Brazosport College

Syllabus for PTAC 1432 – Process Instrumentation I

Instructor: **Office:**
Office Phone: **Email:**
Alt Phone:

I. COURSE DESCRIPTION:

PTAC 1432 - Process Instrumentation I CIP 4103010003
Study of the instruments and instrument systems used in the chemical processing industry including terminology, primary variables, symbology, control loops, and basic troubleshooting.
Credit Hours: 4 (3 lecture, 2 lab)

January 2022

A. **Required skill level**: College-level reading and writing. Math: College-level with corequisite (placement code 3).

II. COURSE OBJECTIVES

TOPIC	OBJECTIVES
Introduction to Instrumentation	1. Discuss the evolution and importance of process instrumentation to the process industries. 2. Explain the importance of monitoring process variables. 3. Discuss the operator's leadership role, in relation to safety, when monitoring process variables. 4. Explain the importance of process instrumentation to a process technician: • Eyes and ears of the process technician • Tool for monitoring and troubleshooting process control • Effective communications with instrument technician for troubleshooting and repairs 5. Define terms associated with instrumentation: • local • remote • indicating • recording • pneumatic • electronic • process variables • controlling • analog • digital o DCS (Distributive Control Systems) o PLC (Programmable Logic Control) • control loop • differential (delta Δ) • split range 6. Describe the major process variables controlled in the process industries and define their units of measurement: • Flow (gallons per minute, pounds per minute, pounds per hour, barrels per hour, etc.) • Pressure (psig, psia) • Temperature (Fahrenheit, Celsius) • Level (percent, inches of water column, interface) • Analytical (ppm, percentage, ratio, pH, etc.) • Other (vibration, variable speed control, proximity switches, amp-meter, etc.) 7. Explain the relationship between common process variables:

Introduction to Instrumentation (cont.)	• What happens to the pressure in a closed container when temperature increases/decreases? • What happens to the temperature in a closed container when pressure increases/decreases? • What happens to vessel bottom pressure when height of liquid increases/decreases? • What happens to boiling point of a material when pressure increases/decreases? • What happens to the volume of a material when temperature increases/decreases? • What happens to the density of a material when temperature increases/decreases? • What happens to the differential pressure when the flow increases/decreases?
Process Variables, Elements, and Instruments - Pressure	1. Define units of measurement associated with pressure and pressure instruments: • PSIG (pounds per square inch gauge) • PSIA (pounds per square inch atmospheric) • bars • Inches H2O • Inches Hg (mercury) • mm Hg Abs • Inches Hg Vac • atmospheres 2. Discuss the formula used to calculate pressure and identify the three components that affect the force exerted by molecules: • Speed (temperature) • number of molecules • mass (liquid) 3. Identify common types of pressure-sensing/measuring instruments used in the process industries: • gauges • differential pressure cells • manometers • strain gauge 4. Describe the purpose and operation of pressure-sensing/measuring instruments used in industrial settings. 5. Given a standard calculator and conversion formulas convert between the following pressure scales: • pounds per square inch gauge (psig) and pounds per square inch absolute (psia) • inches of mercury (in. Hg) and inches of water (in. H2O) • psi (pounds per square inch) and inches of water column

Process Variables, Elements, and Instruments – Temperature	1. Define units of measure associated with temperature and temperature instruments: • differential (delta) • temperature scales o Fahrenheit o Celsius/Centigrade 2. Describe the effect heat energy has on the movement of molecules. 3. Identify common types of temperature-sensing/measurement devices used in the process industries: • resistance temperature detector (RTD) • thermometer • thermocouple • temperature gauge • bimetallic strip 4. Describe the purpose and operation of various temperature sensing/measurement devices used in the process industries. 5. Given a standard calculator and conversion formulas, complete Fahrenheit and Celsius conversion
Process Variables, Elements, and Instruments – Level	1. Define terms associated with level and level instruments: • ullage (outage) • innage • interface level • direct/indirect measurement • meniscus 2. Identify common types, purposes, and operation of level-sensing/measuring devices used in the process industries: • gauge/sight-glass (reflex or clear glass) • differential pressure cells • floats • displacer • bubblers • nuclear devices • ultrasonic devices • tape/ball • radar 3. Discuss hydrostatic head pressure in relation to level measurement. 4. Describe the level control as it relates to the temperature, density, and volume of liquid.
Process Variables, Elements, and Instruments –	1. Define terms associated with flow and flow measuring instruments: • fluids (gases and liquids) • metered displacement • laminar

