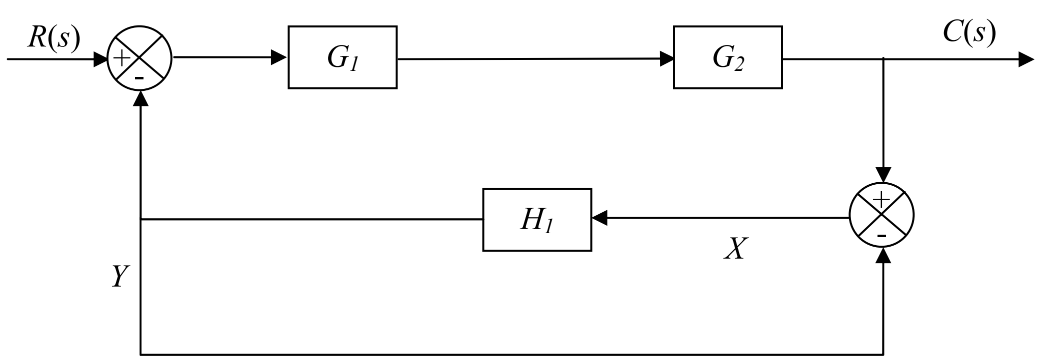

Figure 3: Block Diagram

4. Solve the following differential equations using Laplace transforms (again, $u(t)$ is the unit step function):

a) $2\dot{y}(t) + 3y(t) = e^{-t}$, with $y(0) = 1$;
b) $\ddot{y}(t) + 5\dot{y}(t) + 6y(t) = u(t)$, with $\dot{y}(0) = 1/2$ and $y(0) = -1$

Best wishes,

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