

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

FIRST SEMESTER 2017-2018

CHE F471: Advance Process Control

Comprehensive Examination

Date: 02.12. 2017

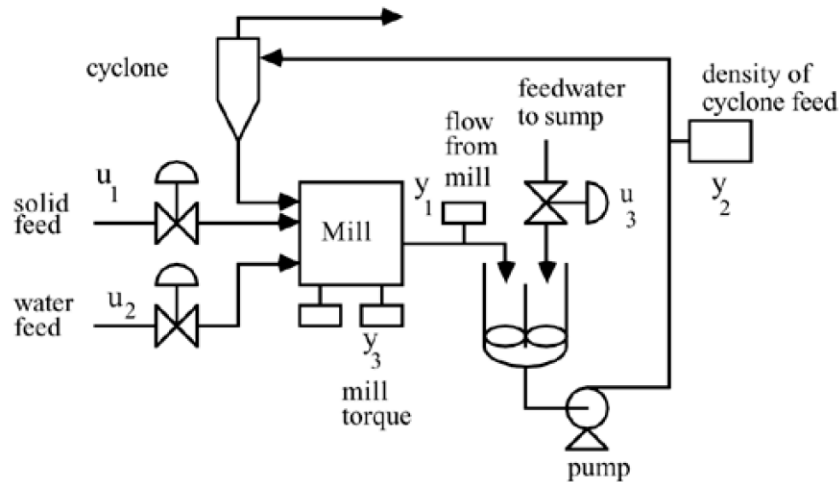
Duration: 9:00 PM - 12:00 PM

Maximum Marks: 40

Please take the proper assumptions whenever it is necessary

PART- A (CLOSE BOOK)

- The objective of a wet grinding circuit is to grind large solid material to form granular material. Solids are fed with a water stream to a ball mill where the solids are ground. The slurry effluent from the ball mill is fed to a sump which is used as surge capacity. The slurry is pumped to a cyclone separator, which separates water from solid material and returns water to the ball mill. A schematic diagram is shown below.



Consider the following process model

$$\begin{pmatrix} y_1(s) \\ y_2(s) \\ y_3(s) \end{pmatrix} = \begin{pmatrix} \frac{370}{500s+1} & \frac{767}{33s+1} & \frac{-50}{10s+1} \\ \frac{903}{500s+1} & \frac{-667e^{-320s}}{(166s+1)} & \frac{-1033}{47s+1} \\ \frac{119}{217s+1} & \frac{153}{337s+1} & \frac{-21}{10s+1} \end{pmatrix} \begin{pmatrix} u_1(s) \\ u_2(s) \\ u_3(s) \end{pmatrix}$$

which has following RGA

$$\Lambda = \begin{pmatrix} -2.36 & 2.96 & 0.40 \\ -0.28 & -0.05 & 1.33 \\ 3.64 & -1.91 & -0.73 \end{pmatrix}$$

- a. What pairing is suggested by the RGA for this system? Why?
 - b. Connect the appropriate input and output variables with controllers, on the diagram above, to form a control instrumentation diagram.
 - c. Discuss the failure sensitivity of this three input–three output system. That is, if any of the control loops failed, would the resulting two input–two output system have the correct pairing? [5 M]
2. a. Explain with suitable three examples where MPC implementation is mandatory. [3 M]
 - b. Develop the model for future control moves with a prediction horizon of P and a control horizon of N for an unconstrained dynamic matrix controller. [7 M]
3. Identify the process with the following data. [5 M]

Sampling instant	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Input	0	1	0.6	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Output	0	0	0.5	0.9	0.91	0.866	0.732	0.612	0.513	0.43	0.361	0.302	0.253	0.212	0.178	0.149

4. a. A finite sequence of $x(n)$ is defined as $x(n) = \{5, 3, -3, 0, 4, -2\}$ find $x(z)$
- b. The discrete-time transfer function of a process is given by

$$\frac{Y(z)}{U(z)} = \frac{5z^{-1} + 3z^{-2}}{1 + z^{-1} + 0.41z^{-2}}$$

- i. Convert this transfer function to an equivalent difference equation.
- ii. What is the steady state value of y ? [5 M]

PART- B (OPEN BOOK)

NOTE: Please take the proper assumptions whenever it is necessary.

1. A student performance (either *PASS* or *FAIL*) can be judged based on mid-term marks and number of hours he/ she spent on a particular subject. The data shown in table decides the whether the student *PASS* or *FAIL* in a particular subject.

Hours studied	35	12	16	45	10	20
Mid-term marks	67	75	89	56	90	50
Final term result	1 (pass)	0 (fail)	1 (pass)	1 (pass)	0 (fail)	?

Predict the student performance if he/ she studied 20 hrs and secured 50 marks in the mid-term. [5 M]

2. Consider a biochemical reactor operated at a stable operating condition (Reference: [Module 7, Bequette](#)), with the state space model

$$A = \begin{bmatrix} 0 & 0.9056 \\ -0.75 & -2.5640 \end{bmatrix}, B = \begin{bmatrix} -1.5301 \\ 3.8255 \end{bmatrix}$$
$$C = [1 \ 0], D = [0]$$

Where the input is the dilution rate (units = min^{-1}) and the output is the biomass concentration (gmol/L). Discuss the effect of sampling time, model length, prediction horizon, and control horizon on the performance for setpoint changes of 0.02 gmol/L. Consider the effect of these parameters on the magnitude of manipulated input changes (i.e., step and constant). What are your recommended tuning parameters if the maximum manipulated input change is 0.2 min^{-1} ? [5 M]

3. Simulate the Tyreus-Luyben parameters for PI and PID controllers to the following process

$$g_p(s) = \frac{e^{-5s}}{10s + 1}$$

Compare these results with Cohen-Coon. Which do you recommend for implementation on a real process? [5 M]