DUBLIN CITY UNIVERSITY

SEMESTER 1 IN-CLASS TEST 2013/2014

MODULE: EE406 – Systems Analysis

PROGRAMME(S):

ME	B.Eng. in Mechatronic Engineering
EE	BEng in Electronic Engineering

YEAR OF STUDY: 4

EXAMINERS:

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Prof. Sakir Sezer

TIME ALLOWED: 2 Hours

INSTRUCTIONS: Answer Question 1

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 (Please mark (X) as appropriate)

☐	*Log Tables*	☐	*Thermodynamic Tables*
☐	*Graph Paper*	☐	*Actuarial Tables*
☐	*Dictionaries*	☐	*MCQ Only – Do not publish*
☐	*Statistical Tables*	☐	*Attached Answer Sheet*

INSTRUCTIONS FOR COMPUTER-BASED WORK

IMPORTANT: PLEASE READ THIS SHEET CAREFULLY BEFORE COMMENCING THIS EXAM.

GENERAL:

- Set up your own directory (called your student ID number) in c:\temp as saving to c:\temp is faster than saving to the USB flash drive.
- All m-files, script files, SIMULINK files, plot files and diary files (with extension txt) must be saved to the network drive Q:\ and to the USB flash drive.
- Save your work regularly. No credit is given for work that has been 'lost'.
- At the end of the exam, it is your responsibility to ensure that all your work has been saved successfully to the network drive Q:\ and to the USB flash drive.

SAVING PLOTS:

- The plot must be generated to your satisfaction in the Figure window. Do not minimize this window.
- Save your plot as type *.fig only. Other formats are not acceptable.
- **N.B.** Make sure that you save your plot to c:\temp\.... Make sure that you use a unique name for the plots.

DIARY FILES:

- It is recommended that you use a separate diary file for each part of a question.
- To open/start a diary file, at the MATLAB Command Prompt, type:

  >> diary c:\temp\IDnum*diary1.txt*

  >> diary on
- To close a diary file, at the MATLAB Command Prompt, type:

  >> diary off

USEFUL MATLAB FUNCTIONS:

abs	acos	angle	asin	atan	axis
bandwidth	bode	break	c2d	cd	clear
clf	close	conv	cos	det	eig
else	evalfr	exit	exp	feedback	figure
find	for	function	grid	help	if
imag	impulse	inv	isstable	label	length
log	log10	logspace	lsim	margin	max
mean	min	norm	nyquist	ones	open
ode45	pi	pinv	plot	pole	poly
print	pzmap	quit	rand	rank	real
residue	rlocfind	rlocus	roots	round	semilogx
series	sign	sim	sin	size	sqrt
ss	ssdata	step	subplot	sum	tan
text	tf	tf2ss	tfdata	title	while
who	xlabel	ylabel	zeros	zgrid	zpk
zpkdata	zoom				

- **Please note:** the use of *stepinfo(), sisotool(), rltool()* and *sgrid()* is not allowed as part of this assessment.

QUESTION 1 **[TOTAL MARKS: 25]**

[See Appendix for applicable formulae]

Q 1(a) **[7 Marks]**

An antenna positioning system, **Figure Q1**, consists of the antenna and drive motor process, $G(s)$, a forward path power amplifier, $C_{PA}(s)$, and a feedback sensor $H(s)$ in a closed loop feedback configuration:

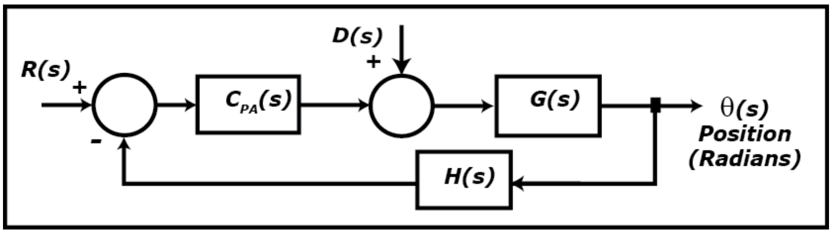

Figure Q1

Present the formula for finding the sensitivity of closed loop system to a parameter of the open loop system. Present the appropriate chain rule version of this formula when the parameter to be varied is k_{PA} and the open loop system containing k_{PA} is $C_{PA}(s)$. Hence, use the chain rule version of the sensitivity formula to find an expression for the sensitivity of the closed loop system in **Figure Q1** to variations in the parameter k_{PA} when $D(s) = 0$ and $C_{PA}(s)$ is:

