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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** | Firearms & Tool Marks |
| **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. (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.(B) The student is expected to communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials.(C) The student is expected to draw inferences based on data related to criminal investigation.(D) The student is expected to evaluate the impact of scientific research on criminal investigation, society, and the environment.(F) The student is expected to research and describe the history of science and contributions of scientists within the criminal justice system.(9) The student analyzes blood spatter at a simulated crime scene. (A) The student is expected to explain the individual characteristics of tool marks.(C) The student is expected to recognize characteristics of bullet and cartridge cases.(D) The student is expected to describe the composition and method of analysis for gunshot residue and primer residue.(E) The student is expected to recognize the type of information available through the National Integrated Ballistics Information Network. |
| **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:* Explain the individual characteristics of tool marks.
* Recognize characteristics of bullet and cartridge cases.
* Explain laboratory methodologies used to determine whether an individual has fired a weapon, such as identifying gunshot residue.
* Recognize the type of information available through the National Integrated Ballistics Information Network.
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| **Rationale** | A crime involving a firearm occurs. In another location, a crime occurs where a criminal forcibly breaks and enters into a building. In both of the above incidents, trace evidence is left behind. A bullet is recovered at a crime scene. An impression of a tool is left on a door. In cases such as these, a single bullet or tool mark can reveal many clues that will eventually lead investigators to a suspect. |
| **Duration of Lesson** | 4 to 6 Hours |
| **Word Wall/Key Vocabulary***(ELPS c1a,c,f; c2b; c3a,b,d; c4c; c5b) PDAS II(5)* | Abrasion Mark – A mark produced when one surface slides across another surfaceBallistics – The study of bullets and firearmsBarrel – The long, metal tube that guides a projectile out of a firearmBore – The interior of a barrelBreechblock – The rear part of a barrelBullet – The projectile that is released when a firearm is dischargedCaliber – The bore diameter of a rifled firearm, usually expressed in hundredths of an inch or millimeters – for example, .22 caliber or 9 millimeterCutting Mark – A mark produced along the edge as a surface is cutDistance Determination – The process of determining the distance between the firearm and the target, usually based on the distribution of powder patterns or the spread of a shot patternEjector – The mechanism in a firearm that throws the cartridge or fired case from a firearmExtractor – The mechanism in a firearm that withdraws a cartridge or fired case from the chamberFirearm – A weapon capable of firing a projectile using a confined explosive as a propellantFirearms Identification – A discipline primarily concerned with determining whether a particular bullet or cartridge was fired by a particular weaponGauge – The size designation of a shotgun; originally the number of lead balls with the same diameter as the barrel that would make a pound. The only exception is the .410 shotgun, in which bore size is 0.41 inchesGreiss Test – A chemical test used to examine patterns of gunpowder residue around bullet holesGrooves – The cut or low-lying portions between the lands in a rifled bore (see Lands and Rifling)Gunshot Residue (GSR) – The tiny particles expelled from a firearm when it is firedIndentation Mark – A mark or impression made by a tool on a softer surfaceLands – The raised portions between the grooves in a rifled bore (see Rifling)Muzzle – The end of the barrel from which the projectile exitsPistol – A handheld firearmRevolver – A pistol with a revolving cylinderRifle – A firearm that has a long barrel; a long gunRifling – The spiral grooves etched into the bore of a firearm barrel that spin the projectile when it is firedSemiautomatic – A pistol with a clip-fed mechanism that fires one shot per pull of the trigger; the empty cartridge ejects, and the next cartridge advances automaticallyTool Marks – Impressions, scratches, or abrasions made when contact occurs between a tool and another objectTrajectory – A projectile’s path of flight |
| **Materials/Specialized Equipment Needed** | * Firearms & Tool Marks Key Terms
* Firearms & Tool Marks Crossword Puzzle and Key
* *Tool Marks Analysis Experiment*
* Tool Marks Analysis Worksheet (one for each group)
* 6–12 tools (2–4 different types)
* Rulers
* Modeling clay
* Plates (plastic or foam)
* *Firearms and Trajectory Activity*
* Firearms and Trajectory Worksheet (one for each group or each student)
* Firearms and Trajectory Worksheet Key
* Calculator with sine function or tangent table
* Ruler (optional)
* Computer with Internet Access
* White board/chalk board
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| **Anticipatory Set**(May include pre-assessment for prior knowledge) | Have students work in five (or fewer) small groups. Provide each group with one of the collecting impressions scenarios below. Have students discuss the situation and brainstorm possible methods that could be employed to examine and collect the discovered evidence. Afterwards, have the entire class discuss all of the scenarios.How would you collect impressions or evidence in the following situations?* You discover a bullet hole lodged in wooden door.
* You discover a bullet hole that has passed through two sheets of drywall.
* You discover several spent shell casings of varying caliber.
* You discover a tool mark on a windowsill.
* You discover indentations and scratches on a doorframe.

