CTE PROGRAM OF STUDY Secondary & Post Secondary	**Industry Sector:**	Building Trades and Construction
	Career Pathway:	Mechanical Construction
	Program:	HVAC- Community College Major

Levels	Grade	ELA	Math	Science	Social Science	CTE Courses	Other Required Courses	Other Recommended Courses and UC/CSU Requirements
SECONDARY	7					**Career Exploration**		
	8							
	9	**California High School minimum graduation requirements** - History/Social Science *(3 years, including American Government and Economics)* - English *(3 years)* - Math *(2 years)* - Science *(2 years- Biology and Physical Science)* - Visual or Performing Arts or Foreign Language *(1 year required)* - PE *(2 years required)* *Other local requirements as required for graduation E.C. 51225.3* ***Students are encouraged to meet UC/CSU entrance requirements.*				Exploring Building Trades & Construction CBEDS # 5535		
						Assessments, advising, or additional preparation		
	10					Principles of Building Trades & Construction CBEDS # 5537		
						Assessments, advising, or additional preparation		
	11					Mechanical Construction CBEDS # 5534		
						Assessments, advising, or additional preparation		
	12					Heating and Air Conditioning CBEDS # 5516		
						Assessments, advising, or additional preparation		
		** Denotes Articulated and Dual Credit courses. These must be taken and moved to the secondary level for credit purposes.						
POST SECONDARY	13	**Minimum Academic Requirements for AA Degree** *Semester/ Quarter Units- Min per Area* Area A-Natural Sciences (3/4) Area B- Social and Behavior Science (3/4) Area C- Humanities (3/4) Area D - Languages and Rationality (3/4) *Section 3- Ethnic Studies (as required)*				**CTE Sequence- First Semester**	**CTE Sequence - Second Semester**	
						Principles of Mechanical Refrigeration	Heating Systems	
						Electrical Systems	Commercial Systems	
						Measurements & Diagnosis	Technician Testing & Certification	
						Technical Computer Applications	Duct Systems	
	14					System Configuration & Control	Preparing for Employment	
						Occupational Safety	Industrial Science	
						Industrial Math	Digital Concepts	
						Welding/ Metals	Facility Automation	
	15	**Suggested Majors:**				Construction Management Industrial Technology		

Sample Occupations Related to this pathway
Occupations requiring a high school diploma or equivalent
Apprentice Program/ Laborer
Service Technician Helper
Entry Level Parts Distributer/Warehouse Person
Occupations requiring some post secondary
Entry Level Service Technician
Entry Level Installer
Entry Level Control Technician
Occupations requiring 2 year degree
Entry Level HVAC Technician
Contractor or HERS Rater
Entry Level Control Technician
Occupations requiring a BA / BS degree
Engineer
Const/ Manufacturing Manager
CTE Instructor
Quality Control Inspector
Building Inspector

Industry recognized certifications, licenses, credentials/ apprenticeships related to this pathway
Contractor License
Trade Specific License
Union Membership
Bldg. Inspector Cert.
NATE Certificate
EPA- 608 License
RETA Certificate
LEED Certificate

	16	Mechanical Engineer		
		HVACR Engineering Technology		

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 1st SEM.**
Program: **HVAC**

Course Title: **Principles of Mechanical Refrigeration** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Principles of Mechanical Refrigeration A. Atoms and molecules B. Heat energy 1. Heat transfer 2. Units of measurement 3. Sensible and latent heat C. Gas laws D. Heat of compression E. Pressure and evaporation temperatures F. Three physical states II. System Components A. Compressors 1. Types 2. Application 3. Operation B. Condensers 1. Types 2. Application 3. Operation a. De-Superheating b. Condensing c. Sub-cooling C. Metering devices 1. Types 2. Application 3. Operation a. Flow control/pressure drop b. Flash gas/adiabatic expansion D. Evaporators	Refrigerant system components and principles of operation. Refrigerants, temperature pressure relationships, sensible and latent heat transfer in the refrigeration process. Analysis of system operation as a diagnostic tool. 3 units: 3 lec hrs. 18 Weeks.

1. Types
2. Application
3. Operation
    a. Boiling at saturation
    b. Superheating

E. Additional system components
1. Filter dries (liquid and suction)
2. Receiver
3. Sight glass
4. Solenoid valves
5. Accumulators
6. Others

III. Operational Perimeters as Measured by:

A. Pressures
1. Gauge
2. Absolute

B. Temperatures
C. Current draw
D. Discharge superheat
Measurement procedures
E. Liquid sub-cooling
Measurement procedures
F. Suction line superheat
Measurement procedures
G. Condenser temperature rise
H. Evaporator temperature drop
I. Compression ratio
Measurement procedures

IV. Refrigerants

A. Classification by group (1,2 or 3)
B. CFC, HCFC, HFC
C. Ozone depletion factors
D. Application
E. Temperature pressure relationship
F. ID codes (number, color, composition)
G. Replacement refrigerants
1. Azeotropic/zeotropic refrigerants
2. Dew point/bubble point

3. Glide 4. Fractionation H. Refrigerant conversions V. Lubricants A. Types B. Miscibility C. Conversion procedures VI. Evacuation A. Effects of system contamination B. Removal of moisture C. Removal of non-condensable vapor D. Vacuum measurement 1. U tube manometer a. Inches mercury column b. Inches water column 2. Electronic vacuum gauge Microns E. Vacuum measurement and testing 1. Moisture detection 2. Leak detection 3. Proof of tight dry systems F. Evacuation standards 1. Manufacturers recommendations 2. Triple evacuation G. Vacuum pump selection 1. Types 2. Single or two stage 3. CFM (free air) 4. Gas ballast VII. Dynamic system operation A. Effects of: 1. Evaporator load 2. Condenser heat rejection 3. Refrigerant charge 4. Metering device type 5. Operating condition/efficiency of components 6. Efficiency rating equipment (SEER)	