$$C_{PA}(s) = \frac{k_{PA}}{0.15s + 1}$$

Q 1(b) **[6 Marks]**

Present the Final Value Theorem formula for the steady-state error. The antenna system in **Figure Q1** is subjected to a wind disturbance, $D(s) = 2/s$; determine the required value for k_{PA} in order to maintain the steady-state error of the system at -30^o when the input $r(t)$ is zero and the other system elements are given as:

$$G(s) = \frac{420.5}{s(s + 10.5 + j10)(s + 10.5 - j10)}, \quad H(s) = 2$$

Q 1(c) **[3 Marks]**

Use **MATLAB** to find the closed loop transfer function, $T(s)$, of the system (with $D(s) = 0$) and hence, predict the steady-state error solely due to an input $r(t) = 1u(t), t > 0$.

Q 1(d) **[5 Marks]**

Use **SIMULINK** to generate the output of the system presented in **Figure Q1** in response to an input signal $r(t) = 1u(t),\ t > 0$ over 20 seconds, $D(s) = 0$, and using the value for k_{PA} found in **Q1(b)**; $G(s)$ should be implemented as a *Zero-Pole* block. Use **MATLAB** to plot the system output, along with the input signal, on the same plot and then save this plot. Use **MATLAB** to measure the steady-state error.

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

Use **SIMULINK** to generate the output of the system presented in **Figure Q1** in response to a wind disturbance, $D(s) = 2/s$ over 20 seconds, with $r(t) = 0u(t)$, and using the value for k_{PA} found in **Q1(b)**; $G(s)$ should be implemented as a *Zero-Pole* block. Use **MATLAB** to plot the disturbance-driven system output, along with the *reference* input signal, on the same plot and then save this plot. Use **MATLAB** to measure the steady-state error. Does the measured steady-state error match that specified in **Q1(b)**, briefly explain why it does/does not match.

[**Note:** Save the simulations for **Q1(d)** and **Q1(e)** in two separate diagrams or files.]

[End of Question 1]

APPENDIX

Please note: the use of *stepinfo()*, *sisotool()*, *rltool()* and *sgrid()* is not allowed as part of this assessment.

Selection of Laplace and Z-Transforms

f(t)	*F(s)*	*F(z),*
1	$\frac{1}{s}$	$\frac{T}{1-z^{-1}}$
t	$\frac{1}{s^2}$	$\frac{Tz^{-1}}{(1-z^{-1})^2}$
t^2	$\frac{1}{s^3}$	$\frac{T^2z^{-1}(1+z^{-1})}{(1-z^{-1})^3}$
e^{-aT}	$\frac{1}{s+a}$	$\frac{1}{1-e^{-aT}z^{-1}}$
te^{-aT}	$\frac{1}{(s+a)^2}$	$\frac{Te^{-aT}z^{-1}}{(1-e^{-aT}z^{-1})^2}$

Transient Performance formulae - 1st order system:

$$s = -a$$
$$\tau = \frac{1}{a}, \quad t_s = \frac{4}{a} \quad t_r = \frac{2.2}{a}$$

Transient Performance formulae - 2nd order under-damped system:

$$\boldsymbol{s = -\zeta\omega_n \pm j\omega_n\sqrt{1-\zeta^2}}$$
$$\%\ \boldsymbol{Overshoot = 100e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}}\%, \quad \boldsymbol{t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}}$$
$$\boldsymbol{t_s = \frac{4}{\zeta\omega_n}}, \quad \boldsymbol{t_r = \frac{\pi - \tan^{-1}\left(\sqrt{1-\zeta^2}/\zeta\right)}{\omega_n\sqrt{1-\zeta^2}}}$$

2nd order under-damped transient performance – frequency domain formulae:

$$Phase\ Margin = tan^{-1}\left[2\zeta\left\{\frac{1}{(4\zeta^4+1)^{1/2}-2\zeta^2}\right\}^{1/2}\right]$$
$$M_P = \frac{1}{2\zeta\sqrt{1-\zeta^2}}$$
$$\omega_b = \frac{4}{\zeta t_s}\sqrt{(1-2\zeta^2)+\sqrt{4\zeta^4-4\zeta^2+2}}$$
$$\omega_b = \frac{\pi}{t_p\sqrt{1-\zeta^2}}\sqrt{(1-2\zeta^2)+\sqrt{4\zeta^4-4\zeta^2+2}}$$

[End of Appendix]

[End of Examination]