Firearms & Tool Marks

Course
Forensic Science

Unit XIV
Firearms & Tool Marks

Essential Question
How do crime scene investigators examine tool mark impressions, bullet fragments, and bullet holes?

TEKS
§130.295(c)
(1)(A)(B)
(2)(G)(H)
(3)(A–D)(F)
(14)(A–D)

Prior Student Learning
– *Lab Safety*
– *Scientific Method*
– *Crime Scene Investigation*

Estimated Time
4 to 6 hours

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.

Objectives
The student will be able to:
1. Explain the individual characteristics of tool marks.
2. Recognize characteristics of bullet and cartridge cases.
3. Explain laboratory methodologies used to determine whether an individual has fired a weapon, such as identifying gunshot residue.
4. Recognize the type of information available through the National Integrated Ballistics Information Network.

Engage
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?
1. You discover a bullet hole lodged in wooden door.
2. You discover a bullet hole that has passed through two sheets of drywall.
3. You discover several spent shell casings of varying caliber.
4. You discover a tool mark on a windowsill.
5. 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.

Key Points
I. Key Terms
   A. Abrasion mark – a mark produced when one surface slides across another surface
   B. Ballistics – the study of bullets and firearms
   C. Barrel – the long, metal tube that guides a projectile out of a firearm
   D. Bore – the interior of a barrel

E. Breechblock – the rear part of a barrel
F. Bullet – the projectile that is released when a firearm is discharged
G. Caliber – the bore diameter of a rifled firearm, usually expressed in hundredths of an inch or millimeters – for example, .22 caliber or 9 millimeter
H. Cutting mark – a mark produced along the edge as a surface is cut
I. Distance 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 pattern
J. Ejector – the mechanism in a firearm that throws the cartridge or fired case from a firearm
K. Extractor – the mechanism in a firearm that withdraws a cartridge or fired case from the chamber
L. Firearm – a weapon capable of firing a projectile using a confined explosive as a propellant
M. Firearms Identification – a discipline primarily concerned with determining whether a particular bullet or cartridge was fired by a particular weapon
N. Gauge – 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 inches
O. Greiss test – a chemical test used to examine patterns of gunpowder residue around bullet holes
P. Grooves – the cut or low-lying portions between the lands in a rifled bore (see Lands and Rifling)
Q. Gunshot residue (GSR) – the tiny particles expelled from a firearm when it is fired
R. Indentation mark – a mark or impression made by a tool on a softer surface
S. Lands – the raised portions between the grooves in a rifled bore (see Rifling)
T. Muzzle – the end of the barrel from which the projectile exits
U. Pistol – a handheld firearm
V. Revolver – a pistol with a revolving cylinder
W. Rifle – a firearm that has a long barrel; a long gun
X. Rifling – the spiral grooves etched into the bore of a firearm barrel that spin the projectile when it is fired
Y. 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
Z. Tool marks – impressions, scratches, or abrasions made when contact occurs between a tool and another object
AA. Trajectory – a projectile's path of flight

II. Types of Firearms
A. 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

B. Long Guns
1. Long guns may be single-shot, repeating, semi-automatic, or automatic
2. Examples
a) Rifle – a firearm that has a long barrel; a long gun
b) 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

III. Discharging the Firearm
A. Pulling the trigger releases the weapon's firing pin which strikes the primer – the primer ignites the powder
B. The expanding gases generated by the burning gunpowder propel the bullet forward through the barrel
C. The shell is impressed with markings by its contact with the metal surfaces of the weapon's firing and loading mechanisms
D. Impressions found on the weapon and markings found on the bullet are used by forensic scientists for examination and comparison

IV. Firearm Analysis
A. 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)

8. Once a manufacturer chooses a rifling process, the class characteristics of the weapon's barrel will remain consistent
9. Each will have the same number of lands and grooves, with the same approximate width and direction of twist

B. 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

C. 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

D. 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
   a) Ejector – the mechanism that throws the cartridge or fired case from the firearm
   b) Extractor – the mechanism by which the cartridge of a fired case is withdrawn from the firing chamber
   c) Magazine or clip – the mechanism that holds the bullets

V. Identification

A. 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

B. 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. Residue
A. 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

B. 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
4. 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. Trajectory
- A. Is the flight path of a projectile
- B. Can be calculated by finding two reference points along the flight path of the projectile
- C. 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
- D. 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
- E. 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
- F. 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
- G. Calculation (Distance vs. Drop)

