UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE *EXTRACTION METALLURGY*
SUBJECT	:	**PROCESS CONTROL III**
CODE	:	**MPE 32-1**
DATE	:	SUMMER EXAM 2014 01 NOVEMBER 2014
DURATION	:	(X-PAPER) 08:30 - 11:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

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NUMBER OF PAGES : 3 PAGES AND 2 ANNEXURES

INSTRUCTIONS : CALCULATORS ARE PERMITTED.

REQUIREMENTS :

INSTRUCTIONS TO STUDENTS

PLEASE ANSWER ALL THE QUESTIONS.

QUESTION PAPER TO BE HANDED IN WITH SCRIPT

QUESTION 1

The following set of equations:

$dx_1/dt = 2x_1 + 3x_2 + 1 \quad with\ x_1(0)=0$
$dx_2/dt = 2x_1 + x_2 + e^t \quad with\ x_2(0)=0$

Find the solution of the above given set of equations.

[16]

QUESTION 2

2.1 Using the Heaviside expansion, calculate the time function of the given Laplace Transfroms below:

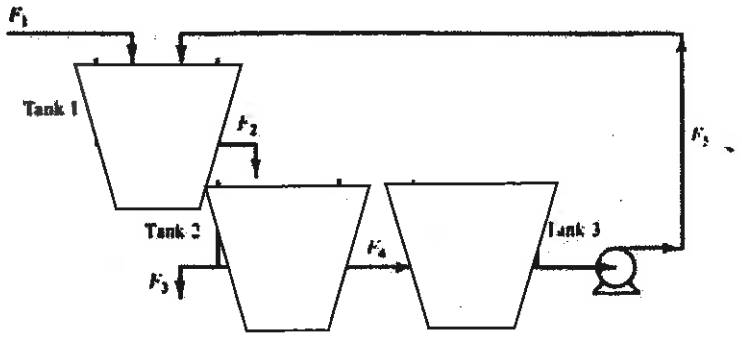
$$\bar{X}(s) = 1/(s+)^3(s+2)$$

2.2 Conduct the qualitative study and state whether the process with Laplace Transforms is the function given above is stable

[14]

QUESTION 3

Develop the mathematical model for the system shown in figure bellow. Discuss the state variables that will generate your state equations for this system and what type of balance equations have you used? All flow rates are volumetric, and the volumes of the three tanks are A1, A2 and A3 (m^3), respectively. The flow rate F3 is constant, while all other effluent flow rates are proportional to the corresponding hydrostatic liquid pressures that cause the flow.



[25]

QUESTION 4

4.1 With your BTech project, you are to design a specific configuration to control your process. Discuss why you would go for a specific configuration. Be concise.

4.2 Establish the mathematical model of your BTech project. Please, state the aim of your project and discuss the state variables beforehand. Then conduct a qualitative study on your project.

4.3 Criticize the complexity of your model

[15]

QUESTION 5

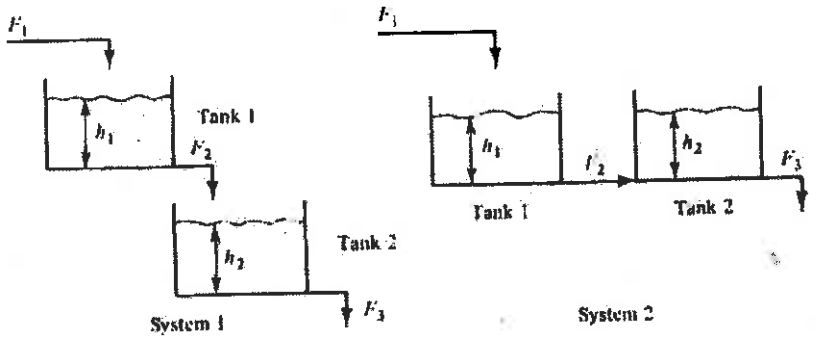
It is said that a proportional law is not as reliable as the integral proportional law. Discuss the above statement. Elaborate as much as you can.

