Zagazig University
Faculty of Engineering
Computer and Systems Department

Course: CSE 425 – Process Control
4^{th} Year Computer & Systems Engineering
Mid-term Exam – April 10, 2022

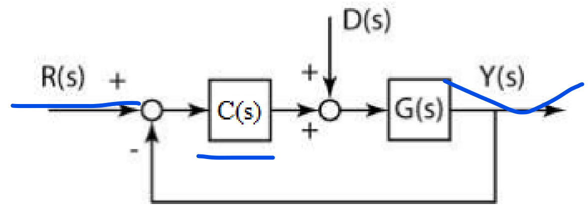
No of pages: 1	Time allowed: 60 min	Total marks: 20

Question (1): (10 Marks)

(a) Why does the standard output range, 4-20 mA, of a transmitter in process control start from 4 mA and not from 0 mA?

(b) Consider the following closed-loop system, where

$$C(s) = 1 + \frac{1}{s}, \quad G(s) = \frac{1}{(s+1)^2}.$$



1- Find the transfer function Y(s)/D(s).
2- Is the controller (C(s)) able to remove the effect of disturbance at steady state?
3- Sketch the response for a step disturbance.

(c) With the aid of linearization, find the transfer function of the following nonlinear system around u = 2.

$$\frac{dy}{dt} + y = u^3.$$

Question (2): (10 Marks)

(a) Consider the following process graph.

[1] Does this process have positive or negative gain?

[2] Can we predict the shape of the step response from this graph? Why or why not?

[3] For which values of controller output (in %) is the process gain maximum?

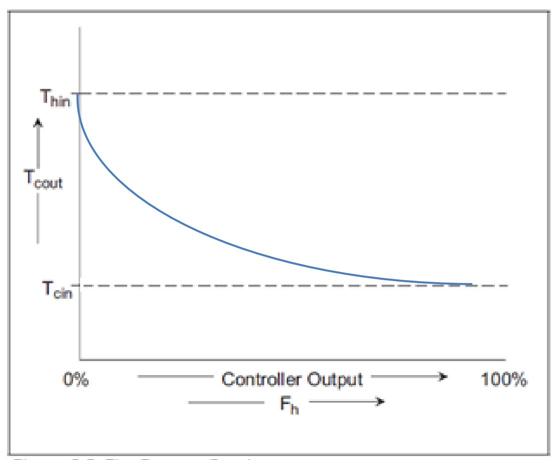


Figure 3-2. The Process Graph

(b) For the following transfer functions, sketch the unit step response showing the final value and if there is overshoot or inverse response?

$$\frac{T(s)}{F(s)} = \frac{-5s + 18}{s^2 + 6s + 9}$$

(c) True or False:

[1] The proportional control action depends on past errors.

[2] Integral control is slow compared to proportional control.

[3] Derivative control is termed the "persistent mode".

All best wishes….

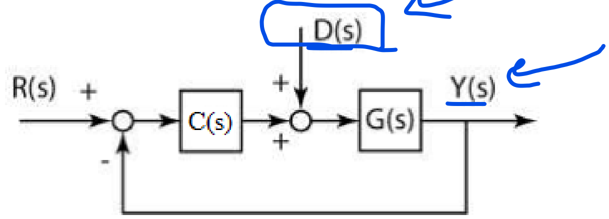
Model Answer

Question (1): (10 Marks)

(a) The standard output range, 4-20 mA, of a transmitter in process control start from 4 mA to avoid the ambiguity between minimum reading and open-circuit fault.'

