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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** | Fire Behavior |
| **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.(C) The student is expected to describe the process of thermal layering that occurs in structural fires and how to avoid disturbing the normal layering of heat(G) The student is expected to explain the special conditions that occur during a fires growth such as flame over, rollover, flashover, thermal layering, and backdraft  |
| **Basic Direct Teach Lesson**(Includes Special Education Modifications/Accommodations and one English Language Proficiency Standards (ELPS) Strategy) |
| **Instructional Objectives** | The student will be able to:1. Understand basic fire behavior
2. Identify the stages of fire development
3. Explain the visual indicators of a backdraft
4. Check a door for heat safely while donning personal protective equipment (PPE)
5. Check the heat level in a room safely while donning PPE
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| **Rationale** | Firefighters need to understand fire and its behavior to anticipate fire conditions (during development and extinguishment) that may change rapidly and risk firefighter safety. Some conditions require a reassessment of strategies and tactics to accomplish the action plan. |
| **Duration of Lesson** | 3 to 6 hours |
| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* |  |
| **Materials/Specialized Equipment Needed** | * Computer with Internet access, projector, and screen
* Computers with computer-based presentation software
* One poster board (for two students) or card stock paper
* Pencils, colors, markers, or other drawing materials
* Personal protective equipment (PPE)
* Fire Behavior Key Terms Handout
* Fire Behavior Quiz and Key
* Fire Behavior Key Terms Quiz and Key
* Fire Behavior Skill Rubric: Checking a Door for Heat
* Fire Behavior Skill Rubric: Checking for Heat Level in a Room
* Discussion Rubric
* Individual Work Rubric
* Presentation Rubric
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | Have the students watch backdraft training videos. (*Note:* To find the videos conduct an Internet search for the following key words: “Backdraft Training Part One CTFireCop” and “Backdraft Training Part Two CTFireCop.”) After watching the videos, facilitate a class discussion about the importance of understanding fire behavior using the following questions:* How can recognizing potential hazards completely change a firefighter’s plan of action?
* What are the possible consequences of failing to recognize changes in fire behavior?
* What is the point of no return in a flashover?
* How could recognizing rollover save lives?

Use the Discussion Rubric for assessment. |
| **Direct Instruction \*** | 1. Fire Development in a Compartment
	1. Compartment – an enclosed room or space within a building
		1. In an unconfined compartment, heat dissipates
		2. In a confined compartment, heat is absorbed by the walls, ceiling, floor, and other objects in the compartment
		3. Heat transfer – raises the temperature of all the materials in the compartment until they begin to pyrolyze
			1. Pyrolysis – the chemical decomposition of a substance through the action of heat (IFSTA, 2008)
		4. Ventilation-controlled – the term used to describe a fire when the air supply limits fire development
	2. Factors that affect fire development
		1. Fuel type
		2. Availability of an air supply
		3. Availability and proximity of additional fuel
		4. Compartment geometry (i.e. volume and ceiling height)
		5. Ventilation and changes in ventilation
		6. Thermal properties of the enclosure
		7. Ambient conditions (e.g. wind, temperature, humidity, etc.)

II. Stages of Fire Development in a Compartment* 1. Incipient Stage
		1. Is the first stage of the burning process
		2. Requires ignition – the moment when the three elements of the fire triangle (fuel, air, and heat) come together and combustion occurs
			1. Piloted ignition
			2. Non-piloted ignition
			3. Spontaneous ignition
		3. Includes the following characteristics
			1. The fire is small and confined to the initially ignited material
			2. A plume of hot gases and flame rise from the fire and mix with the cooler air within the room (convection)
			3. As the plume reaches the ceiling, hot gases begin to spread horizontally across the ceiling with a “mushrooming” effect
			4. Hot gases that are in contact with the surfaces of the compartment and its contents conduct heat to other materials (conduction)
			5. The fire has not yet influenced the environment to a significant extent
		4. Is when occupants can safely escape and the fire can be safely extinguished with a portable extinguisher
		5. Transitions to the growth stage at a rate dependent upon the type and configuration of the fuel involved
	2. Growth Stage
		1. General Information
			1. The early stage of a fire during which fuel and oxygen are virtually unlimited
			2. Includes the following characteristics
				1. A rapidly increasing release of heat
				2. The fire begins to influence the environment within the compartment
				3. As the wall surfaces become hot, burning fuel receives more reflected radiant heat (radiation), which further increases the speed of fire development
		2. Thermal layering
			1. Heated gases tend to separate into layers according to temperature
			2. The difference in density between the hot smoke and the cooler air causes them to separate into two distinct layers

