

## Second year Instrumentation course sequence

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### Summer Quarter

- INST230 – Motor Controls** 3 credits
  - INST231 – PLC Programming** 3 credits
  - INST232 – PLC Systems** 3 credits
  - INST233 – Protective Relays (elective)** 3 credits
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### Fall Quarter

- INST200 – Introduction to Instrumentation** 2 credits  
(or)
  - INST205 – Job Prep I or INST206 – Job Prep II** 1 credit
  
  - INST240 – Pressure and Level measurement** 6 credits
  - INST241 – Temperature and Flow measurement** 6 credits
  - INST242 – Analytical measurement** 5 credits
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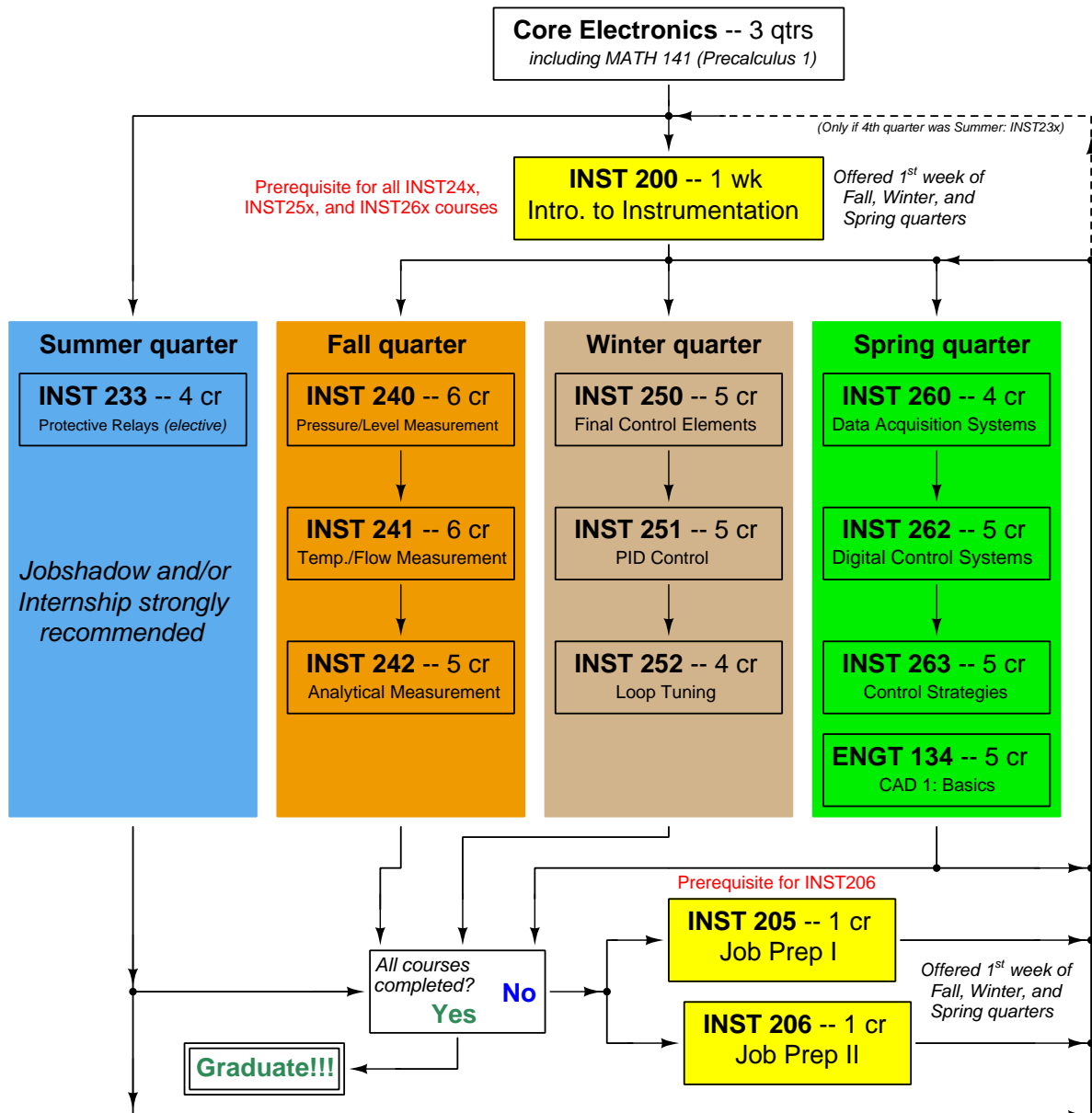
### Winter Quarter

- INST200 – Introduction to Instrumentation** 2 credits  
(or)
  - INST205 – Job Prep I or INST206 – Job Prep II** 1 credit
  
  - INST250 – Final Control Elements** 5 credits
  - INST251 – PID Control** 5 credits
  - INST252 – Loop Tuning** 4 credits
  - CHEM&161 – Chemistry** 5 credits
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### Spring Quarter

- INST200 – Introduction to Instrumentation** 2 credits  
(or)
- INST205 – Job Prep I or INST206 – Job Prep II** 1 credit
  
- INST260 – Data Acquisition Systems** 4 credits
- INST262 – Digital Control Systems** 5 credits
- INST263 – Control Strategies** 5 credits
- ENGT134 – CAD 1: Basics** 5 credits

## Sequence of second-year Instrumentation courses



The particular sequence of courses you take during the second year depends on when you complete all first-year courses and enter the second year. Since students enter the second year of Instrumentation at four different times (beginnings of Summer, Fall, Winter, and Spring quarters), the particular course sequence for any student will likely be different from the course sequence of classmates.

Some second-year courses are only offered in particular quarters with those quarters not having to be in sequence, while others are offered three out of the four quarters and must be taken in sequence. The following layout shows four typical course sequences for second-year Instrumentation students, depending on when they first enter the second year of the program:

### Possible course schedules depending on date of entry into 2nd year



file sequence

## INST 200 (Introduction to Instrumentation)

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### Lab

Building a simple control loop: *Questions 111 and 112*, due by the end of day 5

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### Feedback questions

*Questions 101 through 110*. “Feedback questions” serve as practice problems for upcoming exams and are completely optional. Your instructor will evaluate your answers and return detailed notes to you in response. Please submit them to your instructor **at the end of day 5**.

