UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *CHEMICAL ENGINEERING*
SUBJECT	:	**PROCESS CONTROL III**
CODE	:	**ICP 3111**
DATE	:	SUMMER EXAMINATION 2017 17 NOVEMBER 2017
DURATION	:	(SESSION 1) 08:30 - 11:30
WEIGHT	:	40: 60
TOTAL MARKS	:	100

EXAMINER	:	MS THANDIWE SITHOLE
MODERATOR	:	DR MAMVURA
NUMBER OF PAGES	:	4 PAGES

INSTRUCTIONS	:	QUESTION PAPERS MUST BE HANDED IN.
REQUIREMENTS	:	CALCULATOR PERMITED

QUESTION 1[18 MARKS]

Give the PID control law and explain all the terms therein [08]
By means of drawing show an example of override control application using LSS. [10]

QUESTION 2[15 MARKS]

A temperature transmitter has a range from 0 to 120°C which corresponds to a linear analog signal range of 4 mA to 20 mA. Determine the value of the temperature that corresponds to a current signal of 15 mA.

[15]

QUESTION 3 [15 MARKS]

An equal percentage control valve has a C_v of 100 at 30% valve travel and a C_v of 147 at 40% valve travel;

(a) Calculate the C_v at 70% valve travel;

(b) Calculate the maximum valve C_v;

(c) Calculate the valve rangeabiliy. [15]

QUESTION 4 [26 MARKS]

As a process engineer you are requested to design a control around the distillation process shown in the figure 4.1.Figure 4.1 shows a distillation process from the feed to the distillate process. Illustrate how you will control this process. [16]

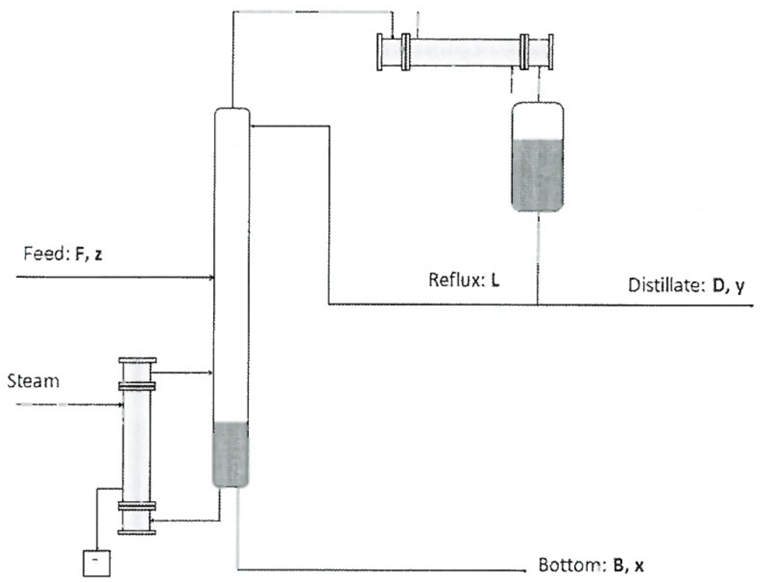


Figure 4.1: Schematic of a binary distillation column process flow diagram

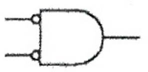
4.2 During optimization of the distillation column one of your team member decides to adjust the feed. Suppose the product (distillate) purity drops below the target value, explain how the control system will readjust the product purity.

[10]

QUESTION 5 [26 MARKS]

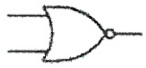
5.1. Complete truth tables for the following gates, and also write the Boolean expression for each gate: **[8]**

A



A	B	Output
0	0	
0	1	
1	0	
1	1	

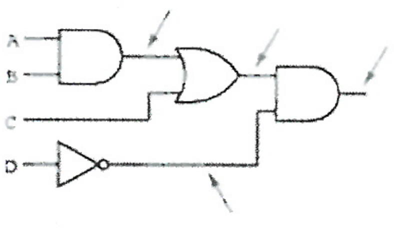
B



A	B	Output
0	0	
0	1	
1	0	
1	1	

5.2. The results should be obvious once the truth tables are both complete. Is there a general principle at work here? Do you think we would obtain similar results with Negative-OR and NAND gates? Explain. **[4]**

5.3. Convert the following logic gate circuit into a Boolean expression, writing Boolean sub-expressions next to each gate output in the diagram: **[8]**



