I. INTRODUCTION

A. Principles of electricity as required by HVAC, including proper use of test equipment, electrical circuits, and component theory and operation.

B. Electrical Principles (HART 1401) is a required course for the completion of a two-year Associate of Applied Science degree in Heating, Air Conditioning and Refrigeration or a Certificate of Completion in Residential or Commercial Heating Air Conditioning and Refrigeration. It is also a required course for the completion of a two-year Associate of Applied Science degree in Maintenance Technology or a Certificate of Completion in Building Trades or Carpentry Trades or Construction Trades.

C. This course is occupationally related and serves as a preparation for careers in the Heating, Air Conditioning and Refrigeration and Building Trades career fields.

D. Prerequisite(s): None

E. Alphanumeric coding used throughout the syllabus denotes the integration of SCANS occupational competencies (C) and Foundation Skills (F).

II. LEARNING OUTCOMES

Upon the successful completion of this course, Electrical Principles, the student will:

A. Explain atomic structure and basic values such as voltage, current, resistance, and power. (C5, 6, 7) (F1, 2, 3, 6)

B. Determine electrical values for combination circuits in direct current (DC) and alternating currents (AC) containing resistance, inductance, and capacitance. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

C. Perform electrical continuity, voltage and current tests with appropriate meters. (C5, 6, 7, 15, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
D. Calculate voltage drop based on conductor length, type of material, and size. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

E. Utilize electrical measuring instruments. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

F. Demonstrate electrical safety. (C5, 6, 7) (F1, 2, 3, 6)

G. Identify and use electrical tools and equipment. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

H. Identify electrical circuits. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

I. Define electrical terms. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

J. Explain and use Ohm’s law. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

K. Read electrical schematics and wiring diagrams. (C3, 5, 6, 7) (F1, 2, 3, 8, 9, 10)

L. Wire an electric distribution panel. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

M. Understand the operation of single and three phase power supplies. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

III. INSTRUCTIONAL MATERIALS

A. The instructional materials identified for this course are viewable through www.ctcd.edu/books

B. Supplementary Reading: As assigned by the instructor.

C. References: As selected by the instructor.

D. Audio-Visual Aids:

1. “Multimeters Explained”, #E10, Bergwall (Video) or #DE-10 (CDRom)
2. “Basic Electricity for Air Conditioning”, #832, #1-4, Bergwall (Video)
3. “Electrical Safety”, # E22, Bergwall (Video)
4. “Basic Electricity for Air Conditioning”, #833, #8-15, Bergwall (Video)
5. “Building Trades - Electricity,” Meridian Ed Corp, #V6307 (Video)
6. “Electrical Safety,” Meridian Ed. Corp, #V5193 (Video)
8. “Electrical Principles,” Meridian Ed Corp, #ME5129 (Video)
9. “Electrical Circuits - Ohm’s Law,” Meridian Ed Corp, #ME5134 (Video)
10. “Electrical Components,” Meridian Ed Corp, #V5136 (Video)

E. Other Instructional Materials: As selected by the instructor.
IV. COURSE REQUIREMENTS

A. Your first responsibility is scholarship. The grade you receive will be the result of your efforts both in the classroom and in the laboratory.

B. This course is designed to require a steady, continuous effort from the student. Class participation, initiative and work efforts will be considered in grade computation.

C. Reading and study assignments will be made by the instructor. Reading of all study assignments is required, as well as specific tasks outlined by the instructor or listed on handouts, laboratory activity sheets, or in the student workbook (if used). Specific reading assignments will be assigned by the instructor or in the student workbook if used. Students are required to complete these assignments by the time specified by the instructor. Quizzes may be given on any or all reading assignments.

D. The study of a subject is not limited to the classroom, laboratory, or limits of the syllabus. Each student should seek out and study all available material available on the subject being taught. This might include use of the Internet or the library. In general, two hours of study outside the regular class period is recommended for each hour of classroom work.

