National Exams May 2019

16-Mec-A3, SYSTEM ANALYSIS AND CONTROL

3 hours duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Candidates may use a Casio **or** Sharp approved calculator. This is a **closed book** exam.

3. Any four (4) questions constitute a complete paper. Only the first four (4) questions as they appear in your answer book will be marked.

4. All questions are of equal value.

Question 1:

From the following characteristic equations, determine whether the corresponding control systems are stable or unstable. Consider that limited stability is instability.

a) $p^4 + 4p^3 + 8p^2 + 8p + 3 = 0$

b) $p^5 + 2p^4 + 3p^3 + 8p^2 + p + 4 = 0$

Question 2:

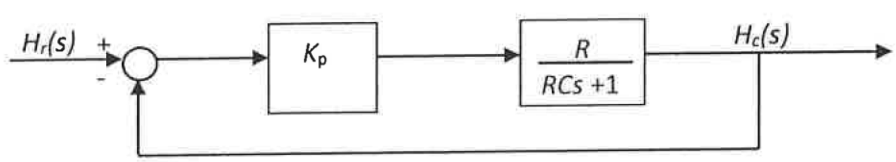
Find the impulse response for systems with the following transfer function.

a) $G(s) = \dfrac{100}{(s+2)\,(s+5)\,(s+5)}$

b) $G(s) = \dfrac{1}{.04s^2 + .08s + 1}$

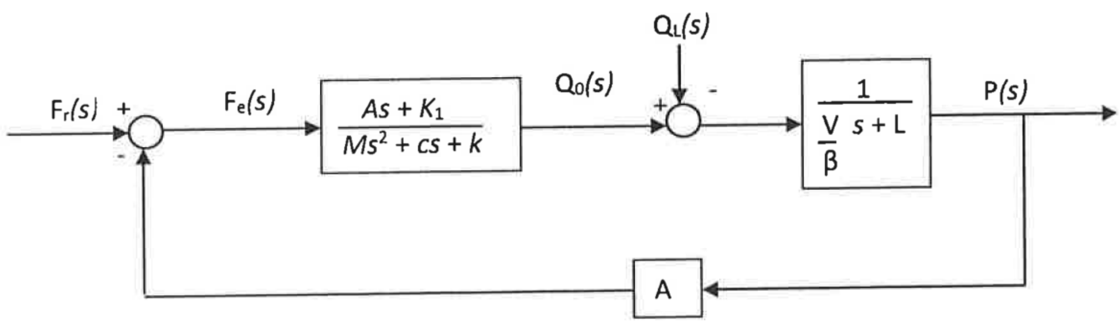
Question 3:

A block diagram for a liquid-level system is shown below. Determine the steady-state response $h_{css}(t)$ if a step reference input $H_R u(t)$ is applied.



Question 4:

For the hydraulic system of the figure below, determine the relationship between the system parameters required for absolute stability. Use Routh's criterion.



Question 5:

Plot Bode diagrams for the following open-loop transfer functions. For the attenuation curve in each case plot the asymptotic approximation first and then put in the actual curve by making corrections at the break points or calculating the actual value of the attenuation at specific frequencies.

a) $G(s)\,H(s) = \dfrac{150}{s\,(s^2 + 2s + 9)}$

b) $G(s)\,H(s) = \dfrac{50}{s^2\,(s + 10)}$

Question 6:

Construct root-locus plots for the following open-loop transfer functions. Scale several points; check the results by solving the system characteristic equations.

a) $G(s)\,H(s) = \dfrac{K'(s+1)}{s+5}$

b) $G(s)\,H(s) = \dfrac{K'(s+3)}{(s+1)(s+6)}$

Table of Laplace Transforms

$f(t)$	$\mathcal{L}[f(t)] = F(s)$	
1	$\frac{1}{s}$	(1)
$e^{at}f(t)$	$F(s-a)$	(2)
$\mathcal{U}(t-a)$	$\frac{e^{-as}}{s}$	(3)
$f(t-a)\mathcal{U}(t-a)$	$e^{-as}F(s)$	(4)
$\delta(t)$	1	(5)
$\delta(t-t_0)$	e^{-st_0}	(6)
$t^n f(t)$	$(-1)^n \frac{d^n F(s)}{ds^n}$	(7)
$f'(t)$	$sF(s) - f(0)$	(8)
$f^n(t)$	$s^n F(s) - s^{(n-1)} f(0) - \cdots - f^{(n-1)}(0)$	(9)
$\int_0^t f(x)g(t-x)dx$	$F(s)G(s)$	(10)
$t^n \ (n = 0, 1, 2, \dots)$	$\frac{n!}{s^{n+1}}$	(11)
$t^x \ (x \geq -1 \in \mathbb{R})$	$\frac{\Gamma(x+1)}{s^{x+1}}$	(12)
$\sin kt$	$\frac{k}{s^2+k^2}$	(13)
$\cos kt$	$\frac{s}{s^2+k^2}$	(14)
e^{at}	$\frac{1}{s-a}$	(15)
$\sinh kt$	$\frac{k}{s^2-k^2}$	(16)
$\cosh kt$	$\frac{s}{s^2-k^2}$	(17)
$\frac{e^{at}-e^{bt}}{a-b}$	$\frac{1}{(s-a)(s-b)}$	(18)
$\frac{ae^{at}-be^{bt}}{a-b}$	$\frac{s}{(s-a)(s-b)}$	(19)
te^{at}	$\frac{1}{(s-a)^2}$	(20)
$t^n e^{at}$	$\frac{n!}{(s-a)^{n+1}}$	(21)
$e^{at}\sin kt$	$\frac{k}{(s-a)^2+k^2}$	(22)
$e^{at}\cos kt$	$\frac{s-a}{(s-a)^2+k^2}$	(23)
$e^{at}\sinh kt$	$\frac{k}{(s-a)^2-k^2}$	(24)
$e^{at}\cosh kt$	$\frac{s-a}{(s-a)^2-k^2}$	(25)
$t\sin kt$	$\frac{2ks}{(s^2+k^2)^2}$	(26)
$t\cos kt$	$\frac{s^2-k^2}{(s^2+k^2)^2}$	(27)
$t\sinh kt$	$\frac{2ks}{(s^2-k^2)^2}$	(28)
$t\cosh kt$	$\frac{s^2-k^2}{(s^2-k^2)^2}$	(29)
$\frac{\sin at}{t}$	$\arctan \frac{a}{s}$	(30)
$\frac{1}{\sqrt{\pi t}} e^{-a^2/4t}$	$\frac{e^{-a\sqrt{s}}}{\sqrt{s}}$	(31)
$\frac{a}{2\sqrt{\pi t^3}} e^{-a^2/4t}$	$e^{-a\sqrt{s}}$	(32)
$\mathrm{erfc}\left(\frac{a}{2\sqrt{t}}\right)$	$\frac{e^{-a\sqrt{s}}}{s}$	(33)