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### Circuit Concepts Review Exam

**Day 1 – Complete mastery of these objectives due by the end of the quarter**

*Specific objectives for the practice “mastery” exam:*

- Sketch wires connecting components together to form a circuit fulfilling a specified function (*series vs. parallel connections, components as sources vs. loads*)
- Analyze a series-parallel DC resistor circuit (*Ohm’s Law, Kirchhoff’s Laws*)
- Analyze a simple AC circuit (*Ohm’s Law, reactance and impedance, Conservation of Energy*)
- Solve for a specified variable in an algebraic formula
- Calculate side lengths and/or angles in a right triangle
- Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms (*predicting the effects of shorts vs. opens*)

*Question 113* identifies resources for you to review these foundational circuit concepts

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## Recommended daily schedule

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### Day 1

**8:00 AM to 8:05 AM** Roll call.

**8:05 AM to 9:00 AM** Review of the career possibilities within the field of Instrumentation and discuss student expectations as a group (Question 1). The online career guide *So You Want To Be An Instrument Technician?* will be our reference for this.

**9:00 AM to 10:00 AM** Review of industry expectations and policies (Question 2). The **General Values, Expectations, and Standards** pages will be our reference for this (printed copies will be made available).

**10:00 AM to 11:00 AM** Practice mastery exam (reviewing first-year electrical concepts, Question 3).

**11:00 AM to 12:00 Noon** Lunch break.

**12:00 Noon to 1:00 PM** Starting project work in the lab (Question 111): safety orientation, assignment of control system and process board, form lab teams (max. 4 students per team).

**1:00 PM to 3:00 PM** Early dismissal of class today, leaving time for the instructor to work with INST205/206 Job Prep course students. Students are welcome to continue working in the lab room during this time.

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Day 2

**8:00 AM to 8:05 AM** Roll call and distribute INSTREF (flash drives) to students.

**8:05 AM to 8:30 AM** Practice mastery exam review.

**8:30 AM to 11:00 AM** Project work in the lab.

**11:00 AM to 12:00 Noon** Lunch break.

**12:00 Noon to 12:30 PM** Review “How To . . .” page. Read FERPA forms and sign at students’ individual discretion.

**12:30 Noon to 2:00 PM** Instructor-led practice of writing outlines for today’s reading assignments (listed in questions 21-25). Normally this is something students do on their own prior to class, but today your instructor will work with you in class demonstrating how this can be done. You will need to have the *Lessons In Industrial Instrumentation* textbook available to read during this session, as well as a means to write extensive notes for your outline (preferably on your computer).

**2:00 PM to 2:30 PM** Apply some of the “challenges” listed in Question 0 to the reading we did.

**2:30 PM to 3:00 PM** Brainstorm time-management strategies, particularly lab projects and homework. Discuss practical solutions for managing time, including the use of a personal calendar, designated study times and places, etc.

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Day 3

**8:00 AM to 8:05 AM** Roll call.

**8:05 AM to 8:30 AM** First-year circuit analysis review.

**8:30 AM to 11:00 AM** Project work in the lab.

**11:00 AM to 12:00 Noon** Lunch break.

**12:00 Noon to 3:00 PM** Students check off homework (questions 41-48) with instructor during one of six half-hour timeslots (e.g. 12:00 PM to 12:30 PM, 12:30 PM to 1:00 PM, etc.). Timeslots are chosen by each student, with no more than 4 students at a time.

**Theory session topic:** Analog electronic and HART instruments, signals

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**8:00 AM to 8:05 AM** Roll call.

**8:05 AM to 8:15 AM** Review lab objectives and give recommendations for loop diagrams (e.g. take photographs of terminal block connections, work on sketching diagram outside of lab hours so as to focus on getting other objectives certified, etc.)

**8:15 AM to 11:00 AM** Project work in the lab.

**11:00 AM to 12:00 Noon** Lunch break.

**12:00 Noon to 3:00 PM** Students check off homework (questions 61-70) with instructor during one of six half-hour timeslots (e.g. 12:00 PM to 12:30 PM, 12:30 PM to 1:00 PM, etc.). Timeslots are chosen by each student, with no more than 4 students at a time.

**Theory session topic:** Standard diagrams for instrumentation ; Signal wiring and tube connections

Questions 61 through 80; answer questions 61-70 in preparation for discussion (remainder for practice)

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Day 5

**8:00 AM to 8:05 AM** Roll call.

**8:05 AM to 8:15 AM** Review lab objectives and give recommendations for completion.

**8:15 AM to 11:00 AM** Project work in the lab.

**11:00 AM to 12:00 Noon** Lunch break.

**12:00 Noon to 3:00 PM** Students check off homework (questions 81-85) with instructor during one of six half-hour timeslots (e.g. 12:00 PM to 12:30 PM, 12:30 PM to 1:00 PM, etc.). Timeslots are chosen by each student, with no more than 4 students at a time.

**Theory session topic:** Problem-solving

Questions 81 through 100; answer questions 81-85 in preparation for discussion (remainder for practice)

Feedback questions (*101 through 110*) are optional and may be submitted for review at the end of the day

**Important note:** 3:00 PM today is the deadline for completion of all lab project objectives! As with all INST200-level courses, failure to complete all mastery objectives by the deadline results in the course grade being capped at a C– with one more school day granted for completion. Failure to complete every mastery objective by this later date results in a failing (F) grade for the course.

**Recommended schedule**

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Day 1

**Theory session topic:** *Résumé and cover letter writing, job searching* – **attendance is mandatory!**

Independent activity: *Work on résumé and cover letter*

Independent activity: *Work on homework questions – 1 through 10*

This is the major assignment for this course: creating a résumé and cover letter both targeted to a specific instrumentation job (as *all* résumés and cover letters should be targeted). The tutorial *So You Want To Be An Instrument Technician?* available from the *Socratic Instrumentation* website delineates standards your résumé must meet. Your major task is to write a résumé and a cover letter for yourself and submit them to your instructor *error-free* by Day 5. Questions 1 through 10 in this worksheet are homework questions for you to complete, also due by Day 5 of this course (unless you have completed a jobshadow or internship during this course or during the break immediately prior).

Since both your résumé and cover letter must be targeted to a specific instrumentation job, you will also need a job description to reference. For those recently completing a jobshadow or internship, you are welcome to use that employer as the reference (i.e. writing your résumé and cover letter as though that employer were ready to hire an instrument technician, based on your experience jobshadowing or interning there). Otherwise, you will need to locate an actual job description from an employer (e.g. copied from the results of a job search engine, from an employer’s website “career” page, etc.) and include that job description along with your submission of résumé and cover letter.