E. Students are required to attend class and laboratory sessions regularly. Those who fail to do so may be dropped from the course with a grade of “FN”. During a 16 week semester, it is the policy of Central Texas College to withdraw a student who has five absences and during a 10 week semester withdraw a student who has three absences.

F. Students are required to be present for all examinations. See paragraph V (Examinations) for additional information.

G. Laboratory assignments will be completed on an individual basis except when limited by tools and/or materials. Projects will be subjectively graded by the instructor. When group projects are graded, all students will receive the same grade. Students assigned to a group must be present at all times when the project is being worked on. Students who are not present while a project is in progress will be given a “0” for the project. Students are required to complete all laboratory assignments by the time specified by the instructor.
V. **EXAMINATIONS**

A. There will be a minimum of three major examinations:

1. Three Week Exam
2. Mid Term Exam
3. Final Exam (this is a comprehensive exam)
4. Additional examinations may be given if the instructor determines it is necessary for proper evaluation of the students in the class.

B. **Students must be present for all examinations. Make up examinations will not be given.** Students who know they will be absent on the day of an examination must make arrangements with the instructor prior to the absence. **Students who are absent on the day of the examination due to illness must present to the instructor a note from their doctor.**

C. Students without an excused absence will be given a zero for that examination.

VI. **SEMESTER GRADE COMPUTATIONS**

A. Grade Computation:

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Three Week Exam</td>
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<tr>
<td>Final Exam</td>
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<tr>
<td>Quizzes</td>
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<tr>
<td>Hands On Performance Test</td>
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<tr>
<td>Laboratory</td>
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<tr>
<td>Total Points</td>
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B. Ratio: Points to Grade

<table>
<thead>
<tr>
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<th>Hour</th>
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</thead>
<tbody>
<tr>
<td>900-1000</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>800-899</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>700-799</td>
<td>C</td>
<td>2</td>
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<tr>
<td>600-699</td>
<td>D</td>
<td>1</td>
</tr>
<tr>
<td>0-599</td>
<td>F</td>
<td>0</td>
</tr>
<tr>
<td>Withdrawal</td>
<td>W</td>
<td>0</td>
</tr>
<tr>
<td>Incomplete</td>
<td>I</td>
<td>0</td>
</tr>
</tbody>
</table>
C. Students must take the final examination to receive a grade for the course.

D. Students absent on days a laboratory assignment is presented will lose the points for that laboratory assignment. This point loss may be recovered (only by students having an excused absence) by making up the assignment at a time other than regular class periods. The student must present the excuse to the instructor on the first class day after the absence and coordinate the make up time with the instructor. The project must be completed within four working days after the absence. If the make up is not completed within the allotted time the student will receive a “0” for the project.

VII. NOTES AND ADDITIONAL INSTRUCTIONS FROM THE COURSE INSTRUCTOR

A. Course Withdrawal: It is the student’s responsibility to officially withdraw from a course if circumstances prevent attendance. Any student who desires to, or must, officially withdraw from a course after the first scheduled class meeting must file a Central Texas College Application for Withdrawal (CTC Form 59). The withdrawal form must be signed by the student.

CTC Form 59 will be accepted at any time prior to Friday of the 12th week of classes during the 16-week fall and spring semesters. The deadline for sessions of other lengths is:

10-week session Friday of the 8th week

The equivalent date (75% of the semester) will be used for sessions of other lengths. The specific last day to withdraw is published each semester in the Schedule Bulletin.

A student who officially withdraws will be awarded the grade of “W” provided the student’s attendance and academic performance are satisfactory at the time of official withdrawal. Students must file a withdrawal application with the College before they may be considered for withdrawal.

A student may not withdraw from a class for which the instructor has previously issued the student a grade of “F” or “FN” for nonattendance.

