BANGLADESH UNIVERSITY OF BUSINESS AND TECHNOLOGY (BUBT)
Faculty of Engineering and Applied Sciences
Department of Electrical and Electronic Engineering
Program: B.Sc. in EEE
EEE 401: Control System Design
(Section: 1 & 2; Shift: Day; Intake: 24, 25, 26)

Final Exam	**Fall 2021-22**	**Total Marks: 40**	**Time: 2 hrs.**

Course Instructor: Sk. Hasibul Alam

Instructions:
- Answer all questions. Q1 includes 5 (five) short questions in total with 2 marks each.
- The marks on the right-hand side in square brackets indicate marks for that question only.

CO2: Develop the mathematical models of physical systems in forms suitable for use in the analysis and design of control systems. [PO2]

Q1. **(a)** A critically damped 2nd-order system has one pole at -5 on real axis. Where is its other pole on *s*-plane? **[2]**

(b) In the context of SSE, a system has velocity constant of 75. What is the SSE for a standard parabolic input to this system? **[2]**

(c) A 2nd-order system has poles at $-8 \pm 6j$. What is its natural frequency? **[2]**

(d) The settling time of a 2nd-order underdamped system is 4 seconds. If the damping ratio of this system is 0.5, what is its natural frequency? **[2]**

(e) A 7th-order system has 4 poles on jω-axis, and 3 poles on LHP. While completing the Routh table, a row of zeros will occur. What is the power of *s* for that row? **[2]**

Q2. **(a)** Using Mason's gain formula, reduce the system shown in Fig. Q2(a) to a single transfer function $T(s) = C(s)/R(s)$. Here, the system has three finite poles but no finite zeros. **[5]**

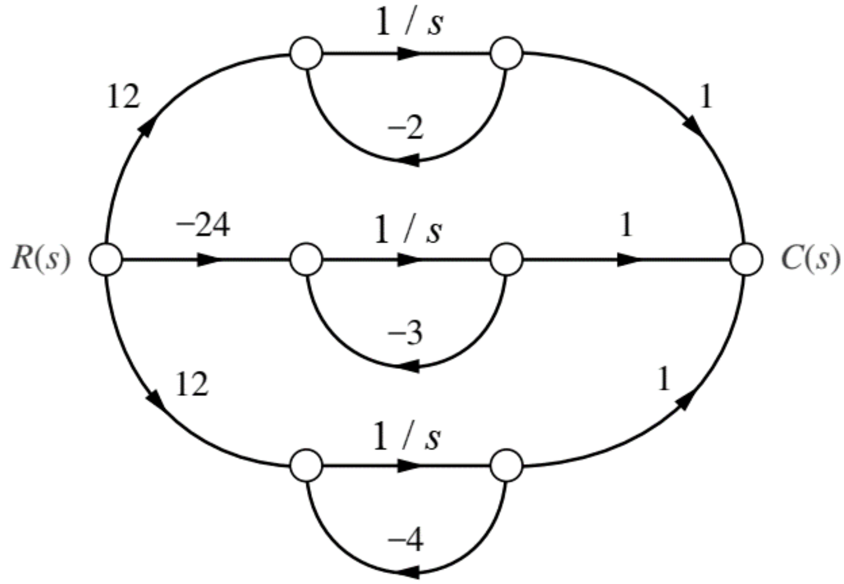

Fig. Q2(a)

(b) Draw the SFG in cascade form for the following transfer function: **[5]**

$$T(s) = \frac{C(s)}{R(s)} = \frac{105}{s^3 + 15s^2 + 71s + 105}$$

<u>CO3:</u> Analyze the time and frequency-domain responses of control systems to standard input signals. [PO2]

Q3. **(a)** Use Routh-Hurwitz stability criterion to find how many poles are on RHP, LHP and jω-axis for the following transfer function: **[10]**

$$T(s) = \frac{C(s)}{R(s)} = \frac{64}{s^5 + 7s^4 - 8s^3 - 56s^2 - 9s - 63}$$

(b) A unity negative feedback system has the following forward transfer function. Find its SSE for $6t^2u(t)$. **[5]**

$$G(s) = \frac{5(s+4)(s+6)}{s^2(s+3)(s+5)(s+9)}$$

(c) A unity negative feedback system has the following forward transfer function. Determine the value of *K*, for which the the system will have 20% overshoot. Then find the peak time of its step response. **[5]**

$$G(s) = \frac{K}{s^2 + 10s}$$

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Final Exam **Summer 2021** **Total Marks: 40** **Time: 3 hrs.**

Course Instructor: Sk. Hasibul Alam

Instructions:

- 'M' is the last digit of your student ID.
- Answer all questions. Q1 includes 5 (five) short questions in total with 1 (one) mark each.
- The marks on the right-hand side in square brackets indicate marks for that question only.
- Attach your answer script in PDF format in Google Classroom.
- Do not forget to rename your PDF file as: **ID**.pdf
  (Example: 16173208999.pdf)
- Upload the answer script in portrait orientation.

