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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, & Security |
| **Course Name** | Forensic Science |
| **Lesson/Unit Title** | Forensic Glass Analysis |
| **TEKS Student Expectations** | **130.339. (c) Knowledge and Skills**(2) The student, for at least 40 of instructional time, conducts laboratory and/or field investigations using safe, environmentally appropriate, and ethical practices. (A) The student is expected to demonstrate safe practices during laboratory and field investigations.(B) The student is expected to demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.(3) The student uses scientific methods and equipment during laboratory and field investigations. (F) The student is expected to collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, dissection equipment, meter sticks, and models, diagrams, or samples of biological specimens or structures.(G) The student is expected to analyze, evaluate, make inferences, and predict trends from data.(H) The student is expected to communicate valid conclusions supported by the data through methods such as investigative reports, lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.(4) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. (A) The student is expected to analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, to encourage critical thinking.(D) The student is expected to evaluate the impact of scientific research on criminal investigation, society, and the environment.(E) The student is expected to evaluate models according to their limitations in representing biological objects or events.(F) The student is expected to research and describe the history of science and contributions of scientists within the criminal justice system.(7) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. (A) The student is expected to demonstrate how to process trace evidence such as glass, paint, fibers, hair, soil, grass, and blood collected in a simulated crime scene.(B) The student is expected to compare and contrast the composition of various types of glass such as soda lime, borosilicate, leaded, and tempered.(C) The student is expected to determine the direction of a projectile by examining glass fractures.(D) The student is expected to define refractive index and explain how it is used in forensic glass analysis. |
| **Basic Direct Teach Lesson**(Includes Special Education Modifications/Accommodations and one English Language Proficiency Standards (ELPS) Strategy) |
| **Instructional Objectives** | The students will be able to:* Calculate the direction of a projectile by examining glass fractures.
* Compare the composition of glass fragments.
* Process trace evidence (such as soil, grass, blood, fibers, glass, and hair) collected in a simulated crime scene.
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| **Rationale** | Glass fragments located at a crime scene can be essential to determining the identity and sometimes the location of a suspect. However, in all cases, the forensic scientist is required to draw comparison samples and determine the class or category of the glass sample or glass fragment. |
| **Duration of Lesson** | Teacher’s Discretion  |
| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* | * Glass – A hard, amorphous, transparent material made by heating a mixture of sand and other additives
* Amorphous – Without shape or form; applied to glass, it refers to having particles that are arranged randomly instead of in a definite pattern
* Density – The ratio of the mass of an object to its volume, expressed by the equation, density = mass/volume
* Becke line – The line created as refracted light becomes concentrated around the edges of a glass fragment
* Obsidian – Volcanic glass
* Soda-lime glass – The most common glass – inexpensive and easy to melt and shape
* Leaded glass – Glass containing lead oxide
* Tempered glass – Glass which is strengthened by introducing stress through rapid heating and cooling of the glass surface
* Laminated glass – Two sheets of ordinary glass bonded together with a plastic film
* Radial fracture – A crack in the glass that extends outward like the spoke of a wheel from the point at which the glass was struck
* Concentric fracture – A crack in the glass from a rough circle around the point of impact
* Refraction – The change in the direction of light as it changes speed when moving from one substance into another
* Refraction index – A measure of how light bends as it passes from one substance to another
* Silicon dioxide (SiO2) – The chemical name for silica
* Normal line – A line drawn perpendicular to the interface surface of two different media
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| **Materials/Specialized Equipment Needed** | * Forensic Glass Analysis Key Terms

• Discussion Rubric• Individual Work Rubric• Research Rubric* *Forensic Glass Analysis Experiment*
* Forensic Glass Analysis Experiment Guidelines handout
* Apron
* Safety gloves
* Safety goggles
* Glass fragments
* Bromoform (d = 2.89g/cm3)
* Bromobenzene (d = 1.52g/cm3)
* Pasteur pipettes
* Stirring rods
* Test tubes
* Tweezers
* Computer with Internet Access
* Science specific calculator
* White board/chalk board
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | Use the following questions for a class discussion. Use the Discussion Rubric for assessment.* What is glass made of?