B. Administrative Withdrawal: An administrative withdrawal may be initiated when the student fails to meet College attendance requirements. The instructor will assign the appropriate grade on CTC Form 59 for submission to the registrar.
C. **Incomplete Grade**: The College catalog states, “An incomplete grade (“IP”) may be given in those cases where the student has completed the majority of the coursework but, because of personal illness, death in the immediate family, or military orders, the student is unable to complete the requirements for a course.” Prior approval from the instructor is required before the grade of “IP” for Incomplete is recorded. A student who merely fails to show for the final examination will receive a zero for the final and an “F” for the course.

D. **Cellular Phones and Pagers**: Cellular phones and beepers will be turned off while the student is in the classroom or laboratory.

E. **American’s With Disabilities Act (ADA)**: Disability Support Services provides services to students who have appropriate documentation of a disability. Students requiring accommodations for class are responsible for contacting the Office of Disability Support Services (DSS) located on the central campus. This service is available to all students, regardless of location. Explore the website at [www.ctcd.edu/disability-support](http://www.ctcd.edu/disability-support) for further information. Reasonable accommodations will be given in accordance with the federal and state laws through the DSS office.

F. **Instructor Discretion**: The instructor reserves the right of final decision in course requirements.

G. **Civility**: Individuals are expected to be cognizant of what a constructive educational experience is and respectful of those participating in a learning environment. Failure to do so can result in disciplinary action up to and including expulsion.

H. Absence from the class may be unavoidable in some situations. These include illness or a death in the immediate family. In case of an unavoidable absence, a note from a doctor or funeral home must be presented to the instructor upon the first class attended following said absences.
VIII. COURSE OUTLINE

A. Lesson One: Basic Electricity

1. Learning Outcomes: Upon successful completion of this lesson the student will:

   a. Explain atomic structure and basic values such as voltage, current, resistance, and power. (C5, 6, 7) (F1, 2, 3, 6)
   b. Discuss & demonstrate electrical safety. (C5, 6, 7) (F1, 2, 3, 6)
   c. Identify and use electrical tools and equipment. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   d. Define electrical terms. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   e. Explain and use Ohm’s law. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   f. Understand the operation of single and three phase power supplies. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

2. Learning Activities:

   a. The student will complete reading assignments as assigned (F1, F11, C5, C6).
   b. The student will study the words/terms and complete written assignments specified by the instructor (F1, F11, C5, C6).
   c. The student will attend classroom lectures and participate in classroom discussions (F5, F6, F7, F9, F10, C1, C5, C6, C7)
   d. The student will observe demonstrations performed by the instructor (F5, F10, C5, C6, C14).
   e. The student will complete laboratory learning activities assigned by the instructor. See the laboratory learning activity list attached (F1 thru F17, C1, C3, C5 thru C9, C14 thru 16, C18 thru C20).

3. Equipment and Materials:

   a. TV/VCR
   b. Electrical test instruments
   c. Split A/C system with electric furnace
   d. Electrical circuit devices
   e. Hand tools
   f. Overhead projector (as required)
   g. Other as required by the instructor

4. Audio-Visual Aids: (Recommended)
a. To be selected by the instructor from those listed in Section III D above.
b. Others as selected by the instructor

5. **Lesson Outline:**

a. Introduce the course
b. Annotate class roster
c. Explain work and energy
d. Define units of energy
e. Conservation of energy
   (1) Efficiency
   (2) Structure of matter
      (a) atomic structure
      (b) molecules
      (c) elements
      (d) compounds
   (3) Electrical charge
   (4) Valance electrons
   (5) Free electrons
   (6) Static electricity
f. Charge
   (1) Unit of charge
   (2) Current
   (3) Current in solids
   (4) current in liquids and gases
   (5) Unit of current
   (1) Voltage
      (a) potential energy
      (b) potential difference
   (2) Electromotive force
   (3) Unit of voltage
   (4) Polarity
   (5) Sources of voltage
h. Resistance
   (1) Conductors
   (2) Semiconductors
   (3) Unit of resistance
   (4) Temperature coefficient
   (5) Resistivity
   (6) Resistors
i. Power and energy
   (1) Unit of power
   (2) Efficiency
   (3) Powers of ten
   (4) Multiple and sub-multiple units
   (5) Special unit conversions
j. Circuit essentials
   (1) Circuit symbols and diagrams
   (2) Ohm’s law
   (3) Calculating cost

