U. P. RAJARSHI TANDON
OPEN UNIVERSITY

Certificate Course in Forensic Science

CFS-03

FORENSIC PHYSICS, BALLISTICS DIGITAL FORENSIC AND SPECIAL TOPICS

Block

5

FORENSIC PHYSICS AND BALLISTICS

Unit 17 SPEAKER IDENTIFICATION AND AUDIO-VIDEO AUTHENTICATION

UNIT 18 BALLISTICS

UNIT 19 MECHANISM OF FORMATION OF GUN SHOT RESIDUES

Block

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DIGITAL FORENSICS AND SPECIAL TOPICS

UNIT 20 COMPUTER FORENSICS AND CYBER CRIME

UNIT 21 POLYGRAPH

UNIT 22 NARCO ANALYSIS

UNIT 23 BRAIN FINGERPRINTING

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FORENSIC PHYSICS AND BALLISTICS

Unit 17 **3**

SPEAKER IDENTIFICATION AND AUDIO-VIDEO AUTHENTICATION

UNIT 18 **11**

BALLISTICS

UNIT 19 **37**

MECHANISM OF FORMATION OF GUN SHOT RESIDUES

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UNIT-17 : SPEAKER IDENTIFICATION AND AUDIO-VIDEO AUTHENTICATION

Structure

17.0 Introduction
17.1 Objectives
17.2 Speaker identification
17.3 Voice production theory
17.4 Acoustic characteristics of speech
17.5 Audio - video authentication
17.6 Analog and digital tape recording
17.7 Summary

17.0 INTRODUCTION

In audio-visual forensics studies and application, video authentication is an intricate process requiring extensive training, experience and sophisticated tools and equipment. The ever-changing technological advances and increased use of recording devices by businesses and the general public requires the expertise needed by today's AV forensics professionals.

The process of authenticating a digital video file and videotape is for the purpose of verifying it as legal evidence in the court of law. Recording over tapes is a common practice with consumers. It's also quite common with security camera/surveillance tapes. Repeated over-recording of surveillance tapes is pretty much the norm since the use of new, blank tapes for every recording use would be costly, especially if security cameras are on 24/7. As a result of reusing tapes, videotapes being considered for use as evidence in court must often be examined for authenticity and recording integrity by AV forensics professionals.

17.1 OBJECTIVES

The main objective of the module is to study the voice encountered as evidence in cases of trap investigation, threatening calls, anonymous calls in ransom case investigation, hostile witness and tampering of audio recorded conversation. The scientific investigations of recorded voice collaborate to scientific evidence in respect of speaker recognition. The main objectives of this study are as follows:

- Checking of contents of parcel for its integrity.
- The original cassettes need to be verified whether it is in accordance with the forwarding memo.
- Physical examination of tapes for authenticity. There are several factors to consider such as:
  i) The length of tape on reel.
  ii) The physical damage to (or condition of) the reel/cassette.
  iii) Preparation of copies of recorded audio tapes: Duplicate copies haveto be repaired on good quality cassettes using high quality calibrated tape recorder.

17.2 SPEAKER IDENTIFICATION

Voice is frequently encountered as evidence in cases of kidnapping for ransom, threatening calls, anonymous calls, hoax calls, obscene calls, terrorist threats, trap investigation and so on. The scientific investigation of the recorded voice corroborates evidence in respect of speaker identification.

The history of speech sound analysis goes back a little more than one hundred years to Alexander Bell who developed a visual representation of the spoken word. It was in the early 1940's that a new method of speech sounds analysis was developed. This machine named sound spectrograph was automatic sound wave analyzer, produced a visual record of speech portraying three parameters viz., frequency, intensity and time.

Today voice identification & analysis has matured into a sophisticated identification technique, using the latest technology science has to offer. The research, which is still continuing today, demonstrates the validity and reliability of the process when performed by a trained examiner using established, standardized procedures.

