

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:

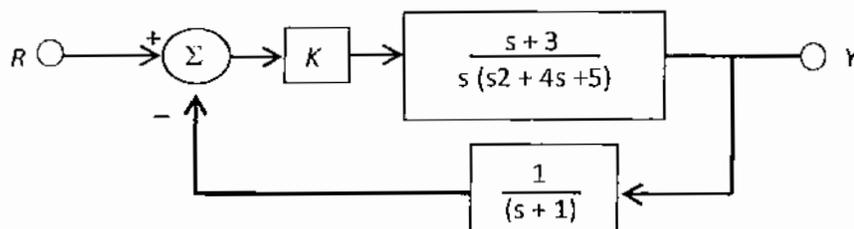
- The DC gain;
 - The final value to a step input.
2. Find the time function corresponding to each of the following Laplace transforms using Partial-fraction expansions:

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

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

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

3. Consider the system 1.0



System 1.0

- 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.

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

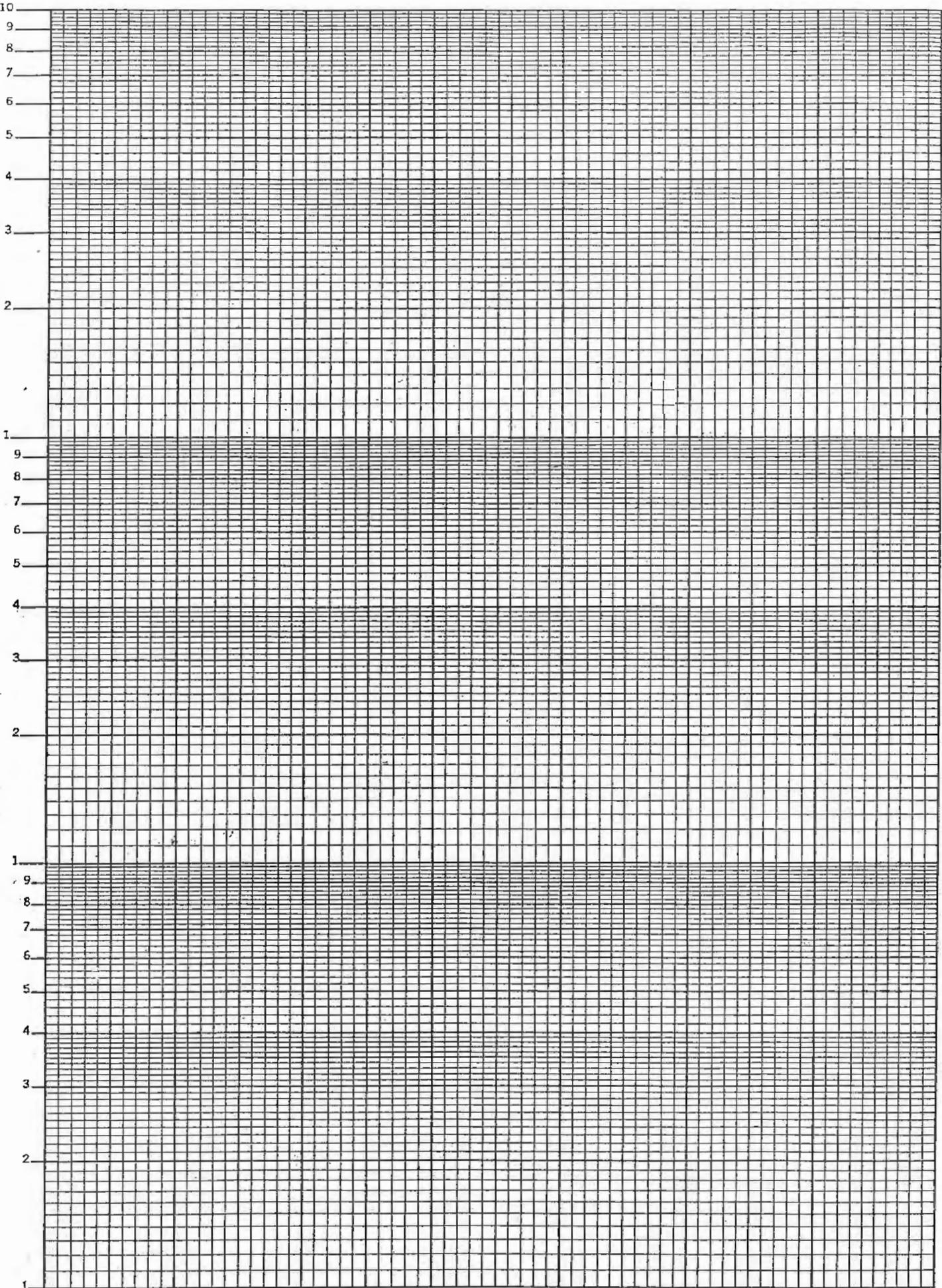
5. A position control system has the closed-loop transfer function (meter/meter) given by

$$\frac{Y(s)}{R(s)} = \frac{b_0s + b_1}{s^2 + a_1s + a_2}$$

- 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

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



Semi-Logarithmic
3 Cycles x 10 to the inch