1. Measure how many feet the bullet hole is above the ground
2. Attempt to locate the bullet's origin, and measure the distance from the two reference points
3. 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
4. $\frac{\text{Distance to the window}}{\text{Distance along horizon}} = \frac{\text{Distance to the shooter (c)}}{\text{Distance to the side of the building}}$
   c = _____
5. c (the hypotenuse) = the distance to the shooter
6. a = distance to the building
7. b = the height of the shooter from the horizon (not from the ground)
8. $c^2 = a^2 + b^2$
9. b = ____in. ~ ____ft.
10. Compare the distance from the building with the height of the bullet hole (determined in step # 6) and the horizon
11. With this information the investigator can determine where the shooter was, and at what height (or floor) the bullet originated

VIII. Firearm Evidence Collection

A. Firearms are collected by holding the weapon by the edge of the trigger guard or the checkered portions of the grip
B. 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)
C. When a revolver is recovered, the chambers, their positions, and corresponding cartridges must be recorded
D. Firearm evidence must be marked for identification (usually a tag on the trigger guard), and a chain of custody must be established
E. Bullets recovered at the crime scene are scribed with the investigator's initials, either on the base or the nose of the bullet
F. The obliteration of striation markings that may be present on the bullet must be scrupulously avoided
G. 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
H. Fired casings must be identified with the investigator's initials placed near the outside or inside mouth of the shell
I. 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 Impressions

A. 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
4. The shape and pattern of such imperfections are further modified by damage and wear during the life of the tool
5. The comparison microscope is used to compare crime scene tool marks with test impressions made with the suspect tool
6. When practical, the entire object or the part of the object bearing the tool mark should be submitted to the crime laboratory for examination
7. Under no circumstances should the crime scene investigator attempt to fit the suspect tool into the tool mark
8. 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

B. 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

X. Points of Comparison
A. 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
B. New computer software and websites may be able to assist in making shoeprint and tire impression comparisons
C. Also, bite mark impressions on skin and foodstuffs have proven to be important evidence in a number of homicide and rape cases

Activities

1. 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*

2. 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.

3. 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.

Assessments

Firearms & Tool Marks Exam and Key
Firearms and Trajectory Worksheet Key
Firearms & Tool Marks Crossword Puzzle Key
Discussion Rubric
Individual Work Rubric
Research Rubric

Materials

Firearms & Tool Marks computer-based presentation
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

Resources

Texas Education Agency, Forensic Certification Training, Sam Houston State University
Forensic Science: Fundamentals & Investigation (1st Edition), Anthony Bertino
Forensic Science: From the Crime Scene to the Crime Lab (1st Edition), Richard Saferstein
The Science Spot – Forensic Science
http://www.sciencespot.net/Pages/classforsci.html
http://www.americanfirearms.org/history.php
http://www.pbs.org/opb/historydetectives/technique/gun-timeline/
http://library.thinkquest.org/04oct/00206/text_casestudies.htm
http://www.innocenceproject.org/docs/DNA_Exonerations_Forensic_Science.pdf
Investigator/Officer's Personal Experience
To find the video lectures do an Internet search for the following:

- CSI and "Impressions" Richard Saferstein
- CSI and Firearms Richard Saferstein

Accommodations for Learning Differences

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/history.php
- http://www.pbs.org/opb/historydetectives/technique/gun-timeline/
- http://library.thinkquest.org/04oct/00206/text_casestudies.htm
- http://www.innocenceproject.org/docs/DNA_Exonerations_Forensic_Science.pdf

State Education Standards

Texas Essential Knowledge and Skills for Career and Technical Education
§130.295. Forensic Science (One Credit).

(1) The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:
  (A) demonstrate safe practices during laboratory and field investigations; and
  (B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.

(2) The student uses scientific methods and equipment during laboratory and field investigations. The student is expected to:
  (G) analyze, evaluate, make inferences, and predict trends from data; and
  (H) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.

(3) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:
  (A) in all fields of science, 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, so as to encourage critical thinking by the student;
  (B) communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials;
  (C) draw inferences based on data related to promotional materials for products and services;
  (D) evaluate the impact of scientific research on society and the environment;
  (F) research and describe the history of science and contributions of scientists.

(14) The student evaluates bullet and tool mark impressions in a criminal investigation. The student is expected to:
  (A) explain the individual characteristics of tool marks;
  (B) recognize characteristics of bullet and cartridge cases;
  (C) explain laboratory methodologies used to determine whether an individual has fired a weapon such as identifying gun shot residue; and
  (D) recognize the type of information available through the National Integrated Ballistics Information Network.