Conclude, by having the class watch two lectures by former Chief Forensic Scientist Richard Saferstein that briefly discuss impression evidence, tool marks, and firearms. To find the video lectures do an Internet search for the following:* CSI and “Impressions” Richard Saferstein
* CSI and Firearms Richard Saferstein

Use the Discussion Rubric for assessment. |
| **Direct Instruction \*** | I. Word WallII. Types of Firearms* 1. Handguns
		1. Pistol – a handheld firearm
		2. Revolver – a pistol with a revolving cylinder (features several firing chambers within a revolving cylinder)
		3. Semiautomatic – a pistol with a clip-fed mechanism that fires one shot per pull of the trigger; the empty cartridge ejects, and the next cartridge advances automatically (features a removable magazine)
		4. Fully-automatic – a firearm with a clip-fed mechanism that fires repeatedly and for as long as the trigger is held down
	2. Long Guns
		1. Long guns may be single-shot, repeating, semi-automatic, or automatic
		2. Examples
			1. Rifle – A firearm that has a long barrel; a long gun
			2. Shotgun – Uses shell ammunition that contains numerous ball-shaped projectiles, called shot
				1. The narrowing of the smooth barrel, called the choke of the shotgun, can concentrate the shot when fired
				2. Gauge is the diameter of the shotgun barrel; originally the number of lead balls having the same diameter as the barrel that would weigh a pound
				3. The higher the gauge number, the smaller the barrel’s diameter
				4. The only exception is the .410 shotgun, in which bore size is 0.41 inches
1. Discharging the Firearm
	1. Pulling the trigger releases the weapon’s firing pin which strikes the primer – The primer ignites the powder
	2. The expanding gases generated by the burning gunpowder propel the bullet forward through the barrel
	3. The shell is impressed with markings by its contact with the metal surfaces of the weapon’s firing and loading mechanisms
	4. Impressions found on the weapon and markings found on the bullet are used by forensic scientists for examination and comparison

IV. Firearm Analysis1. Gun barrel markings
	1. The barrel’s inner surface leaves its markings on any bullet that passes through it (these markings are unique to each gun)
	2. The gun barrel is produced from a solid bar of steel that has been hollowed out by drilling
	3. The microscopic drill marks left on the barrel’s inner surface are randomly irregular and make each barrel unique
	4. Barrels are also manufactured with spiral grooves, known as rifling
	5. The parts of the original bore left between the grooves are called lands
	6. The grooves guide the bullet through the barrel, giving it a rapid spin to ensure accuracy
	7. The diameter of the gun barrel, measured between opposite lands, is known as the caliber (expressed in hundredths of an inch or millimeters – for example, .22 caliber or 9 millimeter)
		1. Once a manufacturer chooses a rifling process, the class characteristics of the weapon’s barrel will remain consistent
		2. Each will have the same number of lands and grooves, with the same approximate width and direction of twist
	8. Striations
		1. Fine lines found in the interior of the barrel
		2. Impressed into the metal as a result of minute imperfections found on the rifling cutter’s surface
		3. Or produced by minute chips of steel pushed against the barrel’s inner surface by a moving broach cutter
		4. Form the individual characteristics of the barrel
		5. The inner surface of the barrel leaves striation markings on a bullet passing through it
	9. Bullets
		1. No two rifled barrels, even those manufactured in succession, will have identical striation markings
		2. The number of lands and grooves, and their direction of twist, are easy points of comparison during the initial stages of an examination between an evidence bullet and a test-fired bullet
		3. Any differences in these characteristics immediately eliminate the possibility that both bullets traveled through the same barrel
	10. Cartridge Comparison
		1. The firing pin, breechblock, and ejector and extractor mechanisms also create distinctive signatures on cartridge cases
		2. The shape of the firing pin is impressed into the softer metal of the primer on the cartridge case
		3. The cartridge case, travelling rearward, is impressed with the surface markings of the breechblock
		4. Other distinctive markings that may appear on the shell as a result of metal-to-metal contact are caused by the
			1. Ejector – The mechanism that throws the cartridge or fired case from the firearm
			2. Extractor – The mechanism by which the cartridge of a fired case is withdrawn from the firing chamber
			3. Magazine or clip – The mechanism that holds the bullets