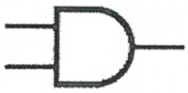
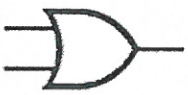
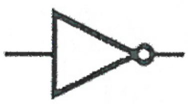
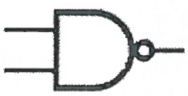
5.4. An Exclusive-OR gate has the following Boolean expression:

$A\overline{B} + \overline{A}B$

Draw the schematic diagram for a gate circuit exhibiting this Boolean function, constructed entirely from NAND gates. **[6]**

END OF EXAMINATION QUESTIONS P.T.O FOR APPENDICES

Appendix A :Traditional digital logic gate symbols, Boolean functions and truth table

Type	Distinctive shape	Boolean algebra between A & B	Meaning	Truth table
AND		$A \cdot B$	Output is true if and only if (iff) both A and B are true	**INPUT** | **OUTPUT** A | B | A AND B 0 | 0 | 0 0 | 1 | 0 1 | 0 | 0 1 | 1 | 1
OR		$A + B$	True iff A is true, or B is true, or both.	**INPUT** | **OUTPUT** A | B | A OR B 0 | 0 | 0 0 | 1 | 1 1 | 0 | 1 1 | 1 | 1
NOT		$\overline{A}$	True iff A is false.	**INPUT** | **OUTPUT** A | NOT A 0 | 1 1 | 0
NAND		$\overline{A \cdot B}$	A and B are not both true.	**INPUT** | **OUTPUT** A | B | A NAND B 0 | 0 | 1 0 | 1 | 1 1 | 0 | 1 1 | 1 | 0

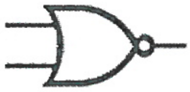
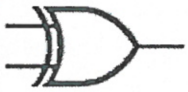
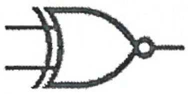
NOR		$\overline{A+B}$	True iff neither *A* nor *B*.	**INPUT** **OUTPUT** A B A NOR B 0 0 1 0 1 0 1 0 0 1 1 0
XOR		$A \oplus B$	True iff *A* is not equal to *B*.	**INPUT** **OUTPUT** A B A XOR B 0 0 0 0 1 1 1 0 1 1 1 0
XNOR		$\overline{A \oplus B}$	True iff *A* is equal to *B*.	**INPUT** **OUTPUT** A B A XNOR B 0 0 1 0 1 0 1 0 0 1 1 1

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.	$\mathbf{e}^{at}$	$\frac{1}{s-a}$
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.	$\mathbf{e}^{at}\sin(bt)$	$\frac{b}{(s-a)^2+b^2}$	20.	$\mathbf{e}^{at}\cos(bt)$	$\frac{s-a}{(s-a)^2+b^2}$
21.	$\mathbf{e}^{at}\sinh(bt)$	$\frac{b}{(s-a)^2-b^2}$	22.	$\mathbf{e}^{at}\cosh(bt)$	$\frac{s-a}{(s-a)^2-b^2}$
23.	$t^n\mathbf{e}^{at},\quad n=1,2,3,\ldots$	$\frac{n!}{(s-a)^{n+1}}$	24.	$f(ct)$	$\frac{1}{c}F\left(\frac{s}{c}\right)$
25.	$u_c(t)=u(t-c)$ Heaviside Function	$\frac{\mathbf{e}^{-cs}}{s}$	26.	$\delta(t-c)$ Dirac Delta Function	$\mathbf{e}^{-cs}$
27.	$u_c(t)f(t-c)$	$\mathbf{e}^{-cs}F(s)$	28.	$u_c(t)g(t)$	$\mathbf{e}^{-cs}\mathfrak{L}\{g(t+c)\}$
29.	$\mathbf{e}^{ct}f(t)$	$F(s-c)$	30.	$t^n f(t),\quad n=1,2,3,\ldots$	$(-1)^n F^{(n)}(s)$
31.	$\frac{1}{t}f(t)$	$\int_s^{\infty}F(u)\,du$	32.	$\int_0^t f(v)\,dv$	$\frac{F(s)}{s}$
33.	$\int_0^t f(t-\tau)g(\tau)\,d\tau$	$F(s)G(s)$	34.	$f(t+T)=f(t)$	$\frac{\int_0^T \mathbf{e}^{-st}f(t)\,dt}{1-\mathbf{e}^{-sT}}$
35.	$f'(t)$	$sF(s)-f(0)$	36.	$f''(t)$	$s^2F(s)-sf(0)-f'(0)$

37. $f^{(n)}(t)$ $\quad s^nF(s)-s^{n-1}f(0)-s^{n-2}f'(0)\cdots-sf^{(n-2)}(0)-f^{(n-1)}(0)$