College and Career Readiness Standards

Mathematics Standards
III. Geometric Reasoning
D. Logic and reasoning in geometry
1. Make and validate geometric conjectures.

Firearms & Tool Marks Key Terms

Abrasion mark – a mark produced when one surface slides across another surface

Ballistics – the study of bullets and firearms

Barrel – the long, metal tube that guides a projectile out of a firearm

Bore – the interior of a barrel

Breechblock – the rear part of a barrel

Bullet – the projectile that is released when a firearm is discharged

Caliber – the bore diameter of a rifled firearm, usually expressed in hundredths of an inch or millimeters – for example, .22 caliber or 9 millimeter

Cutting mark – a mark produced along the edge as a surface is cut

Distance 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 pattern

Ejector – the mechanism in a firearm that throws the cartridge or fired case from a firearm

Extractor – the mechanism in a firearm that withdraws a cartridge or fired case from the chamber

Firearm – a weapon capable of firing a projectile using a confined explosive as a propellant

Firearms Identification – a discipline primarily concerned with determining whether a particular bullet or cartridge was fired by a particular weapon

Gauge – 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 inches

Greiss test – a chemical test used to examine patterns of gunpowder residue around bullet holes

Grooves – 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 fired

Indentation mark – a mark or impression made by a tool on a softer surface

Lands – the raised portions between the grooves in a rifled bore (see Rifling)

Muzzle – the end of the barrel from which the projectile exits

Pistol – a handheld firearm

Revolver – a pistol with a revolving cylinder

Rifle – a firearm that has a long barrel; a long gun

Rifling – the spiral grooves etched into the bore of a firearm barrel that spin the projectile when it is fired

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

Tool marks – impressions, scratches, or abrasions made when contact occurs between a tool and another object

Trajectory – a projectile's path of flight

Name:_____ Date:_____

Firearms & Tool Marks Exam

Matching

a. Grooves
b. Bore
c. Caliber
d. Breechblock
e. Semiautomatic
f. Trajectory
g. Gauge
h. Lands
i. Muzzle
j. Rifling

1._____ The spiral grooves formed in the bore of a barrel that impart spin to the projectile when it is fired

2._____ The end of the barrel from which the projectile exits a firearm

3._____ The size designation of a shotgun; originally the number of lead balls with the same diameter as the barrel that would weigh a pound

4._____ The flight path of a projectile

5._____ The cut or low-lying portions between the lands in a rifled bore

6._____ The rear part of a barrel

7._____ The diameter of the bore of a rifled firearm, usually expressed in hundredths of an inch or millimeters

8._____ The raised portions between the grooves in a rifled bore

9._____ 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

10._____ The interior of a firearm barrel

Multiple choice questions

11.____ Shotguns are examples of
a. Handguns
b. Long guns
c. Revolvers
d. Semiautomatic weapons

12.____ Which of the following best describes the trajectory of a projectile?
   a. The height of the shooter
   b. The flight path of the bullet
   c. The housing for the bullet's gunpowder
   d. The pattern of lands and grooves on the projectile

13.____ The caliber of a bullet is related to its
   a. Diameter
   b. Length
   c. Speed
   d. Weight

14.____ Semiautomatic pistols store cartridges in a
   a. Magazine (clip)
   b. Cylinder
   c. Firing pin
   d. Muzzle

15.____ The revolver features several firing chambers located within
   a. The grip of the firearm
   b. The muzzle of the firearm
   c. A reloadable magazine
   d. A rotating cylinder

16.____ The barrel of a shotgun
   a. Is indistinguishable from that of a rifle
   b. Is engraved with grooves but not lands
   c. Is generally shorter than a rifle
   d. Is smooth without the grooves and lands found in a rifle

17.____ The reason grooves are rifled into the bore of a gun is so that a
   a. Bullet moving through will have unique striations
   b. Manufacturer can put its unique marks on its product
   c. Bullet will be reduced in size before it exits the gun
   d. Bullet will be made to spin and hence have a true and accurate course on leaving the barrel

18.____ Generally, the gauge of a shotgun is _____ to the diameter of its barrel.
   a. Not related
   b. Indirectly related
   c. Directly related
   d. Sometimes related

19.____ Distinctive markings of shells and cartridges can be made by the
   a. Firing pin
   b. Extractor and ejector mechanism
   c. Breech block
   d. All of the above

