



El Camino College
COURSE OUTLINE OF RECORD – Official

Course Acronym:	ACR
Course Number:	6
Descriptive Title:	Refrigeration and Air Conditioning Control Systems
Division:	Industry and Technology
Department:	Air Conditioning and Refrigeration
Course Disciplines:	Air Conditioning and Refrigeration, Heating
Catalog Description:	This course explores control system theory, electrical components and complex control systems with emphasis on supervisory control systems which employ direct digital, proportional and integral control modes and theoretical faults. The course provides the foundational skills required to analyze and service basic circuits as well as, complex analog control circuitry.
Prerequisite:	Air Conditioning and Refrigeration 5 with a minimum grade of C or equivalent
Co-requisite:	
Recommended Preparation:	Air Conditioning and Refrigeration 21
Enrollment Limitation:	
Hours Lecture (per week):	3
Hours Laboratory (per week):	3
Outside Study Hours:	6
Total Course Hours:	108
Course Units:	4
Grading Method:	Letter Grade only
Credit Status:	Credit, degree applicable
Transfer CSU:	Yes
Effective Date:	Prior to July 1992
Transfer UC:	No
Effective Date:	
General Education: ECC	
Term:	
Other:	
CSU GE:	
Term:	

	Other:
	IGETC:
	Term:
	Other:
Student Learning Outcomes:	<p>SLO #1 Electrical Control Relays</p> <p>After reading the textbook and participating in class discussions, students will apply their knowledge of appropriate lab practices, concepts and theories by observing and testing the proper operation of an air conditioning electrical control relay.</p> <p>SLO #2 Microprocessor Controls</p> <p>Students completing this course will gain the knowledge necessary to perform basic testing of HVACR system microprocessor controls.</p> <p>SLO #3 Ladder & Schematic Diagrams</p> <p>Upon completion of this course students will apply the basic knowledge and skills learned to service and troubleshoot microprocessor controls using ladder and schematic diagrams.</p>
Course Objectives:	<ol style="list-style-type: none"> 1. Score 100% accuracy on a safety test. 2. Evaluate electrical and electronic components used in the operation of air conditioning and refrigeration equipment. 3. Explain and evaluate the system components used in the operation of air conditioning and refrigeration equipment. 4. Operate and discuss the system components used in the operation of air conditioning and refrigeration equipment. 5. Compare and contrast the appropriate electrical and electronic devices to be used in the control systems of an air conditioning system. 6. Diagnose and repair electrical problems associated with heating and cooling systems.
Major Topics:	<p>I. OVERVIEW OF ELECTRICAL CONTROL SYSTEMS (5 hours, Lecture)</p> <ol style="list-style-type: none"> A. Safety test B. Shop safety <p>II.ELECTRIC CONTROL DEVICES (8 hours, Lecture)</p> <ol style="list-style-type: none"> A. Contactors, relays and transformers B. Thermostats and time clocks C. Pressure controls D. Temperature controls <p>III.ELECTRIC CONTROL DEVICES (9 hours, Lab)</p> <ol style="list-style-type: none"> A. Contactors, relays and transformers B. Thermostats and time clocks C. Pressure controls D. Temperature controls

- E. Heating, Ventilation and Air Conditioning (HVAC) controller board function and wiring

IV. HEATING CONTROL SYSTEMS (7 hours, Lecture)

- A. Fan switches
- B. Limit switches
- C. Electronic control boards
- D. Safety controls
- E. Gas valves
- F. Ignition controls
- G. HVAC controller board I/O commands analysis and test.

V. HEATING CONTROL SYSTEMS (7 hours, Lab)

- A. Fan switches
- B. Limit switches
- C. Electronic control boards
- D. Safety controls
- E. Gas valves
- F. Ignition controls
- G. Controller board flow diagram and function

VI. DIAGNOSE CONTROL SYSTEMS (7 hours, Lecture)

- A. Air conditioning - low and high voltage
- B. Refrigeration - commercial and industrial

VII. DIAGNOSE CONTROL SYSTEMS (8 hours, Lab)

- A. Air conditioning - low and high voltage
- B. Refrigeration - commercial and industrial
- C. Troubleshooting based on ladder diagram flow chart control

VIII. ELECTRIC CONTROL SYSTEMS (7 hours, Lectures)

- A. Single phase diagrams
- B. Three phase diagrams
- C. Designing single and three phase controller circuit

IX. ELECTRIC CONTROL SYSTEMS (8 hours, Lab)

- A. Single phase diagrams
- B. Three phase diagrams
- C. Testing of single and three phase contactor controller