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Day 2

Independent activity: *Work on résumé and cover letter*

Independent activity: *Work on homework questions – 1 through 10*

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Day 3

Independent activity: *Work on résumé and cover letter*

Independent activity: *Work on homework questions – 1 through 10*

**Recommend submitting rough draft of résumé to instructor by email** (Adobe PDF format only!)

**Recommend submitting rough draft of cover letter to instructor by email** (Adobe PDF format only!)

**Please submit the job description along with the resume and cover letter** (any format)

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Day 4

Independent activity: *Final editing of résumé and cover letter*

Independent activity: *Finish all homework questions – 1 through 10*

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## Day 5

Activity: *Submit all required work to the instructor*

**Instrumentation-specific résumé due at the end of the day (no spelling or grammar errors)**  
(Adobe PDF format only!)

**Instrumentation-specific cover letter due at the end of the day (no spelling or grammar errors)**  
(Adobe PDF format only!)

**Instrumentation job description from an actual employer due at the end of the day (any format)**

**Homework due at the end of the day** (*questions 1 through 10*)

Note: Successfully completing a “jobshadow” experience either during the week this course is scheduled or during the school break immediately preceding this course counts as equivalent credit for all assignments (including attendance at the classroom session) *except* the résumé and cover letter. Your instructor will need proof of your jobshadow completion, so be sure to leave a contact phone number and/or email for the jobshadow employer that your instructor may use for this purpose. If you target your résumé and cover letter to your jobshadow employer, there is no need to submit a job description.

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### **IMPORTANT NOTES!**

This course is largely self-directed. It is *imperative* you attend the classroom session and also complete all the prescribed activities by the end of the school day on Day 5. Anyone absent from the classroom session (unless due to a jobshadow or an emergency situation) will be dropped from the course as a no-show. Barring some personal (documented) emergency preventing your timely submission of assignments, any late work will result in a failing grade for the course! The work you must submit by Day 5 is listed in **bold** print above.

While completing a jobshadow or internship during this course or during the prior school break does count as equivalent credit for questions 1 through 10, it does *not* substitute for the résumé or cover letter. Neither does a completed jobshadow or internship substitute for registration and payment for the course, as no grade may be submitted for you unless and until you are registered.

The résumé and cover letter you submit on Day 5 are final edits, not drafts. Spelling errors, grammatical problems, unprofessional formatting, or any of the other mistakes described in the *So You Want To Be An Instrument Technician?* career guide are unacceptable. *Your final résumé and cover letter must be good enough to meet the standards of an actual employer.* This is why you are encouraged to submit rough drafts on Day 3. If you have doubts about the content or formatting of either your résumé or your cover letter, the time to consult with your instructor and receive input is *well before* Day 5!



**Recommended schedule**

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Day 1

Classroom session: *Informational interviews, job searching* – **attendance is mandatory!**

Independent activity: *Contact employer(s) to set up informational interview(s)*

Independent activity: *Work on homework questions – 1 through 11 (includes informational interview assignment)*

Independent activity: *Complete and submit a “Degree Application” form with the BTC registration office so that you will be awarded a degree upon completion of all required coursework*

This is the major assignment for this course: conducting an *informational interview* of an employer, targeted to instrumentation-related work. A recommended resource for you is the tutorial *So You Want To Be An Instrument Technician?* available from your instructor as a free electronic book. Using this or any other reference on informational interviewing, your major task is to interview a representative of some employer who hires technicians and submit the notes from that interview to your instructor by Day 5. Questions 1 through 11 in this worksheet are homework questions for you to complete, also due by Day 5 of this course (unless you have completed a jobshadow or internship during this course or during the break immediately prior).

Do not be surprised if an employer does not answer your query for an informational interview. It is recommended that you contact multiple employers in order to ensure successful completion of this exercise, and that you interview all who agree to your request. Informational interviews do not take long to conduct, and they have been known to lead to job offers!

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Day 2

Independent activity: *Work on homework questions – 1 through 11 (includes informational interview assignment)*

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Day 3

Independent activity: *Work on homework questions – 1 through 11 (includes informational interview assignment)*

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Day 4

Independent activity: *Finish all homework questions – 1 through 11 (includes informational interview assignment)*

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Day 5

**Homework due at the end of the day** (*questions 1 through 11, includes informational interview assignment*)

Note: Successfully completing a “jobshadow” experience either during the week this course is scheduled or during the school break immediately preceding this course counts as equivalent credit for all course assignments including the informational interview as well as attendance at the classroom session. Your instructor will need proof of your jobshadow completion, so be sure to leave a contact phone number and/or email for the jobshadow employer that your instructor may use for this purpose.

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**IMPORTANT NOTES!**

This course is largely self-directed, with little formal instruction given. It is *imperative* that you attend the classroom session and also complete all the prescribed activities by the end of the school day on Day

5. Anyone absent from the classroom session (unless due to a jobshadow or an emergency situation) will be dropped from the course as a no-show. Completing the informational interview in particular will likely require more time than you think, so start early! Barring some personal (documented) emergency preventing your timely submission of assignments, any late work will result in a failing grade for the course! The work you must submit by Day 5 is listed in **bold** print above.

While completing a jobshadow or internship during this course or during the prior school break does count as equivalent credit for all course assignments, it does *not* substitute for registration and payment for the course. No grade may be submitted for you unless and until you are registered.

Of these, the one most often responsible for students' failure of the course is the informational interview, because companies may not be able to provide you with an interview opportunity in a timely manner. *Work on getting the informational interview done as soon as possible!* Contact multiple employers to ensure success.

Lab

Pressure measurement loop: *Questions 91 and 92*, **completed objectives due by the end of day 5, section 2**

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Exam

*Day 5 of next section* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Convert between different pressure units (PSI, ”W.C., bar, etc.) showing proper mathematical cancellation of units (i.e. the “unity fraction” technique)
  - Calculate pressure applied to a DP instrument in a realistic scenario
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a series-parallel circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Sketch proper wire connections for sourcing or sinking PLC I/O points
  - INST251 Review: Determine the effect of a component fault or condition change in a single-loop controlled process
  - INST260 Review: Convert between different numeration systems (decimal, binary, hexadecimal, octal)
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Concepts of pressure and pressure unit conversions

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Pressure measurement technologies

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Instrument calibration

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Electronic pressure measurement

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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## Introduction to Fall Quarter

This quarter focuses on the subject of *measurement*. Ideas to keep in mind for special projects (alternatives to standard lab as well as extra-credit) include measuring and recording physical variables in and around the college campus. For those who have studied programmable logic controllers (PLCs), there will be application to use your PLCs again if equipped with analog inputs to receive the 4-20 mA signals produced by industrial transmitters.