Flow **Process Variables, Elements, and Instruments – Flow** **(cont.)**	• turbulent • differential pressure • weight measurement 2. Identify the most common types of flow-sensing and measuring devices used in the process industries and their purposes and operation: • orifice plate • venturi tube • flow nozzle • pitot tube • multiport pitot tube (Annubar) • rotameters • magmeter • turbine meters • mass flow meter (Coriolis) • vortex meter • ultrasonic meter • others 3. Describe the purpose and operation of flow-sensing/measurement devices used in process industries. 4. Explain the difference between total volume flow and flow rate. 5. Explain the difference between mass flow and volume flow.
Process Variables, Elements, and Instruments – Analytical	1. Define terms associated with analytical instruments: • pH (acid/base) and ORP (oxidation reduction potential) • conductivity • Optical Measurements • Chromatography • Combustion • TOC (total organic carbon) 2. Identify the most common types of analytical devices used in the process industries: • gas/liquid chromatograph • ORP (oxidation reduction potential)/ pH meter • conductivity meter • Color analyzers • optical analyzers • turbidity analyzer/meter • opacity analyzer/meter • TOC (total organic carbon) analyzer • spectrophotometers a. UV (ultraviolet)/VIS (visible) b. IR (Infrared) • O_2 analyzer

Process Variables, Elements, and Instruments – Analytical (cont.)	• LEL (lower explosive limits) 3. Explain the purpose of analytical devices used in process industries. 4. Explain how analytical data affects the role of the process technician. 5. Review the difference between online versus laboratory analysis.
Miscellaneous Measuring Devices	1. Define terms associated with miscellaneous measuring devices: • load cells • density • vibration • rotational speed • amperage • decibels 2. Identify common types of miscellaneous measuring devices: • Vibration meter • load cells • proximity sensors (pickups for speed) • Amp meters. • decibel meters, etc.
Introduction to Control Loops (Simple Loop Theory)	1. Explain the function of a control loop. 2. Describe process control loop elements: • Process Variables (PV) • measuring means (primary element/transmitter) • controller (set point) • final control element (valve or louvers) 3. Explain signal transmission: • Pneumatic • Electronic • Analog • Discrete • Digital • mechanical 4. Classify the functions of a control scheme: • Sensing • Measuring • comparing • transducing-(converting) • controlling 5. Review the differences between “open” and “closed” control loops. 6. Explain the purpose of instrument air systems. 7. Describe the various types of instrument air systems: • Instrument air • Nitrogen

	• Process gases
Control Loops: Controllers	1. Explain the terms associated with controllers: • direct acting • reverse acting • set point • auto/manual switch • local/remote switch • tuning o proportional band/gain o integral/reset o derivative/rate 2. Given a drawing or actual device, identify and explain the operation of the following: • local controller • remote controller • split-range controller • ratio controller • Cascade/Remote Set Point (RSP) controller 3. Identify an application which would require the following devices: • local controller • remote controller • split range controller • ratio controller • Cascade controller 4. Explain "bumpless" transfer of auto to manual-control. 5. Explain the "bumpless" transfer of manual to auto control. 6. Explain the process for switching from auto control to manual control on a local controller. 7. Explain the process for switching from manual control to automatic control on a local controller. 8. Demonstrate various control skills, such as: • make set point adjustments on a local controller • operate a local controller in manual mode • make set point adjustments on a remote controller • switch from manual to automatic control on a remote controller without bumping the process
Control Loops: Primary Sensors, Transmitters, and Transducers	1. Explain the function of measuring instruments (pressure, temperature, level, and flow) and review their role in the overall control loop process. 2. Explain the purpose and operation of the transmitter (D/P Cell) in a control loop. 3. Compare and contrast the transmitter input and output signals

