



Name :

Roll No. :

Invigilator's Signature :

CS/M.Tech (CI)/SEM-2/CIM-202/2013

2013

PROCESS INSTRUMENTATION AND CONTROL

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

*Candidates are required to give their answers in their own words
as far as practicable.*

Answer Question No. 1 and any *two* from each of
Group-B and Group-C.

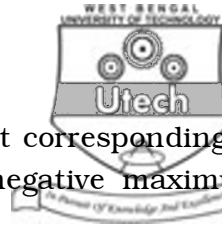
GROUP – A

Answer *all* questions.

1. Justify the correctness of the statements with reasons :

14 × 1 = 14

- i) Composition control in a CSTR is a batch process.
- ii) A ratio controller may be suitable for an oil fired furnace but not for an electric furnace.
- iii) A nozzle and flapper constitute a pneumatic high gain amplifier.
- iv) The nucleonic gauge for thickness control of an aluminium sheet may use an alpha source.
- v) Rate before reset means derivative time is larger than the integral time in a PID controller.

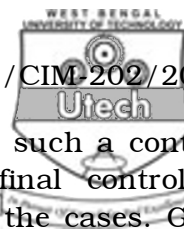


- vi) A three term controller has its output corresponding to three levels — positive maximum, negative maximum and zero.
- vii) A 20% proportional band means a proportional gain of 20.
- viii) If the output of the process has a self sustained oscillation, it is an unstable system. This means that all the on-off controlled processes are unstable.
- ix) Delayed negative feedback is used in a PI controller.
- x) The unit of half life of a radioisotope is time.
- xi) Thermistor is almost ten times more sensitive than RTD.
- xii) Electromagnetic flowmeter is suitable for non-conductive liquid only.
- xiii) Cavitations are the healthy phenomenon for the control valve.
- xiv) Optical pyrometer based temperature measurement is an invasive technique.

GROUP – B

Answer any *two* of the following. $2 \times 14 = 28$

- 2. a) Draw neat simulation and functional block diagrams to derive the transfer functions of the following pneumatic controllers :
 - i) Force balanced PID controller
 - ii) Displacement balanced PD controller. 8
- b) Show how a digital PID controller can be simulated. How is the sampling period chosen ? What is an incremental PID controller ? 6



3. a) What is ratio control system ? Discuss such a control system for a specific process. The final controlled variable may be taken as flow in both the cases. Give examples of a few ratio control systems. 6

- b) What is a cascade control system ? How would you determine the type of the process that would require a cascade control system ?

In a continuous flow chemical reactor, its temperature is used to adjust the set point of the jacket temperature controller, which regulates the input temperature of the cooling fluid. Draw the block diagram of the control loop, explain its principle of operation and discuss in what way it serves a better control performance as compared with the single loop control system. 8

4. a) What are the different types of chemical reactors ? Compare them.

Use mass balance and energy balance principles. Derive the equations governing the dynamics of a CSTR for control of composition of a product. Assume an exothermic catalytic reaction in the process. 8

- b) Explain the nucleonic methods of measurement of liquid level in tank. Discuss the radioisotopes and the detectors chosen. Sketch the performance characteristics in each case. 6

5. Explain the following in brief : 14

- a) Override control
- b) PID stack controller
- c) Imaging technique of measurement
- d) Feed forward control and its difference from cascade control
- e) PID interacting controller using Op-Amps.



GROUP – C

Answer any *two* of the following. $2 \times 14 = 28$

6. a) What do you mean by cold junction compensation for a thermocouple ? Describe the automated cold junction compensation technique. 5
- b) Explain, with a schematic diagram, the principle of operation of a constant temperature type hot wire anemometer. What are the advantages of this anemometer ? 5
- c) Explain the operating principle of capacitive pressure transducer. 4
7. a) Explain how a Coriolis mass flowmeter can measure the fluid flow rate. Write on the advantages and disadvantages of Coriolis mass flowmeter. 6
- b) An instrument converts linearly $0-300 \text{ m}^3/\text{s}$ flow rate to a $4-20 \text{ mA}$ current signal. Calculate the current for $225 \text{ m}^3/\text{s}$ flow rate. 3
- c) Explain, with a schematic diagram, the working principle of a capacitive level gauge. 5
8. a) Draw the block diagram of a distributed control system. Explain the overall operation of control system. 6
- b) Why is the tuning of controller required ? Explain the Ziegler-Nicols open loop tuning method. 5
- c) In an application of the Ziegler-Nicols closed loop tuning method, a process begins oscillation when ultimate controller gain is 15.5 and ultimate time period is 11.5 minutes. Find the nominal three mode controller settings. 3
9. a) Define valve coefficient, rangeability and turn-down ratio. 3
- b) Draw the control valve characteristics. 2
- c) An equal percentage valve has a maximum flow rate of $75 \text{ m}^3/\text{s}$ and a minimum flow rate of $2 \text{ m}^3/\text{s}$. If the full travel of stem is 2 cm , find the flow rate at 1 cm opening. 4
- d) Write a short note on pneumatic actuator. 5