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SEMESTER 1 IN-CLASS TEST SOLUTIONS 2022/2023

MODULE: EE458 - Control Systems Analysis

PROGRAMME(S):

ME	B.Eng. in Mechatronic Engineering
ECE	BEng Electronic & Computer Engineering
ECSAO	Study Abroad (Engineering & Computing)
ECEI	BEng Electronic & Computer Engineering

YEAR OF STUDY: 4,O

EXAMINER(S):

Dr. Mingming Liu	(Internal)	(Ext:6279)
Dr. Rudi Villing	(External)	External
Prof. Martin Glavin	(External)	External

TIME ALLOWED: 1 Hour

INSTRUCTIONS: Answer Question 1.
Marks will be lost if all necessary work in not clearly shown.
Marks will be lost if **Matlab** figures are not clearly labelled.
This exam is total of 25 marks.

PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE INSTRUCTED TO DO SO.
The use of programmable or text storing calculators is expressly forbidden.
Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones.

Requirements for this paper:
1. Log Tables

QUESTION 1 (Solutions) **[TOTAL MARKS: 25]**

Q1(a) **[15 Marks, (i)3, (ii)2, (iii)2, (iv)2, (v)2, (vi)2, (vii)2]**

(i) The forward path transfer function is as follows:

$$T_{fd} = \frac{(1+k_1)}{s(s+a)}$$

The closed-loop transfer function can be obtained as:

$$T_{CLTF} = \frac{T_{fd}}{1+T_{fd}k_2} = \frac{\frac{(1+k_1)}{s(s+a)}}{1+\frac{(1+k_1)}{s(s+a)}k_2} = \frac{(1+k_1)}{s(s+a)+(1+k_1)k_2} = \frac{1+k_1}{s^2+as+k_2+k_1k_2}$$

(ii) The sensitivity value $S_{K_1}^{T} = \frac{k_1(s^2+as)}{(1+k_1)(s^2+as+k_2+k_1k_2)}$

(iii) The sensitivity value $S_a^T = S_G^T S_a^G = \frac{-as}{s^2+as+k_2+k_1k_2}$.

(iv) Final expression is $T(s) = \frac{3}{s^2+4s+3}$. It's a second order type 0 system.

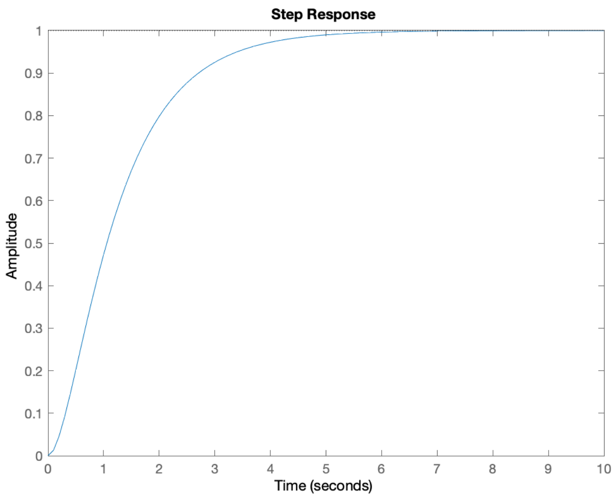
(v) Check the poles of the system, we get two poles located at -1 and -3 which indicate that the system is stable.

(vi) The characteristic equation of $T(s)$ is $s^2+4s+3=0$.

(vii) Using the FVT, we can find that the steady-state error of the system is 0.

Q 1(b) **[6 Marks, (i)3, (ii)3]**

(i) The output plot is shown below



(ii) The steady-state error is indeed 0 after the measurement.

Q 1(c) **[4 Marks]**

Let us assume that the step input is in the following form

$$R(s) = \frac{a}{s}$$

Applying the final value theorem, we can obtain that:

$$E_{ss} = \lim_{s\to 0} s\left(R(s) - Y(s)\right) = \lim_{s\to 0} s\left(\frac{a}{s} - \frac{a}{s} * \frac{\mu^n s + 1}{(\mu^{n-1} s + 1)}\right) = a - a = 0$$

[END OF SOLUTIONS]