Control Loops: Primary Sensors, Transmitters, and Transducers (cont.)	(communication). 4. Discuss differential pressure cell (D/P) in relation to the transmitter signal. 5. Explain the function of a transducer (signal converter): • I (current) to P (pneumatic) • P (pneumatic) to I (current) 6. Compare and contrast the relationship between air (3 psig to 15 psig) and electric signals (4 ma to 20 ma). 7. Given an example of a process control scheme, demonstrate how a control loop functions.
Switches, Relays, Alarms	1. Explain the purpose and function of a switch. 2. Explain the purpose and function of a relay. 3. Explain the purpose and function of an alarm. 4. Review placement and use of a switch within a control loop (open and closed). 5. Review the placement and use of a relay within a control loop (open and closed) and in a process unit. 6. Review the placement and use of an alarm within a control loop (open and closed) and in a process unit. 7. Identify switches, relays, and alarms on a Piping & Instrumentation Diagram.
Instrument Air Systems	1. Discuss potential causes of instrument air failure: • Compressor shuts down • Wet/dew point (dryers) • Plugging (scale, rust) • Backup air failure • Regulator failure • Incorrect manifold alignment 2. Discuss corrective actions for each of the following scenarios: • Compressor shut down • Wet (dew point) • Plugging • Backup air failure • Regulator failure • Incorrect manifold alignment
Control Valves and Final Control Elements	1. Explain the purpose and operation of the following: • control valves o three-way valve o gate valve o globe valve (needle valve) o butterfly valve 2. Explain the purpose and operation of the following: • valve positioner

Control Valves and Final Control Elements (cont.)	• manual operation (hand-jack) • transducer (converter) 3. Define terms associated with valves and other final control elements: • "air to close" (fail open) • "air to open" (fail closed) • fail last/in-place/as is • double-acting diaphragm valve actuator • double-acting piston valve actuator • solenoid • variable speed motor 4. Given a drawing or actual device, identify the main components of a control valve: • Body • Bonnet • Disc • Actuator • Stem • Seat • Spring • Valve positioner • Hand-jack 5. Illustrate three types of final control elements and provide an application for each type: • control valve – manipulates a process flow (liquid/gas) in response to a control signal • damper/louver – manipulates an air flow to control draft setting or temperature setting • motor – start, stop or variable speed in response to a control signal 6. Explain the role of the final control element as it relates to the process and the control loop. 7. Given a drawing or actual instrument, identify and describe the operation of the following: • instrument air regulator • louver, damper, final control element • variable speed motor used as a final control element 8. Review reasons why the action of a valve actuator may not correspond with the action of the valve: • Calibration • Valve stroke • Direct versus indirect action • Incorrect air supply pressure / contamination • Sticking valve • Transducer operation 9. Review actions for troubleshooting the items in number 7. 10. Compare and contrast a spring and diaphragm actuator to a cylinder

Control Valves and Final Control Elements (cont.)	actuator. 11. Explain the purpose of a valve positioner and describe its operation. 12. Review the function of each of the three gauges located on a pneumatic valve positioner: • Air supply • Signal • Output signal to actuator 13. Given a signal pressure from an I/P determine what the valve position should be for the following: • Fail open • Fail closed
Interlocks and Safety Features	1. Explain the purpose of interlocks: • Safety • Process 2. Review the purpose of safety features: • Interlocks and valve actions • ESD (Emergency Shutdown Devices) • Limit switches (proximity, permissive) • Redundant instrumentation • Fail safe position • Overspeed 3. Discuss potential consequences for bypassing or ignoring any of the safety features listed above.
Symbology; Process Diagrams – Part 1	1. Review the types of drawings that contain instrumentation that an operator might use. 2. Explain the lettering and numbering standards based on ISA (Instrumentation Society of Automation) instrumentation symbols. (Legend) 3. Demonstrate how to determine the instrument type from the symbol information. 4. Draw the standards for instrument line symbols: • Electrical • Pneumatic • Digital 5. Using a legend, correctly identify instrumentation on a drawing.
Process Diagrams – Part 2	1. Compare and contrast P&IDs and PFDs. 2. Given a PFD, trace process flows on the drawing and/or in the field locating major equipment. 3. Given a P&ID with a legend, locate and identify the components:
Instrumentation Sketching	1. Given a P&ID, with a control loop, explain the relationship of one piece of instrumentation to another. 2. Given a process flow diagram of a major system, illustrate/draw