20.____ Generally speaking, the amount of gunpowder particles found around a bullet hole is _____ to the distance from which the weapon was fired.
   a. Indirectly related
   b. Directly related
   c. Not related
   d. Somewhat related

21.____ Gunpowder residue patterns can be detected by
   a. The Greiss Test
   b. DNA sequence analysis
   c. Both A and B
   d. Neither A nor B

22.____ To prevent the disturbance of latent fingerprints on a firearm, the weapon should be lifted by
   a. The outside of the barrel or the trigger
   b. Using disposable forceps
   c. Inserting a pencil into the barrel
   d. The edge of the trigger guard or by the checkered portion of the grip

23.____ Tools and tool marks are often found at burglary scenes and can be useful evidence. Proper evidence collection by the field investigator would include
   a. Taking a photograph and cast of the marks, if necessary
   b. Immediately dusting the tool for fingerprints
   c. Making test marks with the suspected tool onto a soft metal surface at the crime scene
   d. Packing tools and tool mark evidence together so that the crime lab personnel know they are thought to be a matched set

24.____ Which is **not** a class characteristic of a suspect's sneakers?
   a. Size
   b. Brand
   c. Style
   d. Wear marks

25.____ Which of the following is not expected to show any evidential marks or impressions?
   a. A cartridge casing from a shotgun
   b. A cartridge casing fired from a handgun
   c. A fired bullet
   d. A shotgun pellet

26.____ Which of the following factors is least likely to be considered by a technician examining tool marks?
   a. The brand name of the tool
   b. The side or portion of the tool making the impression
   c. The angle at which the tool was held
   d. The direction of the tool movement as it passes over the surface

27.____ Which of the following results is not possible from a laboratory examination of firearm evidence?
   a. Determining how far from the victim the weapon was held
   b. Determining that two or more cartridge casings were fired from the same weapon
   c. Identifying a bullet as having been combined with a particular shell prior to being discharged
   d. All of the above

28.____ The mechanism in a firearm that withdraws a cartridge or fired case from the chamber is the
   a. Rifling
   b. Breech block
   c. Extractor
   d. Ejector

29.____ A mark or impression made by a tool on a softer surface is a(n)
   a. Tool mark
   b. Abrasion mark
   c. Cutting mark
   d. Indentation mark

30.____ A mark produced when a surface slides across another surface is a(n)
   a. Tool mark
   b. Abrasion mark
   c. Cutting mark
   d. Indentation mark

True or False Questions

31.____ The lands and grooves of a barrel's rifling improve the accuracy of a bullet.
   a. True
   b. False

32.____ The caliber of a cartridge is usually measured in one-hundredths of an inch.
   a. True
   b. False

33.____ If a tool mark impression is matched to a specific tool, then the owner of that tool must have been at the crime scene.
   a. True
   b. False

34.____ Pry bar and crowbar marks cannot be distinguished from each other.
   a. True
   b. False

35.____ The amount of gunshot residue on a victim is usually proportional to the distance between the victim and the shooter.
   a. True
   b. False

Firearms & Tool Marks Exam Key

1. J
2. I
3. G
4. F
5. A
6. D
7. C
8. H
9. E
10. B
11. B
12. B
13. A
14. A
15. D
16. D
17. D
18. C
19. D
20. B
21. A
22. D
23. A
24. D
25. D
26. A
27. C
28. C
29. D
30. B
31. A
32. A
33. B
34. B
35. A

Tool Marks Analysis Worksheet

Student Names: _____

Date: _____

Objective: Your team will need to examine and document the tool marks made by each tool.

At each station

1) To prepare for the experiment, roll the modeling clay flat so that it is flat inside the plate. Make several impressions of each tool in your slab of modeling clay.
2) Use a ruler to record the measurements for each tool and its impression surface.
3) Document any unique characteristics you notice on each tool or its impression. Write your observations in the Data Table (see below).
4) After you have documented both of the tools at the station, roll the clay into another ball to prepare for the next group and wait until it's time to rotate to the next station.

Analyze

- Dimensions of the impression
- Ridges and/or patterns
- Defects and/or unique characteristics
- Paint chips or metal shards left on the tool

Data Table

Tool #	Width of Tip (mm)	Length of Tip (mm)	Characteristics of Tool
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

(adapted from T. Trimpe hht://sciencespot.net & R. Saferstein - Forensic Science)

Firearms and Trajectory Worksheet

Objective

1) Analyze the crime scene
2) Determine information about the shooter's position

Background Information

Investigators will first measure how many feet the bullet hole is above the ground. Investigators then attempt to locate where the bullet originated and measure the distance from the two reference points. Next investigators measure the horizontal distance from the broken window to the bullet hole and compare this distance to the length of the bullet's path from the hole in the car's window to the bullet hole.

