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| **TEXAS CTE LESSON PLAN**[www.txcte.org](http://www.txcte.org) |
| **Lesson Identification and TEKS Addressed** |
| **Career Cluster** | Law, Public Safety, Corrections, and Security |
| **Course Name** | Firefighter I |
| **Lesson/Unit Title** | Physical States of Matter and the Combustion Process |
| **TEKS Student Expectations** | **130.334. (c) Knowledge and Skills**(6) The student describes the stages of a fire, the process of combustion, and the appropriate action to be taken for extinguishment. (B) The student is expected to define terms such as fire, flash point, ignition temperature, fire point, flammable (explosive) range, boiling point, oxidation, pyrolysis, reducing agent, vaporization, combustion, vapor density, and specific gravity(D) The student is expected to define fire triangle and fire tetrahedron(E) The student is expected to describe heat energy sources such as chemical, electrical, mechanical, and nuclear (G) The student is expected to explain the special conditions that occur during a fire's growth such as flame over, rollover, flashover, thermal layering, and backdraft (H) The student is expected to identify the units of heat measurement and how to convert units(7) The student describes the methods of heat transfer. (A) The student is expected to describe methods of heat transfer such as conduction, convection, and radiation (B) The student is expected to describe examples of heat transfer in fire emergencies such as conduction, convection, and radiation(8) The student analyzes the physical states of matter in which fuels are commonly found. (A) The student is expected to describe the physical states of matter in which fuels are commonly found such as solid, liquid, and gaseous fuels |
| **Basic Direct Teach Lesson**(Includes Special Education Modifications/Accommodations and one English Language Proficiency Standards (ELPS) Strategy) |
| **Instructional Objectives** |

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| The student will be able to: |
|  | 1. Describe the stages of fire |
|  | 2. Explain the process of combustion |
|  | 3. Identify the methods of heat transfer |
|  | 4. Differentiate the physical states of matter in which fuels are commonly |
|  | found |

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| **Rationale** | Understanding how fuel characteristics and their physical states affect the combustion process, extinguishing methods, burning rates, and ignition is important knowledge for firefighters. The more they understand the more effective they will be in accomplishing their goals. Firefighting is inherently dangerous, and the more a firefighter learns to prepare themselves for the experience, the more effective and efficient they become. |
| **Duration of Lesson** | 3 hours |
| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* |  |
| **Materials/Specialized Equipment Needed** | * Computer/Projector
* Physical States of Matter and the Combustion Process Quiz
* Physical States of Matter and the Combustion Process Quiz Key
* Discussion Rubric
* Internet access
* College and career planning guides (career cruising)
* Firefighter professional journals and magazines
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | Engage students in a discussion relating fuel characteristics, their physical states, and the combustion process. Explain how vapor density, specific gravity, and surface-to-mass ratio can affect strategies and tactics used in fighting fire and mitigating hazardous materials incidents. Use documented experiences from fire service professional journals, or draw from the instructor’s experience if possible. Use the Discussion Rubric for assessment. |
| **Direct Instruction \*** |

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| I. Fire/Combustion Defined |
| A. Fire: rapid, self-sustaining oxidation accompanied by heat and light |
| in varying intensities |
| B. Combustion: a chemical reaction that releases energy as heat and |
| usually light |
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| II. Fire Triangle |
| A. Fuel |
| B. Heat (energy) |
| C. Oxidizer (air) |
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| III. Fire Tetrahedron |
| A. Fuel |
| B. Heat (energy) |
| C. Oxidizer (air)D. Chemical Chain Reaction |

IV. Chemistry of Fire1. Oxidizers
	1. Oxygen is the most common
		1. Occurs as 21% of air
		2. Increasing the amount of an oxidizer may increase the intensity of the fire.
		3. Other oxidizers
			1. fluorine
			2. chlorine
	2. Fuels
		1. Fuel occurs in the three states of matter: solid, liquid, and gas.
		2. The state is often temperature-dependent.
		3. The fuel and the oxidizer must be in gaseous states to combine.
		4. The fuel is vaporized by input heat in a process called pyrolysis.
		5. The most common fuels contain carbon and hydrogen.
		6. Complete combustion yields H20 and CO2.
		7. Most combustion is incomplete, producing smoke, CO, and other fire gases.

V. Physics of Fire* 1. Pyrolysis
		1. Pyrolysis is a chemical change brought about by heat.
	2. Solid fuels
		1. As heat is added to solid fuels, the molecules are broken down into smaller components that vaporize and recombine with the oxidizer.
		2. When the fuel is hot enough to self-sustain combustion, it is at its ignition temperature.
		3. The size, arrangement, continuity, and moisture content of the solid fuel can affect the rate of pyrolysis.
	3. Liquid fuels
		1. Factors affecting liquid fuels:
			1. Flow like water but do not readily separate
			2. Specific Gravity: the weight of the liquid compared to the weight of an equal volume of water
			3. Boiling Point: when the vapor pressure equals atmospheric pressure
			4. Volatility: the ease at which the liquid gives off vapors at ambient temperatures
			5. Flash Point: the minimum temperature at which a liquid gives off vapors sufficient to form an ignitable mixture with air
			6. Miscibility: the ability of the liquid to mix with water
	4. Gaseous fuels
		1. Tend to expand indefinitely
1. Flammable Limits/Flammable Range: the fuel mixture can be too rich or too lean to burn
2. Classification: flammable or nonflammable
3. Some nonflammable gases support combustion: oxygen is an example
4. Flammable vapors are not always visible