Instrumentation Sketching (cont.)	control loops for the following variables: • Flow • Level • Temperature • Pressure 3. Using training resources (process simulator, training unit, etc.) sketch instrumentation control loops.
Monitoring Process Variables	1. Given a P&ID identify key process variables that should be monitored.
Instrumentation Troubleshooting	1. Review the extent of an operator's role when troubleshooting problems with process instruments (i.e., identify and not repair, which may vary between sites). 2. Discuss hazards and consequences of deviation for operating outside normal control range of process variables. 3. Identify typical malfunctions found in primary sensing elements and transmitters. 4. Explain the importance of process knowledge in troubleshooting. 5. Illustrate the proper use of equipment related to process troubleshooting. 6. Discuss safety and environmental issues related to troubleshooting process instruments. 7. Describe the symptoms of incorrect instrument calibration: • Variation between local sight glass and level transmitter • Variation between local pressure gauge and pressure transmitter • Inconsistency among instruments • How do process changes affect accurate measurement? o Flow rate o Density/specific gravity (composition) o Temperature o Pressure 8. Given a scenario, demonstrate proactive action for correcting an abnormal process variable. 9. Given a simulator or actual device, determine whether a control loop is in or out of control and identify the information used to make the decision.

III. STUDENT LEARNING OUTCOME

OUTCOME	METHOD OF ASSESSMENT
Describe the various process variables (flow, level, pressure, temperature, analytical, etc.) found in a plant and explain how instruments are used to sense, measure, and transmit this information to the control system.	Chapters: 1-6 Questions: 1-25

OUTCOME	METHOD OF ASSESSMENT
Using knowledge of symbols, process diagrams and instrumentation, sketch a simple process diagram, including control loops.	Chapter: 7 Questions: 26-32
Identify the types of control loops (simple and complex) and explain their operation.	Chapters: 10, 12, 14-16 Questions: 33-58
Identify the components of a closed control loop (primary element, transmitter, controller, transducer, final element) and explain their interrelationships.	Chapters: 10-13 Questions: 59-76
Identify typical instrument malfunctions found in control loops and explain how they may affect a process (cause and effect).	Chapters: 22-23 Questions: 77-88

IV. TEXTBOOK OR COURSE MATERIAL INFORMATION

A. Textbook

1. Process Instrumentation, 2nd Ed. 2020, NAPTA, Pearson Publisher. ISBN: 978-0135213926 (required)
2. Safety Glasses (required)

Required course materials are available at the Brazosport College bookstore, on campus or online at http://brazosport.edu/bookstore/home.html. A student of this institution is not under any obligation to purchase a textbook from the college bookstore. The same textbook is/may also be available from an independent retailer, including an online retailer."

For Distance Education Courses include the following: Contact the Brazosport College Bookstore with a credit card for course materials. Phone: 979-230-3651. Fax: 979-230-3653. Email:bookstore@brazosport.edu. Website: http://brazosport.edu/bookstore/home.html

B. Course Outline

This course consists of four units, covering 23 chapters.
Appropriate laboratories are included.

WEEK #	TOPIC
08/24/20	CHAPTER 1 Introduction and Process Variables
08/31/20	CHAPTER 2 Process Variables, Elements, and Instruments: PRESSURE CHAPTER 3 Process Variables, Elements, and Instruments: TEMPERATURE
09/07/20	CHAPTER 4 Process Variables, Elements, and Instruments: LEVEL CHAPTER 5 Process Variables, Elements, and Instruments: FLOW
09/14/20	Exam 1, Lab 1