Calculation using Distance vs. Drop

* $\frac{\text{Distance to window}}{\text{Distance along horizon}} = \frac{\text{Distance to shooter (c)}}{\text{Distance to side of building}}$ * distance is placed in inches

c = _____

Hypotenuse (c) = distance to the shooter
a = distance to the building
b = height of the shooter from the horizon (not from the ground)
Hypotenuse^2 = a^2 + b^2

(Distance of shooter)^2 = (Distance to side of building)^2 + b^2

_____in^2 = _____in^2 + b^2

_____in^2 - _____in^2 = b^2

_____in^2 = b^2

** b = _____in ~ ___ft **convert from inches to feet

Compare the distance from the building with the height of the bullet hole (determined from step # 6) and the horizon of the bullet.

Use this information to determine where the shooter was and at what height (or floor) the bullet originated

Materials

Calculator with sine function or tangent table
Ruler (optional)

Scenario

A victim was shot from a bullet that came through his front car window. Witnesses saw a muzzle flash from a nearby building, but were unsure from which floor the flash originated.

Procedures

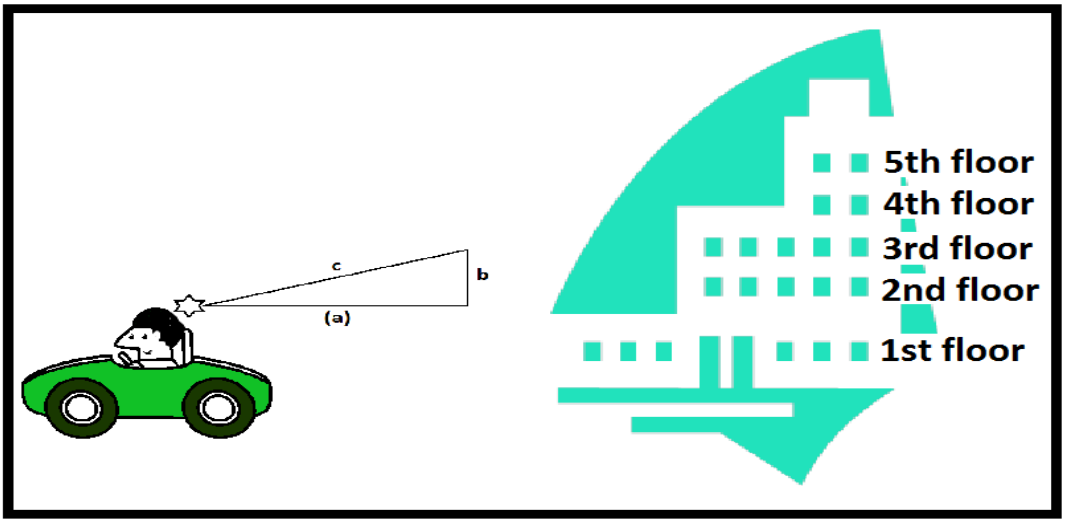
1. Use the information below and the formula above to calculate and find the shooter.
2. The distance from the car to the building where the muzzle flash was seen is 60 feet (720 inches).
3. The entrance wound (bullet hole) on the victim is located 4 feet above the ground.
4. The distance along the path of the bullet to the window is 23.9 inches.
5. The distance along the horizon to the window is 23.5 inches.

(adapted from A. Bertino - Forensic Science)

Firearms and Trajectory Worksheet (continued)

Name: _____ Date: _____

Conclusions and Observations



Solve the following:

1. What was the distance to the shooter (c)? _____

2. The distance to the building is 60 feet; based on the hypotenuse, the Height of shooter ~ _____ feet above the horizon.