V. Identification* 1. Comparison Microscope
		1. The most important tool for a firearms examiner
		2. Two bullets can be observed and compared simultaneously within the same field of view
		3. Not only must the lands and grooves of the test and evidence bullet have identical widths, but the longitudinal striations on them must coincide
	2. Computerized Imaging
		1. Computerized imaging technology has made it possible to store bullet and cartridge surface characteristics similarly to automated fingerprint files
		2. The National Integrated Ballistics Information Network (NIBIN) produces database files from bullets and cartridge casings retrieved from crime scenes, or test fires from retrieved firearms, often linking a specific weapon to multiple crimes
		3. It is important to remember, however, that the ultimate decision for making a final comparison must be determined by the forensic examiner through traditional microscopic methods

VI. Residue1. Firearm Residue
	1. When a firearm is discharged, the bullet, unburned and partially burned particles of gunpowder, and smoke are propelled out of the barrel toward the target
	2. If the muzzle of the weapon is close enough, these products will be deposited onto the target
	3. The distribution of gunpowder particles and other residues around a bullet hole allows for an estimation of the distance from which a handgun or rifle was fired
	4. The precise distance from which a handgun or rifle has been fired is determined through careful comparison of the powder-residue pattern located on the victim’s clothing or skin against test patterns the suspect weapon males when fired at varying distances from a target
	5. By comparing the test and evidence patterns, the examiner may find enough similarity in shape and density to formulate an opinion about the distance from which the shot was fired
	6. When the weapon is held in contact with (or less than 1 inch from) the target, it creates a star-shaped (stellate) tear pattern around the bullet hole entrance, rimmed by a smokeless deposit of vaporous lead
	7. A halo of vaporous lead (smoke) deposited around a bullet hole normally indicates a discharge of 12 to 18 inches or less
	8. Scattered specks of unburned and partially burned powder grains without any accompanying soot are often observed at distances up to 25 inches (and occasionally as far as 36 inches)
	9. More than 3 feet will not usually result in deposits of powder residue, and the only visual indication will be a dark ring around the hole, known as a bullet wipe
	10. When garments or other evidence relevant to a shooting are taken to the crime laboratory, the surfaces of all items are first examined microscopically for the presence of gunpowder residue
	11. Chemical tests, such as the Greiss test, may be needed to detect gunpowder residues that are not visible
	12. The firing distances for shotguns must again be determined through test firing. The muzzle to target distances can be established by measuring the spread of the discharged shot
2. Primer Residue on the Hands
	1. Firing a weapon also propels residues back toward the shooter
	2. Traces of these residues are often deposited on the shooter’s firing hand, and detection can provide valuable information as to whether an individual has recently fired a weapon
	3. Examiners measure the amount of barium and antimony on the suspect’s hands, particularly the thumb web, the back of the hand, and the palm
3. They may also characterize the morphology of particles containing these elements to determine whether a person has fired, handled, or was near a discharged firearm