Lab

Pressure measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5*

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Exam

*Day 5* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Convert between different pressure units (PSI, ”W.C., bar, etc.) showing proper mathematical cancellation of units (i.e. the “unity fraction” technique)
  - Calculate pressure applied to a DP instrument in a realistic scenario
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a series-parallel circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Sketch proper wire connections for sourcing or sinking PLC I/O points
  - INST251 Review: Determine the effect of a component fault or condition change in a single-loop controlled process
  - INST260 Review: Convert between different numeration systems (decimal, binary, hexadecimal, octal)
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Pressure instrument accessories

Questions 1 through 20; answer questions 1-11 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Pneumatic pressure instruments

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Pneumatic pressure instruments (continued) and pressure switches

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam

Questions 61 through 80; answer questions 61-66 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

Level measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5, section 4*

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Exam

*Day 5 of next section – Complete mastery of these objectives due by the next exam date*  
*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, powers and/or resistances in a DC series-parallel circuit
  - Determine suitability of different level-measuring technologies for a given process fluid type
  - Calculate ranges for hydrostatic (DP) level-measuring instruments given physical dimensions and fluid densities
  - Calculate buoyant force values for a displacer-type level-measuring instrument at different liquid levels
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a Wheatstone bridge circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC discrete output given input switch conditions and a simple RLL program listing
  - INST251 Review: Determine the effect of a component change on the gain of a pneumatic controller mechanism
  - INST263 Review: Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Level measurement technologies and liquid densities

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Hydrostatic level measurement

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Displacer level measurement

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Measuring liquid-liquid interfaces

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Level measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5*

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Exam

*Day 5 – Complete mastery of these objectives due by the next exam date*

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, powers and/or resistances in a DC series-parallel circuit
  - Determine suitability of different level-measuring technologies for a given process fluid type
  - Calculate ranges for hydrostatic (DP) level-measuring instruments given physical dimensions and fluid densities
  - Calculate buoyant force values for a displacer-type level-measuring instrument at different liquid levels
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a Wheatstone bridge circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC discrete output given input switch conditions and a simple RLL program listing
  - INST251 Review: Determine the effect of a component change on the gain of a pneumatic controller mechanism
  - INST263 Review: Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Ultrasonic, radar, and magnetostrictive level measurement

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Weight, capacitance, radiation, and nonlinear level measurement

Questions 21 through 40; answer questions 21-31 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Discrete level measurement

Questions 41 through 60; answer questions 41-47 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam (site visit)

Questions 61 through 80; answer questions 61-64 in preparation for discussion at an industrial site specified by your instructor. (All remaining questions for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

Temperature measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5, section 2*

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Exam

*Day 5 of next section* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages and currents in an ideal AC transformer circuit
  - Sketch proper wire connections showing how to simulate an RTD or thermocouple input to a temperature transmitter using simple electronic components
  - Calculate temperatures or voltages in thermocouple and RTD circuits given access to thermocouple and RTD tables
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a Wheatstone bridge circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate either the full-load current or the horsepower of an electric motor (either single- or three-phase) given the line voltage and one of the other parameters
  - INST250 Review: Calculate  $C_v$  rating of control valve for liquid (non-cavitating) service
  - INST263 Review: Determine effect of a fault in a selector or override control system
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Temperature measurement technologies

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Principles of heat and temperature

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** RTDs and thermistors

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Thermocouples

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day



Lab

Temperature measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5*

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Exam

*Day 5* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages and currents in an ideal AC transformer circuit
  - Sketch proper wire connections showing how to simulate an RTD or thermocouple input to a temperature transmitter using simple electronic components
  - Calculate temperatures or voltages in thermocouple and RTD circuits given access to thermocouple and RTD tables
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a Wheatstone bridge circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate either the full-load current or the horsepower of an electric motor (either single- or three-phase) given the line voltage and one of the other parameters
  - INST250 Review: Calculate  $C_v$  rating of control valve for liquid (non-cavitating) service
  - INST263 Review: Determine effect of a fault in a selector or override control system
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Thermocouples (continued)

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Thermocouple and RTD applications

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Non-contact pyrometers, temperature switches, calibration standards, and accessories

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam

Questions 61 through 80; answer questions 61-65 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

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## Lab

Flow measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5, section 4*

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## Exam

*Day 5 of next section – Complete mastery of these objectives due by the next exam date*

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, and phase shifts in an AC reactive circuit
  - Calculate flow rate / pressure drop for a nonlinear flow element
  - Determine suitability of different flow-measuring technologies for a given process fluid type
  - Identify specific instrument calibration errors (zero, span, linearity, hysteresis) from data in an “As-Found” table
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate voltages and currents within balanced three-phase AC electrical circuits
  - INST250 Review: Calculate split-ranged valve positions given signal value and valve calibration ranges
  - INST262 Review: Determine proper AI block parameters to range a Fieldbus transmitter for a given application
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## Recommended daily schedule

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### Day 1

**Theory session topic:** Flow measurement technologies

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

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### Day 2

**Theory session topic:** Fluid dynamics

Questions 21 through 40; answer questions 21-30 in preparation for discussion (remainder for practice)

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### Day 3

**Theory session topic:** Pressure-based flowmeters

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice)

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### Day 4

**Theory session topic:** High-accuracy pressure-based flow measurement

Questions 61 through 80; answer questions 61-70 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Flow measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5*

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Exam

*Day 5 – Complete mastery of these objectives due by the next exam date*

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, and phase shifts in an AC reactive circuit
  - Calculate flow rate / pressure drop for a nonlinear flow element
  - Determine suitability of different flow-measuring technologies for a given process fluid type
  - Identify specific instrument calibration errors (zero, span, linearity, hysteresis) from data in an “As-Found” table
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate voltages and currents within balanced three-phase AC electrical circuits
  - INST250 Review: Calculate split-ranged valve positions given signal value and valve calibration ranges
  - INST262 Review: Determine proper AI block parameters to range a Fieldbus transmitter for a given application
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Turbine, vortex, and positive-displacement flowmeters

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Magnetic and ultrasonic flowmeters

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** True mass flowmeters, weirs and flumes

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam (site visit)

Questions 61 through 80; answer questions 61-63 in preparation for discussion at an industrial site specified by your instructor. (All remaining questions for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

Analytical measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5, section 3*

---

Exam

*Day 6 of section 3*

*Capstone Assessment takes the place of a mastery exam (see question 93)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Balancing a chemical reaction
  - Explain the operating principle of a specified analyzer type
  - Calculate temperatures or voltages in thermocouple and RTD circuits given access to thermocouple and RTD tables
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST252 Review: Identify cause of poor loop performance from a trend graph
  - INST262 Review: Use decibels to calculate power gains and losses
- 

