ECE 317 Midterm

Use of calculators is not permitted. Mark your answers on your Scantron Form No 882-E.

Figure 1 below shows a closed loop feedback system which controls the output of the plant represented by $G(s)$. In the control design two extra blocks, $G_c(s)$ and $H(s)$, have been added. A number of questions below will refer to Figure 1.

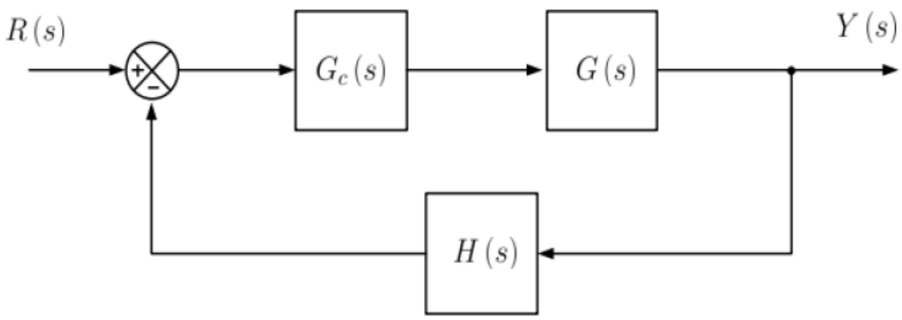


Figure 1

1) Referring to Figure 1, the closed loop transfer function is given by:

   a. $\frac{G_c(s)G(s)}{1+G_c(s)G(s)H(s)}$
   b. $-G(s)H(s)$
   c. $G_c(s)G(s)$
   d. $H(s)$
   e. $-G_c(s)G(s)H(s)$

2) Referring to Figure 1, the loop gain transfer function is given by

   a. $\frac{G_c(s)G(s)}{1+G_c(s)G(s)H(s)}$
   b. $-G(s)H(s)$
   c. $G_c(s)G(s)$
   d. $H(s)$
   e. $-G_c(s)G(s)H(s)$

3) Referring to Figure 1, the primary purpose of adding block $H(s)$ is to:

   a. Increase the loop gain
   b. Filter the high frequencies being fed back
   c. Set the closed loop gain
   d. Loop gain shaping

4) Referring to Figure 1, the primary purpose of adding block $G_c(s)$ is to:

   a. Increase the loop gain
   b. Filter the high frequencies being fed back
   c. Set the closed loop gain
   d. Loop gain shaping

5) With reference to Figure 1, we now consider the plant, $G(s) = \frac{10}{s}$. This plant is

a. Stable
b. Marginally stable
c. Unstable

6) The DC gain of this plant (i.e. the plant of Question 5) is

a. 0
b. 1
c. 10
d. ∞

7) As part of a closed loop design we will enclose the plant of Question 5 in a feedback configuration as shown in Figure 1. We wish to achieve a closed loop transfer function system with a DC gain of 10. $H(s)$ should have a value of:

a. 0
b. 0.1
c. 1
d. 10
e. There is insufficient information provided to determine this

8) Continuing our design, we will use a proportional controller in our closed loop system. If we wish to achieve a risetime of *22* ms to a step input, at what value should the closed loop pole be positioned.

a. $s = -10$
b. $s = -50$
c. $s = -100$
d. $s = -150$
e. $s = -200$

9) Continuing our design, we will now design a proportional controller for the system where the requirements are: i) the closed loop pole position is set to $s = -200$, and, ii) $H(s) = 0.5$. The proportional controller is given by:

a. $G_c(s) = 10$
b. $G_c(s) = 20$
c. $G_c(s) = 30$
d. $G_c(s) = 40$
e. $G_c(s) = 50$

10) Application of negative feedback to an unstable system can stabilize it.

a. True
b. False

11) Application of negative feedback to a system can increase its speed of response.

a. True
b. False

12) Application of negative feedback to a system can desensitize the closed loop transfer function to parameter variations in the plant.

a. True
b. False

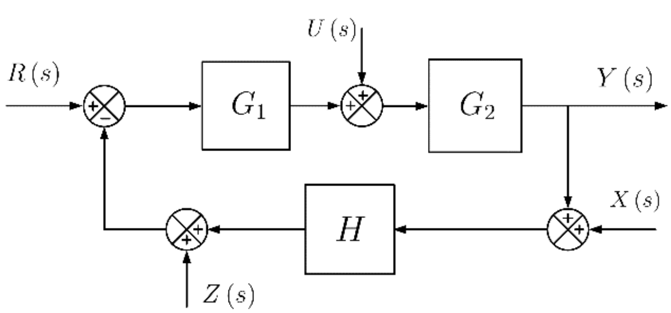
13) With reference to Figure 1, to achieve the benefits of negative feedback the following is a requirement:

a. $|G_c(s)| \gg 1$
b. $|G_c(s)\ G(s)| \gg 1$
c. $|G_c(s)\ G(s)H(s)| \gg 1$
d. $|G(s)\ H(s)| \gg 1$
e. $|G_c(s)\ H(s)| \gg 1$