17.3 VOICE PRODUCTION THEORY

Human organs that combine to produce intelligible speech are:

- The lungs & windpipe
- The larynx
- Upper throat
- The mouth
- The nasal cavities

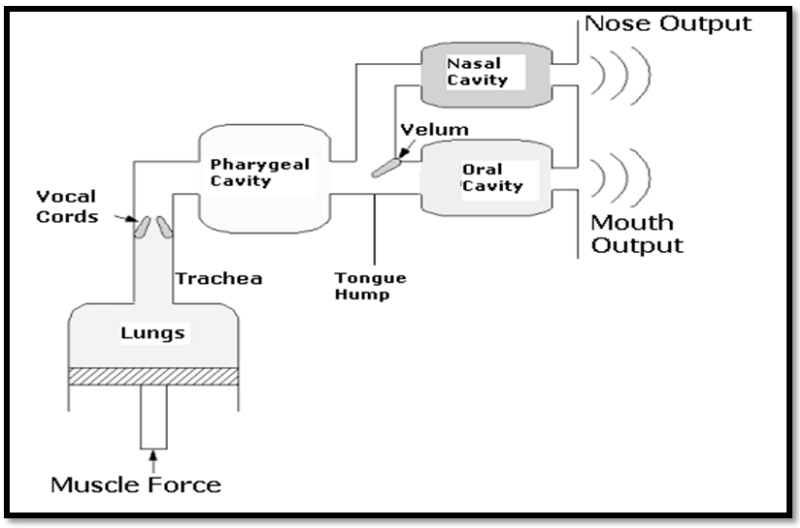


Figure1: Schematic diagram showing the various organs responsible for intelligible speech

Characteristics of speech for identification of speakers

The speaker or voice - identification is based on two parameters namely;

- Auditory (listening) characteristic
- Spectrographic (visual) characteristics

17.4 ACOUSTIC CHARACTERISTICS OF SPEECH

- The inter speakers are differentiated by the attributes of voice production machine, language of speech and manner of speaking. The auditory analysis reveals dynamics of speech such as dialect, pitch, articulation, general voice quality, intonation, stress/emphasis disguise, speech defects etc.
- In some situations, the speaker makes an attempt to disguise the normal voice during recording of the specimen voice sample. The presence of emotional and psychological tensions at the time of recording, some of the spectrographic features are likely to change/shift from the normal.
- The use of good quality listening instrument helps the examiner to assess the apparent age of speaker, dynamics of loudness, degree of nasality and pathology of voice (whispery, creaky, breath of hoarse).
- After listening to the questioned and standard, the auditory features i.e. linguistic and phonetic features (dialect, accent articulation, vocal quality, stress etc.,) are compared. Peculiar speech habits are also scrutinized.
- **Spectrographic characteristics**
  The latest technology introduced in the spectrographic instrumentation facilitates the comparison of two voices, one suspected and the other known or standard by means of a combination of words and sentences selected from speeches to arrive at a conclusion whether the suspect is responsible for a particular voice / speech or not.
  Spectrogram is a three dimensional representation of sound.
- Horizontal axis represents time.
- Vertical axis represents frequency.
- Darkness represents intensity.

  These three dimensions give information on how the frequency and intensity change with time

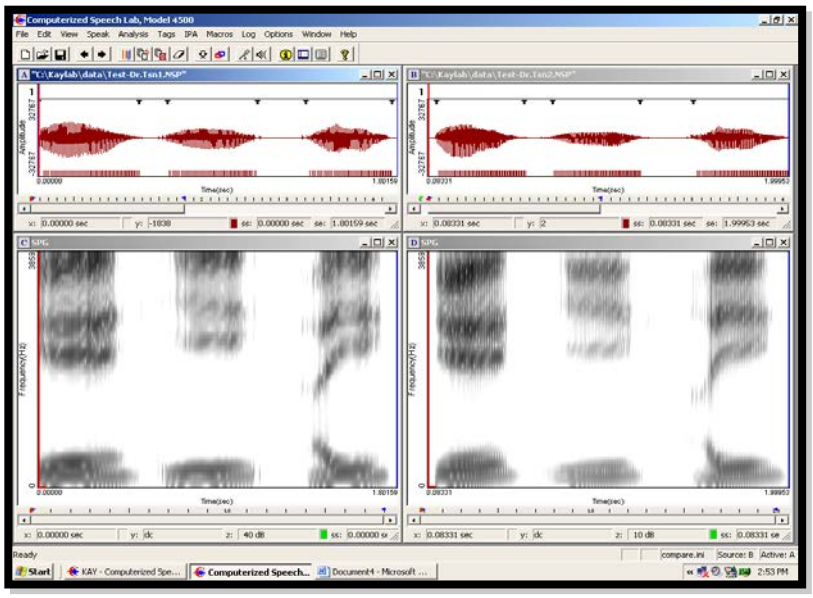


Figure 2: The similarity in the above two spectrograms indicate that the samples were spoken by the same individual.