3. From which floor was the bullet fired? _____

4. List problems that might interfere with the accuracy of your results?
   _____
   _____
   _____

5. What problems would be encountered if you couldn't accurately determine the trajectory?
   _____
   _____
   _____

6. Draw lines illustrating how you arrived at your conclusion.

(adapted from A. Bertino - Forensic Science)

Firearms and Trajectory Worksheet Key

Calculation using Distance vs. Drop

$$\frac{23.9 \text{ inches}}{23.5 \text{ inches}} = \frac{(c)}{720 \text{ inches}}$$

c = 732.3 inches

Hypotenuse = distance to the shooter

a = distance to the building b = height of shooter from horizon (not ground)

$\text{Hypotenuse}^2 = (a)^2 + (b)^2$

$(732.3 \text{ in})^2 = (720 \text{ in})^2 + b^2$

$536{,}300 \text{ in}^2 = 518{,}400 \text{ in}^2 + b^2$

$536{,}300 \text{ in}^2 - 518{,}400 \text{ in}^2 = b^2$

$17{,}900 \text{ in}^2 = b^2$

b = 133 in ~ 11ft

1. What was the distance to the shooter (c)? **732.3 inches**

2. The distance to the building is 60 feet then based on the Hypotenuse the Height of shooter ~ **(133 in) or 11** feet above the horizon.

3. Prediction, the bullet was fired from which floor ? **second**

4. List problems that might interfere with the accuracy of your results?
inconsistent or no witnesses, multiple entrance wounds on victim from multiple locations, evidence contaminated, (answers may vary)

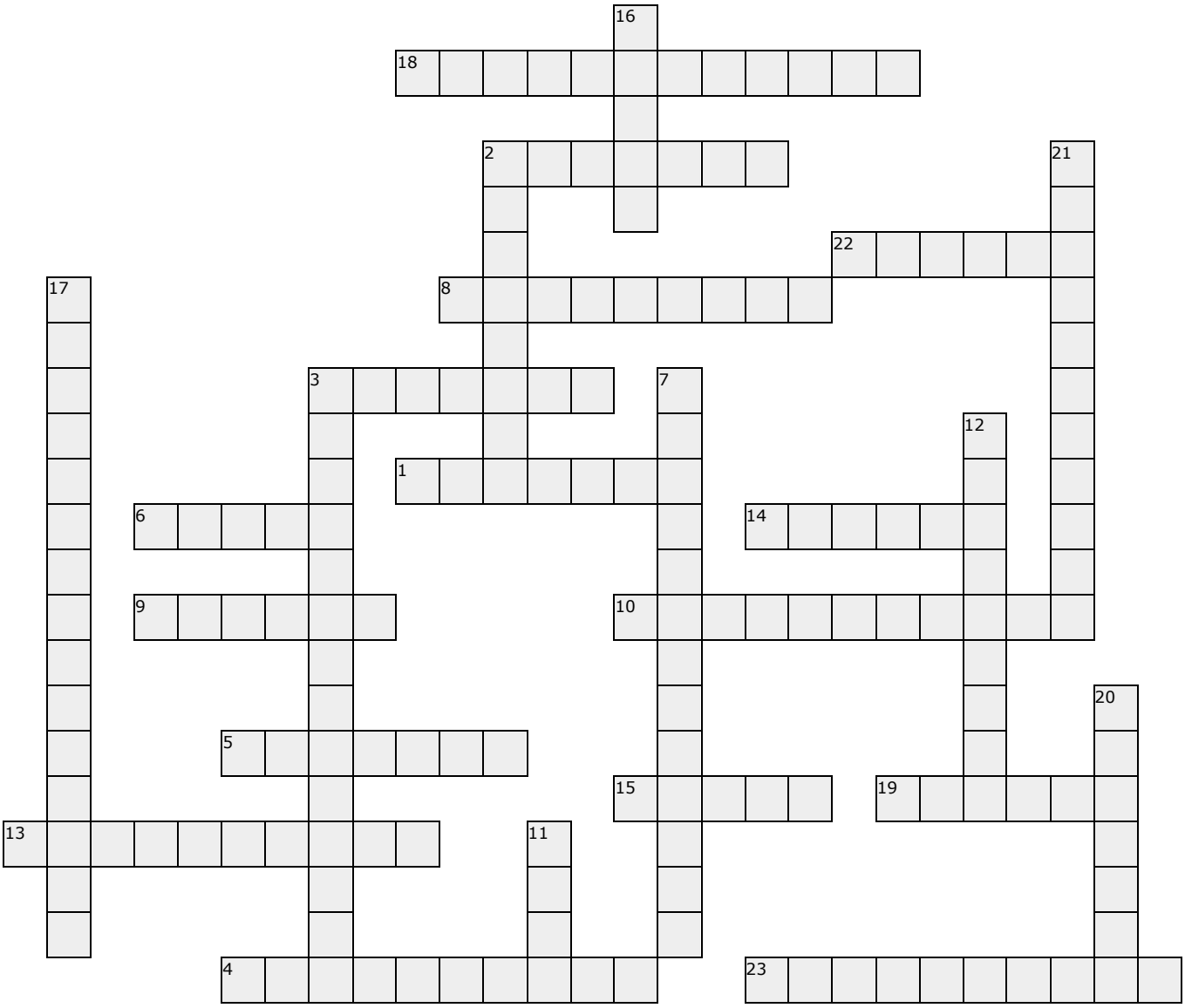
5. What problems would be encountered if you couldn't accurately determine the trajectory angle?
Unable to locate shooter, unable to locate additional evidence, case will be difficult to close. If suspect is eventually found, when case goes to court, it will be difficult to convict with questionable evidence.

