National Exams May 2018

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.

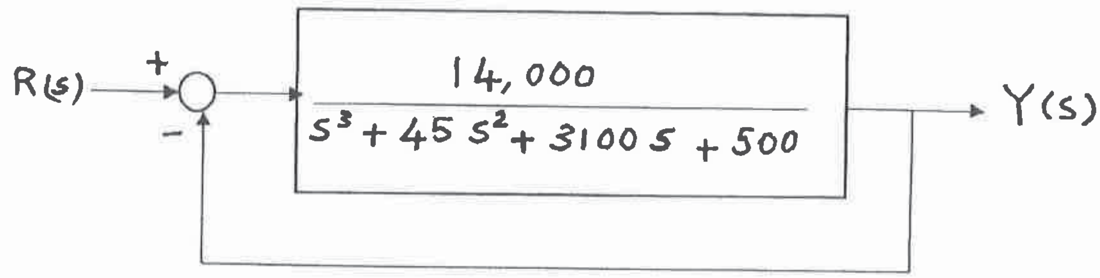
2. Candidates may use a Casio **or** Sharp approved calculator. This is a **closed book** exam. No aids other than semi-log graph papers are permitted.

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.

Question 1:

A closed-loop control system is seen below;



a) Determine the transfer function $T(s) = Y(s) / R(s)$.

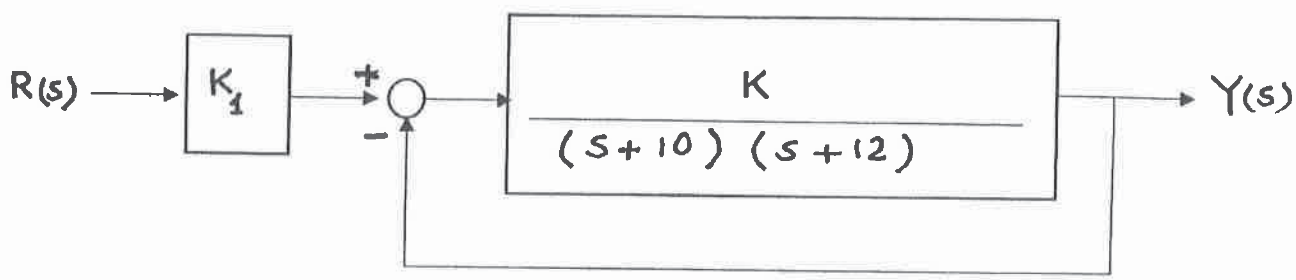
b) Determine the poles and zeros of $T(s)$.

c) Use a unit step input, $R(s) = 1/s$ and obtain the partial fraction expansion for $Y(s)$.

d) Predict the final value of $y(t)$ for the unit step input.

Question 2:

A system is shown in the figure below;



a) Determine the steady – state error for a unit step input in terms of K and K_1, where $E(s) = R(s) - Y(s)$.

b) Select K_1 so that the steady-state error is zero.

Question 3:

A feedback control system has a characteristic equation

$$s^6 + 5s^5 + 14\,s^4 + 40\,s^3 + 64\,s^2 + 80\,s + 96 = 0$$

Determine whether the system is stable, and determine the values of the roots.

Question 4:

A unity negative feedback system has a transfer function

$$G(s) = \frac{K\,(s^2 + 0.105625)}{s\,(s^2 + 1)}$$

$$= \frac{K\,(s + j0.325)\,(s - j0.325)}{s\,(s^2 + 1)}$$

Sketch the root locus as a function of K. Carefully calculate where the segments of the locus enter and leave the real axis.

Question 5:

A unity feedback control system has a transfer function

$$G(s) = \frac{K\,(s^2 + 6s + 12)}{s^2\,(s + 1)}$$

We desire the dominant roots to have a damping ratio equal to 0.707. Find the gain K when this condition is satisfied. Show that the complex roots are $s = -2.3 \pm j2.3$ at this gain.

Question 6:

Sketch the Bode Diagram representation of the frequency response for the transfer functions;

a) $$GH(s) = \frac{s - 10}{s^2 + 6s + 10}$$

b) $$GH(s) = \frac{30(s + 8)}{s(s + 2)(s + 4)}$$

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)
$t^n \; (n = 0, 1, 2, \ldots)$	$\frac{n!}{s^{n+1}}$	(11)
$t^x \; (x > -1 \in \mathbb{R})$	$\frac{\Gamma(x+1)}{s^{x+1}}$	(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)
$\operatorname{erfc}\left(\frac{a}{2\sqrt{t}}\right)$	$\frac{e^{-a\sqrt{s}}}{s}$	(33)