t. Series-parallel circuit

k. Measuring electrical quantities

l. Batteries and Cells
   (1) Lead acid cells
   (2) Nickel cadmium cells
   (3) Carbon zinc and zinc chloride cells
   (4) Alkaline-manganese dioxide cells
   (5) Mercury oxide cells
   (6) Silver oxide cells

m. Lamps
   (1) Neon
   (2) Light emitting diodes

n. Resistors
   (1) Classification
   (2) Power ratings
   (3) Resistor tolerance
   (4) Color code

o. Switches
   (1) Types and symbols
   (2) Ratings

p. Wire and Cables
   (1) Electrical cables
   (2) Conductor specification
   (3) Insulation

q. Fuses and Breakers
   (1) Shorts and opens
   (2) Multiple load circuits
   (3) Power
   (4) Series
      (a) resistance
      (b) voltage
      (c) voltage drop and polarity
      (d) current
      (e) opens in series
      (f) shorts in series

r. Solving series circuit problems (applications)

s. Parallel circuits
   (1) Resistance
   (2) Voltage
   (3) Voltage drop
   (4) Current
   (5) Solving parallel circuit problems
u. Kirchhoff's law
v. Review for Exam #1
w. Exam #1
B. Lesson Two: Alternating Current Circuits

1. **Learning Outcomes:** Upon the successful completion of this lesson the student will:

   a. Explain atomic structure and basic values such as voltage, current, resistance, and power. (C5, 6, 7) (F1, 2, 3, 6)
   b. Determine electrical values for combination circuits in direct current (DC) and alternating currents (AC) containing resistance, inductance, and capacitance. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   c. Calculate voltage drop based on conductor length, type of material, and size. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   d. Utilize electrical measuring instruments. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   e. Discuss & demonstrate electrical safety. (C5, 6, 7) (F1, 2, 3, 6)
   f. Identify and use electrical tools and equipment. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   g. Identify electrical circuits. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   h. Read electrical schematics and wiring diagrams. (C3, 5, 6, 7) (F1, 2, 3, 8, 9, 10)

2. **Learning Activities:**

   a. The student will complete reading assignments as assigned (F1, F11, C5, C6).
   b. The student will study the words/terms and complete written assignments specified by the instructor (F1, F11, C5, C6).
   c. The student will attend classroom lectures and participate in classroom discussions (F5, F6, F7, F9, F10, C1, C5, C6, C7)
   d. The student will observe demonstrations performed by the instructor (F5, F10, C5, C6, C14).
   e. The student will complete laboratory learning activities assigned by the instructor. See the laboratory learning activity list attached (F1 thru F17, C1, C3, C5 thru 9, C14 thru 16, C18 thru 20).

3. **Equipment and Materials:**

   a. TV/VCR
   b. Hand tools
   c. Central A/C unit w/electric furnace
   d. Electrical circuit devices
   e. Electrical test instruments
   f. Other as required by the instructor
4. **Audio Visual Aids:** (Recommended)
   
a. To be selected by the instructor from those listed in Section III D above.
b. Others as selected by the instructor

5. **Lesson Outline:**

a. **Magnetism**
   - (1) Electromagnetism
   - (2) Magnetic materials
   - (3) Induced voltage
   - (4) Transformer action
   - (5) Magnetic quantities and units
   - (6) Electromagnets
   - (7) Relays and solenoids
   - (8) Meter movements

b. **Alternating current and voltage**
   - (1) Quantifying alternating current
   - (2) Alternating current generators
   - (3) Three-phase alternating circuits

c. **Power in alternating circuits**
   - (1) Power in out-of-phase circuits
   - (2) Phases
   - (3) True power and apparent power
   - (4) Power factor
   - (5) Circuit breaker laboratory exercise

d. Review for Exam #2
e. Exam #2
Lesson Three: Electromagnetism in Alternating Current Circuits