[10]

QUESTION 6

The two systems shown in figures below are representing two leaching processes that are taking place at room temperature. However, it is said that the reactions taking place are releasing heat such that the temperature is increasing. But the aim is to keep the temperature at room temperature level. A cooling system is envisaged. Show how mathematically the cooling system is impacting on the heat balance of the systems.

(See Figure next page)



[20]

TOTAL MARKS 100

Laplace Transform Pairs

$f(t)$	$\bar{f}(s)$
1	$\frac{1}{s}$
$t^n,\ n=0,1,2,\cdots$	$\frac{n!}{s^{n+1}}$
$t^v,\ v>1$	$\frac{\Gamma(v+1)}{s^{v+1}}$
$t^{n-1/2}$	$\left(\frac{\sqrt{\pi}}{2}\right)\left(\frac{3}{2}\right)\left(\frac{5}{2}\right)\cdots\left(\frac{n-1}{2}\right)\frac{1}{s^{n+1/2}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$\frac{e^{-at}-e^{-bt}}{b-a}$	$\frac{1}{(s+a)(s+b)}$
$\frac{ae^{-at}-be^{-bt}}{b-a}$	$\frac{s}{(s+a)(s+b)}$
$\frac{e^{at}-1}{a}$	$\frac{1}{s(s-a)}$
$\frac{e^{at}-at-1}{a^2}$	$\frac{1}{s^2(s-a)}$
$\frac{e^{at}-\frac{1}{2}a^2t^2-at-1}{a^3}$	$\frac{1}{s^3(s-a)}$
$(1+at)e^{at}$	$\frac{s}{(s-a)^2}$
$\frac{1+(at-1)e^{at}}{a^2}$	$\frac{1}{s(s-a)^2}$
$\frac{2+at+(at-2)e^{at}}{a^3}$	$\frac{1}{s^2(s-a)^2}$
$t^ne^{at},\ n=0,1,2,\cdots$	$\frac{n!}{(s-a)^{n+1}}$
$\frac{\frac{1}{a}e^{at}-\frac{1}{b}e^{bt}+\frac{1}{b}-\frac{1}{a}}{a-b}$	$\frac{1}{s(s-a)(s-b)}$

Laplace Transform Pairs

$f(t)$	$\bar{f}(s)$
$\sin(at)$	$\frac{a}{s^2+a^2}$
$\cos(at)$	$\frac{s}{s^2+a^2}$
$\frac{1-\cos(at)}{a^2}$	$\frac{1}{s(s^2+a^2)}$
$\frac{at-\sin(at)}{a^3}$	$\frac{1}{s^2(s^2+a^2)}$
$\frac{\sin(at)-at\cos(at)}{2a^3}$	$\frac{1}{(s^2+a^2)^2}$
$\frac{t\sin(at)}{2a}$	$\frac{s}{(s^2+a^2)^2}$
$\frac{\sin(at)+at\cos(at)}{2a}$	$\frac{s^2}{(s^2+a^2)^2}$
$\frac{\cos(at)-\cos(bt)}{b^2-a^2}$	$\frac{s}{(s^2+a^2)(s^2+b^2)}$
$\frac{1-\cos(at)-\frac{1}{2}at\sin(at)}{a^4}$	$\frac{1}{s(s^2+a^2)^2}$
$\frac{\frac{1}{a}\sin(at)-\frac{1}{b}\sin(bt)}{b^2-a^2}$	$\frac{1}{(s^2+a^2)(s^2+b^2)}$
$\sin(a+bt)$	$\frac{s\sin(a)+b\cos(a)}{s^2+b^2}$
$\cos(a+bt)$	$\frac{s\cos(a)-b\sin(a)}{s^2+b^2}$
$\sin(at)\sin(bt)$	$\frac{2abs}{\left[s^2+(a-b)^2\right]\left[s^2+(a+b)^2\right]}$
$\cos(at)\cos(bt)$	$\frac{s\left(s^2+a^2+b^2\right)}{\left[s^2+(a-b)^2\right]\left[s^2+(a+b)^2\right]}$
$\sin(at)\cos(bt)$	$\frac{a\left(s^2+a^2-b^2\right)}{\left[s^2+(a-b)^2\right]\left[s^2+(a+b)^2\right]}$

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