7. CFM vs. temperature rise/drop B. Electrical/mechanical system interaction C. Analysis of system operation D. Troubleshooting procedures VIII. Access Valves A. Types B. Operation C. Installation IX. Tools and Test Equipment A. Manifold gauge set B. Thermometers C. Manometers D. Electronic vacuum gauge E. Electronic sight glass F. Electronic leak detection G. Ultra-sonic leak detection H. Fluorescent leak detection I. Others as related to curriculum	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 1st SEM.**
Program: **HVAC**

Course Title: **Electrical Systems** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Safety: General and trade specific safety information is presented during the first week of instruction. Safety instruction is provided throughout the course as new equipment and tools are introduced. A safety test is administered before lab work is permitted. II. Basic Electricity A. Structure of matter B. Movement of electrons C. Conductors D. Insulators E. Direct/Alternating current F. Electromagnetism III. Measurements A. Voltage B. Amperage C. Resistance (ohms) D. Watts E. Ohms law 1. Resistive loads 2. Inductive loads IV. Basic Circuits A. Circuit components B. Complete circuits C. Factors affecting current flow V. Circuit Types A. Simple circuit B. Series circuit 1. Characteristics of voltage	Theory and application of electrical principles. Single and three phase power, transformers, wiring diagrams, control logic, test instruments, single phase motors and controls. Brazing, evacuation, charging, recovery, wiring and testing of refrigerant systems. 7 units: 5 lec hrs. & 5 lab hrs. 18 Weeks**.**

2. Characteristics of amperage 3. Characteristics of resistance C. Parallel circuit 1. Characteristics of voltage 2. Characteristics of amperage 3. Characteristics of resistance D. Series/Parallel VI. Alternating Current Generation A. Induction B. Single and three phase power C. Sine waves D. Frequency E. Peak voltage F. RMS voltage VII. Transformers A. Mutual induction B. Step up/Step down C. Multi-tap D. VA (KVA) rating E. Maximum load calculations F. VA load test procedures VIII. Power Distribution A. Service transformers 1. Residential 2. Delta 3. Wye 4. Buck boost 5. PUC voltage requirements B. Service panels 1. Wiring (code requirements) 2. Load balancing C. Sub-panels Wiring (code requirements) D. Load centers IX. Electrical Symbols X. Wiring Diagrams A. Pictorial B. Ladder	

XI. Test Instruments
- A. Analog
- B. Digital
- C. Test procedures

XII. Capacitors
- A. Theory of operation
- B. Construction
- C. Types
  1. Run
  2. Start
- D. Voltage ratings
- E. Micro-farad ratings
- F. Effects of wiring in series and parallel
- G. Test procedures
- H. Replacement guidelines
- I. Factors affecting life expectancy

XIII. Single Phase Induction Motors
- A. Construction
- B. Theory of operation
- C. Applications
- D. Shaded pole motors
- E. Split phase motors (ISIR, CSIR)
  Start winding controls
  a. Centrifugal switch
  b. Current relay
  c. Solid state (conversions)
- F. Motor terminal identification
- G. PSC motors
  1. Compressor
  2. Single and multi speed fractional hp.
     Blower control wiring
- H. CSCR motors
  1. Potential relays
     a. Specifications
     b. Back EMF
  2. Adjustable potential relays
  3. PTCR start assist components
- I. Electronically Commutated Motors (ECM)

J. Motor protection K. Motor specifications L. Test procedures XIV. Refrigeration Piping A. Copper tubing 1. Types 2. Sizing 3. Flaring 4. Swaging 5. Preparation B. Brazing and soldering 1. Alloys Application 2. Flux 3. Oxy-acetylene brazing 4. Soldering Lecture is in support of lab. Methods: 1. Lecture 2. Individual Instruction 3. Demonstration 4. Visual Aids 5. Laboratory Assignments 6. Computer Simulations	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 1st SEM.**
Program: **HVAC**

Course Title: **Measurements and Diagnosis** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Safety: II. The Indoor Environment A. Indoor conditions and the human body 1. The cooling process 2. Ambient air temperature 3. Relative humidity Comfort levels for General and trade specific safety instruction is presented during week one of the course. Safety instruction is provided throughout the course as new equipment and tools are introduced. A safety test is administered to each student before lab work is permitted. B. heating & cooling 1. Temperature (dry bulb) 2. Relative humidity 3. Circulation III. Properties of Air Psychrometric chart 1. Dry bulb (DB) 2. Wet bulb (WB) 3. Relative humidity 4. Dew point 5. Saturation temperature 6. Specific volume 7. Density 8. Grains moisture per lb. of air 9. Enthalpy a. Latent heat b. Sensible heat c. Total heat	Diagnosis of the refrigerant systems through the analysis of pressures, temperatures, and current draw. Air flow measurement, analysis of heat content, and test procedures. Use of the volt, ohm and amp meters, manifold gauge, incline manometer, magnehelic gage, pitot tubes, anemometers, digital/sling psychorometer and the psychrometric chart as diagnostic tools. 7 units: 5 lec hrs. & 5 lab hrs. 18 Weeks.