* How many types of glass can you name?
* Name as many objects as you can that are composed of glass.
* How do you think forensic scientist use glass in an investigation?
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| **Direct Instruction \*** | 1. The Composition of Glass
	1. Is a hard, brittle, amorphous material
		1. Called an amorphous solid because its atoms are arranged in a random fashion
		2. Due to its irregular atomic structure, it produces a variety of fracture patterns when broken
	2. Made by melting the following ingredients at extremely high temperatures
		1. Sand
			1. The primary ingredient
			2. Also known as silica or silicon dioxide (SiO2)
		2. Lime or calcium oxide (CaO) is added to prevent the glass from becoming soluble in water
		3. Sodium oxide (Na2O) is added to reduce the melting point of silica or sand
	3. Has numerous uses and thousands of compositions
	4. Three categories of substances found in all glass
		1. Formers
			1. Makes up the bulk of the glass
			2. Examples: silicon dioxide (SiO2), boron trioxide (B2O3) and phosphorus pentoxide (P2O5)
		2. Fluxes
			1. Change the temperature at which the formers melt during the manufacturing of glass
			2. Examples: sodium carbonate (Na2CO3) and potassium carbonate (K2CO3)
		3. Stabilizers
			1. Strengthen the glass and make it resistant to water
			2. Calcium carbonate (CaCO3) is the most frequently used
	5. The raw materials for making glass are all oxides
		1. The composition of any sample can be given in terms of the percentage of each oxide used to make it
		2. Example: the approximate composition of window or bottle glass
			1. Silica (SiO2) – 73.6 %
			2. Soda (Na2O) – 16.0 %
			3. Lime (CaO) – 5.2 %
			4. Potash (K2O) – 0.6 %
			5. Magnesia (MgO) – 3.6 %
			6. Alumina (Al2O3) – 1.0 %
2. Types of Glass
	1. Obsidian is a natural form of glass that is created by volcanoes
	2. Soda-lime glass
		1. The most basic, common, inexpensive glass – also the easiest to make
	3. Used for manufacturing windows and bottle glass
3. Leaded glass
	1. Contains lead oxide which makes it denser
	2. Sparkles as light passes through it (light waves are bent)
	3. Used for manufacturing fine glassware and art glass
	4. Is commonly called crystal
4. Tempered glass
	1. Stronger than ordinary glass
	2. Strengthened by introducing stress through rapid heating and cooling of the glass surface
	3. When broken, this glass does not shatter, but fragments or breaks into small squares
	4. Used in the side and rear windows of automobiles
5. Laminated glass
	1. Constructed by bonding two ordinary sheets of glass together with a plastic film
	2. Also used by automobile manufactures

IV. Comparing Glass1. Investigation/analysis includes
	1. Finding
	2. Measuring
	3. Comparing
		1. Individual Characteristics
			1. Only occurs when the suspect and crime scene fragments are assembled and physically fitted together
			2. Comparisons of this type require piecing together irregular edges of broken glass as well as matching all irregularities and striations on the broken surfaces
			3. Most glass evidence is either too fragmentary or minute to permit a comparison of this type
		2. Class Characteristics (Density and Refractive Index)
			1. The general composition of glass is relatively uniform and offers no individualization
			2. Trace elements in glass may prove to be distinctive and measureable characteristics
			3. The physical properties of density and refractive index are used most successfully for characterizing glass particles, but only as a class characteristic
			4. This data (density and refractivity) gives analysts the opportunity to compare and exclude different sources of data
2. Methods of comparison
	1. Density and Measurements
		1. Density comparison
			1. A method of matching glass fragments
			2. Density (D) is calculated by dividing the mass (M) of a substance by its volume (V)
				1. D = M / V
			3. Example
		2. A solid is weighed on a balance against known standard gram weights to determine its mass
		3. The solid’s volume is then determined from the volume of water it displaces
		4. Measured by filling a cylinder with a known volume of water (v1), adding the object, and measuring the new water level (v2)
		5. The difference (v2 – v1) in milliliters is equal to the volume of the solid
		6. Density can now be calculated from the equation in grams per milliliter
3. Flotation comparison