VII. Trajectory1. Is the flight path of a projectile
2. Can be calculated by finding two reference points along the flight path of the projectile
3. The reference points can be a bullet hole in an object, such as a wall or a window, or a bullet wound on a victim
4. Investigators
	1. Look for clues at a crime scene to help calculate a bullet’s trajectory and figure out where a shooter discharged the firearm
	2. Might position the corpse (in cases involving a victim’s body) as it was at the time of impact and use a metal or wooden dowel to indicate the path of the bullet
	3. Can also use lasers to trace straight paths to determine the position of the shooter or shooters
5. Gravity and Trajectory
	1. Two major forces are acting on a bullet once it is fired: the forward force of the gunshot and the downward force of gravity
	2. A bullet begins to drop as it leaves the barrel of a firearm
	3. If the shot is taken at a very distant object, the line of sight of the target must be adjusted to compensate for the effect of gravity on the bullet
	4. If the target is closer, there would be less adjustment
	5. Wind speed and direction are also factors affecting adjustments the shooter must make to hit the target
6. Locating the Shooter (Example)
	1. A bullet is shot and found in a vehicle
	2. The bullet first penetrated the front driver’s side window and then the seat
	3. The bullet may have come from a building across the street
	4. Police need to recreate the crime scene and determine the path of the bullet using the hole in the car’s window and the bullet hole in the seat as their reference points
	5. Using a laser beam, they project a line creating the approximate trajectory path of the bullet from the building to the car
	6. Investigators must also measure the distance from the car to the building
	7. To determine the position of the shooter, they must determine the distance between the shooter and the bullet hole in the car seat
	8. This requires at least two reference points from which to project a line back to the source (the shooter in the building)
	9. To determine the distance between the shooter and the hole in the car seat, investigators must set up a direct proportion using the two right angles
7. Calculation (Distance vs. Drop)
8. Measure how many feet the bullet hole is above the ground
9. Attempt to locate the bullet’s origin, and measure the distance from the two reference points
10. Measure the horizontal distance from the broken window to the bullet hole horizontally and compare this distance to the diagonal length of the bullet path from the hole in the car’s window to the bullet hole
11. Distance to the window = Distance to the shooter (c)

Distance along horizon Distance to the side of the buildingc = 1. c (the hypotenuse) = the distance to the shooter
2. a = distance to the building
3. b = the height of the shooter from the horizon (not from the ground)
4. c2 = a2 + b2
5. b = \_\_\_\_in. ~ \_\_\_\_ft.
6. Compare the distance from the building with the height of the bullet hole (determined in step # 6) and the horizon
7. With this information the investigator can determine where the shooter was, and at what height (or floor) the bullet originated

VIII. Firearm Evidence Collection1. Firearms are collected by holding the weapon by the edge of the trigger guard or the checkered portions of the grip
2. Before the weapon is sent to the laboratory, all precautions must be taken to prevent accidental discharge of a loaded weapon (in most cases, it will be necessary to unload the weapon)
3. When a revolver is recovered, the chambers, their positions, and corresponding cartridges must be recorded
4. Firearm evidence must be marked for identification (usually a tag on the trigger guard), and a chain of custody must be established
5. Bullets recovered at the crime scene are scribed with the investigator’s initials, either on the base or the nose of the bullet
6. The obliteration of striation markings that may be present on the bullet must be scrupulously avoided
7. The investigator must protect the bullet by wrapping it in tissue paper before placing it in a pillbox or an envelope for shipment to the crime laboratory
8. Fired casings must be identified with the investigator’s initials placed near the outside or inside mouth of the shell
9. Discharged shotgun shells are initialed on the paper or plastic tube or on the metal nearest the mouth of the shell

IX. Tool Marks and Other Impressions1. Tool Marks
	1. A tool mark is considered to be any impression, cut, gouge, or abrasion caused by a tool coming into contact with another object
	2. A careful examination of the impression can reveal important class characteristics, such as the size and shape of the tool
	3. It is the presence of minute imperfections on a tool that imparts individuality to it.
		1. The shape and pattern of such imperfections are further modified by damage and wear during the life of the tool
		2. The comparison microscope is used to compare crime scene tool marks with test impressions made with the suspect tool
		3. When practical, the entire object or the part of the object bearing the tool mark should be submitted to the crime laboratory for examination
		4. Under no circumstances should the crime scene investigator attempt to fit the suspect tool into the tool mark
		5. Any contact between the tool and the marked surface may alter the mark and will, at the least, raise serious questions about the integrity of the evidence
	4. Other Impressions
		1. Impressions of other kinds, such as shoe, tire, or fabric, may be important evidence
		2. Before any impression is moved or otherwise handled, it must be photographed (including a scale) to show all observable details of the impression
		3. If the impression is on a readily recoverable item, such as glass, paper, or floor tile, the evidence is transported intact to the laboratory
		4. If the surface cannot be submitted to the laboratory, the investigator may be able to preserve the impression in a manner similar to lifting a fingerprint
		5. When shoe and tire marks are impressed into soft earth at a crime scene, their preservation is best accomplished by photography and casting
		6. In areas where a bloody footwear impression is very faint or where the subject has tracked through blood, leaving a trail of bloody impressions, chemical enhancement can visualize latent or nearly invisible blood impressions
2. Points of Comparison
	1. A sufficient number of points of comparison, or the uniqueness of such points, will support a finding that both the questioned and test impressions originated from the same source
	2. New computer software and websites may be able to assist in making shoeprint and tire impression comparisons
	3. Also, bite mark impressions on skin and foodstuffs have proven to be important evidence in a number of homicide and rape cases