(b) Consider the following closed-loop system, where

$$C(s) = 1 + \frac{1}{s}, \quad G(s) = \frac{1}{(s+1)^2}.$$



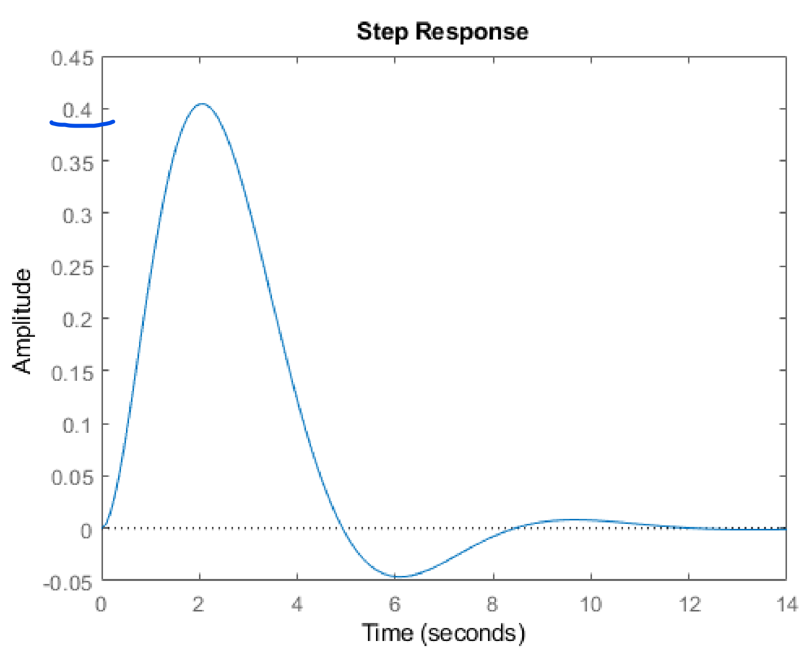
1- Find the transfer function Y(s)/D(s).

$$\frac{Y(s)}{D(s)} = \frac{G(s)}{1 + C(s)G(s)} = \frac{\frac{1}{(s+1)^2}}{1 + \left(\frac{s+1}{s}\right)\frac{1}{(s+1)^2}} = \frac{s}{s^3 + 2s^2 + 2s + 1}$$

2- Is the controller (C(s)) able to remove the effect of disturbance at steady state?

As the dc gain of the transfer function above is ZERO, the disturbance will be removed at steady state.

3- The step disturbance response



(c) With the aid of linearization, find the transfer function of the following nonlinear system around u = 2.

$$\frac{dy}{dt} + y = u^3.$$

$$\frac{dy}{dt} = f(y,u) = -y + u^3.$$

$$\dot{y}^* = \frac{\partial f}{\partial y} y^* + \frac{\partial f}{\partial u}\Big|_{u=2} u^* = -y^* + 3u^2 u^* = -y^* + 12u^*$$

So the transfer function will be

$$\frac{Y^*(s)}{U^*(s)} = \frac{12}{s+1}$$

<u>Question (2): (10 Marks)</u>

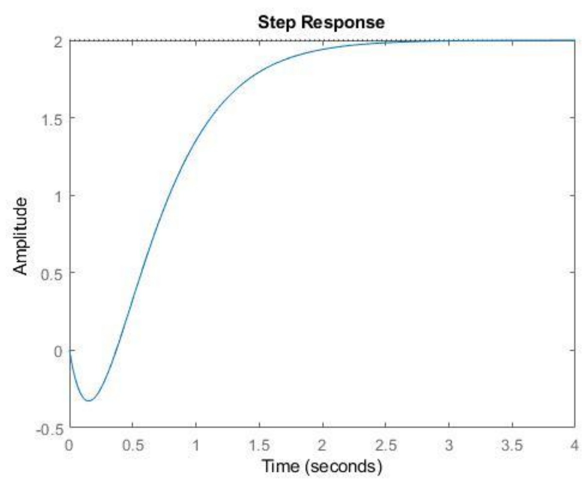
(a) Consider the following process graph.

[1] Does this process have positive or negative gain? **<u>NEGATIVE GAIN</u>**

[2] **<u>We can't predict the shape</u>** of the step response from this graph because the process graph describes only steady state relationship between MV and PV.

[3] For which values of controller output (in %) is the process gain maximum? **<u>At 0%.</u>**

(b) The response shows an inverse response



(c) True or False:

[1] The proportional control action depends on past errors. False

[2] Integral control is slow compared to proportional control. True

[3] Derivative control is termed the "persistent mode". False