	1. A sample of glass is dropped into and sinks to the bottom of a liquid containing an exact volume of a dense liquid, such as bromobenzene (d = 1.52g/mL)
	2. Then, a denser liquid, such as bromoform (d = 2.89g/mL) is added one drop at a time until the piece of glass rises from the bottom and attains neutral buoyancy
	3. Neutral buoyancy occurs when an object has the exact same density as the surrounding fluid – it neither sinks nor floats, but is suspended in place beneath the surface of the fluid
	4. The same procedure is then performed with another piece of glass, and if the volume needed to attain neutral buoyancy is the same as for the first sample, then the densities of the two samples are equal
	5. The exact density of each sample can be calculated by using the following formula: d = X (2.89) + Y (1.52)

X + Y* + - 1. X and Y refer to the volumes of the respective liquids, with the numbers in parentheses referring to the densities of each liquid
1. Refractivity
	1. Refractive Index
		1. A measure of how much an object slows light
			1. Light slows down when it passes through any medium (the denser the medium, the slower the light travels)
			2. Any object that transmits light has its own refractive index
		2. A ratio of the velocity of light in a vacuum to the velocity of light in a medium (refractive index = velocity of light in a vacuum / velocity of light in a medium)
		3. Used to compare glass samples
	2. When light passes through media with different refractive indexes
		1. Refraction (bending of the light) occurs
		2. Therefore, objects appear bent or distorted underwater
		3. Every liquid has its own refractive index
		4. If a piece of glass is placed in a liquid (with a different refractive index) an outline of the glass is clearly visible
			* 1. This line is known as the Becke Line
			1. When light passes through a piece of glass placed in a liquid with the same refractive index
				1. The glass bends light at the same angle as the liquid
				2. The Becke Line disappears
				3. The glass seems to disappear
2. Glass Fracture Patterns
	1. Glass has a certain degree of elasticity
		1. It breaks when its elastic limit is exceeded
		2. The elasticity produces fractures when it is penetrated by a projectile (i.e. a bullet)
	2. Types of fractures
		1. Radial
			1. Produced first
			2. Always form on the side of the glass opposite to where the impact originated
			3. Look like spider webs that spread outward from the impact hole
			4. Always terminate into an existing fracture
		2. Concentric
			1. Form next
			2. Encircle the bullet hole
			3. Always start on the same side as that of the destructive force
	3. Determining the sequence of multiple bullet holes
		1. The radial fractures from the second bullet hole always terminate into the fractures from the first bullet hole
		2. The radial fractures from a third bullet terminate into the radial fractures from the second bullet, and so forth
	4. Determining the first shooter
		1. Examine the termination lines of the radial fractures from each bullet hole
		2. Compare the size of the exit and entrance holes of each bullet
	5. Determining the direction from which a bullet was fired
		1. Compare the size of the entrance hole to the size of the exit hole
			1. Exit holes
				1. Are always larger, regardless of the type of material that was shot
				2. A larger piece of glass is knocked out of the surface where the bullet is leaving because glass is elastic and bows outward when struck
			2. Entrance holes
				1. The bullet makes a very small hole when it enters
				2. The glass always blows back in the direction of the impact because of its elasticity
				3. The glass snaps back violently after being stressed and can blow shattered glass back several meters
				4. Most of the shattered glass lands on the impacted side of the glass instead of by the exit hole

VI. Collecting Glass as Evidence1. Avoid the loss or contamination of any evidence samples
2. Identify and photograph all the glass samples before moving them
3. Collect the largest fragments
4. Identify the outside and the inside surfaces of any glass
5. Indicate the relative position of multiple window panes in a diagram
6. Note any other trace evidence found on or embedded in the glass, such as skin, hair, blood, or fibers
7. Package all the collected materials properly to maintain the chain of custody
8. Separate the glass by physical property, such as size, color, and texture
9. Catalog the samples and keep them separated to avoid contamination between two different sources
