UNIVERSITY OF JOHANNESBURG

PROGRAM	BACCALAUREUS TECHNOLOGIAE *CHEMICAL ENGINEERING*
SUBJECT	**PROCESS CONTROL IV**
CODE	**ICP411**
DATE	SUMMER EXAMINATION 1 DECEMBER 2016
DURATION	3.0 HRS (PAPER) 8:30-11:30
TOTAL MARKS	100
FULL MARKS	100

EXAMINER	MRS T. MASHIFANA
MODERATOR	PROF. M.S. ONYANGO
NUMBER OF PAGES	FIVE (5) INCLUDING THIS COVER PAGE

INSTRUCTIONS	THIS IS A CLOSED BOOK EXAM NON-PROGRAMMABLE CALCULATORS PERMITTED (ONLY ONE PER CANDIDATE) SHOW ALL UNITS IN CALCULATIONS!!! ANSWER ALL THE QUESTIONS NO ELECTRONIC DEVICES ALLOWED.

QUESTION 1: Second order systems process modelling

A step change of magnitude 4 is introduced into a system having the following transfer function:

$$\frac{Y(s)}{X(s)} = \frac{10}{s^2 + 1.6s + 4}$$

Find:

a) Y(t);
b) Percent overshoot;
c) Ultimate value of Y(t);
d) Maximum value of Y(t) and
e) Period of oscillation.

[35]

QUESTION 2: Feedback control

2.1. Derive the transfer function for

(a) Proportional controller (4)

(b) Proportional-integral controller (6)

2.2. Summarize the effect of the following control mode on a first order control loop

(a) Proportional-integral controller (5)

[15]

QUESTION 3: General feedback control loop stability criterion

Each of the following systems is feedback controlled with a proportional controller. Find the range values of the proportional gain K_c that produce stable (if it is possible) closed-loop response. Assume that $G_m = G_f = 1$.

a) $G_p(s) = \dfrac{2}{0.1s + 1}$ (10)

b) $G_p(s) = \dfrac{10}{2s^2 + 3s - 4}$ (15)

[25]

QUESTION 4: Routh-Hurwitz Criterion for Stability

Consider the closed loop feedback control system given in Figure 4.1 below

a) Find the characteristic equation of the system
b) Construct the Routh array for the control system
c) Ia the system stable for Kc = 2.5? Why?
d) Is the system stable for Kc = 7.5? Why?
e) For what values of Kc will the system always be stable: why?

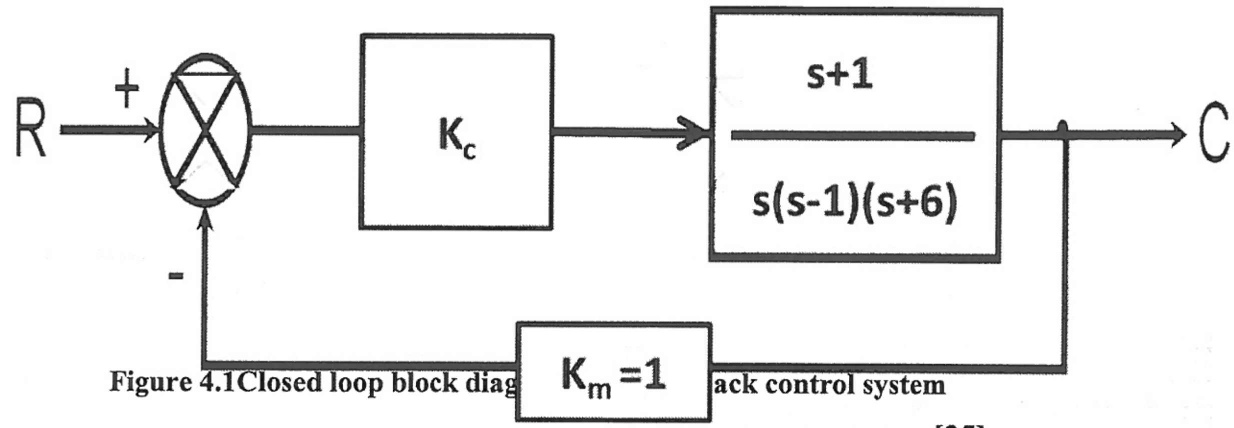

Figure 4.1Closed loop block diag ack control system

[25]

TOTAL MARKS = 100

FULL MARKS = 100

Laplace transforms table

Table of Laplace Transforms

	$f(t)=\mathfrak{L}^{-1}\{F(s)\}$	$F(s)=\mathfrak{L}\{f(t)\}$		$f(t)=\mathfrak{L}^{-1}\{F(s)\}$	$F(s)=\mathfrak{L}\{f(t)\}$
1.	1	$\frac{1}{s}$	2.	e^{at}	$\frac{1}{s-a}$
3.	$t^n,\quad n=1,2,3,\ldots$	$\frac{n!}{s^{n+1}}$	4.	$t^p, p > -1$	$\frac{\Gamma(p+1)}{s^{p+1}}$
5.	$\sqrt{t}$	$\frac{\sqrt{\pi}}{2s^{\frac{3}{2}}}$	6.	$t^{n-\frac{1}{2}},\quad n=1,2,3,\ldots$	$\frac{1\cdot 3\cdot 5\cdots(2n-1)\sqrt{\pi}}{2^n s^{n+\frac{1}{2}}}$
7.	$\sin(at)$	$\frac{a}{s^2+a^2}$	8.	$\cos(at)$	$\frac{s}{s^2+a^2}$
9.	$t\sin(at)$	$\frac{2as}{(s^2+a^2)^2}$	10.	$t\cos(at)$	$\frac{s^2-a^2}{(s^2+a^2)^2}$
11.	$\sin(at)-at\cos(at)$	$\frac{2a^3}{(s^2+a^2)^2}$	12.	$\sin(at)+at\cos(at)$	$\frac{2as^2}{(s^2+a^2)^2}$
13.	$\cos(at)-at\sin(at)$	$\frac{s(s^2-a^2)}{(s^2+a^2)^2}$	14.	$\cos(at)+at\sin(at)$	$\frac{s(s^2+3a^2)}{(s^2+a^2)^2}$
15.	$\sin(at+b)$	$\frac{s\sin(b)+a\cos(b)}{s^2+a^2}$	16.	$\cos(at+b)$	$\frac{s\cos(b)-a\sin(b)}{s^2+a^2}$
17.	$\sinh(at)$	$\frac{a}{s^2-a^2}$	18.	$\cosh(at)$	$\frac{s}{s^2-a^2}$
19.	$e^{at}\sin(bt)$	$\frac{b}{(s-a)^2+b^2}$	20.	$e^{at}\cos(bt)$	$\frac{s-a}{(s-a)^2+b^2}$
21.	$e^{at}\sinh(bt)$	$\frac{b}{(s-a)^2-b^2}$	22.	$e^{at}\cosh(bt)$	$\frac{s-a}{(s-a)^2-b^2}$
23.	$t^n e^{at},\quad n=1,2,3,\ldots$	$\frac{n!}{(s-a)^{n+1}}$	24.	$f(ct)$	$\frac{1}{c}F\left(\frac{s}{c}\right)$
25.	$u_c(t)=u(t-c)$	e^{-cs}	26.	$\delta(t-c)$	e^{-cs}