VI. Heat and Temperature1. Sources of heat energy:
	1. Chemical
	2. Mechanical
	3. Electrical
	4. Nuclear
2. British Thermal Unit
	1. The amount of heat needed to raise the temperature of 1 pound of water by 1 degree Fahrenheit
3. Calorie
	1. The amount of heat needed to raise the temperature of 1 gram of water by 1 degree Celsius

VII. Heat Transfer1. Three (3) methods of heat transfer:
	1. Conduction: through a medium without visible motion
	2. Convection: through a circulating medium (liquid or gas)
	3. Radiation: by wavelengths of energy
2. Direct Flame Contact is a combination of the three methods of heat transfer as objects are bathed in flames

VIII. Classification of Fires1. Class A: ordinary combustibles
2. Class B: flammable liquids (gases)
3. Class C: energized electrical equipment
4. Class D: flammable metals
5. Class K: cooking materials (cooking oils/fats/grease)

IX. Stages/Phases of Fire1. Incipient stage: oxygen at 21%, flame temperature 180 degrees F – 220 degrees F. The heat has not spread to other fuels nearby
2. Growth stage: early stage of a fire; availability of fuel and oxygen is unlimited. Characterized by rapid increase of heat (temperature)
3. Fully Developed: energy release is at a maximum rate and limited only by the availability of fuel and/or oxygen
4. Decay: when much of the fuel has been consumed, the energy being released has diminished, and the temperature decreases. In this stage, the fire goes from ventilation-controlled to fuel-controlled

X. Related terminology* 1. Flashover: phenomena in which all surfaces and objects in a fire have been heated to their ignition temperature and ignite
	2. Backdraft: an instantaneous explosion or rapid burning of superheated gases that occurs when oxygen is introduced into an oxygen-depleted space
	3. Rollover/Flame over: phenomena where unburned gases accumulated at the top of a compartment ignite and flames spread across the ceiling

*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Guided Practice \*** | Students demonstrate how the fire triangle is directly related tonon-flaming/smoldering fires, and how the 4th component of the fire tetrahedron (chemical chain reaction) is directly related to extinguishing fires in a flaming mode. This may be done in an extinguisher demonstration controlled and monitored by the local fire department, using appropriate extinguishers to extinguish a smoldering fire and a flaming fire.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Independent Practice/Laboratory Experience/Differentiated Activities \*** | Students compare and contrast the similarities and differences between a fire triangle and a fire tetrahedron, then write a summary. This may also be done by building two- and three-dimensional models to show the different components. Use the Summary Rubric for assessment.*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **Lesson Closure** |  |
| **Summative/End of Lesson Assessment \***  | Physical States of Matter and the Combustion Process Quiz and KeyDiscussion RubricSummary Rubric*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:***Accommodations for Learning Differences:** For reinforcement, students will participate in peer teaching (mentoring), team learning, guided research, and note taking (web based), and/or keep journals with key words and definitions. |
| **References/Resources/****Teacher Preparation** | 1418001775, *Introduction to Fire Protection* (3rd Edition), Klinoff, Robert0879392886, *Essentials of Firefighting* (5th Edition), IFSTA |
| **Additional Required Components** |
| **English Language Proficiency Standards (ELPS) Strategies** |  |
| **College and Career Readiness Connection[[1]](#footnote-1)** | English Language Arts1. Reading

B. Understand new vocabulary and concepts and use them accurately in reading, writing, and speaking.* + 1. Identify new words and concepts acquired through study of their relationships to other words and concepts.
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| **Recommended Strategies** |
| **Reading Strategies** |  |
| **Quotes** |  |
| **Multimedia/Visual Strategy****Presentation Slides + One Additional Technology Connection** |  |
| **Graphic Organizers/Handout** |  |
| **Writing Strategies****Journal Entries + 1 Additional Writing Strategy** |  |
| **Communication****90 Second Speech Topics** |  |
| **Other Essential Lesson Components** |
| **Enrichment Activity**(e.g., homework assignment) | For enrichment, students will participate in a fire extinguisher demonstration controlled and monitored by the local fire department, or other fire protection service employer |
| **Family/Community Connection** |  |
| **CTSO connection(s)** | SkillsUSA |
| **Service Learning Projects** |  |
| **Lesson Notes** |  |

1. Visit the Texas College and Career Readiness Standards at <http://www.thecb.state.tx.us/collegereadiness/CRS.pdf>, Texas Higher Education Coordinating Board (THECB), 2009. [↑](#footnote-ref-1)