10. Separate the glass fragments from any other trace evidence (e.g., hair, blood, fibers) once in the lab
11. Examine any clothing (or other objects that may have been used to break the glass) related to the crime scene for glass fragments and other trace evidence

*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 \*** | Complete independent practice before guided practice.Forensic Glass Analysis Experiment. Have the students work in small groups (3–4 students per group) to conduct the Forensic Glass Analysis Experiment – Density of Glass: The Flotation Method Activity. Prior to class, set up each work station with the materials for the experiment (see the lab materials list below). Briefly review the lab safety procedures with the students and then hand out copies of Density of Glass: The Flotation Method Handout and the Density of Glass: The Flotation Method Worksheet. Explain the directions for the lab experiment. Allow the students some time to complete the worksheet and the density equation (approximately 10–15 minutes). Discuss the questions from the worksheet as a class. Use the Discussion Rubric for assessment.*Note: The students’ answers will vary depending on the glass sample size used. Make sure the students have recorded all the data, either on a separate sheet of paper or on the back of the handout. Also, you may want to engage students in further discussions regarding their perceptions of the importance of scientific data and experiments.**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 \*** | Complete independent practice before guided practice.Glass Analysis Research. Have students write a research paper on the procedure used for the analysis of glass. Students can include a variety of topics (e.g., density, flotation, refraction, glass fragmentations). Use the Research Rubric for assessment.Glass Evidence Collection Research. Have students write a research paper on the proper collection and preservation of glass evidence. The research should include elements such as collecting evidence, including procedures, packaging evidence, obtaining evidence, including control evidence, and labeling evidence. Use the Research 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 \***  | Forensic Glass Analysis Exam and Key*Individualized Education Plan (IEP) for all special education students must be followed. Examples of accommodations may include, but are not limited to:*NONE |
| **References/Resources/****Teacher Preparation** | Texas Education Agency, Forensic Certification Training, Sam Houston State UniversityForensic Science: Fundamentals & Investigation (1st Edition), Anthony BertinoForensic Science: From the Crime Scene to the Crime Lab (1st Edition), Richard SafersteinChemMatters, “More Than Meets the Eye” Brian RohrigThe Science Spot – Forensic Science <http://www.sciencespot.net/Pages/classforsci.html> Investigator/Officer’s Personal ExperienceCorning Museum of Glass <http://www.cmog.org/> Federal Bureau of Investigation: Laboratory Services* Forensic Glass Comparison: Background Information Used in Data Interpretation <http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/april2009/review>
* Introduction to Forensic Glass Examination <http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/jan2005/standards/2005standards4.htm/>
* Collection, Handling, and Identification of Glass <http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/jan2005/standards/2005standards5.htm/>
* Glass Density Determination <http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/jan2005/standards/2005standards8.htm/>
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| **Additional Required Components** |
| **English Language Proficiency Standards (ELPS) Strategies** |  |
| **College and Career Readiness Connection[[1]](#footnote-1)** |  |
| **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 reinforcement, the students will define and illustrate Forensic Glass Analysis key terms. Use the Individual Work Rubric for assessment.For enrichment, the students will write research paper on a glass-related topic (e.g., The History of Glass, Glass in America, Methods of Glass Analysis). Use the Research Rubric for assessment.The following are websites may be useful to research: Corning Museum ofGlass site and FBI: Laboratory Services (see the links in the Resources section). |
| **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)