**Program Name** : **Diploma in Instrumentation / Instrumentation and Control**

**Program Code** : **IS / IC**

**Semester** : **Sixth**

**Course Title** : **Process Control**

**Course Code** : **22644**

## 1. RATIONALE

In process industry Instrumentation technologists are expected to handle process control systems in different unit operations such as heat exchanger, evaporators, distillation column, boilers and others. The instrumentation technologists should be able to select proper control schemes such as feed forward, ratio, cascade etc for various processes to be controlled. This course is therefore designed such a way that s/he would be able to maintain different types of process control systems and the associated skills required to do the related jobs.

## 2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain different types of process control systems.**

## 3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Interpret different process control elements.
b) Maintain the different types of control valves for different processes.
c) Choose relevant control strategy for various processes.
d) Maintain instrumentation in various unit operations.
e) Maintain the DCS system for different process applications.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme | | | Credit (L+T+P) | Examination Scheme | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | | | | | | | Practical | | | | | | |
| L | T | P | | Paper Hrs. | ESE | | PA | | Total | | ESE | | PA | | Total | | |
| | | | | | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | |
| 3 | - | 2 | 5 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25# | 10 | 25 | 10 | 50 | 20 | |

*(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.*

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

## 5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

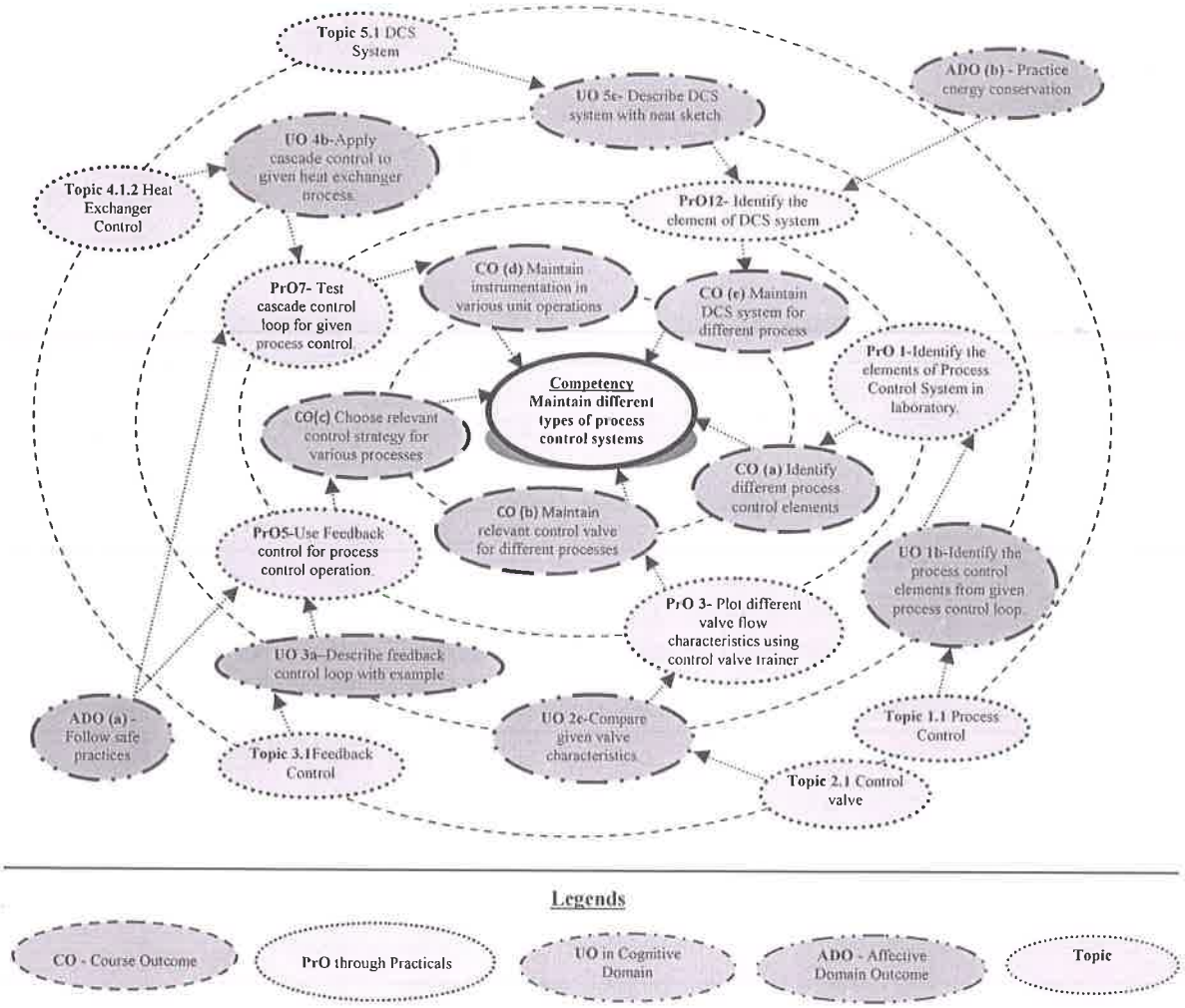


**Figure 1 - Course Map**

## 6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Identify the elements of Process Control System in laboratory. | I | 02* |
| 2 | Use the process control loop to interpret the specified parameters of given application. | I | 02 |
| 3 | Use control valve cut section to distinguish various parts of the given control valve. | II | 02* |