6. Draw lines illustrating how you arrived at your conclusion
The shooting occurred 15 feet above the ground; thus, the line should be on the second floor

(adapted from A. Bertino - Forensic Science)

Name:_____ Date:_____

Firearms & Tool Marks Crossword Puzzle



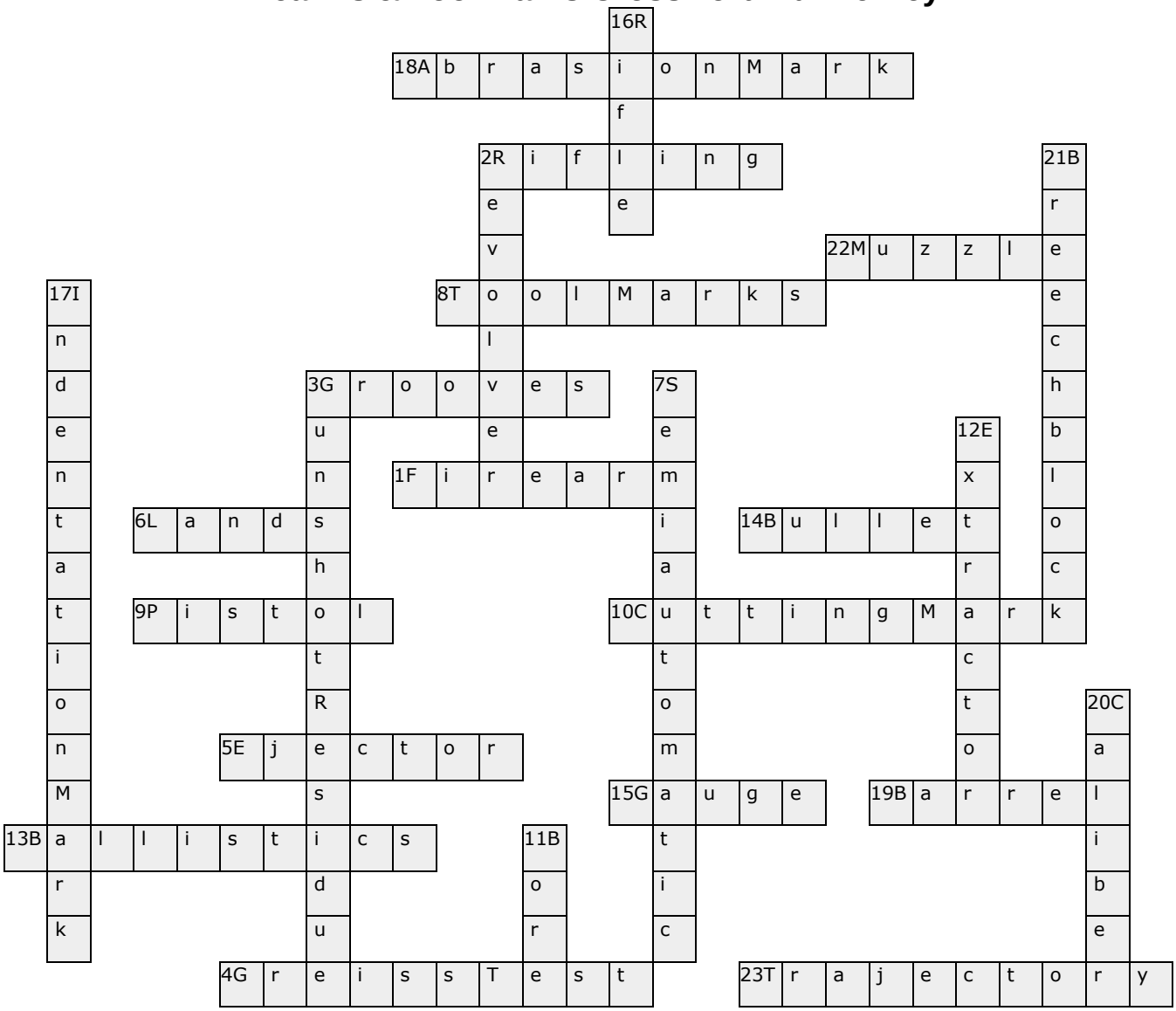
Across:

1. A weapon capable of firing a projectile using a confined explosive as a propellant
2. The spiral grooves formed in the bore of a firearm barrel that spin the projectile when it is fired
3. The cut or low-lying portions between the lands in a rifled bore
4. A chemical test used to examine patterns of gunpowder residues around bullet holes
5. The mechanism in a firearm that throws the cartridge or fired case from a firearm
6. The raised portion between the grooves in a rifled bore
8. Any impression, scratch, or abrasion made when contact occurs between a tool and another object
9. A handheld firearm
10. A mark produced along the edge as a surface is cut
13. The study of projectiles and firearms
14. The projectile that is released when a firearm is discharged
15. The size designation of a shotgun; originally the number of lead balls with the same diameter as the barrel that would weigh a pound
18. A mark produced when a surface slides across another surface
19. The long, metal tube that guides a projectile out of a firearm
22. The end of the barrel from which the projectile exits a firearm
23. The path of flight of a projectile

Down:

2. A pistol with a revolving cylinder
3. The tiny particles expelled from a firearm when it is fired
7. A pistol with a clip-fed mechanism that fires one shot per pull of the trigger
11. The interior of a firearm barrel
12. The mechanism in a firearm that withdraws a cartridge or fired case from the chamber
16. A firearm that has a long barrel; a long gun
17. A mark or impression made by a tool on a softer surface
20. The diameter of the bore of a rifled firearm, usually expressed in hundredths of an inch or millimeters
21. The rear part of a firearm barrel

Firearms & Tool Marks Crossword Puzzle Key



Across:

1. Firearm
2. Rifling
3. Grooves
4. GreissTest
5. Ejector
6. Lands
8. ToolMarks
9. Pistol
10. CuttingMark
13. Ballistics
14. Bullet
15. Gauge
18. AbrasionMark
19. Barrel
22. Muzzle
23. Trajectory

Down:

2. Revolver
3. GunshotResidue
7. Semiautomatic
11. Bore
12. Extractor
16. Rifle
17. IndentationMark
20. Caliber
21. Breechblock

Name_____ Date_____

Discussion Rubric

Objectives	4 pts. Excellent	3 pts. Good	2 pts. Needs Some Improvement	1 pt. Needs Much Improvement	N/A	Pts.
Participates in group discussion						
Encourages others to join the conversation						
Keeps the discussion progressing to achieve goals						
Shares thoughts actively while offering helpful recommendations to others						
Gives credit to others for their ideas						
Respects the opinions of others						
Involves others by asking questions or requesting input						
Expresses thoughts and ideas clearly and effectively						
Total Points (32 pts.)						

Comments:

Name_____ Date_____

Individual Work Rubric

Objectives	4 pts. Excellent	3 pts. Good	2 pts. Needs Some Improvement	1 pt. Needs Much Improvement	N/A	Pts.
Follows directions: Student completed the work as directed following the directions given, in order and to the level of quality indicated.						
Time management: Student used his/her time wisely and remained on task 100% of the time.						
Organization: Notes and materials were kept in a neat, legible and organized manner. Information was readily retrieved.						
Evidence of learning: Student documented information in his/her own words and can accurately answer questions related to information retrieved.						
***Research/Gathering information (if relevant):** Student used a variety of methods and sources to gather information. Student took notes as they gathered information.						
Total Points (20 pts.)						

Comments:

Name_____ Date_____

Research Rubric

Objectives	4 pts. Excellent	3 pts. Good	2 pts. Needs Some Improvement	1 pt. Needs Much Improvement	N/A	Pts.
Question/goal: Identified and communicated a question or goal of the research.						
Research/Gathering information (if relevant): Student used a variety of methods and sources to gather information. Student took notes as they gathered information.						
Conclusion/Summary: Draws insightful conclusions and observations from information gathered. Information is organized in a logical manner.						
Communication: Communicates the information gathered and summary/conclusions persuasively. Demonstrates skill in use of media used to communicate the results of research.						
Reflection: Reflects on the importance of the research and potential application.						
Total Points (20 pts.)						

Comments: