TO FIND UJ, JUST LOOK AMONG THE TOP 4% GLOBALLY

RETHINK. REINVENT.

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CHEMICAL ENGINEERING TECHNOLOGY

PROGRAM	: BACHELORS TECHNOLOGY
SUBJECT	: PROCESS CONTROL IV
CODE	: ICP411
DATE	: SUMMER SSA EXAMINATION 2015 9 DECEMBER 2015
DURATION	: (SESSION 2) 11:30 - 14:30
TOTAL MARKS	: 100
FULL MARKS	: 100

EXAMINER	: PROF. K. JALAMA
MODERATOR	: PROF. M. S. ONYANGO
NUMBER OF QUESTIONS	: FOUR (4)
NUMBER OF PAGES	: SIX (6) INCLUDING THIS COVER PAGE

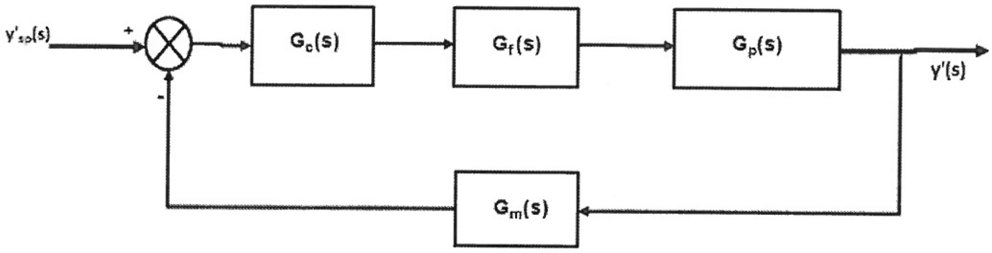
INSTRUCTIONS :

- THIS IS A CLOSED-BOOK EXAM;
- CALCULATORS ARE ALLOWED ;
- NO COMPUTERS ALLOWED;
- NUMBER AND ANSWER ALL QUESTIONS
- UNIVERSITY OF JOHANNESBURG EXAMINATION REGULATIONS APPLY

GOOD LUCK

QUESTION 1 [25]

Consider the block diagram of the closed-loop system shown below where K_c = 1 and τ_I = 0.5. For a unit step change in the set-point, determine whether the system response will be oscillatory of not. If the response is oscillatory, compute the overshot, decay ratio and period of oscillation.



$$G_c = K_c\left(1+\frac{1}{\tau_I s}\right) \qquad G_f = G_m = 1 \qquad G_p = \frac{1}{s+1}$$

QUESTION 2 [25]

The characteristic equation of a closed loop system is given by

$2s^2 + 6s + 10 = 0$

Using the general feedback control loop stability criterion determine whether the system is stable.

QUESTION 3 [25]

The data for process reaction curve of temperature control system to a step change of magnitude 2 are given in the table below.

Time t [min]	Reaction curve y(t)
0	0.02
1	0.07
2	0.18
3	0.47
4	1.19
5	2.69
6	5.00
7	7.31
8	8.81
9	9.53
10	9.82
11	9.93
12	9.98
13	9.99
14	10.00
15	10.00

Compute the settings of a PID controller using the **Cohen-Coon** tuning methodology. Use the graph paper in attachment.

The following settings have been recommended by Cohen-Coon.

For proportional controllers: $K_c = \frac{1}{K}\frac{\tau}{t_d}(1+\frac{t_d}{3\tau})$

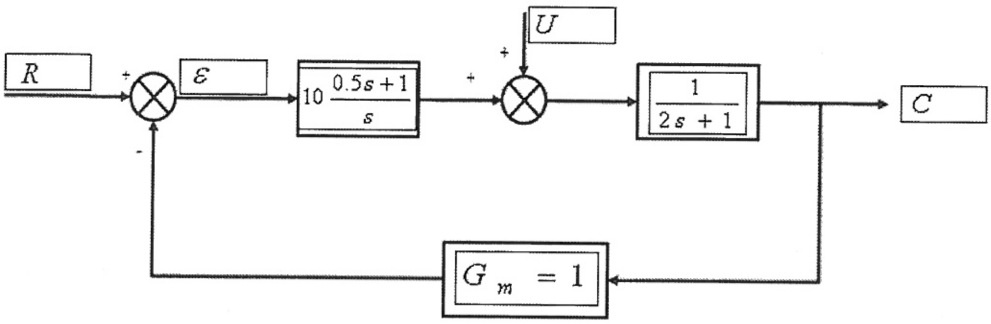
For PI controllers: $K_c = \frac{1}{K}\frac{\tau}{t_d}(0.9+\frac{t_d}{12\tau})$ $\quad \tau_I = t_d \frac{30+3\frac{t_d}{\tau}}{9+20\frac{t_d}{\tau}}$