| 4 | Use control valve trainer setup to plot flow characteristics of different types of valves. | II | 02* |
| 5 | Use valve sizing set up to calculate $C_v$ for the given valve. | II | 02* |
| 6 | Test the operation of control valve positioner | II | 02* |
| 7 | Test Feedback control loop for given process control equipment. | III | 02 |
| 8 | Test cascade control loop for given process control. | III | 02* |
| 9 | Test ratio control loop for given process control. | III | 02* |
| 10 | Apply feedback control loop to heat exchanger or evaporation process. | IV | 02* |
| 11 | Apply cascade control loop to heat exchanger or evaporation | IV | 02 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| | process. | | |
| 12 | Draw P and ID control scheme evaporation process. | I and IV | 02* |
| 13 | Draw P and ID control scheme boiler process. | I and IV | 02* |
| 14 | Draw P and ID control scheme distillation process. | I and IV | 02* |
| 15 | Identify the element of DCS system in the video programme | V | 02 |
| 16 | Interpret the performance of process control using DCS trainer or simulator | V | 02* |
| | **Total** | | **32** |

***Note***

i. *A suggestive list of* **PrOs** *is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

| S. No. | Performance Indicators | Weightage in % |
|---|---|---|
| 1 | Preparation of experimental setup. | 20 |
| 2 | Setting and operation. | 20 |
| 3 | Safety measures. | 10 |
| 4 | Observation and recording. | 10 |
| 5 | Interpretation of result and conclusion. | 20 |
| 6 | Answer to sample questions. | 10 |
| 7 | Submission of report in time. | 10 |
| **Total** | | **100** |

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

| S. No. | Equipment Name with Broad Specifications | PrO. S. No. |
|---|---|---|
| 1 | Process control loop setup | 1,2 |
| 2 | Cut - Sections of different Control valves | 3 |
| 3 | Control Valve characteristics trainer set-up | 4 |
| 4 | CV Calculation Trainer Set-up. | 5 |
| 5 | Control Valve positioner | 6 |
| 6 | Feedback Control Trainer set up | 7 |
| 7 | Cascade or ratio Control trainer Set-up | 8,9 |
| 8 | Heat exchanger/Distillation/ Any other unit operations set up or simulator | 10 to11 |
| 9 | DCS trainer setup | 15,16 |
| 10 | DCS simulator software | 16 |

