Brazosport College

Syllabus for INTC 1401 – Principles of Industrial Measurements (Hybrid)

Instructor: Jack Richmond
Office Phone: 979-230-3589
Alt. Phone: 979-230-3618
Office: L.204C
Email: jack.richmond@brazosport.edu

I. COURSE DESCRIPTION:

INTC 1401 - Principles of Industrial Measurements. CIP 1504040011
Principles and devices for the measurement of process variables such as temperature, pressure, flow, level, and basic control functions. **Credit Hours:** 4 (3 lecture, 2 lab)

Brandon Hartman

Stephen Reckner

Jack Richmond

Gary Hicks

Jeff Detrick

August 2020

A. Prerequisite: N/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 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 3. 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 4. 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.) 5. Explain the relationship between common process variables: • What happens to the pressure in a closed container when temperature increases/decreases?

TOPIC	OBJECTIVES
Introduction to Instrumentation (cont.)	• 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 Pressure 2. Define units of measurement associated with pressure and pressure instruments and how to convert from one to another: • PSIG (pounds per square inch gauge) • PSIA (pounds per square inch atmospheric) • PSIV (pounds per square inch vacuum) • Inches of Water Column 3. Identify common types of pressure-sensing/measuring instruments used in the process industries: • gauges-(types) • differential pressure cells • manometers-(types) 4. Describe the purpose and operation of pressure-sensing/measuring instruments used in industrial settings.
Process Variables, **Elements and Instruments – Temperature**	1. Define units of measure associated with temperature and temperature instruments and be able to convert from one to another. • differential (delta) • temperature scales o Fahrenheit o Celsius/Centigrade 2. Describe the difference between temperature and heat and 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) • thermocouple • temperature gauge • bimetallic strip

TOPIC	OBJECTIVES
Process Variables, **Elements and Instruments – Temperature (cont.)**	4. Describe the purpose and operation of various temperature sensing/measurement devices used in the process industries.
Process Variables, Elements and Instruments – Level	1. Define terms associated with level and level instruments: • interface level • direct/indirect measurement 2. Name the most common types 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 • radar 3. Describe the purpose and operation of various types of level sensing/measuring devices. 4. Discuss hydrostatic head pressure in relation to level measurement. 5. Describe the relationship between temperature and level measurement as it relates to the density of liquid. 6. Describe the relationship between temperature and level measurement as it relates to the volume of a liquid.
Process Variables, Elements and Instruments – Flow	1. Define terms associated with flow and flow measuring instruments: • fluids (gases and liquids) • metered displacement • laminar • turbulent • differential pressure 2. Name the most common types of flow-sensing/measuring devices used in the process industries: • orifice plate • venturi tube • flow nozzle • pitot tube • annubar • rotometers • magmeter • turbine meters • mass flow meter (Coriolis) • vortex meter

TOPIC	OBJECTIVES
Process Variables, Elements and Instruments – Flow (cont.)	• ultra-sonic • others 3. Describe the purpose and operation of flow-sensing/measurement devices used in process industries. 4. Explain the difference between mass flow and volume flow rates.
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 2. Identify the most common types of analytical devices used in the process industries: • gas/liquid chromatograph • conductivity meter • spectrophotometers a. UV (ultraviolet)/VIS (visible) b. IR (Infrared) • O_2 analyzer • LEL (lower explosive limits) 3. Describe the purpose of analytical devices used in process industries. 4. Explain the difference between on-line versus laboratory analysis.
Miscellaneous Measuring Devices	1. Define terms associated with miscellaneous measuring devices: • load cells • density • vibration • rotational speed • amperage 2. Identify common types of miscellaneous measuring devices: • Vibration meter • load cells • proximity sensors (pickups for speed) • Amp meters.
Introduction to Control Loops (Simple Loop Theory)	1. Describe process control: • Process Variables (PV) • measuring means (primary element/transmitter) • controller (set point) • final control element (valve or louvers) 2. Explain the function of a control loop. 3. Identify the functions of a control scheme: • Sensing • Measuring • comparing

TOPIC	OBJECTIVES
Introduction to Control Loops (Simple Loop Theory) (cont.)	• transducing (converting) • controlling 4. Describe the differences between "open" and "closed" control loops. 5. Explain signal transmission: • Pneumatic (3-15 PSIG) • Electronic (4-20mA) • Analog • Digital
Control Loops: Controllers	1. Define 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
Control Loops: Primary Sensors, Transmitters, and Transducers	1. Describe the function of measuring instruments (pressure, temperature, level, and flow) and explain their role in the overall control loop process. 2. Describe the purpose and operation of the transmitter (D/P Cell) in a control loop. 3. Compare and contrast the transmitter input and output signals (communication). 4. Discuss differential pressure cell (D/P) in relation to the transmitter signal. 5. Describe the function of a transducer (signal converter). • I (current) to P (pneumatic) 6. Describe the relationship between air (3 psig to 15 psig) and electric signals (4 ma to 20 ma). 7. Given a process control scheme, explain how a control loop functions.
Control Valves and Final Control Elements	1. Explain the purpose and operation of the following: • control valves o Rising stem o Rotary 2. Explain the purpose and operation of the following: • valve positioner • manual operation (hand-jack)

Control Valves and Final Control Elements (cont.)	• 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 • single-acting diaphragm valve actuator • double-acting piston valve actuator • solenoid 4. Explain the function of each of the three gauges located on a pneumatic valve positioner. • Air supply • Signal • Output signal to actuator 5. Given a signal pressure from an I/P determine what the valve position should be (in percent), for 3, 6, 9, 12 &15 PSI.
Interlocks and Safety Features	1. Describe the purpose of interlocks. • Safety • Process 2. Describe the purpose of safety features. • Interlocks and valve actions • SIS (Safety Instrumented Systems) • Limit switches (proximity, permissive) • Redundant instrumentation • Fail safe position • Over speed 3. Discuss potential consequences for bypassing or ignoring any of the safety features listed above.
Symbology; Process Diagrams	1. Describe the types of drawings that contain instrumentation (P&ID's, Loop Sheets, etc.) 2. Describe the lettering and numbering standards based on ISA (International Society of Automation) instrumentation symbols. 3. Describe how to determine the instrument type from the symbol information based on ISA (International Society of Automation) instrumentation symbols 4. Describe the standards for instrument line symbols based on ISA (International Society of Automation) instrumentation symbols 5. Using a legend, correctly identify instrumentation on a drawing.

III. STUDENT LEARNING OUTCOMES

OUTCOME	METHOD OF ASSESSMENT
Student will learn basic DC electrical formulas and demonstrate how to calculate different electrical parameters.	Lab exercise, Interim tests and final exam questions.
Student becomes familiar with terms that identify electrical properties	Interim tests and final exam questions.
Student learns to identify the standard instrument signals found in Industrial control systems	Lab exercise during semester and final exam questions.
Students explain how the basic components of a control loop function together.	Interim tests and final exam questions.
Student demonstrates understanding of the several pressure measuring scales by drawing a comparative chart.	Interim tests and final exam questions.
Student demonstrates understanding of temperature measurement by the use of Thermocouples and RTD's	Lab exercise during the semester.
Student demonstrates understanding of pH measurement by explaining the principle and scale of measurement	Interim tests and final exam questions.
Student demonstrates knowledge and understanding of the various parts of a control valve and explains the term "valve trim"	Interim tests and final exam questions.
Student will explain the use of a carrier gas in chromatography	Interim tests and final exam questions.

IV. TEXTBOOK OR COURSE MATERIAL INFORMATION

A. Textbook

1. Process Instrumentation, 2nd Ed., NAPTA, Feb. 2020, Pearson Publisher. ISBN:978-0135213926
2. Calculator TI-30XIIS
3. Visorgogs Safety Glasses

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 is a sample outline which may vary with individual instructors. It will also vary based on whether the course is a summer course or a fall/spring course. Students should contact their instructor for the outline of the course they are taking.

WEEK #	TOPIC
1	Overview of instrumentation and introduction to P&ID's Lab: Use P&ID's at pilot plants
2	Basic direct current electrical theory including OHM's Law and Kirchhoff's Laws Evaluation of series, parallel and combination series/parallel circuits Lab: Three resistor laboratory exercise and introduction to electrical multimeters
3	Review of basic electrical and P&ID's
4	Test / Intro to temperature
5	Temperature scales and conversions for Fahrenheit, Celsius, Rankine, Kelvin Conduction convection and radiation principles Types of temperature measuring devices including Thermocouples, RTD's, Thermistors, Bimetallic, Pressure Spring and Infrared Thermometers. Lab: calibrate thermocouple temperature transmitter
6	Introduction to pressure measurements and scales (Gauge, Vacuum and Absolute) Conversions between scales Introduction to Hydrostatic Head pressure equivalents and conversions Lab: Calibrate pressure switch
7	Introduction to Level measurement using differential pressure Specific gravity concepts for liquid and gas Radar and ultrasonic level measurements Archimedes principle and displacer type level instruments Lab: Calibrate electronic differential pressure transmitter
8	Review of temperature, pressure and level sections
9	Test / Intro to Flow measurement
10	Principles of measurement for mass and volumetric flows Flow principles including velocity profiles, laminar vs turbulent flow and Reynolds numbers Relationship of differential pressure to flow rate Orifice plates and their application in flow measurement Variable Area, Vortex, Magnetic, Doppler and Ultrasonic flow measurement principles Lab: Pressure regulator operational check, disassembly, reassembly and operational check
11	Control Valve types and construction for rising stem and rotary Accessories including positioners, hand jacks and limit switches Inherent Flow Characteristics and internal components Troubleshooting and requirements for operation Flashing and Cavitation Calibrations for split ranging

12	Controller principles of operation including direct and reverse action, Gain, Reset and Rate control tuning functions and PID equivalents Open Loop charts
13	Review Controllers, Control Valves and Flow
14	Test Begin final review
15	Final review
16	Final

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

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

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. Please refer to the Brazosport College Student Guide for more information. This is available online at http://brazosport.edu/students/for-students/student-services/
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. Sanctions may be imposed beyond your grade in this course by the Dean of 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:

- Lecture /Class assignments/Homework assignments
  Laboratory participation 20%
- Three Unit examinations 40%
- Final examination 40%

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:

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

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/

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 Activities	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.