National Exams May 2016

07-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. No aids other than semi-log graph papers are permitted.

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.

1. For a second-order system with transfer function

$$G(s) = \frac{3}{s^2 + 2s - 3}$$

determine the following:

a) The DC gain;

b) The final value to a step input.

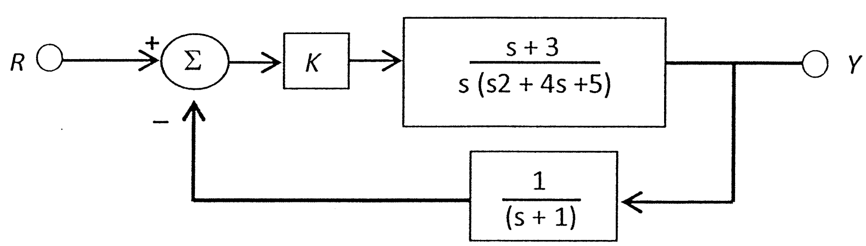
2. Find the time function corresponding to each of the following Laplace transforms using Partial-fraction expansions:

a) $F(s) = \dfrac{2}{s\,(s+2)}$

b) $F(s) = \dfrac{10}{s\,(s+1)\,(s+10)}$

c) $F(s) = \dfrac{3s+2}{s^2 + 4s + 20}$

3. Consider the system 1.0



System 1.0

a) Using Routh's stability criterion, determine all values of K for which the system is stable.

b) Sketch the root locus of the characteristic equation versus K. Include angles of departure and arrival, and find the values for K and s at all breakaway points, breaking points and imaginary-axis crossings.

4. Sketch the asymptotes of the Bode plot magnitude and phase for the following open-loop transfer function.

$$L(s) = \frac{100}{s(0.1s+1)(0.5s+1)}$$

5. A position control system has the closed-loop transfer function (meter/meter) given by

$$\frac{Y(s)}{R(s)} = \frac{b_0 s + b_1}{s^2 + a_1 s + a_2}$$

a) The steady-state error to a step reference is zero.

b) The steady-state error to a ramp reference input of 0.1 m/sec is not more than 1 mm.

6. Use Routh's stability criterion to determine how many roots with positive real parts the following equations have:

a) $s^4 + 8s^3 + 32s^2 + 80s + 100 = 0$

b) $s^5 + 10s^4 + 30s^3 + 80s^2 + 344s + 480 = 0$

c) $s^4 + 2s^3 + 7s^2 - 2s + 8 = 0$

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)
$\text{erfc}\left(\frac{a}{2\sqrt{t}}\right)$	$\frac{e^{-a\sqrt{s}}}{s}$	(33)

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