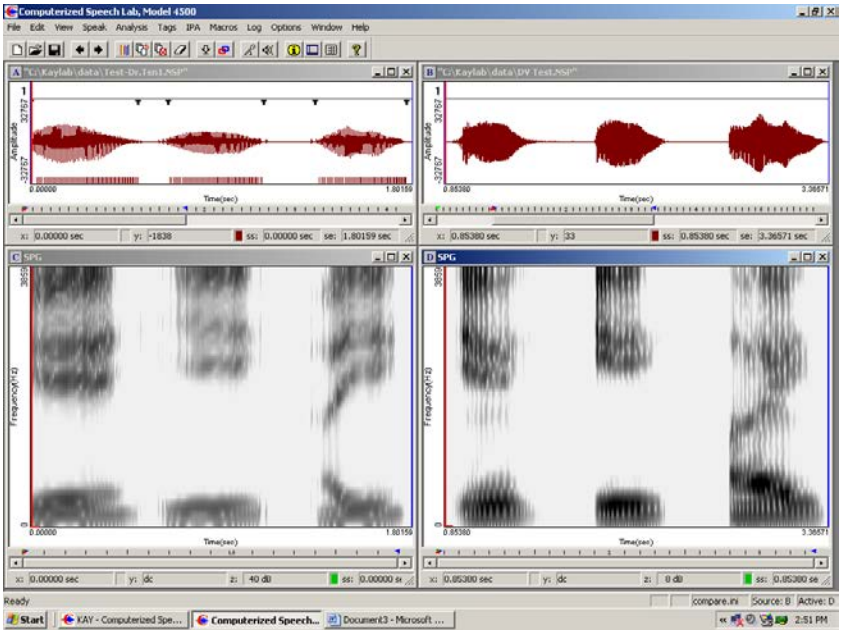


Figure 3 : The above spectrograms of two different speech samples are dissimilar indicating the two samples were spoken by two different individuals.

Reporting procedure:

When the analysis is complete the examiner integrates his findings from both the auditory and spectrographic analysis into one of the following five conclusions:

- A positive identification
- Probable identification
- Positive elimination
- Probable elimination
- No decision

17.5 AUDIO-VIDEO AUTHENTICATION

Video Authentication is the process of verifying whether the digital video in use is genuine (not been tampered with in anyway). This technology assumes immense importance, as without it video can never be admissible proof in the court of law. Video Authentication confirms the integrity of the video.

The first step in the authentication process for an analogue video tape is to make a copy on the VCR used to create the original evidence. This is called making an exemplar. VCRs actually have an identity, much like humans do. With people, we identify human characteristics like eye color, hair color, weight, body size/type, DNA, fingerprints. VCRs also have record “signatures” which forensics experts need to examine. Essentially, these identifying signatures or recording characteristics are: stop, start, record, record interruptions and other indications discovered on the tape’s audio tracks. With video recorders, we identify signature characteristics in several ways. First, there are two distinct audio tracks generated on most videotapes that have replicated (or recorded)

images existing on tape formats, such as VHS tape. The two tracks are: (1) Linear and (2) Non-linear. Audio tracks provide forensics experts with much information – as does the video control track.

We begin documenting the identity of the (alleged) recording device or VCR by recording a fresh video test pattern – via an NTSC test pattern generator – and a series of audio tones generated by an industry-standard tone generator. These are recorded onto a virgin (blank) tape. Hertz frequencies are also examined. Hertz, or Hz, is an audio frequency measurement, similar to decibels (db) measuring audio volume intensity. HZ frequencies examined in forensics generally include 250 Hz, 1000 Hz, 3000 Hz and 8000 Hz. Reading and comparing these frequencies is achieved by use of a computer spectrum analyzer.

A comparison analysis is conducted on the exemplar and on the original evidence tape. Note that even if the videotape being examined under forensics scrutiny has no picture, the audio tracks can still be examined for evidence, along with the video's control track. Once we have an exemplar made on the same equipment on which the evidence was made, it's time to address further comparisons.

Video recording signatures (think of them as similar to human signatures) are examined. Stop/start record signatures are studied; record-interrupt distances are measured physically. Examining the tape itself by applying 'Krylon magnetic tape developing fluid' exhibits the nature of the signature or anomaly. This fluid is amazingly effective in revealing the true recording signature – very similar to how fingerprint dusting powder reveals a person's fingerprints.

