Indian Institute of Technology Bombay
AE 308 **Control Theory**
AE 775 **System Modelling, Dynamics and Control**

Aerospace Engineering
Assignment 1
September 26, 2022

Q.1. Find the transfer function of the system whose step response is shown in Figure 1. Assume the system is of second-order. [10]

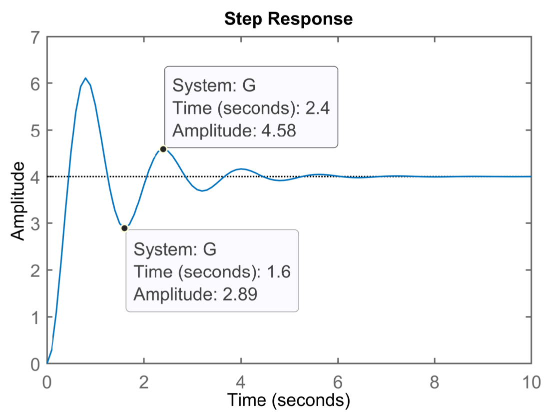

Figure 1: Step Response of the unknown system.

Q.2. Consider a second-order system transfer function in normalized form

$$G(s) = \frac{w_n^2}{s^2 + 2\zeta w_n s + w_n^2}.$$

Let $G_1(s)$, $G_2(s)$ and $G_3(s)$ be three different transfer functions given in the above structure and the location of poles of $G_1(s)$, $G_2(s)$ and $G_3(s)$ be different. The poles are, respectively, (p_{11}, p_{12}), (p_{21}, p_{22}) and (p_{31}, p_{32}). Find (p_{11}, p_{12}), (p_{21}, p_{22}) and (p_{31}, p_{32}) in the complex plane such that $G_1(s)$, $G_2(s)$ and $G_3(s)$ have the same settling time (2%). Give justification. [10]

Q.3. Find the transfer function of the system whose step response is shown in Figure 2. Assume the system is of second-order. Let the transfer function so obtained is $G(s)$, now introducing a pure integrator before the input to the system obtaining modified system $M(s) = \frac{1}{s}G(s)$, calculate the steady state error of the modified system $M(s)$ when input fed to the system is (a) impulse (b) step. [10]

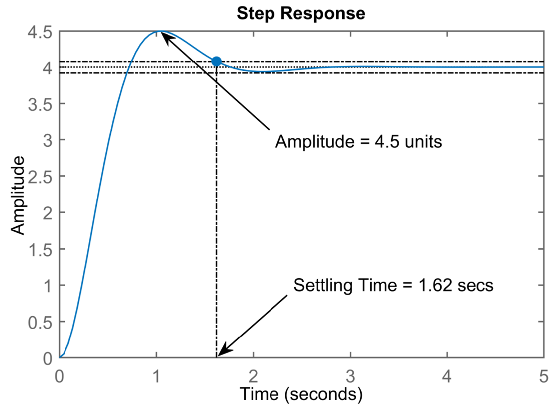

Figure 2: Step Response of the unknown system.

Q.4. Consider the control system described by the signal flow graph given below. Obtain the closed–loop transfer function using Mason's gain formula. [10]

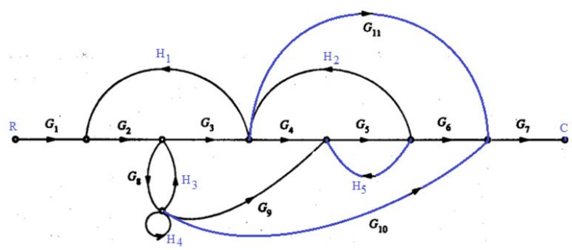

Figure 3: SFG

Q.5. For the signal flow graph (SFG) of a control system shown below, using Mason's formula,

find the system transfer function and the system characteristic equation. [10]

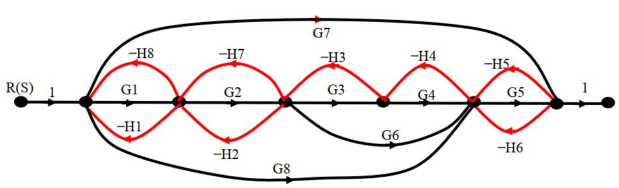

Figure 4: SFG

Q.6. For the signal flow graph (SFG) of a control system shown below in figure 5, find the

system transfer function. [10]

Q.7. Consider the control system shown below in figure 6, draw the corresponding sig-

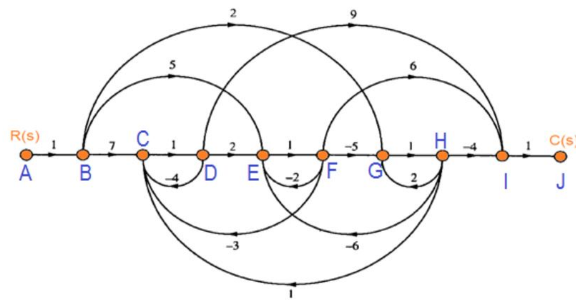

Figure 5: SFG

nal flow graph, and obtain the closed–loop transfer function using Mason's gain formula. [10]

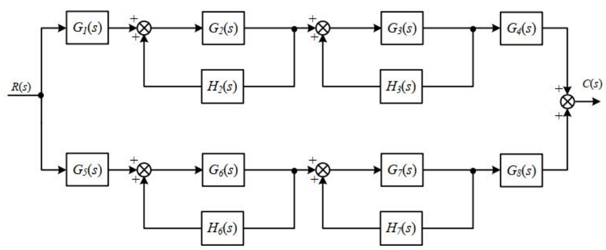

Figure 6: Block Diagram

Q.8. Use Laplace transform to solve the initial value problem [10]

$$y' + 2y = 26sin3t, y(0) = 3$$

Q.9. Given the standard second-order transfer function

$$G(s) = \frac{w_n^2}{s^2 + 2\zeta w_n s + w_n^2}.$$

A) Describe how the addition of a pole on the real axis (left half plane) affect the system step response [5]

B) Describe how the addition of a zero on the real axis (left half plane) affect the system step response [5]

Q.10. A) Consider an LTI system with input and output related through the equation

$$y(t) = \int_{-\infty}^{t} e^{-(t-\lambda)} x(\lambda - 2)\, d\lambda$$

What is the impulse response h(t) of the system? [5]

B) Determine the response of the system when the input x(t) is as shown in the figure below. [5]

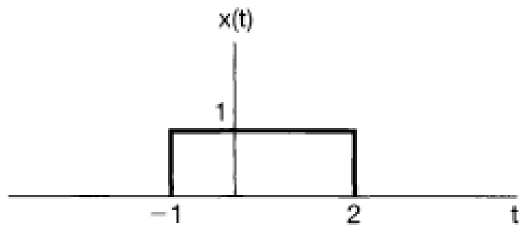

Figure 7: Input x(t)