For PID controllers: $K_c = \frac{1}{K}\frac{\tau}{t_d}(\frac{4}{3}+\frac{t_d}{4\tau})$ $\quad \tau_I = t_d \frac{32+6\frac{t_d}{\tau}}{13+8\frac{t_d}{\tau}}$ $\quad \tau_D = t_d \frac{4}{11+2\frac{t_d}{\tau}}$

Question 4 **[25]**

From the closed-loop system given below, determine the following transfer functions:

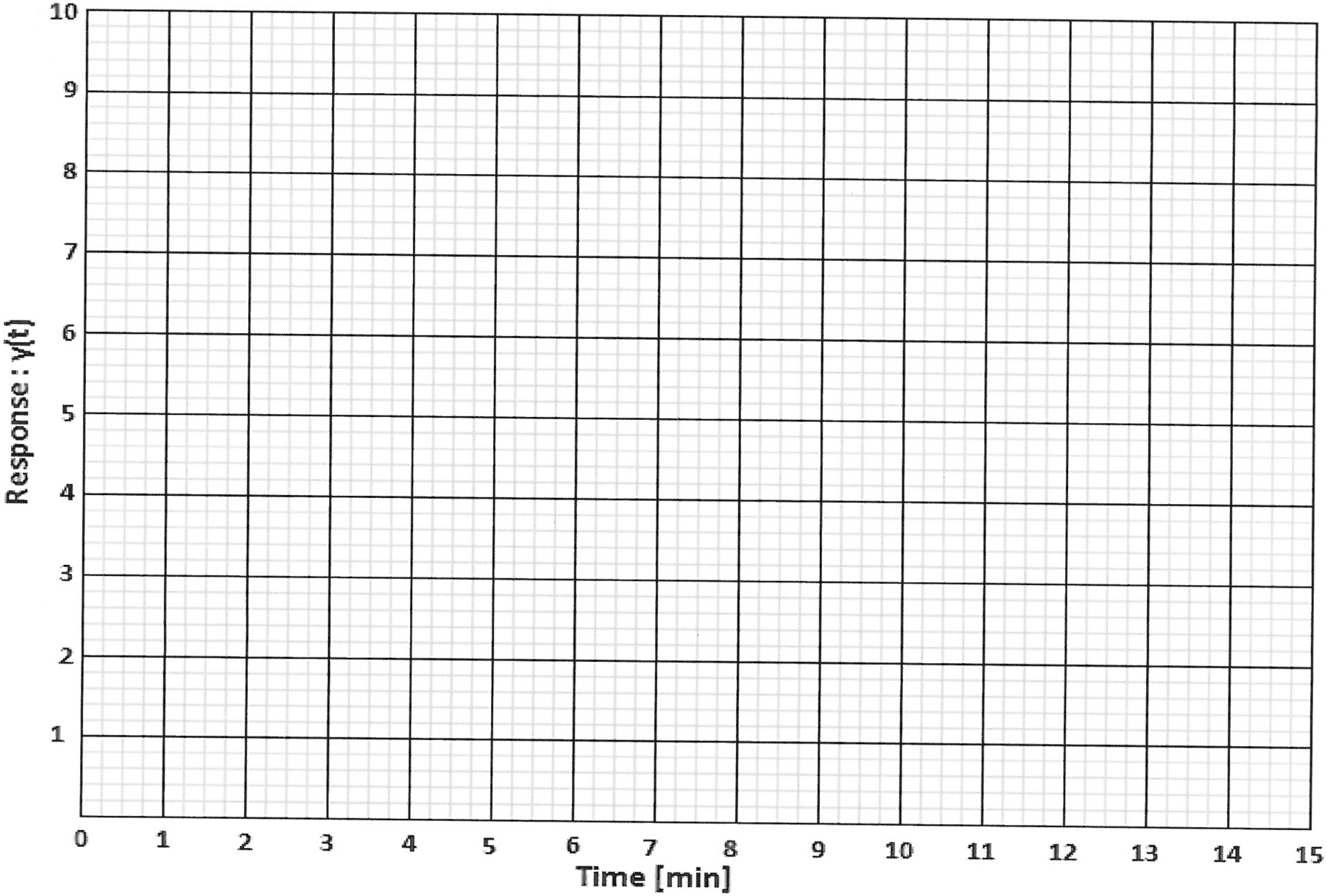
a) C/R;
b) C/U


U
+
R
+
ε
$10\,\frac{0.5s+1}{s}$
+
$\frac{1}{2s+1}$
C
-
$G_m = 1$

Laplace transforms table

Table of Laplace Transforms

	$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$		$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$
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.	$t^{n-\frac{1}{2}},\quad n=1,2,3,\ldots$	$\frac{1\cdot3\cdot5\cdots(2n-1)\sqrt{\pi}}{2^n s^{n+\frac{1}{2}}}$
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}


10
9
8
7
6
5
4
3
2
1
0
Response : y(t)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Time [min]