09/21/20	CHAPTER 6 Process Variables, Elements, and Instruments: ANALYTICS CHAPTER 7 Process Diagrams and Instrumentation Symbology
09/28/20	CHAPTER 8 Switches, Relays, and Alarms CHAPTER 9 Signal Transmission and Conversion
10/05/20	Exam 2, Lab 2
10/12/20	CHAPTER 10 Introduction to Control Loops: Simple Loop Theory CHAPTER 11 Control Loops: Primary Sensors, Transmitters, and Transducers
10/19/20	CHAPTER 12 Control Loops: Controller and Final Control Element Overview CHAPTER 13 Control Loops: Control Valves and Regulators
10/26/20	CHAPTER 14 Controllers CHAPTER 15 Control Schemes
11/02/20	CHAPTER 16 Advanced Control Schemes CHAPTER 17 Introduction to Digital Control CHAPTER 18 Programmable Logic Controls
11/09/20	Exam 3, Lab 3
11/16/20	CHAPTER 19 Distributed Control Systems (DCSs) CHAPTER 20 Instrumentation Power Supply CHAPTER 21 Emergency Shutdown (ESD), Interlocks, and Protective Devices
11/23/20	Thanksgiving
11/30/20	CHAPTER 22 Instrumentation Malfunctions CHAPTER 23 Instrumentation Troubleshooting
12/07/20	Final Exam

Important Semester Dates:
Last Day to Withdraw from Classes– Check BC Academic Calendar at http://catalog.brazosport.edu/index.php

Office Hours:
For fulltime faculty, office hours may change from semester to semester. Current faculty office hours are included on the syllabus, see link: https://brazosport.edu/faculty-and-staff/resources/course-syllabi-instructor-information/

For an adjunct faculty, no office hours are required, and they are not assigned an office. To set up an appointment with an adjunct, contact the instructor as per the email address on the syllabus, see link: https://brazosport.edu/faculty-and-staff/resources/course-syllabi-instructor-information/

V. STUDENTS WITH DISABILITIES

Brazosport College is committed to providing equal education opportunities to every student. BC offers services for individuals with special needs and capabilities including counseling, tutoring, equipment, and software to assist students with special needs.

For student to receive any accommodation, documentation must be completed in the Office of Disability Services. Please contact Phil Robertson, Special Populations Counselor at 979-230-3236 for further information.

VI. TITLE IX STATEMENT

Brazosport College faculty and staff are committed to supporting students and upholding the College District's non-discrimination policy. Under Title IX and Brazosport College's policy FFDA (Local), discrimination based on sex, gender, sexual orientation, gender identity, and gender expression is prohibited. If you experience an incident of discrimination, we encourage you to report it. While you may talk to a faculty or staff member at BC, please understand that they are "Responsible Employees" and must report what you tell them to college officials. You can also contact the Title IX Coordinators directly by using the contact information below. Additional information is found on the Sexual Misconduct webpage at www.brazosport.edu/sexualmisconduct.

Alex Crouse, Director of Student Life and Title IX Coordinator
979-230-3355; alex.crouse@brazosport.edu

Mareille Rolon, HR Coordinator and Deputy Title IX Coordinator
979-230-3303; mareille.rolon@brazosport.edu

VII. ACADEMIC HONESTY

Brazosport College assumes that students eligible to perform on the college level are familiar with the ordinary rules governing proper conduct including academic honesty. The principle of academic honesty is that all work presented by you is yours alone. Academic dishonesty including, but not limited to, cheating, plagiarism, and collusion shall be treated appropriately.

Academic dishonesty violates both the policies of this course and the Student Code of Conduct. In this class, any occurrence of academic dishonesty will be referred to the Dean of Student Services for prompt adjudication, and may, at a minimum, result in F, in this course. Sanctions may be imposed beyond your grade in this course by the Dean of Student Services. Please refer to the Brazosport College Student Guide for more information. This is available online at http://brazosport.edu/students/for-students/student-services/.

VIII. ATTENDANCE AND WITHDRAWAL POLICIES

Class attendance contributes to your final grade, but you must attend class to successfully complete the course. If you are unable to complete this course, you must complete and submit a withdrawal form with the registrar's office. If the student decides to drop out of the class, it is the responsibility of the student to initiate a withdrawal before the withdrawal deadline in order to get a "W" on their transcript. If this is not done the student will receive a grade based on test grades and class grades earned during their attendance and absence (i.e. zeros on all missed materials, exams, skills tests, and final exam).