(1) The hottest gasses are found at the ceiling* + 1. The coolest gases are found at the floor
	1. Synonymous terms
		1. Heat stratification
		2. Thermal balance
	2. Firefighters want to maintain the level of the hot gas layer at the ceiling or raise it above the floor to provide a more tenable environment for themselves and trapped occupants
	3. This action requires the effective application of fire control and ventilation tactics
1. Isolated flames
	1. Pockets of flames may be observed moving through the hot gas layer (ghosting)
	2. Ghosting is
		1. Classified as a fire gas ignition
		2. May be an indicator of developing flashover conditions
2. Rollover
	1. The condition when unburned fire gases accumulate at the top of a compartment and ignite, propagating flames through the hot gas layer or across the ceiling
		1. Superheated gases are pushed (under pressure) away from the fire area into the uninvolved areas, where they mix with oxygen
		2. When the gases reach their flammable range and additional oxygen is supplied (e.g. by opening doors and/or applying fog streams), they ignite and expand very rapidly in a rolling action across the ceiling
		3. Generally, a rollover precedes a flashover, but rollovers do not always result in flashovers
	2. Similarities with ghosting include that it is
		1. Classified as a fire gas ignition
		2. A significant indicator of an impending flashover
3. Flashover
	1. The rapid transition between the growth stage and the fully developed stage
	2. The conditions in the compartment change very rapidly from partial to full involvement
	3. When a flashover occurs, burning gases push out of the compartment’s openings at a substantial velocity
	4. Indicators of flashover
		1. Smoke – the presence of hot gases overhead and the lowering of the hot gas layer are key indicators for firefighters within the compartment
			1. May or may not be visible from the exterior
			2. Remember, smoke is unburned fuel that is ready to ignite
		2. Air flow – any air flow that moves toward the fire can result in flashover
			1. Heat – rapidly increasing temperature is frequently a late indicator
			2. Flame – may or may not be visible
			3. Building type – is not an indicator, but building factors can influence how quickly a fire will reach flashover
		3. Flashover – when the temperature in a compartment results in the simultaneous ignition of all of the combustible contents in the space (IFSTA, 2008)
		4. The temperature range is from 900°F to 1200°F
			1. Auto-ignition temperature of carbon monoxide (CO) is 1128°F
4. Fully Developed Stage
	1. The stage of the burning process when energy release is at the maximum rate and is limited only by the availability of fuel and oxygen (IFSTA, 2008)
	2. Includes the following characteristics
		1. All of the combustible materials in the compartment are burning
		2. The burning fuels in the compartment are releasing the maximum amount of heat possible for the available fuel and ventilation
		3. The fire is considered ventilation-controlled because the heat release is dependent upon the compartment’s openings
		4. Hot unburned gases are likely to flow from the origin compartment to the adjacent compartments or the exterior
5. Decay Stage
	1. Consumption of fuel
		1. A fire enters the decay phase when it consumes the fuel available in the compartment and its rate of heat release declines
			1. The fire’s classification changes from ventilation-controlled to fuel-controlled
			2. Temperature in the compartment may remain high for a significant amount of time
		2. Flammable products of combustion that have accumulated can be ignited and result in a smoke explosion
	2. Limited Ventilation
		1. Fire enters the decay stage due to a lack of oxygen
		2. Heat release also declines
		3. A continuing combustion reaction may maintain an extremely high temperature within the compartment
		4. A large volume of flammable products of combustion can accumulate within the compartment
			1. They can ignite explosively when mixed with additional air, which results in backdraft
	3. Backdraft
		* 1. An instantaneous explosion or rapid burning of superheated gases that occurs when oxygen is introduced into an oxygen-depleted, confined space
			2. The stalled combustion resumes with explosive force
			3. Occurs during ventilation-controlled fires because of
				1. Inadequate or improper ventilation procedures
				2. An increase in ventilation
			4. The mixture of flammable products can be well above their flammable limits
			5. High temperatures remain
			6. The more confined the air/fuel mixture is, the more violent the backdraft
			7. Pre-backdraft indicators
				1. Low oxygen
				2. High heat
				3. Smoldering fire
				4. High fuel-vapor concentrations
			8. Common indicators of the potential for a possible backdraft
				1. Confined or excessive heat in windowless buildings
				2. Inwardly drawn smoke (sucking phenomenon)
				3. Little or no visible flame
				4. Smoke leaving the building in puffs
				5. Black smoke becoming dense gray-yellow
				6. Pressurized smoke exiting small openings
				7. Smoke stained windows with heat-induced cracking of glass
			9. When potential backdraft conditions are encountered, firefighters should delay entry until after action is taken to change the conditions inside the building or compartment
				1. Gas cooling with hose streams
				2. Vertical ventilation
			10. Effects of a backdraft can vary considerably depending on several factors
				1. Volume of flammable products of combustion
				2. Degree of confinement
				3. The speed with which fuel and air are mixed
				4. Where ignition occurs