10. State points
11. Process lines
    Process identification

IV. Air Measurements
- A. Static pressure
- B. Velocity pressure
- C. Total pressure
- D. Velocity, feet per minute (fpm)
- E. Volume, cubic feet per minute (cfm)

V. Measurement tools
- A. Pitot tube
  Measurement procedures
    a. Square and rectangular duct (accuracy within 2%)
    b. Round duct (accuracy within 2%)
       Center line method (accuracy within 5%)
- B. Incline manometer
- C. Magnehelic gage
- D. Anemometer
- E. Flow hood
- F. Sling/digital psychrometer

VI. Air Flow Requirements (cfm/ton)
- A. Air conditioning
- B. Heat pumps
- C. Effects of cfm on:
  1. Temperature drop
  2. Temperature rise

VII. Air Volume (cfm) Measurements
- A. External static pressure method
  1. Measurement procedure method
  2. Factors affecting external static pressure
  3. External static vs. manufacturers pressure
- B. Calculated CFM (in duct) derived from:
  1. Velocity (fpm)
     a. Velocity pressure
     b. Air density (lb./cubic ft.)
     c. Calculations
  2. Cross sectional area of duct (sq. ft.)

a. Square and rectangular
b. Round

C. Anemometer
1. Measurement procedures (fpm) at register face.
2. Calculated free area of register surface

D. Flow hood

E. Temperature Rise Method (sensible heating)
1. Heat content of fuel cubic ft.
2. Measurement procedures
3. BTUH input measurement
a. Cubic ft. (natural gas) to BTUH input meas. & calculation
b. Orifice # size @ manifold pressure tables
c. Watt to BTUH equivalent (electrical furnace)
4. Efficiency factors
5. Formulas and calculations

VIII. System Performance and Diagnosis

A. CFM

B. Velocity (throw)

C. Proof of capacity

D. Condensation problems

E. Troubleshooting procedures

IX. Thermostats

A. Types
1. Milli-volt
2. Low voltage
3. Line voltage
4. Micro-electronic Programmable
5. Multi-stage
6. Auto change-over Minimum interlock

B. Sub-bases

C. Temperature sensing and switching
1. Bimetals
a. Snap action contacts
b. Mercury switch
2. Bellows with charged bulb

3. Electronic sensing Thermistors D. Mounting procedures Wiring color codes E. Field wiring controls circuits 1. Single transformer 2. Dual transformer/split systems F. Anticipation 1. Adjustable heat anticipation Current measurement procedures 2. Cooling (fixed) anticipation G. Humidistat X. Charging and System Diagnosis A. Accuracy of system charge vs. efficiency (Btu/h/w) B. Analysis system charge 1. Expected operating pressures based upon: a. Refrigerant type b. Outdoor ambient c. Return air temperature (load) d. SEER rating of equipment e. Metering device type f. Compression ratio g. Application 2. Charging tables a. Head and Suction pressures b. Calculated superheat (cap. tube system) c. Sub-cooling 3. Charging methods by system type C. Measured superheat compared to recommended/required 1. Thermostatic expansion valves 2. Manufacturers recommendations for fixed restrictor D. Running amps compared to full load amps E. Evaporator temperature drop Effect of load on temperature rise F. Condenser temperature rise 1. Air cooled a. Effect of SEER rating b. Effect of reduced air flow	

2. Water cooled G. Percent of active coil H. Analysis of operating conditions 1. Charging 2. Troubleshooting Methods: 1. Lecture 2. Individual Instruction 3. Demonstration 4. Visual Aids 5. Laboratory Assignments 6. Computer Simulations	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 1st SEM.**
Program: **HVAC**

Course Title: **Technical Computer Applications** TOPS: **934** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
Computer literacy (components, operating systems, file management). Word processing (create/modify documents, formatting). Presentation programs (multimedia, modify/enhancing presentations). Spreadsheet program (create/modify spreadsheets, designing charts). Database program (build/modify database, reports, forms). Internet (web browsers and search engines). E-mail (address book, creating/sending messages, and sending messages with attachments.	An introduction to computers, their use, and the development of general computer skills for technical programs. 2 units; 1 lecture hour; 2 lab hours; 18 weeks.

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 2nd SEM.**
Program: **HVAC**

Course Title: **Heating Systems** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Safety: General and trade specific safety instruction is presented during week one of the course. Safety instruction is provided throughout the course as new equipment and tools are introduced. A safety test is administered to each student before lab work is permitted. II. The Combustion Process A. Combustion triangle B. Fuel air ratio C. Flame structure D. By-products of combustion Incomplete combustion III. Fuels A. Natural and propane B. Heat content (BTU/cubic ft.) C. Specific gravity D. Units of measure (therm, gal.) E. Delivery systems IV. Burners A. Types 1. Stamped steel slotted 2. Ribbon 3. Inshot 4. Cast slotted B. Adjustments Primary air C. Maintenance V. Plumbing Requirements	Theory of operation, diagnosis, service and repair of natural and induced draft heaters, condensing furnaces, resistance heaters and heat pumps. Electromechanical and solid state controls, ignition systems, flame sensing, gas controls and venting. 7 units: 5 lec hrs. & 5 lab hrs. 18 Weeks.