IX. COURSE REQUIREMENTS AND GRADING POLICY TESTING MAKE-UP POLICY

A. Grading:

Attendance	10%
Laboratory Activities	25%
Class Activities/HW/Quizzes	15%
3 Exams	30% (10% each)
Finals	20%

Grades are assigned as follows:

Grade	Final Average
A	90-100
B	80-89
C	70-79
D	60-69
F	Below 60

X. STUDENT CONDUCT STATEMENT

Students are expected to be aware of and follow the Brazosport College Student Code of Conduct. Students have violated the Code if they "fail to comply with any lawful directions, verbal or written, of any official at BC." Lawful directions include precautions and requirements taken to prevent the spread of COVID-19 at Brazosport College. Students who do not follow safety requirements, including the wearing of a mask, may be removed from class by their instructor and referred to the Dean of Student Services.

XI. CAMPUS CLOSURE STATEMENT

Brazosport College is committed to the health and safety of all students, staff, and faculty and adheres to all federal and state guidelines. The College intends to stay open for the duration of the semester and provide access to classes and support services on campus in the safest way possible. The College will also comply with lawful orders given by applicable authorities, including the Governor of Texas, up to and including campus closure. It is possible that on campus activities may be moved online and/or postpone if such orders are given.

XII. STUDENT RESPONSIBILITIES

Students are expected to fully participate in this course. The following criteria are intended to assist you in being successful in this course:

1. Understand the syllabus requirements
2. Use appropriate time management skills
3. Communicate with the instructor
4. Complete course work on time, and
5. Utilize online components (such as Desire2Learn) as required

a. Class attendance

Much of the learning occurs in the classroom setting and cannot be made up by reading the textbook. Therefore, class participation is essential to your learning, and attendance is taken.

b. Homework

As a standing homework assignment, students should review and read the scheduled sections of the textbook before coming to class and prepare questions for class discussion. Students should again review the scheduled section following the class (review forward, read, review back)

c. Class participation

Participation grade is based on the quality (not frequency) of your contributions to laboratory and class activities. Those receiving high grades in class participation will be those who:

1. Are prepared for class
2. Arrive for class on time
3. Have excellent attendance
4. Make comments and ask questions that significantly contribute to the learning environment of the class

d. Lab participation:

a. Students are expected to come to lab every night prepared for lab activities. This includes the following:
   1. Having their lab books or materials.
   2. Wearing the proper attire to perform the lab as outlined in the lab safety procedures.
   3. Having the proper attire for the lab as outlined in the lab safety procedures.
   4. Arriving to lab on time. Lab attendance will be counted separately from lecture attendance.

b. Failure to meet any or all of the above participation requirements will result in a loss of points for that lab.

e. **Exams:** Exams will be taken electronically, during scheduled class time. It is the student's responsibility to ensure that they have access to D2L prior to taking the exam.

a. Make-up exams will be given at the discretion of the instructor. If the make-up exam is permitted, it must be completed within 7 days of the missed exam. There will be NO extension to this timeframe.

b. Make-up exams will be penalized 10 points, making the exam only worth 90% of the initial possible score.

XIII. OTHER STUDENT SERVICES INFORMATION

Information about the Library is available at http://brazosport.edu/students/for-students/places-services/library/about-the-library/ or by calling 979-230-3310.

For assistance with online courses, an open computer lab, online and make-up testing, audio/visual services, and study skills, visit Learning Services next to the Library, call 979-230-3253, or visit http://brazosport.edu/students/for-students/places-services/learning-services/.

For drop-in math tutoring, the writing center, supplemental instruction and other tutoring including e-tutoring, visit the Student Success Center, call 979-230-3527, or visit /http://brazosport.edu/students/for-students/student-success-center/math-center/.

To contact the Physical Sciences and Process Technology Department call 979-230-3618.

The Student Services provides assistance in the following:

Counseling and Advising	979-230-3040
Financial Aid	979-230-3294
Student Life	979-230-3355

To reach the Information Technology Department for computer, email, or other technical assistance call the Helpdesk at 979-230-3266.

Get the information you need – when you need it. Click http://geni.us/BRAZO to install **BC Connect** on your mobile device to receive reminders, explore careers, map your educational plan, be in the know about events, find out about scholarships, achieve your goals and much more.