CO2: Develop the mathematical models of physical systems in forms suitable for use in the analysis and design of control systems. [PO2]

Q1. (a) A 2nd-order system has poles at $\pm(\mathrm{M}+6)j$. Find its damping ratio. **[2]**

(b) A system has static error constant (acceleration) of $(\mathrm{M}+850)$. What is the SSE for standard step input to this system? **[2]**

(c) The forward TF of a unity-negative feedback system has $(\mathrm{M}+8)$ number of finite poles on real axis, and $(\mathrm{M}+5)$ number of finite zeros on real axis. How many angles of asymptote will be obtained when drawing its root locus? **[2]**

(d) A 3rd-order system has poles at $-5 \pm 12j$ and $-(\mathrm{M}+13)$. Is its 2nd-order approximation valid? **[2]**

(e) A row of zeros appears in the s^7 row of a Routh table. After completing the table, every row has a positive number in its 1st column, except s^3 row has a negative number in its 1st column. How many poles are on the jω-axis for this system? **[2]**

Q2. **(a)** Reduce the system shown in Fig. Q2(a) to a single transfer function $T(s) = C(s)/R(s)$. **[5]**

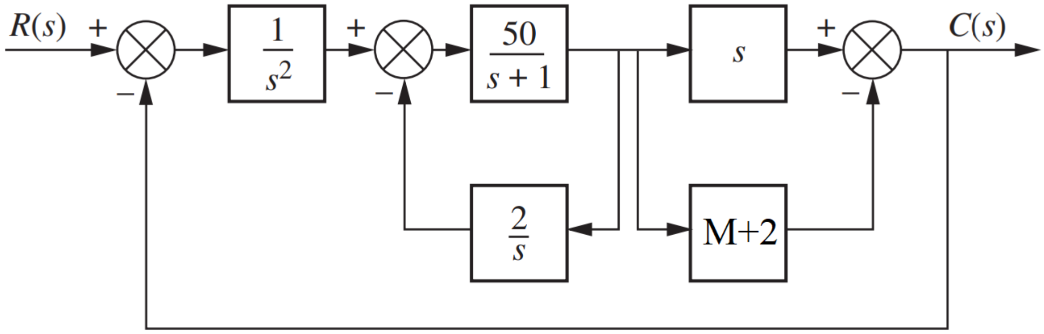

Fig. Q2(a)

(b) Draw the SFG in controller canonical form for the following transfer function: **[5]**

$$\frac{C(s)}{R(s)} = \frac{s^2 + 5s + 40 + \mathrm{M}}{s(s+3)(s+4)(s+6)}$$

<u>CO3:</u> Analyze the time and frequency-domain responses of first and second-order systems to standard input signals; address the performance of control systems, and determine the stability of these system. [PO2]

Q3. **(a)** Use Routh-Hurwitz stability criterion to find how many poles are on RHP, LHP and jω-axis for the following transfer function: **[5]**

$$T(s) = \frac{C(s)}{R(s)} = \frac{\mathrm{M} + 150}{s^6 + 4s^5 - 20s^4 - 50s^3 + 139s^2 + 46s - \mathrm{M} - 120}$$

(b) A non-unity negative feedback system has the following forward and feedback transfer function. Find the SSE for $15t^2u(t)$. **[5]**

$$G(s) = \frac{50 + \mathrm{M}}{s(s+3)} \quad ; \quad H(s) = \frac{1}{s+7}$$

(c) Sketch the root locus for a unity negative feedback system having the following forward transfer function: **[5]**

$$G(s) = \frac{K(s+4)(s+\mathrm{M}+8)}{(s+1)(s+2)(s+5)(s+\mathrm{M}+7)(s+\mathrm{M}+9)}$$

(d) Sketch and refine the root locus for a unity negative feedback system having the following forward transfer function: **[5]**

$$G(s) = \frac{K(s^2 + 11s + 30)}{(s^2 + 4s + 13)(s + \mathrm{M} + 7)}$$