A. Shut-off valves B. Drip legs C. Flex connectors, unions D. Cabinet penetrations E. Line size F. Fuel lines 1. Black iron 2. Fletcher (coated) 3. Mega flex/TracPipe VI. Vent systems A. Single wall B. “B” vent C. Triple wall D. PVC, ABS E. Clearance to combustibles VII. Furnace Efficiencies A. AFUE B. Conventional furnace C. Mid efficiency D. Condensing E. Effect on temperature rise VIII. Furnace Configurations A. Upflow B. Downflow C. Low-boy D. Horizontal E. Unit heaters F. Infrared G. Wall and floor IX. Combustion Air Requirements Uniform Mechanical Code X. Heat Exchangers A. Types B. Methods of crack detection XI. Drafting (heat exchangers) A. Natural B. Induced C. Forced	

D. Proof of draft 1. Pressure differential 2. Sail switch 3. Centrifugal switch XII. Gas Controls A. Gas valves Combination valves B. Pressure regulators Adjustments a. Natural b. Propane c. Special settings C. Safeties (shut-off flow controls) XIII. Proof of pilot/flame systems A. Thermocouples, pilot generators B. Bimetals C. Liquid filled (mercury) D. Flame rectification E. Cad cell XIV. Ignition Systems A. Glow coils B. Spark (standing pilot or IID) C. Direct spark ignition D. Hot surface ignition XV. Limit Switches A. Types B. Trip temperatures C. Locations D. Adjustments (differentials) XVI. Blower Controls (time delay) A. Bimetal (insertion) B. Resistance heater w/ bimetal relay C. Electronic XVII. Flame Rectification A. Flame and conductivity B. Theory of flame rectification C. Control logic D. Single and two wire spark/sense circuits	

E. Integrated control modules F. Test procedures XVIII. Heat Pumps A. Theory of operation B. Refrigerant circuit components C. Electrical controls 1. Electromechanical 2. Solid state D. Wiring diagrams and control logic E. Equipment sizing Balance points F. Charging G. Troubleshooting procedures XIX. Resistance Heaters A. Supplementary heat B. Tempered air during defrost C. Wiring diagrams D. Outdoor thermostat settings E. Limits and fused links Lecture is in support of lab. Methods: 1. Lecture 2. Individual Instruction 3. Demonstration 4. Visual Aids 5. Laboratory Assignments 6. Computer Simulations	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 2nd SEM.**
Program: **HVAC**

Course Title: **Commercial Systems** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Safety: General and trade specific safety instruction is presented during week one of the course. Safety instruction is provided throughout the course as new equipment and tools are introduced. A safety test is administered to each student before lab work is permitted. II. Three Phase Motors A. Characteristics of three phase power 1. Sine waves 2. Power factor B. Advantages of three phase motors C. Motor construction D. Dual voltage motors 1. Wye wound (9 lead) 2. Delta wound (12 lead) E. Motor rotation Phase sequencing F. Across the line start vs. part winding start G. Test procedures 1. Ohm meter tests 2. Meg ohm meter a. Test procedures b. Dielectric absorption test c. Analysis of test results 3. Voltage imbalance test procedures a. Voltage imbalance test procedures b. Effect on current imbalance c. Heat and acid formation (hermetic compressors)	Operation and diagnosis of three phase motors, solid state and electromechanical controls and refrigerant flow controls. Sizing of related electrical and gas distribution systems. 7 units: 5 lec hrs. & 5 lab hrs. 18 Weeks.

d. Troubleshooting voltage and current imbalance 4. Motor starting test equipment III. Motor Protection A. Fuses B. Two/three leg protection C. Line/Pilot duty D. Thermal bimetal Ambient compensation E. Starter overload relays F. Thermal and magnetic protection G. Magnetic protection H. External inherent protection I. Tri-block overload protection 1. Heater selection 2. Electronic sensing and controls J. Electronic motor protection Thermistors K. Lock-out relays L. Control strategies Wiring diagrams IV. Thermostatic Expansion Valves (TXV) A. Theory of operation B. Valve construction 1. Internal components 2. Equalization (internal/external) 3. Distributors 4. Nozzles 5. Sweat, flared, flanged C. Power element assembly 1. Normally charged 2. Selective charges 3. Pressure limiting 4. Bulb mounting and insulation D. Balanced port TXV E. Bleed type valve (RBV) F. Solid state controlled expansion valve Thermistor sensor	

- G. Valve capacity and pressure drop
- H. Superheat measurement
  Adjustment procedure

V. Automatic Expansion Valves
- A. Application
- B. Operation
- C. Adjustment

VI. Refrigeration/Commercial Flow Controls
- A. Solenoid valves
  Coil replacement
- B. Evaporator pressure regulator valves
  1. Application
  2. Operation
  3. Adjustment
- C. Crankcase pressure regulator valves
  1. Application
  2. Operation
  3. Adjustment
- D. Head pressure control valves (OROA)
  1. Application
  2. Operation
  3. Adjustment
- E. Hot gas by pass valve (ADR)
  1. Application
  2. Operation
  3. Adjustment
- F. Cylinder uploading
- G. Pressure Operated Water Valve (head pressure)

VII. Electrical controls
- A. High/low pressure controls
  1. Adjustment
  2. Control wiring
- B. Low ambient controls
  1. Fan cycling head pressure control
     a. Adjustment
     b. Control wiring
  2. Electronic fan speed control
- C. Oil pressure failure settings

1. Differential pressure settings
2. Control wiring

D. Defrost cycle timers/controls
Defrost methods

E. Direct digital control (DDC)
1. Point types
2. Control logic
3. Control wiring

F. Energy Management Systems (EMS)
1. Localized
2. Remote
3. Centralized computer control

VIII. National Electrical Code (NEC)

A. Selecting conductor AWG and insulation
1. Resistive loads
2. Inductive loads
Ampacity calculation
3. Ambient compensation
4. Voltage drop calculation