14) The output, *y*, of a static, non-linear system is given by $y = x^3$, where *x* is the input. The small-signal transfer function G_{yx}, the transfer function from input *x* to output *y*, evaluated at the operating point $X = 2$ is

a. 1
b. 2
c. 4
d. 8
e. 12

15) For the system below, the transfer function, $\frac{Y(s)}{X(s)}$, is:



a. $\frac{G_1G_2}{1+G_1G_2H}$
b. $-\frac{G_1G_2H}{1+G_1G_2H}$
c. $\frac{1}{1+G_1G_2H}$
d. $-\frac{G_1G_2}{1+G_1G_2H}$
e. $\frac{G_1G_2H}{1+G_1G_2H}$

16) The characteristic polynomial of a system is given by $d(s) = s^2 + 2s + 4$.
The undamped natural frequency is given by:

a. 1 rad/s
b. 2 rad/s
c. 3 rad/s
d. 4 rad/s
e. 5 rad/s

17) The transient response to a step input of the system of the previous question (Question 16) is:

a. undamped
b. underdamped
c. critically damped
d. overdamped
e. critically overdamped

18) A second order system has a damping ratio of 0.5 and undamped natural frequency of 4 rad/s.
The ($\pm$2 %) settling time is:

a. 0.5 s
b. 1 s
c. 2 s
d. 3 s
e. 4 s

19) Consider the polynomial: $Q(s) = s^7 + 3s^6 + 5s^4 + 3s^3 + 3s^2 + 2s + 1$
From visual inspection alone (i.e. without forming the Routh table),
what can be said about its roots:

a. They are all in the LHP (left half plane)
b. They are all in the RHP (right half plane)
c. There is at least one RHP (right half plane) root
d. There are IM (imaginary axis) roots or RHP roots or both
e. Nothing can be said about the roots

20) Transfer function $G(s) = \frac{s-2}{s(s^2+3)}$ is

a. Stable
b. Marginally stable
c. Unstable

21) Transfer function $G(s) = \frac{s-1}{s^2+2s+1}$ is

a. Stable
b. Marginally stable
c. Unstable

Questions (22), (23), (24) and (25) refer to the characteristic polynomial

$$Q(s) = s^4 + 4s^3 + s^2 + 2s + 3$$

We wish to determine the nature of the roots of $Q(s)$.
The first two rows of the Routh table are given here:

s^4	**1**	**1**	**3**
s^3	**4**	**2**	

Complete the table and determine:

22) The number of RHP (right half plane) roots:
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4

23) The number of LHP (left half plane) roots:
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4

24) The number of IM (imaginary axis) roots:
   a. 0
   b. 1
   c. 2
   d. 3
   e. 4

25) This polynomial Q(s) is:
   a. Stable
   b. Marginally stable
   c. Unstable

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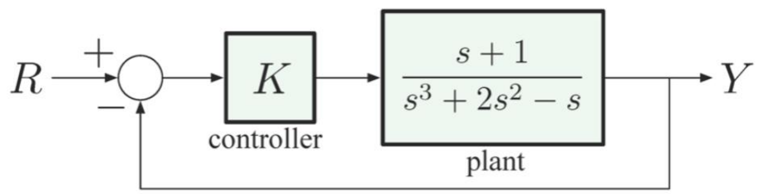
Questions (26) and (27) refer to the following feedback system, where parameter *K* represents a variable gain:



26) The closed loop characteristic polynomial is found to be

$$Q(s) = s^3 + 2s^2 + (K-1)s + K.$$

The first two rows of the Routh table are shown here:

s^3	**1**	**K-1**
s^2	**2**	**K**

The range of *K* for which the system is stable is:

a. $K > -2$
b. $K > -1$
c. $K > 2$
d. $K > 0$
e. $K < 0$

27) The frequency of oscillation when $K = 2$ is (in rad/s):

a. 1
b. 2
c. 3
d. 4
e. 5

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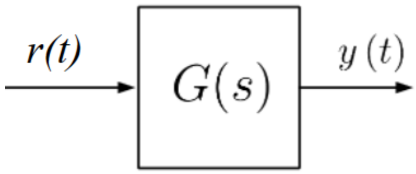
Questions (28), (29) and (30), refer to the system with the input shown next:

$$G(s) = \frac{6}{s+3} \quad \text{and} \quad r(t) = \sqrt{2}\cos(3t - 25°)$$

The steady state output has form $y_{ss}(t) = A\cos(Bt + C°)$,
where parameters, *A*, *B* and *C* are determined below.



28) Parameter *A* is given by:

a. 1
b. 2
c. 3
d. 4
e. None of the above

29) Parameter *B* is given by:

a. 1
b. 2
c. 3
d. 4
e. 5

30) Parameter *C* is given by:

a. 45
b. 10
c. 0
d. -45
e. -70