After viewing the entire videotape using the "fast forward" mode, where ever a record interrupt is visually observed, the tape is stopped as near as possible to the exact interruption spot. The tape is disengaged (ejected) and physical exam of the tape commences. Krylon magnetic tape developing fluid is applied to the tape itself to reveal stops in the tape.

When a new videotape is inserted into a recorder, the tape is threaded into the engage mechanism. This places the tape against the recording head; this action actually pulls the tape out of the shell and threads it across the tape head. This process can be recreated if it becomes necessary.

If a recording is stopped, the engage mechanism disengages. If the recording is continued, and the tape is not shuttled, the tape is re-engaged and the recording continues. However, some physical "glitch" will be evident in both the TV monitor image and in the physical examination of the developed magnetic tape. In addition, evidence of this interrupt is often obvious (and substantiated) by examining the control track.

After the first identified record interrupt is examined and documented, physical study of the tape continues by repeating the process in search for any other interrupts – re-engaging the VHS tape into fast-forward tracking mode until another glitch is noticed. Naturally, the entire above process of developing and observing is again repeated for each instance of noted interruption.

Next, as required by the scientific community and forensics procedures, the exact length of the videotape must be established. While most videotapes have a time/length stamped on the spine, length verification is needed. The length is imprinted on the spine of the plastic shell that houses the physical tape itself – for example; 120 or 160 may be imprinted. However, the stated length must be verified by taking a measurement. To do this, the tape is completely rewound to the beginning and the tape counter is reset as the start point. Then, fast-forwarding the tape to the end, the digital counter's reading at the tape's end point is observed and noted. Now, if the reading on the videotape display count is less than the indicated stamped length, this can be an indication that the tape has been tampered with.

If the time is more than what is indicated on the spine, that's acceptable. Then, using a cross pulse monitor, any glitches discovered on the tape are measured and checked considering other conditions that exist on the tape (i.e., the tape's "fingerprints"). The cross pulse monitor measures the glitches – different electrical and magnetic fields on the videotape – similar to how an EKG records and measures electronic signals from a human heart. Even if there is no video image on the tape, tape signatures can still be revealed during this monitoring test as long as the tape has been recorded on at some point.

If a recording is stopped, and the tape was disengaged from the tape head then re-recorded, we would notice something very different. Physical examination using the magnetic tape developing fluid would reveal a straight vertical line, indicating the stop, and a straight vertical line indicating the re-start of the recording. A professional, frame-accurate video deck would reveal frame-accurate stop/start with no fade-in. Many of these tests can be conducted or recreated using a professional frame-accurate video deck. If any frames need to be examined further, the video sequence is loaded into a computer using a professional video capture card, manufactured by Targa.

NOTE: Targa is a professional-brand capture card. Off-market and consumer video capture cards are not of the highest resolution; they should not be used when forensics/scientific reliability is at stake.

Note, also, that videotapes can be physically cut and spliced. Thus, glitches detected during the process will also prompt the forensics expert to examine a tape for physical splicing (as opposed to electronic splicing or edits resulting from re-recording over tape images).

A splice repair is generally made with an adhesive-style clear tape on the videotape. To the untrained eye, these could appear to be several scene changes. To the trained eye, these indicate that the tape has been recorded on previously or is possibly a physical splice to be examined. Note, too, that it's a good idea to read these and other stop/start signatures using an oscilloscope, as well as physically using Krylon fluid to confirm record-interrupt theories.

Next, all test results must be compared from the original evidence tape to the exemplar test results to determine if both tapes were made on the same equipment. The scientific community requires that forensics experts document all test steps and procedures, as well as equipment type, as in the authentication process in order to substantiate conclusions arrived at.

17.6 ANALOG AND DIGITAL TAPE RECORDING

An analog recording is one where a property or characteristic of a physical recording medium is made to vary in a manner analogous to the variations in air pressure of the original sound. Generally, the air pressure variations are first converted (by a transducer such as a microphone) into an electrical analog signal in which either the instantaneous voltage or current is directly proportional to the instantaneous air pressure (or is a function of the pressure). The variations of the electrical signal in turn are converted to variations in the recording medium by a recording machine such as a tape recorder or record cutter—the variable property of the medium is modulated by the signal. Examples of properties that are modified are the magnetization of magnetic tape or the deviation (or displacement) of the groove of a gramophone disc from a smooth, flat spiral track.