B. Selecting fuses and circuit breakers
1. Resistive loads
2. Inductive loads
Multiple inductive loads

C. Disconnect requirements

IX. Uniform Plumbing Code (UPC)

A. BTU to CFM conversion
Specific gravity other than .60

B. Required gas pipe size (UPC tables)

C. Appliance connectors

D. Underground piping
Depth requirements
a. Fletcher pipe
b. Plastic gas pipe

E. Location and support requirements

F. Inspection and pressure testing

X. Condensate Removal

Methods:
1. Lecture

2. Individual Instruction 3. Demonstration 4. Visual Aids 5. Laboratory Assignments 6. Computer Simulations	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 2nd SEM.**
Program: **HVAC**

Course Title: **Technician Testing and Certification** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. EPA section 608 certification A. Core 1. Stratospheric ozone depletion 2. Ozone depletion potential 3. Clean Air Act 4. Montreal Protocol 5. The three R's 6. Recovery devices 7. Sales restrictions 8. Substitute refrigerants & oils 9. Recovery techniques 10. Dehydration 11. Recovery cylinders 12. Safety 13. Shipping B. Type I Certification 1. Equipment requirements 2. Leak repair requirements 3. Recovery techniques 4. Safety & Shipping C. Type II Certification 1. Leak detection 2. Leak repair requirements 3. Recovery techniques 4. Recovery requirements 5. Safety D. Type III Certification 1. Leak detection 2. Leak repair requirements	Prepares students/technicians for specific HVAC industry competency, licensing and certification examinations. Those exams may include, but are not necessarily limited to, EPA Section 608 (proper refrigerant handling techniques), R-410A safety certification, Air-Conditioning and Refrigeration Institute's (ARI) Industry Competency Exam(s) (ICE) and North American Technician Excellence (NATE) Installation/Service Technician Certification(s). Substantial out-of-class study will be required to prepare for each exam. The exams are an integral part of the course and will be conducted by an approved proctor for each organization. In addition to normal registration fees, all test fees imposed by competency, licensing and certifying organizations are the responsibility of the student. 1 unit: 2 lec hrs. 9 Weeks.

3. Recovery techniques 4. Recharging techniques 5. Recovery requirements 6. Safety II. Refrigerant R-410A Safety Certification A. R-22 Phase-out, R-410A as a replacement 1. Phase-out schedule of HCFC refrigerants 2. R-410A safety considerations B. Refrigeration and Air Conditioning System Operation and Measurements 1. System components and operation 2. Performance measurements and test procedures a. Superheat b. Sub-cooling c. Compression ratio 3. R-410A considerations due to high operating pressures a. Construction of system components b. Service tools and equipment C. Refrigerant chemistry 1. CFCs, HCFCs and HFCs 2. Blends a. Azeotropic refrigerants b. Ternary blends 3. Fractionation 4. Temperature glide D. Refrigeration oils and their application 1. Lubricant groups a. Mineral based lubricants b. Synthetic lubricants 1. Alkylbenzene 2. Polyalkylene glycols (PAGs) 3. Polyol Ester (POEs) E. Refrigerant and lubricant compatibility F. Waste oils III. Industry Competency Exam (ICE) A. Mechanical refrigeration 1. Refrigerant system components 2. The refrigerant cycle	

3. Heat transfer a. Latent Heat b. Sensible heat c. Specific heat 4. System performance and measurements 5. Diagnosis B. Motors and Controls 1. Electrical fundamentals 2. Series and parallel circuits 3. Refrigeration and air conditioning controls 4. Control circuits and test procedures 5. Single phase motor types a. Start winding controls b. Start and run capacitors c. Test procedures 6. Three phase motors C. Heat pumps 1. Refrigerant circuiting 2. Electrical controls D. Gas fired heaters 1. Ignition controls 2. Fuel flow controls 3. Safeties 4. Vent systems 5. Combustion air requirements 6. Test procedures E. Airflow measurement 1. Basic duct system design 2. Psychometrics F. Installation standards and procedures IV. NATE “Core” Exam (NATE core and ICE content overlap) A. Mechanical refrigeration 1. Refrigerant system components 2. The refrigerant cycle 3. Heat transfer a. Latent heat b. Sensible heat c. Specific heat	

4. System performance and measurements 5. Diagnosis B. Motors and Controls 1. Electrical fundamentals 2. Series and parallel circuits 3. Refrigeration and air conditioning controls 4. Control circuits and test procedures 5. Single phase motor types a. Start winding controls b. Start and run capacitors c. Test procedures 6. Three phase motors C. Airflow measurement 1. Basic duct system design 2. Psychometrics D. Safety E. Hazardous materials F. Hand, power and diagnostic tools Methods: 1. Lecture 2. Discussion 3. Demonstration 4. Manufacturers training videos and software	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **13 2nd SEM.**
Program: **HVAC**

Course Title: **Duct Systems** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Safety: General and trade specific safety instruction is presented during week one of the course. Safety instruction is provided throughout the course as new equipment and tools are introduced. A safety test is administered to each student before lab work is permitted. II. Heat Load Calculation/Equipment Selection (Overview) A. Manual J (single family residence) B. Manual S C. Capacity Requirements (field assessment) 1. Square foot/ton 2. CFM/square foot III. Duct System Design (Residential) A. Duct System Layout B. Determining pressure drop 1. Air duct calculator a. Flex duct b. Hard pipe 2. Fittings 3. Grills and registers 4. Filters IV. System Installation (per code requirements) A. Duct system B. Duct leakage testing (duct blaster) C. Equipment installation	Layout, design, installation and testing of duct systems. Basic sheet metal fabrication, soldering and spot welding. Estimating and bidding projects. 3 units: 3 lec hrs. & # lab hrs. 18 Weeks.