## 8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit – I Process Control System** | 1a. Describe with sketch the given type of process control.<br>1b. Explain the functioning of the identified process control elements in the specified process control loop.<br>1c. Draw the P and ID symbol for given process instrument.<br>1d. Describe the preventive maintenance steps of the given type process control system | 1.1 **Process Control:** Principle, Human aided control, Automatic control, Block diagram of process control system, Identification of elements, Benefits, Examples such temperature, level, flow, pressure.<br>1.2 **P and ID symbols:** most commonly used symbols in process loop. |
| **Unit– II Process Control Valves** | 2a. Describe constructional features of given control valve.<br>2b. Select relevant control valve for given process conditions.<br>2c. Compare given valve characteristics.<br>2d. Explain the working principle of given type of control valve.<br>2e. Explain the role of given valve accessories in | 2.1 **Control valve:** Construction, Operating Principle, Direct and Reverse acting control valve, Flow characteristics, control valve selection and sizing, noise-Cavitation and flashing, remedies, Proper installation guideline.<br>2.2 **Different types control valves :** Construction and working of Ball valve, Globe valve(single seated and double seated), Butterfly Valve, Solenoid Valve<br>2.3 **Control Valve Accessories:** Actuators-Electric and pneumatic type, Air Filter regulator. |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | control valve functioning.<br>2f. Describe working of given valve positioner. | 2.4 **Valve Positioner:** Need, Types, their Construction and working. |
| **Unit– III Process Control Strategies** | 3a. Describe feedback control loop with example.<br>3b. Compare the given control strategies.<br>3c. Apply cascade control to given process.<br>3d. Differentiate various ratio control approaches.<br>3e. Explain concept of Selective control.<br>3f. Select override strategy for given process loop.<br>3g. Describe adaptive control strategy with relevant example. | 3.1 **Feedback Control-** Block/schematic diagrams, Concept and Examples.<br>3.2 **Feed Forward Control-**Block/schematic diagrams, Concept and Examples, Comparison with feedback control.<br>3.3 **Cascade Control-** Block/schematic diagrams, Concept and Examples.<br>3.4 **Ratio Control-** Scaling, Direct and indirect approach of ratio control.<br>3.5 **Selective control-**Concept and Examples.<br>3.6 **Override Control-** Concept and Examples.<br>3.7 **Adaptive control-** Concept and Example.<br>3.8 **Split range control-** Concept and Example. |
| **Unit-IV Unit Operations** | 4a. Explain with sketches the working of the given heat exchanger process.<br>4b. Apply cascade control to the given heat exchanger process.<br>4c. Compare given evaporator based on the given criteria.<br>4d. Choose relevant control strategy for the given evaporation process.<br>4e. Select relevant control strategy for given boiler process loop.<br>4f. Select the relevant interlocks for the given process dryer.<br>4g. Choose the relevant control strategy for the given process dryer.<br>4h. Explain with sketches the working of the distillation process. | 4.1 **Heat Exchanger Process-** Principle, Operation, Type of Heat Exchanger-Shell and tube and Plate type<br>4.2 **Heat Exchanger Control -**Feedback Control, Cascade Control, Feedforward Control, Override Control<br>4.3 **Evaporation Process-** Principle, Single effect and multi effect evaporator<br>4.4 **Evaporator Control-** Feedback Control ,Cascade Control, Feedforward Control<br>4.5 **Boiler Process -**Principle, Operation ,Safety interlocks<br>4.6 **Boiler Control-** Feedback, Cascade Control, Feed Forward Control, Ratio Control, Feed Water and Drum Level Control –Three element boiler steam drum level control<br>4.7 **Drying Process-** Principle, Operation, Adiabatic Drying, Continuous Fluid-Bed Dryers, Direct-Fired/ Spray Dryers, Double drum dryer<br>4.8 **Drying Control-**Feedback Control, Cascade Control, Ratio Control<br>4.9 **Distillation Process -**Principle, Operation, Distillation Column equipment<br>4.10 **Distillation Control-**Feedback Control, Cascade Control, Feed forward Control |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit –V Distributed Control System and Project Engineering** | 5a. Choose the DCS system for the given process with justification.<br>5b. Draw the display for the given group of variables.<br>5c. Differentiate the given communication method.<br>5d. Draw P and I diagram for the given process<br>5e. Prepare Instrument Index sheet for the given situation. | 5.1 **DCS System:** Evolution, Architecture, Hierarchy, Selection Criteria, Merits of DCS over other controller.<br>5.2 **Process Displays:** Graphic, Group, Object, Trend, Alarm, and Event.<br>5.3 **Communication Method:** Features of Modbus, Profibus, Ethernet, Devicenet, Controlnet.<br>5.4 **Application:** Thermal power plant<br>5.5 **Project Engineering:** Process flow sheet, Instrument index sheet, control loop wiring diagram, Specification/Data sheet |