X. SPECIAL CONTROL SYSTEMS (6 hours, Lecture)

- A. Electronic controls
- B. Digital controls
- C. Ladder diagram controls

	<p>XI. SPECIAL CONTROL SYSTEMS (8 hours, Lab)</p> <ul style="list-style-type: none"> A. Electronic controls B. Digital controls C. Compact Disc (CD) simulation of ladder diagrams <p>XII. SUPERVISORY CONTROL SYSTEMS (7 hours, Lecture)</p> <ul style="list-style-type: none"> A. Energy management controls B. Direct Digital Controls (DDC) C. Programmable Logic Controller (PLC) CD simulation for DDC <p>XIII. SUPERVISORY CONTROL SYSTEMS (7 hours, Lecture)</p> <ul style="list-style-type: none"> A. Energy management controls B. Logic controllers and DDC <p>XIV. RETROFIT OF EXISTING SYSTEMS (7 hours, Lecture)</p> <ul style="list-style-type: none"> A. Electro mechanical to electronics <ul style="list-style-type: none"> 1. Analogic controller board 2. Digital PLC microcontrollers B. Standard Heating, Ventilation, Air Conditioning (HVAC) systems <ul style="list-style-type: none"> 1. PLC and ladder diagram replacing controller board C. High efficiency systems <p>XV. RETROFIT OF EXISTING SYSTEMS (7 hours, Lab)</p> <ul style="list-style-type: none"> A. Electro mechanical to electronics <ul style="list-style-type: none"> 1. Ladder diagram controls simulation B. Standard HVAC systems C. High efficiency systems
Total Lecture Hours:	54
Total Laboratory Hours:	54
Total Hours:	108
Primary Method of Evaluation:	3) Skills demonstration
Typical Assignment Using Primary Method of Evaluation:	Create a working electrical model of an air conditioning system. Include the following: written electrical wiring schematic, description of all electrical components and working demonstration. Demonstrate to the instructor for evaluation.
Critical Thinking Assignment 1:	Troubleshoot a faulty air conditioning system with the assistance of a schematic diagram. Following an applicable diagnostic flowchart, demonstrate to the instructor that the system is functioning properly.
Critical Thinking Assignment 2:	Differentiate between a contactor and relay. With the assistance of the instructor, apply voltage to each coil. Use an ohmmeter to properly check whether the contacts are open or closed. On the wiring diagram, show the instructor where the contacts are open or closed.

Other Evaluation Methods:	Quizzes Written Homework Class Performance Homework Problems Multiple Choice Completion Matching Items True/False
Instructional Methods:	Demonstration Laboratory Lecture Multimedia presentations Simulation
If other:	
Work Outside of Class:	Study Skill practice Required reading Problem solving activities
If Other:	
Up-To-Date Representative Textbooks:	Althouse, Turnquist, Bracciano and Bracciano. <u>Modern Refrigeration and Air Conditioning</u> . 22nd edition. Goodheart Willcox, 2025 (Textbook is available in printed text and digital text format.) Transition from the 21st Edition to 22nd edition will start summer 2024 and will be effective fall 2024
Alternative Textbooks:	Max Rablee, Programmable Logic Controllers: Hardware and Programming, 5th Edition, Lab Manual, 2023, Goodheart Willcox Rs Logix 500 from Learning Pit - CD Ladder diagram and PLC programming simulation program
Required Supplementary Readings:	
Other Required Materials:	Safety glasses Safety gloves Workbook
Requisite:	Prerequisite
Category:	sequential
Requisite course(s): List both prerequisites and corequisites in this box.	Air Conditioning and Refrigeration-5
Requisite and Matching skill(s): Bold the requisite skill. List	Troubleshoot and service electrical components in HVACR systems using electrical, electronic and mechanical analysis tools.

the corresponding course objective under each skill(s).	ACR 5 -Troubleshoot HVACR systems with the use of a multimeter. ACR 5 - Measure and record voltages on HVACR systems using a digital voltmeter.
Requisite Skill:	or equivalent
Requisite Skill and Matching Skill(s): Bold the requisite skill(s). If applicable	If a students has taken an equivalent course at another college or have experience in electrical theory, students will have the skills to enroll in this course. It is important that students have experience in electrical control systems and electrical theory to succeed in this course.
Requisite course:	Air Conditioning and Refrigeration-21
Requisite and Matching skill(s):Bold the requisite skill. List the corresponding course objective under each skill(s).	Troubleshoot and service electrical components in HVACR systems using electrical, electronic and mechanical analysis tools. ACR 21 - Diagnose operating and safety controls and switches. ACR 21 - Interpret It is important that students have experience in electrical control systems and apply schematic wiring diagrams for air conditioning applications electrical theory to succeed in this course.
Requisite Skill:	
Requisite Skill and Matching skill(s): Bold the requisite skill. List the corresponding course objective under each skill(s). If applicable	
Enrollment Limitations and Category:	
Enrollment Limitations Impact:	
Course Created by:	Raymond Havrella
Date:	09/01/1987
Original Board Approval Date:	
Last Reviewed and/or Revised by:	HENRY DER ANTONIAN
Date:	10/03/2023
Last Board Approval Date:	06/17/2024 effective FALL 2025