D. Fuel connections
E. Electrical connections
    1. Branch circuit
    2. Control wiring
F. Condensate
G. Venting (Split systems)

V. Measuring CFM
A. External static pressure and Mfg. Tables
B. Anemometer
C. Flow Hood

VI. Sheet Metal Fabrication
A. Sheet metal types
B. Pattern drafting (Parallel line development)
C. Hand processes
D. Machine processes
E. Soldering
F. Spot Welding

VII. Job Costing
A. Direct cost
B. Overhead expenses
C. Gross profit
D. Net profit

VIII. Air Filtration
A. Filter types
B. Efficiency standards

Lecture is in support of lab

Methods:
1. Lecture
2. Individual Instruction
3. Demonstration
4. Visual Aids
5. Laboratory Assignments

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **14 1st SEM.**
Program: **HVAC**

Course Title: **System Configuration & Control** TOPS: **946** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
I. Package rooftop configurations A. Economizer 1. Proportional 2. Binary output B. Cooling 1. Proportional 2. Staged C. Heating 1. Proportional 2. Staged II. Terminal unit applications A. Unit ventilator B. Fan coil C. Heat pump III. VAV applications A. Single duct B. Dual duct 1. Pressure independent 2. Pressure dependant 3. Box reheat	Uses energy management software to identify air conditioning system configurations and control strategies. 2 units: 2 lec hrs. 18 Weeks.

IV. Air handlers A. Single path B. Dual path 1. Mixed air control 2. Outside air control 3. Room control (single zone) 4. Return air control 5. Constant discharge air temperature 6. Hot deck, cold deck control 7. Reset of set-points 8. 100% outside air Methods: 1. Lecture 2. Discussion 3. Demonstration 4. Manufacturers training videos and software	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade: **14 1st SEM.**
Program: **HVAC**

Course Title: **Occupational Safety & Health** TOPS: **956.7** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
Introduction to safety: cost of accidents, accidents & efficiency, and growth of the safety movement. Know your accident problems: systematic inspections, legal requirements for safety, unsafe acts, unsafe conditions, and measuring safety performance. Industrial hygiene: chemical agents, physical agents, biological stresses, ergonomics and standard operating procedures. Personal protective equipment: controlling hazards, types of equipment, use of equipment, respiratory protection, and ionizing radiation protection. Materials handling and storage: materials handling problems, lifting & carrying hand & power trucks, and material storage. Guarding machines and mechanisms: principles of guarding, guard design, guarding mechanisms, and lockout procedures. Hand and power tools: control of tool accidents, maintenance & repair, safe use of tools, and portable power tools. Fire prevention and control: determining fire hazards causes of fires, fire extinguishers, and special fire protection problems. Electrical safety: determining electrical hazards causes of electrical hazards, and accident procedures.	Employer and employee responsibility, federal and state legislation, accident reports, industrial hygiene, personal protective equipment, materials handling and storage, hazard communication, guarding machines and mechanisms, hand and portable tools, electrical safety and fire prevention. 2 units; 2 lecture hours; 18 weeks.

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade **14 1st SEM.**
Program: **HVAC**

Course Title: **Industrial Math** TOPS: **1701** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
Arithmetic of Whole Numbers: rounding, estimating, factors, primes, and order of operations. Fractions: adding, subtracting, multiplying, dividing, lowest terms, and comparing. Decimal numbers: adding, subtracting, multiplying, dividing, and decimal fractions. Ratio, Proportion, and Percent: decimal to percent, fractions to percents, percent to decimal, percent to fraction; percent problems-discount, commission, efficiency, tolerances, percentage change; applications of ratio and percentage. Measurement: units, significant digits, precision and accuracy; unit conversions-length, weight, area, volume, speed, temperature; metric to English, English to metric, metric to metric; direct measurements-micrometers, calipers, protractors, gauge blocks. Pre-algebra: signed numbers-addition & subtraction and multiplication & division; exponents and square root; order of operation. Algebra: terms and factors, algebraic expressions, grouping symbols, distributing, factoring, polynomials; solving simple equations involving two operations; solving equations and formulas; word problems; scientific notation. Practical plane geometry: angle measurement; area and perimeter of	Industrial technology and trade- related math problems. The use of signed numbers, algebraic expressions, exponents, polynomials, factoring, algebraic fractions, graphing, radical expressions, quadratic equations and particular emphasis on practical problems common to technical industrial trades. 3 units; 3 lecture hours; 18 weeks.

polygons; triangles, hexagons, and irregular polygons; circles. Solid figures: prisms, pyramids, cylinders/ spheres, and cones. Triangle trigonometry: angles & triangles, radians; trigonometric ratios; solving right triangles; oblique triangles. Advanced algebra: systems of equations-dependent, substitution, elimination, word problems; quadratic equations.	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **14 1st SEM.**
Program: **HVAC**

Course Title: **Exploring Welding/Metals** TOPS: **956.5** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
Welding and Metal Shop Safety: general safety, hand tools, power tools, oxyacetylene equipment, electric arc equipment, and related personal safety. Oxyacetylene Welding: equipment component identification, selecting filler metals, develop fusion welding skills on 16 gauge steel sheet in the flat position, and develop flame cutting skills on steel plate. Shielded Metal Arc Welding: equipment & component identification, selecting proper electrodes, joint types & design and develop welding skills on steel in the flat position with E6010, E7024, E7018, & ER70S-6 electrodes. Tools and Materials Identification: name and uses of welding fabrication tools; identification and properties of different metals. Introduction to Gas Metal Arc (MIG) Welding: equipment and component identification; joint types and design; develop welding skills on steel in the flat position with ER70-6 electrodes. Methods of working with metals other than welding: drill press and portable electric drills; box and pan break; shears/iron worker; grinders; other related equipment. Careers and Higher Education: welding trades & industry and	An introduction to oxyacetylene and shielded metal arc welding in the flat and horizontal positions, along with other methods of joining steel together. An emphasis on safety and developing good manipulative skill. Includes information on cutting, brazing, and an introduction to the MIG process. 3 units; 2 lecture hours; 3 lab hours; 18 weeks.