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

## 9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| I | Process Control System | 04 | 00 | 02 | 04 | 06 |
| II | Process Control Valve | 10 | 04 | 06 | 06 | 16 |
| III | Process Control Strategies | 12 | 04 | 06 | 08 | 18 |
| IV | Unit operations | 14 | 04 | 06 | 08 | 18 |
| V | DCS and Project Engineering | 08 | 04 | 04 | 04 | 12 |
| **Total** | | **48** | **16** | **24** | **30** | **70** |

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare instrument index sheet for boiler application.
b) Prepare specification data sheets of distillation column instrument.
c) Draw control loop wiring diagram of any given process control loop.
d) Prepare technical specification of given valves.
e) Prepare charts for cut section given valve.
f) Prepare installation sketch of given valve.
g) Prepare technical specifications of various manufactures of DCS system.
h) Market survey for procurement of DCS System.
i) Calculate Input and Output from the given P and ID.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Video programs/YouTube may be used to teach various topics and sub topics.
f) Demonstrate students thoroughly before they start doing the practice.
g) Encourage students to refer different book and websites to have deeper understanding of the subject.
h) Observe continuously and monitor the performance of students in Lab.
i) Encourage students to use front/rear panel control of electronic instruments.
j) Encourage students to visit nearby electronic instruments repair workshop units or manufacturing industries.
k) Instruct students to safety concern of handling electronic instruments and also to avoid any damage to the electronic instruments.

## 12. SUGGESTED MICRO-PROJECTS

***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a) Compare technical specification of various valves.
b) Setup cascade loop for any given application.
c) Set up and Test ratio loop.
d) Develop process control loop for temperature control.
e) Develop process control loop for level control.
f) Use control valve for flow control in pipeline.
g) Use control valve for level control application.
h) Use feedback control for temperature control application.
i) Use cascade control for level control application.
j) Develop P and I diagram for boiler process.
k) Develop P and I diagram for distillation column.
l) Calculate number of I/Os from given P and I Diagram.
m) Develop instrument index sheet for given process application.

n) Develop instrument data sheet for different instruments used in given process application.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Process Control Instrumentation Technology | Johnson, Curties D. | PHI Learning, New Delhi, 2017 ISBN 978-0131194571 |
| 2 | Industrial Instrumentation and Control | Singh, S. K. | McGraw Hill Publication, New Delhi, 2016 ISBN: 978-0070678200 |
| 3 | Instrumentation Engineers Handbook Process Control | Liptak, Bela G | Chilton Book Company, New York 2016, ISBN: 978-0801982422 |
| 4 | Applied Instrumentation in the Process Industries | Andrew, W. G; Williams, H. B. | Gulf Publication Company, ISBN-13: 978-0872013827 |
| 5 | Process Automation Handbook | Love, Jonathan | Springer, verlag Londan Ltd, 2007 ISBN-13: 978-1846282812 |
| 6 | Computer- based Industrial Control | Kant, Krishna | PHI Learning Private Ltd, New Delhi, 2010, ISBN: 978-81-203-3988-0 |
| 7 | ISA Handbook of Control Valves | Hutchinson, James W. | Instrument Society of America (1976) ISBN 13: 9780876642344 |
| 8 | Chemical Process Control | Stephanopoulos, George | Pearson India ISBN: 9789332549463 |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) https://www.youtube.com/watch?v=XAItnsUcES0
b) https://youtu.be/ntvxIQPOav8
c) https://youtu.be/_w5SJ1NdKUQ
d) https://www.controleng.com/single-article/fundamentals-of-cascade-control/f25b1cb6548975a2adab1645f11d20d8.html
e) https://www.slideshare.net/haki517/industrial-process-control
f) https://www.youtube.com/watch?v=02p5AKP6W0Q.
g) https://www.youtube.com/watch?v=M7AL7-44YTc
h) https://www.slideshare.net/khalidnawaz754/distillation-column-61131518
i) https://youtu.be/mnbQ5dGjmbY
j) https://youtu.be/RyIBzJs-F-Q
k) https://www.youtube.com/watch?v=pq1C4IiU_aY
l) https://www.slideshare.net/SHIVAJICHOUDHURY/instrumentation-control-for-thermal-power-plant
m) https://youtu.be/I70jgRpf80o