III. Fire Control Theory* 1. Fire Control Theory – fire is controlled and extinguished by limiting or interrupting one or more of the essential elements in the combustion process (fire tetrahedron)
	2. Temperature Reduction (heat)
		1. Cooling with water
			1. Is one of the most common methods
			2. Requires decreasing the temperature of a fuel to a point where it stops producing enough vapor to burn
		2. Is the most effective method available for the extinguishment of smoldering fires
		3. Can extinguish fires with solid or liquid fuels that have high flash points
		4. Requires the application of enough water to absorb the heat from the burning fuel
		5. Cannot extinguish fires involving flammable liquids and gases that have low flash points
	3. Water’s greatest effect occurs when it is vaporized into steam; at 212°F it expands approximately 1700 times
		1. Excess steam production can
			1. Make it difficult to see
			2. Can increase the chances for steam burns
		2. It is important to control steam production through
			1. Using good nozzle techniques
			2. Using an appropriate volume of water
			3. Applying the water in the most effective form based on the existing conditions
				1. Fog stream
				2. Straight stream
				3. Solid stream
1. Fuel Removal (fuel)
	1. Any fire can be effectively extinguished by removing its fuel source
	2. The simplest fuel removal method is allowing the fire to burn until all of the fuel is consumed, which is appropriate in some situations, such as
		1. Fires involving pesticides
		2. Flammable liquid spills
			1. Extinguishing with water creates substantial runoff, which may be more harmful to the environment
			2. Allowing the fire to burn minimizes groundwater pollution
	3. Fuel may also be removed by
		1. Stopping the flow of liquid or gaseous fuel by closing a valve (i.e. the preferred method of extinguishing pressurized gas fires)
		2. Removing solid fuels in the path of a fire
2. Oxygen Exclusion (oxygen)
	1. The process of reducing the oxygen available during the combustion process (e.g. using a cover to extinguish a grease fire in a pan on a range-top)
		1. Reduces a fire’s growth
		2. May completely extinguish a fire if given sufficient time
	2. Carbon dioxide
		1. Displaces oxygen
		2. Disrupts the combustion process
	3. Foam
		1. Blankets the fuel to separate it from oxygen
		2. Will not work on the rare fuels that are self-oxidizing
	4. Closing a door to the fire room before leaving the building
		1. Limits the air supply to the fire
		2. Can sometimes prevent flashover
		3. Can limit fire growth
3. Chemical Flame Inhibition (chemical chain reaction)
	1. Extinguishing agents
		1. Interrupt the combustion reaction
		2. Stop flame production
		3. Include the following examples
			1. Dry chemicals
			2. Halogenated agents (halons)
			3. Halon-replacement agents
		4. Are effective on gas and liquid fuels because they must flame to burn
		5. Do not easily extinguish surface-mode fires because they work on the chemical chain reaction of flaming combustion
		6. Are not practical to use on smoldering fires due to very high agent concentrations and the extended amount of time needed for their extinguishment

*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 \*** | * Demonstrate how to properly check a door for heat. Then have the students perform the skill while donning PPE. Use the Fire Behavior Skill Rubric: Checking a Door for Heat for assessment.
* Demonstrate how to properly check for the heat level in a room. Then have the students perform the skill while donning PPE. Use the Fire Behavior Skill Rubric: Checking for Heat Level in a Room for assessment.
* Before class, research, review, and select several firefighting videos of fires (house and/or training exercises). Have the students watch the videos and assess the fires, describing the stages of the fire and other fire behaviors (e.g. backdraft, rollover, and flashover). Ask the students to identify safety issues that firefighters may be overlooking (e.g. not wearing PPE or SCBA while in dangerous areas; ladders raised above doors or windows). This activity can be a writing activity or a class discussion. Scaffold the discussion or writing as needed. Use the Discussion Rubric or the Individual Work 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 |
| **Independent Practice/Laboratory Experience/Differentiated Activities \*** | Students will draw a diagram of the stages of fire development using half of a poster board (or card stock paper) and drawing materials. The diagram should include arrows pointing to the locations where rollover, flashover, and backdraft may occur. (*Note:* backdraft can occur at any stage where heated gases are trapped and waiting for fresh air.) Use the Individual Work 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 \***  | * Fire Behavior Quiz and Key
* Fire Behavior Key Terms Quiz and Key
* Fire Behavior Skill Rubric: Checking a Door for Heat
* Fire Behavior Skill Rubric: Checking for Heat Level in a Room
* Discussion Rubric
* Individual Work Rubric
* Presentation 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 draw a diagram of the stages of fire development using half of a poster board (or card stock paper) and drawing materials. The diagram should include arrows pointing to the locations where rollover, flashover, and backdraft may occur. (Note: backdraft can occur at any stage where heated gases are trapped and waiting for fresh air.) Use the Individual Work Rubric for assessment.  |
| **References/Resources/****Teacher Preparation** | 0135151112, *Essentials of Firefighting* (5th Edition), International Fire Service Training Association (IFSTA), 2008. |
| **Additional Required Components** |
| **English Language Proficiency Standards (ELPS) Strategies** |  |
| **College and Career Readiness Connection[[1]](#footnote-1)** | Science StandardsI. Nature of Science: Scientific Ways of Learning and Thinking A. Cognitive skills in science1. Utilize skepticism, logic, and professional ethics in science.

2. Use creativity and insight to recognize and describe patterns in natural phenomena. |
| **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 create a computer-based presentation explaining the visual indicators of a backdraft. Use the Presentation Rubric for assessment. |
| **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)