engineering & related degree programs.	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **14 2nd SEM.**
Program: **HVAC**

Course Title: **Preparing for Employment Opportunities** TOPS: **4930.12** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
Importance of human relationships and attitude in employment. Building and maintaining a positive attitude. Vertical and horizontal working relationships. Productivity in employment. Understanding the nature of relationships. Success as a team player. Stress management techniques. Restoring injured relationships. Succeeding in a new job or assignment. Coping with teasing and testing. Absenteeism and human relations. Human relations mistakes. Ethics. Goal setting, attitude, promotion opportunities. Application forms, letters of application, and follow-up letter. Resume preparation. Career planning. Videotaped interview.	Preparing resumes, portfolios, and improving employment seeking skills. 3units; 3 lecture hours; 18weeks.

Interview with person in student's chosen field.	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **14 2nd Sem.** Program: **HVAC**

Course Title: **Industrial Science** TOPS: **1901** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
What is physics: study of matter and energy; mathematical review? Precision instruments: standards for length, mass, and time; conversions of units; compare the Metric and English system of measurements; Metric and English system problems; accuracy in measurements and computations. Force: mechanical systems (force, vector analysis, and torque); fluid systems (pressure and pressure difference, density, and specific gravity); electrical systems (voltage and voltage difference, charge, cells, and batteries); thermal systems (temperature, temperature difference, and heat). Work: mechanical systems (force x distance, linear, angular and radians); fluid system (pressure difference X volume displacement); electrical systems (voltage difference X charge moved). Rate: mechanical system (speed, velocity, and acceleration); fluid system (volume and time); electrical system (electric charge and time); thermal system (thermal conductivity, heat flow rate, specific heat, heat and time). Resistance: mechanical systems (dry, wet, static, kinetic, rolling friction and lubricants); fluid systems (drag, turbulent and laminar	Force, work, resistance, energy, power, force transformers, energy converters, and transducers in the mechanical, fluid, electrical and thermal systems. Applications to the trades. 3units. 3 lec. hours. & 1 lab. hour. 18 weeks.

flow); electrical systems (Ohm's Law, series and parallel resistance and resistivity); Thermal systems (insulating and conducting materials). Energy and conservation of energy: mechanical and fluid energy (potential and kinetic); electrical systems (capacitance, magnetic fields and inductors); thermal systems (heat engines and thermal dynamics). Power: mechanical systems, fluid systems, and electrical systems. Momentum (impulse, inertia, elastic, inelastic collisions and conversion of momentum): linear and angular. Waves and vibration: properties and wave interactions. Radiation Transducers: electromagnetic and nuclear. Light and optical systems: reflection and refraction; interference and diffraction; laser light.	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade: **14 2nd Sem.**
Program: **HVAC**

Course Title: **Digital Concepts** TOPS: **934** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
Introductory concepts: numerical representations, digital number systems, and analog versus digital. Number systems: number conversion, base numbering systems, and ASCII. Logic gates and Boolean Algebra: truth tables, logic gates (TTL technology), logic states, logic circuit expressions, Boolean Algebra, and DeMorgan theorem. Combinational logic: sum of products, K map, and parity bit & error detection. Digital arithmetic: binary addition, 2's complement, and half & full adders. Logic circuits: decoders, encoders, multiplexers, demultiplexers and 7 segment display. Clocked circuits: flip flops, registers, and memory devices.	Introduction to digital systems and subcomponents. Introduction to analog vs. digital world, numbering systems, logic gates, digital transmission and communication, decoders, encoders, multiplexer and multiplexed transmission, registers and memory devices, as well as, digital circuit design on computers. 3 units; 3 lecture hours; 1 lab hour; 18 weeks.

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades/Construction** Career Pathway: **Mechanical Construction** Grade Level: **14 2nd Sem.**
Program: **HVAC**

Course Title: **Facility Automation** TOPS: **934** School: **Fresno City College** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
1. Identify various types of systems used in commercial buildings. 2. Describe HVAC control strategies. 3. Program controllers that interface to lighting, security peripherals, and networking equipment used in commercial building automation. 4. Identify codes and agencies that govern building automation technologies. Expanded Description of Content and Methods: I. Basic standards and practices II. Facility issues III. Cable ratings IV. Industry standards V. Telephone system VI. Security systems VII. Video systems VIII. Networking systems	Facility automation fundamentals identifying various aspects of the control systems within a commercial building. 3 units: 3 lec hrs. & 1 lab hr. 18 weeks.