A digital recording is produced by converting the physical properties of the original sound into a sequence of numbers, which can then be stored and read back for reproduction. Normally, the sound is transduced (as by a microphone) to an analog signal in the same way as for analog recording, and

then the analog signal is digitized, or converted to a digital signal, through an analog-to-digital converter and then recorded onto a digital storage medium such as a compact disc or hard disk.
Both analog and digital systems have limitations. The bandwidth of an analog system is limited by the physical capabilities of the analog circuits and recording medium. The signal-to-noise ratio (S/N) of a digital system is limited by the bit depth of the digitization process. In an analog system, other natural analog noise sources exist, such as flicker noise and imperfections in the recording medium.

CHECK YOUR PROGRESS

1. The speaker identification process requires comparison of:
   (i) Spectrograms
   (ii) Spectroscopy
   (iii) Spectrophotometry
   (iv) Sophisticated technique

2. The purpose of audio-video authentication is to:
   (i) Verify the integrity of the tape
   (ii) Check the medium of recording
   (iii) Compare the recordings
   (iv) Measure the length of the tape

3. The audio-video tapes can be recorded in which of the following form:
   (i) Digital and transverse recording
   (ii) Digital and analog recording
   (iii) Analog and gramophone recording
   (iv) None of the above

Answers

1) I
2) I
3) II

17.7 SUMMARY

Speaker recognition is performed by auditory and instrumental methods. The auditory analysis is based on the different utterances of speakers in the cassettes are segregated in respect of each speaker by the way of repeated listening. The segregated conversations are copied at constant tape speed using freshly cleaned recording head. The segregated conversations of each speaker are repeatedly heard to identify linguistics and phonetic features. The common clue words of speaker from questioned and specimen samples are selected for instrumental analysis (sound spectrograph). The sound spectrograph converts a complex speech waves into visual representation of its frequency components. The input to the spectrograph is a tape record speech sample limited to loop segments in 2.4 seconds at the frequency range 0 to 10Khz. The output consists of graphic display (spectrograph) of frequency/intensity of sound over a time for the analysing sample.
Analysis results are recorded on electro sensitive paper in terms of pattern section and amplitude analysis. On the basis of auditory and instrumental analysis, the conclusions are drawn in respect of speaker recognition and tape authentication.

UNIT - 18 : BALLISTICS

Structure

18.0 Introduction
18.1 Objectives
18.2 Classification of firearms
18.3 Loading and Firing mechanisms of different firearms
18.4 Range of Fire
18.5 Ballistics
  18.5.1 Internal ballistics
  18.5.2 External ballistics
  18.5.3 Terminal ballistics
18.6 Matching of bullets and cartridges
18.7 Summary

18.0 INTRODUCTION

Firearms may be defined as a device consisting of a cylindrical tube through which missiles can be projected in a particular direction by force obtained from burning of a small quantity of gunpowder within the tube. A firearm is a machine through which potential energy of the gunpowder is converted into the kinetic energy of the projectile.

Forensic Ballistics deals with the comparison and identification of crime scene bullets and shell/cartridges, firing pin impressions with the marks on test-fired rounds in the forensic laboratory. If the marks on the bullet made by the test gun barrel are identical to the striations (rifling scratches) on the crime scene bullet, or the firing pin impressions are the same, the crime scene weapon has been identified. The science is grounded on the principal that no two guns will leave the same marks on the ammunition. Bullet striations and firing pin impressions are unique as a person's fingerprints. Firearms identification also involves restoring filed off serial numbers, retracing projectile flights, identifying the various types of bullet wounds, and determining the range of close range shots through powder stain patterns on the target. Firearms identification experts apply the sciences of metallurgy, chemistry (gunshot residue analysis), microscopy and ballistics to name a few. Forensic firearms experts are trained on-the-job in crime laboratories.

18.1 OBJECTIVES

- Recognize the forensic value of the examination of firearms and firearms-related physical evidences.
- Describe the essential characteristics of the common types of firearm and ammunition encountered during forensic investigation.
- Understand the terms internal, external and terminal ballistics.