**Recommended daily schedule**

---

Day 1

**Theory session topic:** Chemical concepts, terms, and symbols

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 93*)

---

Day 2

**Theory session topic:** The Periodic Table, electron shells, and spectroscopy

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Molecular quantities

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Stoichiometry and energy in chemical reactions

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Analytical measurement loop: *Questions 91 and 92, completed objectives due by the end of day 5, section 3*

---

Exam

*Day 6 of section 3*

*Capstone Assessment takes the place of a mastery exam (see question 93)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Balancing a chemical reaction
  - Explain the operating principle of a specified analyzer type
  - Calculate temperatures or voltages in thermocouple and RTD circuits given access to thermocouple and RTD tables
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST252 Review: Identify cause of poor loop performance from a trend graph
  - INST262 Review: Use decibels to calculate power gains and losses
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Conductivity measurement

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 93*)

---

Day 2

**Theory session topic:** pH and pH measurement

Questions 21 through 40; answer questions 21-30 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Potentiometric pH measurement

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Chromatography

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Analytical measurement loop: *Questions 61 and 62, completed objectives due by the end of day 5*

---

Exam

*Day 6*

*Capstone Assessment takes the place of a mastery exam (see question 63)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Balancing a chemical reaction
  - Explain the operating principle of a specified analyzer type
  - Calculate temperatures or voltages in thermocouple and RTD circuits given access to thermocouple and RTD tables
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST252 Review: Identify cause of poor loop performance from a trend graph
  - INST262 Review: Use decibels to calculate power gains and losses
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Optical analyses (dispersive spectroscopy, fluorescence, chemiluminescence)

Questions 1 through 20; answer questions 1-8 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 63*)

---

Day 2

**Theory session topic:** Optical analyses (NDIR)

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Review for exam

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

**Team tool locker inspection:** have students inventory their team tool lockers, posting lists to the outside of the locker doors documenting what’s missing.

---

Day 4

**Tour**

---

Day 5

**Exam**

---

Day 6

**Lab Clean-Up Day**

Capstone Assessment: *Question 63*, **due by the end of the last day**

*The last day of the quarter is a full day, where all students are expected to attend as usual. Together, we will spend this day completing any remaining lab objectives, as well as doing general clean-up, reorganization, equipment repair, and other tasks necessary for the maintenance of our lab facility. See question 64 for a list of necessary tasks to complete.*

Lab

Control valve rebuild and bench-set: *Questions 91 and 92, completed objectives due by the end of day 5, section 2*

---

Exam

*Day 5 of next section* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Determine response of a pneumatic force-balance mechanism to different conditions
  - Determine the effect of a fault in a solenoid-controlled valve system
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of a relay logic circuit given a schematic diagram and switch stimulus conditions
  - INST241 Review: Identify (American) wire colors for different thermocouple types
  - INST262 Review: Identify specific instrument calibration errors (zero, span, linearity, hysteresis) from data in an “As-Found” table
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Principles of fluids and fluid pressure

Questions 1 through 20; answer questions 1-8 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Control valves and actuators

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Fluid power systems

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Pneumatic instruments

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day



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## Introduction to Winter Quarter

This quarter focuses on the subjects of *final control elements* and *PID control*. Ideas to keep in mind for special projects (alternatives to standard lab as well as extra-credit) include applications using variable-frequency motor drives and other non-valve control elements. Applications exist as well for building your own PID controller, either from analog components (i.e. opamps) or using a programmable logic controllers (PLC) with analog I/O.

Lab

Control valve rebuild and bench-set: *Questions 91 and 92, completed objectives due by the end of day 5*

---

Exam

*Day 5* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Determine response of a pneumatic force-balance mechanism to different conditions
  - Determine the effect of a fault in a solenoid-controlled valve system
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of a relay logic circuit given a schematic diagram and switch stimulus conditions
  - INST241 Review: Identify (American) wire colors for different thermocouple types
  - INST262 Review: Identify specific instrument calibration errors (zero, span, linearity, hysteresis) from data in an “As-Found” table
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Pneumatic instruments (continued)

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

---

Day 2

**Theory session topic:** Solenoid valves

Questions 21 through 40; answer questions 21-30 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Valve failure modes and packing systems

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Review for exam (site visit)

Questions 61 through 80; answer questions 61-63 in preparation for discussion at an industrial site specified by your instructor. (All remaining questions for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

---

Day 5

**Exam**

Lab

“Smart” valve positioner: *Questions 91 and 92*, **completed objectives due by the end of day 5, section 4**

---

Exam

*Day 5 of next section* – **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, powers and/or resistances in a DC series-parallel circuit
  - Determine proper fail-safe mode for a control valve in a given process
  - Calculate  $C_v$  rating of control valve for liquid (non-cavitating) service
  - Calculate split-ranged valve positions given signal value and valve calibration ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate either the full-load current or the horsepower of an electric motor (either single- or three-phase) given the line voltage and one of the other parameters
  - INST240 Review: Calculate ranges for hydrostatic (DP) level-measuring instruments given physical dimensions and fluid densities
  - INST263 Review: Identify action of “trip” solenoid from P&ID or loop sheet
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Valve positioners

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Electric valve actuators and VFDs

Questions 21 through 40; answer questions 21-27 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Split-ranged control valves

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Valve sizing

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

“Smart” valve positioner: *Questions 91 and 92, completed objectives due by the end of day 5*

---

Exam

**Day 5 – Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, powers and/or resistances in a DC series-parallel circuit
  - Determine proper fail-safe mode for a control valve in a given process
  - Calculate  $C_v$  rating of control valve for liquid (non-cavitating) service
  - Calculate split-ranged valve positions given signal value and valve calibration ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate either the full-load current or the horsepower of an electric motor (either single- or three-phase) given the line voltage and one of the other parameters
  - INST240 Review: Calculate ranges for hydrostatic (DP) level-measuring instruments given physical dimensions and fluid densities
  - INST263 Review: Identify action of “trip” solenoid from P&ID or loop sheet
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Valve sizing and self-operated valves

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Valve characterization

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Valve problems

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Guest-led workshop on smart valve positioner

Questions 61 through 80; all questions are for your practice only

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

Split-ranged valves with pneumatic positioners: *Questions 91 and 92, completed objectives due by the end of day 5, section 2*

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Exam

*Day 5 of next section – Complete mastery of these objectives due by the next exam date*

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages and currents in an ideal AC transformer circuit
  - Predict the response of a single-loop control system to a component fault or process change
  - Determine the effect of a component change on the gain of a pneumatic controller mechanism
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple relay circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC discrete output given input switch conditions and a simple RLL program listing
  - INST241 Review: Calculate flow rate / pressure drop for a nonlinear flow element
  - INST262 Review: Determine proper AI block parameters to range a Fieldbus transmitter for a given application
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Instrument tube fitting (guest speaker)

Questions 1 through 20 (all for practice)

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Day 2

**Theory session topic:** Feedback control

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Pneumatic process controllers

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Analog electronic process controllers

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

---

Lab

Split-ranged valves with pneumatic positioners: *Questions 91 and 92, completed objectives due by the end of day 5*

---

Exam

*Day 5 – Complete mastery of these objectives due by the next exam date*

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages and currents in an ideal AC transformer circuit
  - Determine the effect of a component fault or condition change in a single-loop controlled process
  - Determine the effect of a component change on the gain of a pneumatic controller mechanism
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple relay circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC discrete output given input switch conditions and a simple RLL program listing
  - INST241 Review: Calculate flow rate / pressure drop for a nonlinear flow element
  - INST262 Review: Determine proper AI block parameters to range a Fieldbus transmitter for a given application
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Differential calculus

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice – *highly recommended*)

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Day 2

**Theory session topic:** Integral calculus

Questions 21 through 40; answer questions 21-30 in preparation for discussion (remainder for practice – *highly recommended*)

---

Day 3

**Theory session topic:** Applications of calculus

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice – *highly recommended*)

---

Day 4

**Theory session topic:** Review for exam

Questions 61 through 80; answer questions 61-69 in preparation for discussion

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

---

Day 5

**Exam**

Lab

Automatically-controlled process: *Questions 91 and 92*, **completed objectives due by the end of day 5, section 4**

---

Exam

*Day 5 of next section* – **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, and phase shifts in an AC reactive circuit
  - Perform numerical differentiation on a simple mathematical function (graphed)
  - Perform numerical integration on a simple mathematical function (graphed)
  - Identify the graphed response of a controller as being either P, I, or D; direct or reverse
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate voltages and currents within balanced three-phase AC electrical circuits
  - INST241 Review: Determine suitability of different flow-measuring technologies for a given process fluid type
  - INST263 Review: Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Proportional-only offset

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Integral-only control

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Proportional + integral control

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Proportional + integral control (continued)

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

---

Lab

Automatically-controlled process: *Questions 91 and 92*, **completed objectives due by the end of day 5**

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Exam

*Day 5* – **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, and phase shifts in an AC reactive circuit
  - Perform numerical differentiation on a simple mathematical function (graphed)
  - Perform numerical integration on a simple mathematical function (graphed)
  - Identify the graphed response of a controller as being either P, I, or D; direct or reverse
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate voltages and currents within balanced three-phase AC electrical circuits
  - INST241 Review: Determine suitability of different flow-measuring technologies for a given process fluid type
  - INST263 Review: Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Derivative and PID control

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Different PID control algorithms

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Digital implementations of PID control

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Review for exam **or** Lab Day (instructor’s choice)

Questions 61 through 80; answer questions 61-67 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

---

Day 5

**Exam**



Lab

Multiple loop tuning: *Question 91, completed objectives due by the end of day 5, section 3*

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Exam

*Day 6 of section 3*

*Capstone Assessment (see question 92)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Identify cause of poor loop performance from a trend graph
  - Identify problem in control loop based on faceplate display and field data
  - Calculate either the numerical derivative or the numerical integral from a graph
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST240 Review: Determine suitability of different level-measuring technologies for a given process fluid type
  - INST263 Review: Determine the effect of a component fault or condition change in a selector or override control system
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Process characteristics

Questions 1 through 20; answer questions 1-8 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 92*)

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Day 2

**Theory session topic:** Process characteristics (continued)

Questions 21 through 40; answer questions 21-27 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Loop tuning methods and Troubleshooting

Questions 41 through 60; answer questions 41-50 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Loop tuning practice

Questions 61 through 80; answer questions 61-67 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Multiple loop tuning: *Question 91, completed objectives due by the end of day 5, section 3*

---

Exam

*Day 6 of section 3*

*Capstone Assessment (see question 92)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Identify cause of poor loop performance from a trend graph
  - Identify problem in control loop based on faceplate display and field data
  - Calculate either the numerical derivative or the numerical integral from a graph
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST240 Review: Determine suitability of different level-measuring technologies for a given process fluid type
  - INST263 Review: Determine the effect of a component fault or condition change in a selector or override control system
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Cascade control

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 92*)

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Day 2

**Theory session topic:** Feedforward control

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Loop problem diagnosis and optimization

Questions 41 through 60; answer questions 41-49 in preparation for discussion (remainder for practice)

---

Day 4

**Theory session topic:** Loop problem diagnosis and optimization (continued)

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Lab

Multiple loop tuning: *Question 61*, **completed objectives due by the end of day 5**

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Exam

*Day 6*

*Capstone Assessment (see question 62)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Identify cause of poor loop performance from a trend graph
  - Identify problem in control loop based on faceplate display and field data
  - Calculate either the numerical derivative or the numerical integral from a graph
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST240 Review: Determine suitability of different level-measuring technologies for a given process fluid type
  - INST263 Review: Determine the effect of a component fault or condition change in a selector or override control system
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Loop problem diagnosis and optimization (continued)

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 62*)

---

Day 2

**Theory session topic:** Loop problem diagnosis and optimization (continued)

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

---

Day 3

**Theory session topic:** Review for exam (site visit)

Questions 41 through 60; answer questions 41-42 in preparation for discussion at an industrial site specified by your instructor. (All remaining questions for practice)

**Team tool locker inspection:** have students inventory their team tool lockers, posting lists to the outside of the locker doors documenting what’s missing.

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Day 4

**Tour**

---

Day 5

**Exam**

---

Day 6

**Lab Clean-Up Day**

Capstone Assessment: *Question 62*, **due by the end of the last day**

*The last day of the quarter is a full day, where all students are expected to attend as usual. Together, we will spend this day completing any remaining lab objectives, as well as doing general clean-up, reorganization, equipment repair, and other tasks necessary for the maintenance of our lab facility. See question 63 for a list of necessary tasks to complete.*

Lab

Data acquisition and transport over Ethernet: *Question 91*, **completed objectives due by the end of day 6, section 3**

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Exam

*Day 6 of section 3* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Sketch proper wire connections for a data acquisition unit to measure an analog sensor signal
  - Convert between different numeration systems (decimal, binary, hexadecimal, octal)
  - Calculate ADC (analog-digital converter) input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of a relay logic circuit given a schematic diagram and switch stimulus conditions
  - INST241 Review: Identify (American) wire colors for different thermocouple types
  - INST250 Review: Convert between different pressure units (PSI, "W.C.", bar, etc.) showing proper mathematical cancellation of units (i.e. the “unity fraction” technique)
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Signal coupling, shielding, and wiring practices

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Digital data representation and analog/digital converters

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Data acquisition hardware

Questions 41 through 60; answer questions 41-46 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Serial communication principles

Questions 61 through 80; answer questions 61-69 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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## Introduction to Spring Quarter

This quarter focuses on the use of *digital computer systems* for measurement and control. Ideas to keep in mind for special projects (alternatives to standard lab as well as extra-credit) include long-range measurement systems using wireless (radio) communication, as well as advanced process-control systems (beyond single-loop PID). For those who have studied programmable logic controllers (PLCs), there will be application to use your PLCs again when we build safety instrumented systems (SIS) later this quarter!

For those who have not yet taken the Summer-quarter PLC courses (INST23X), now is a good time to place orders for your PLC hardware or purchase used from classmates who have already finished those courses. See the INST231 or INST232 worksheets and syllabi for a list of required hardware and software!

Lab

Data acquisition and transport over Ethernet: *Question 91*, **completed objectives due by the end of day 6, section 3**

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Exam

*Day 6 of section 3* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Sketch proper wire connections for a data acquisition unit to measure an analog sensor signal
  - Convert between different numeration systems (decimal, binary, hexadecimal, octal)
  - Calculate ADC (analog-digital converter) input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of a relay logic circuit given a schematic diagram and switch stimulus conditions
  - INST241 Review: Identify (American) wire colors for different thermocouple types
  - INST250 Review: Convert between different pressure units (PSI, "W.C., bar, etc.) showing proper mathematical cancellation of units (i.e. the “unity fraction” technique)
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Serial communication principles (continued)

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Transmission lines and fiber-optic cables

Questions 21 through 40; answer questions 21-27 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** RS-232, 422, and 485 serial networks

Questions 41 through 60; answer questions 41-47 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Ethernet networks

Questions 61 through 80; answer questions 61-67 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Data acquisition and transport over Ethernet: *Question 111*, **completed objectives due by the end of day 6**

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Exam

*Day 6* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate and annotate voltages and currents in a DC series-parallel resistor circuit given source and resistor values
  - Sketch proper wire connections for a data acquisition unit to measure an analog sensor signal
  - Convert between different numeration systems (decimal, binary, hexadecimal, octal)
  - Calculate ADC (analog-digital converter) input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of a relay logic circuit given a schematic diagram and switch stimulus conditions
  - INST241 Review: Identify (American) wire colors for different thermocouple types
  - INST250 Review: Convert between different pressure units (PSI, "W.C., bar, etc.) showing proper mathematical cancellation of units (i.e. the “unity fraction” technique)
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** IP, TCP, and UDP

Questions 1 through 20; answer questions 1-8 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** HART and Modbus protocols

Questions 21 through 40; answer questions 21-29 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Digital network security

Questions 41 through 60; answer questions 41-46 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Digital network security (continued)

Questions 61 through 80; answer questions 61-66 in preparation for discussion (remainder for practice)

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Day 5

**Theory session topic:** Review for exam

Questions 81 through 100; answer questions 81-90 in preparation for discussion (remainder for practice)

Feedback questions (*101 through 110*) are optional and may be submitted for review at the end of the day



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Day 6

**Exam**

Lab

Automatically-controlled process: *Questions 91 and 92*, **completed objectives due by the end of day 5, section 2**

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Exam

*Day 5 of next section* – **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, powers and/or resistances in a DC series-parallel circuit
  - Identify proper controller action (direct or reverse) for a given process
  - Predict the response of a single-loop control system to a component fault or process change
  - Identify specific instrument calibration errors (zero, span, linearity, hysteresis) from data in an “As-Found” table
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Sketch proper wire connections for sourcing or sinking PLC I/O points
  - INST240 Review: Determine suitability of different level-measuring technologies for a given process fluid type
  - INST251 Review: Identify the graphed response of a controller as being either P, I, or D
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Feedback control

Questions 1 through 20; answer questions 1-8 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** PID control

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** DCS configuration

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** DDC, DCS, and SCADA system configuration

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

Automatically-controlled process: *Questions 91 and 92*, **completed objectives due by the end of day 5**

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Exam

*Day 5* – **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, powers and/or resistances in a DC series-parallel circuit
  - Identify proper controller action (direct or reverse) for a given process
  - Determine the effect of a component fault or condition change in an automatically-controlled process
  - Identify specific instrument calibration errors (zero, span, linearity, hysteresis) from data in an “As-Found” table
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Sketch proper wire connections for sourcing or sinking PLC I/O points
  - INST240 Review: Determine suitability of different level-measuring technologies for a given process fluid type
  - INST251 Review: Identify the graphed response of a controller as being either P, I, or D
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Instrument calibration

Questions 1 through 20; answer questions 1-8 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** Instrument calibration (continued)

Questions 21 through 40; answer questions 21-27 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** DCS and SCADA system security

Questions 41 through 60; answer questions 41-46 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam (site visit)

Questions 21 through 40; answer questions 61-63 in preparation for discussion at an industrial site specified by your instructor. (All remaining questions for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

WirelessHART instrument loop: *Question 91*, **completed objectives due by the end of day 5, section 4**

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Exam

*Day 5 of next section* – **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages and currents in an ideal AC transformer circuit
  - Determine proper AI block parameters to range a Fieldbus transmitter for a given application
  - Use decibels to calculate power gains and losses
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC discrete output given input switch conditions and a simple RLL program listing
  - INST241 Review: Determine suitability of different flow-measuring technologies for a given process fluid type
  - INST251 Review: Determine the effect of a component change on the gain of a pneumatic controller mechanism
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** FOUNDATION Fieldbus physical layer

Questions 1 through 20; answer questions 1-7 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** FOUNDATION Fieldbus data link layer

Questions 21 through 40; answer questions 21-27 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** FOUNDATION Fieldbus function blocks

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** FOUNDATION Fieldbus device configuration and troubleshooting

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

Lab

WirelessHART instrument loop: *Question 91, completed objectives due by the end of day 5*

---

Exam

**Day 5 – Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages and currents in an ideal AC transformer circuit
  - Determine proper AI block parameters to range a Fieldbus transmitter for a given application
  - Use decibels to calculate power gains and losses
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC discrete output given input switch conditions and a simple RLL program listing
  - INST241 Review: Determine suitability of different flow-measuring technologies for a given process fluid type
  - INST251 Review: Determine the effect of a component change on the gain of a pneumatic controller mechanism
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Radio communication systems

Questions 1 through 20; answer questions 1-6 in preparation for discussion (remainder for practice)

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Day 2

**Theory session topic:** WirelessHART systems

Questions 21 through 40; answer questions 21-26 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Long-range wireless networks

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

Multi-input control strategy: *Question 91 and 92, completed objectives due by the end of day 5, section 2*

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Exam

*Day 5 of next section* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, and phase shifts in an AC reactive circuit
  - Determine the effect of a component fault or condition change in a single-loop controlled process
  - Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate voltages and currents within balanced three-phase AC electrical circuits
  - INST241 Review: Calculate flow rate / pressure drop for a nonlinear flow element
  - INST250 Review: Calculate split-ranged valve positions given signal value and valve calibration ranges
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**Recommended daily schedule**

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Day 1

**Theory session topic:** Supervisory and cascade control

Questions 1 through 20; answer questions 1-7 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 93*)

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Day 2

**Theory session topic:** Ratio control

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Feedforward control

Questions 41 through 60; answer questions 41-47 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Feedforward with dynamic compensation

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Lab

Multi-input control strategy: *Question 91 and 92, completed objectives due by the end of day 5*

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Exam

*Day 5* – only a simple calculator may be used! **Complete mastery of these objectives due by the next exam date**

*Specific objectives for the “mastery” exam:*

- Electricity Review: Calculate voltages, currents, and phase shifts in an AC reactive circuit
  - Determine the effect of a component fault or condition change in a single-loop controlled process
  - Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
  - Calculate instrument input and output values given calibrated ranges
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a simple circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Calculate voltages and currents within balanced three-phase AC electrical circuits
  - INST241 Review: Calculate flow rate / pressure drop for a nonlinear flow element
  - INST250 Review: Calculate split-ranged valve positions given signal value and valve calibration ranges
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Applications of control strategies

Questions 1 through 20; answer questions 1-9 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 93*)

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Day 2

**Theory session topic:** Limit and Selector controls

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Override controls

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Review for exam

Questions 61 through 80; answer questions 61-68 in preparation for discussion (remainder for practice)

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Day 5

**Exam**

Lab

Control system with automatic shutdown: *Questions 91 and 92, completed objectives due by the end of day 4, section 4*

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Exam

*Day 5 of next section*

*Capstone Assessment takes the place of a mastery exam (see question 93)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
  - Identify problem in control loop based on faceplate display and field data
  - Determine proper AI block parameters to range a Fieldbus transmitter for a given application
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST241 Review: Determine suitability of different flow-measuring technologies for a given process fluid type
  - INST252 Review: Identify cause of poor loop performance from a trend graph
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Introduction to Safety Instrumented Systems (SIS)

Questions 1 through 20; answer questions 1-10 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 92*)

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Day 2

**Theory session topic:** Explosion hazards and intrinsic safety

Questions 21 through 40; answer questions 21-28 in preparation for discussion (remainder for practice)

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Day 3

**Theory session topic:** Solenoid valves and fail-safe design

Questions 41 through 60; answer questions 41-48 in preparation for discussion (remainder for practice)

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Day 4

**Theory session topic:** Electrical power system protection

Questions 61 through 80; answer questions 61-66 in preparation for discussion (remainder for practice)

**Tell continuing students about their need to purchase PLC equipment**

Feedback questions (*81 through 90*) are optional and may be submitted for review at the end of the day

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Lab

Control system with automatic shutdown: *Questions 41 and 42, completed objectives due by the end of day 4*

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Exam

*Day 4*

*Capstone Assessment takes the place of a mastery exam (see question 43)*

*Specific objectives for the optional “mastery” exam (worth +5% on the proportional exam score if passed the very first time):*

- Electricity Review: Design a simple circuit to achieve a stated objective
  - Determine the effect of a component fault or condition change in a cascade-, ratio-, or feedforward-controlled process
  - Identify problem in control loop based on faceplate display and field data
  - Determine proper AI block parameters to range a Fieldbus transmitter for a given application
  - Solve for a specified variable in an algebraic formula (may contain exponents or logarithms)
  - Determine the possibility of suggested faults in a 4-20 mA loop circuit given measured values (voltage, current), a schematic diagram, and reported symptoms
  - Motor/relay/3phase/PLC Review: Determine status of PLC output given input conditions and RLL program
  - INST241 Review: Determine suitability of different flow-measuring technologies for a given process fluid type
  - INST252 Review: Identify cause of poor loop performance from a trend graph
- 

**Recommended daily schedule**

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Day 1

**Theory session topic:** Digital safety system security

Questions 1 through 20; answer questions 1-5 in preparation for discussion (remainder for practice)

Discuss the upcoming Capstone Assessment due by the end of the course (*Question 42*)

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Day 2

**Theory session topic:** Overpressure protection and review for exam (site visit)

Questions 21 through 40; answer questions 21-23 in preparation for discussion at an industrial site specified by your instructor. (All remaining questions for practice)

**Team tool locker inspection:** have students inventory their team tool lockers, posting lists to the outside of the locker doors documenting what’s missing.

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Day 3

**Tour**

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Day 4

**Exam**

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Day 5

**Lab Clean-Up Day**

Capstone Assessment: *Question 43*, **due by the end of the last day**

*The last day of the quarter is a full day, where all students are expected to attend as usual. Together, we will spend this day completing any remaining lab objectives, as well as doing general clean-up, reorganization, equipment repair, and other tasks necessary for the maintenance of our lab facility. See question 44 for a list of necessary tasks to complete.*

**Purchase PLC equipment for Summer quarter**

## INST 290 (Internship)

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An internship is a formal agreement between the student, an employer, and the college resulting in practical work experience on a real job site. Internships may be paid or unpaid at the employer's discretion, but to receive credit for this internship course you must register and pay for it like any other college course.

Expectations and standards for the internship are entirely set by the employer. This is a pass-fail course, your status being solely determined by your supervisor's assessment of your performance.

## **INST 292 (Internship)**

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An internship is a formal agreement between the student, an employer, and the college resulting in practical work experience on a real job site. Internships may be paid or unpaid at the employer's discretion, but to receive credit for this internship course you must register and pay for it like any other college course.

Expectations and standards for the internship are entirely set by the employer. This is a pass-fail course, your status being solely determined by your supervisor's assessment of your performance.