IX. Blueprint reading	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades & Construction** Career Pathway: **Heating & Air Conditioning** Grade Level: **9th**

Course Title: **Exploring Building Trades & Construction** CBEDS: **5535** School: **Secondary** (Sample template)

Critical Course Competencies/Skills/Concepts	Course Description
1. Identify design solutions to given mechanical construction problems. (C1.1) 2. Calculate the required equipment and materials for mechanical construction problems. (C1.2) 3. Apply conventional construction measurement processes accurately (geometric and trigonometric functions) (C1.4) 4. Maintain and care for the common hand tools used in mechanical construction (C2.2) 5. Understand the sequencing of events for a specific construction project. (C4.3) 6. Understand the phases of mechanical construction, such as rough and finish, electrical, sheet metal ducting, and HVAC installation. (C6.3) 7. Understand significant historical trends in the construction industry. (C7.1) 8. Understand hand and portable power tool identification and tool safety. 9. Research colleges and requirements for majors needed for Building Trades. 10. Research job titles in Building Trades to see job requirements, type of work done and salaries paid.	This course represents a contextualized, laboratory-based, integrated curriculum opportunity for all high school students to learn about communication, transportation, energy, production, biotechnology, and integrated technology systems and processes that affect their lives. Students develop critical thinking skills through a variety of multi-modal, problem-solving techniques. Integrated content focuses on demystifying technology; increasing student literacy, confidence, and competence in an age of rapidly advancing technology; and providing students with the basis for making wise academic and career choices. 2 semesters, 1 year

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades & Construction** Career Pathway: **Heating & Air Conditioning** Grade Level: **10th**

Course Title: **Principles of Building Trades & Construction Technology** CBEDS: **5537** School: **Secondary** (sample template)

Course Competencies/Skills/Concepts	Course Description
Identify design solutions to given mechanical construction problems. (C1.1) 1. Calculate the required equipment and materials for mechanical construction problems. (C1.2) 2. Apply conventional construction measurement processes accurately (geometric and trigonometric functions) (C1.4) 3. Solve common mechanical construction problems by using UBC and Air Conditioning Institute Standards. (C4.4) 4. Understand the safe use of electrical materials and electrical connection procedures(C5.1) 5. Use a vector diagram to determine the resultant forces. 6. Measure specific gravity of a liquid with a hydrometer 7. Measure pressures below atmospheric pressure with a manometer and a mechanical pressure gage. 8. Use a multimeter to measure voltages, current and resistance by selecting proper setting for the function switch and range switch. 9. Measure the pump work required to lift a given volume of water a given height, using the fluid work formula.	This course is designed for students planning technical careers. Each of the units deals with one principle as it applies in the four energy systems (mechanical, fluid, thermal, and electrical) that provide power for both simple and complex technological devices and equipment. The units also cover the mathematics needed to understand and apply the principles. 2 semesters, 1 year

10. Use an oscilloscope to measure the period and amplitude and determine the frequency of an electrical signal. 11. Understand Ohm's Law and be able to calculate voltage, current and resistance in series, parallel and series-parallel circuits.	

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades & Construction** Career Pathway: **Heating and Air Conditioning** Grade Level: **11th**

Course Title: **Mechanical Construction** CBEDS: **5534** School: **Secondary** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
1. Identify design solutions to given mechanical construction problems. (C1.1) 2. Calculate the required equipment and materials for mechanical Construction problems. (C1.2) 3. Apply conventional construction measurement processes accurately (geometric and trigonometric functions) (C1.4) 4. Solve common mechanical construction problems by using UBC and Air Conditioning Institute Standards. (C4.4) 5. Understand the safe use of electrical materials and electrical connection procedures(C5.1) 6. Use portable pneumatic tools, such as rough framing nail guns, interior finishing and brad nail guns, hammers, impact wrenches, drills, and compressors, safely and appropriately. (C3.2) 7. Know the importance of customer/relations as applied to project management and wholesale and retail sales.(C4.6) 8. Understand processes and materials appropriate to architectural design and mechanical construction (e.g., structural, electrical, mechanical, and finish phases). (C6.2)	This pathway prepares students for careers in plumbing, electrical, heating, ventilation, air-conditioning (HVAC). This pathway also includes instruction in how these systems work in structures. Students' participation in the SkillsUSA club is a planned and graded component in all courses in this category. 2 semesters, 1 year

CTE PROGRAM OF STUDY

Industry Sector: **Building Trades & Construction** Career Pathway: **Heating and Air Conditioning** Grade Level: **12th**

Course Title: **Heating and Air Conditioning** CBEDS: **5516** School: **Secondary** (sample template)

Critical Course Competencies/Skills/Concepts	Course Description
1. Apply conventional construction measurement processes accurately (geometric and trigonometric functions) (C1.4) 2. Know the use of conventional construction formulas to determine production requirements, such as converting linear measures to volumetric measures and calculating voltage drop/power requirements (electrical), by using specifications in the National Electrical Code. (C1.5) 3. Use portable power tools, such as reciprocating saws, drills, threaders, and benders, safely and appropriately. 4. Understand the sequencing of events for a specific construction project. (C4.3) 5. Solve common mechanical construction problems by using UBC and Air Conditioning Institute Standards. (C4.4) 6. Know the importance of customer/relations as applied to project management and wholesale and retail sales.(C4.6) 7. Understand the safe use of electrical materials and electrical connection procedures(C5.1) 8. Understand processes and materials appropriate to architectural design and mechanical construction (e.g., structural, electrical, mechanical, and finish phases). (C6.2) 9. Understand the phases of mechanical construction, such as rough and finish, electrical, sheet metal ducting, and HVAC installation. (C6.3) 10. Understand significant historical trends in the construction industry. (C7.1) 11. Understand environmental regulations that influence mechanical design. (C7.3) 12. Understand and recognize indoor air quality issues and	This instructional program prepares individuals to install, operate, test, repair, and maintain commercial and domestic heating and air-conditioning systems. Students' participation in the SkillsUSA club is a planned and graded component in this course. 2 semesters, 1 year

regulations. (C7.4)	