1. **Learning Outcomes:** Upon the successful completion of this lesson the student will:
   a. Explain atomic structure and basic values such as voltage, current, resistance, and power. (C5, 6, 7) (F1, 2, 3, 6)
   b. Determine electrical values for combination circuits in direct current (DC) and alternating currents (AC) containing resistance, inductance, and capacitance. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   c. Summarize the principles of magnetism. (C5, 6, 7) (F1, 2, 9)
   d. Calculate voltage drop based on conductor length, type of material, and size. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   e. Utilize electrical measuring instruments. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   f. Discuss & demonstrate electrical safety. (C5, 6, 7) (F1, 2, 3, 6)
   g. Identify and use electrical tools and equipment. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   h. Identify electrical circuits. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   i. Define electrical terms. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   j. Explain and use Ohm’s law. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   k. Read electrical schematics and wiring diagrams. (C3, 5, 6, 7) (F1, 2, 3, 8, 9, 10)
   l. Wire an electric distribution panel. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)
   m. Understand the operation of single and three phase power supplies. (C5, 6, 7, 15, 18, 19, 20) (F1, 2, 3, 8, 9, 10, 12)

2. **Learning Activities:**
   a. The student will complete reading assignments as assigned (F1, F11, C5, C6).
   b. The student will study the words/terms and complete written assignments specified by the instructor (F1, F11, C5, C6).
   c. The student will attend classroom lectures and participate in classroom discussions (F5, F6, F7, F9, F10, C1, C5, C6, C7)
   d. The student will observe demonstrations performed by the instructor (F5, F10, C5, C6, C14).
   e. The student will complete laboratory learning activities assigned by the instructor. See the laboratory learning activity list attached (F1 thru F17, C1, C3, C5 thru 9, C14 thru 16, C18 thru 20).

3. **Equipment and Materials:**
   a. TV/VCR
b. Hand Tools
c. Central A/C unit w/electric furnace
d. Electrical circuit devices
e. Electrical test instruments
f. Other as required by the instructor

4. **Audio Visual Aids:** (Recommended)
a. To be selected by the instructor from those listed in Section III D above.
b. Others as selected by the instructor

5. **Lesson Outline:**
a. Characteristics of inductance
   (1) Factors that determine inductance
   (2) Types of inductors
   (3) Ratings of inductors
b. Inductors in a DC circuit
   (1) Ideal inductors in an AC circuit
   (2) Real inductors in parallel
   (3) Inductors in series
c. Transformers
   (1) Changing voltage values
   (2) Efficiencies of transformers
   (3) Loaded and unloaded transformers
   (4) Transformer cores
d. Types of transformers
   (1) Power transformers
   (2) Isolation transformers
   (3) Transformer ratings
      (a) ‘volt ampere
   (4) Series and parallel windings
   (5) Three-phase transformers
   (6) Transformer laboratory exercise
e. Capacitor terminology
   (1) Capacitor action
   (2) Voltage ratings
   (3) Unit of capacitance
   (4) Determining capacitance
f. Types of capacitors
   (1) Capacitors in a DC circuit
   (2) Capacitors in an AC circuit
   (3) Power and capacitive reactance
g. Capacitors in series
   (1) Capacitors in parallel
   (2) Detecting faulty capacitors
   (3) Testing capacitors
(4) Uses for capacitors
(5) Capacitor laboratory exercise

h. Component identification
   (1) Air conditioner condensing unit
   (2) Electric furnace
   (3) Gas furnace
   (4) Heat pump outside unit
   (5) Commercial refrigeration condensing unit

i. Review for the Final Exam (This is a comprehensive exam)

j. Final Exam