*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 \*** | **Tool Marks Analysis Experiment**Preparation – make copies of the Tool Marks Analysis worksheet (one per group). Label the tools with numbers and use clay to make impressions for your experiment. Set up 3 to 6 stations in the classroom with 2 tools at each station along with rulers, clay and a plate. Allow students to work in groups (3 to 4 students per group) and have approximately 5 to 8 minutes to document the 2 tools before they rotate to a new station. If the class has enough time remaining, allow the groups extra time to look at the tools again, as well as time to clean up.**Experiment** Hand each group a copy of the Tool Marks Experiment worksheet. Allow the groups to visit each station to examine and document each of the tools and its impressions. Tell the students to document all of their observations, and if possible to sketch them. Have the groups use their notes to identify unique characteristics of the tool mark impressions. Allow time for the students to identify the impressions and compare their observations in a group discussion. Re-address how tool marks can be used to solve crimes. Use the Discussion Rubric for assessment.Note: This activity may be adapted as follows:* + Instructors can create their own tool mark impressions in advance and then have students attempt to locate the tools that match the impressions.
	+ Instructors can have students in groups create the tool mark impressions from a set of distributed tools and clay, and then have students exchange impressions and tools and have the next group match the impressions.

**Firearms and Trajectory Activity** Preparation – make copies of the Firearms and Trajectory Worksheet. Directions – hand out calculators and copies of the Firearms and Trajectory Worksheet. Review the objective, background information, scenario, and procedures with the students. Allow time for the students to complete the trajectory equation. Walk around observing the class and instruct students to complete all of the questions. Discuss the questions from the worksheet. *(Note: this can be distributed as an individual* *or group activity. In addition, this activity should take approximately 15 – 20 minutes).* Use the Firearms and Trajectory Worksheet Key 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 \*** | **Firearms & Tool Marks Crossword Puzzle**Have the class complete the Firearms & Tool Marks Crossword Puzzle to become familiar with the key terms from this unit. Use the Firearms & Tool Marks Crossword Puzzle Key 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 \***  | * Firearms & Tool Marks Exam and Key
* Firearms and Trajectory Worksheet Key
* Firearms & Tool Marks Crossword Puzzle Key
* Discussion Rubric
* Individual Work Rubric
* Research Rubric

*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 SafersteinThe Science Spot – Forensic Science * <http://www.sciencespot.net/Pages/classforsci.html>
* <http://www.americanfirearms.org/gun-history/>
* <http://www.pbs.org/opb/historydetectives/technique/gun-timeline/>
* <https://www.innocenceproject.org/cases/>

Investigator/Officer’s Personal ExperienceTo find the video lectures do an Internet search for the following:* CSI and “Impressions” Richard Saferstein
* CSI and Firearms Richard Saferstein
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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 create an illustration of any firearm of their choice, including the mechanisms that make the firearm work (e.g., trigger, hammer, barrel, etc). Use the Individual Work Rubric for assessment.For enrichment, the students will write a research paper of their choice regarding either firearms (e.g., History of Firearms, How a Firearm Works), tool marks, or a legal case where firearms or tool marks were predominately examined. Use the Research Rubric for assessment.The following are informative website for research:* <http://www.americanfirearms.org/gun-history/>
* <http://www.pbs.org/opb/historydetectives/technique/gun-timeline/>
* <https://www.innocenceproject.org/cases/>
 |
| **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)