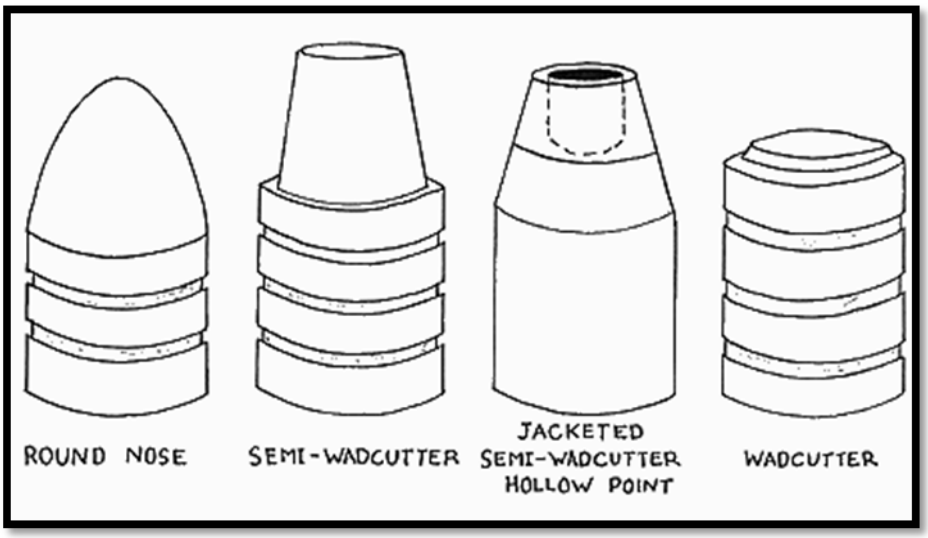
- Discuss the key types of information that may be obtained by the examination of suspect firearms, spent cartridge cases, projectiles and other ejecta, and appreciate how such information can be gained.

18.2 CLASSIFICATION OF FIREARMS

Before studying about classification of firearms, let us be familiar with some terminology commonly used in ballistics

- **Action:** The part of a firearm that loads, fires, and ejects a cartridge. Includes lever action, pump action, bolt action, and semi-automatic. The first three are found in weapons that fire a single shot. Firearms that can shoot multiple rounds ("repeaters") include all these types of actions, but only the semi-automatic does not require manual operation between rounds. A truly "automatic" action is found on a machine gun.
- **Barrel:** The metal tube through which the bullet is fired.
- **Bore:** The inside of the barrel. "Smoothbore" weapons (typically shotguns) have no rifling. Most handguns and rifles have "rifling".
- **Breech:** The end of the barrel attached to the action.
- **Bullets:** The projectile. They are shaped or composed differently for a variety of purposes.

  "round-nose" - The end of the bullet is blunted.
  "hollow-point" - There is a central cavity in the bullet nose not covered by a metal jacket that creates expansion when a target is struck, creating more damage.
  "jacketed" - The soft lead is surrounded by another metal, usually copper, that allows the bullet to penetrate a target more easily.
  "wadcutter" - The front of the bullet is flattened.
  "semi-wadcutter" - Intermediate between round-nose and wadcutter.
  "semi-wadcutter" - Features of both semi-wadcutter and hollowpoint.



- **Butt or buttstock:** The portion of the gun which is held or shouldered.

- **Caliber:** The diameter of the bore measured from land to land, usually expressed in hundredths of an inch (.22 cal) or in millimeters (9mm).
- **Cartridge:** Also called a "round". Made up of a case, primer, powder, and bullet.
- **Centerfire:** The cartridge contains the primer in the center of the base, where it can be struck by the firing pin of the action.
- **Chamber:** The portion of the "action" that holds the cartridge ready for firing.
- **Choke:** A constriction of a shotgun bore at the muzzle that determines the pattern of the fired shot.
- **Double-action:** Pulling the trigger both cocks the hammer and fires the gun.
- **Double barrel:** Two barrels side by side or one on top of the other, usually on a shotgun.
- **Gauge:** Refers to the diameter of the barrel on a shotgun in terms of the number of lead balls the size of the bore it would take to weigh one pound (10 gauge, 12 gauge, etc.) ".410 gauge" really refers to caliber, but is worded as such to refer to a shotgun.
- **Hammer:** A metal rod or plate that typically drives a firing pin to strike the cartridge primer to detonate the powder.
- **Ignition:** The way in which powder is ignited. Old muzzle-loading weapons used flintlock or percussion caps. Modern guns use "primers" that are "rimfire" or "centerfire"
- **Lands and grooves:** Lands are the metal inside the barrel left after the spiral grooves are cut to produce the rifling.
- **Magazine:** This is a device for storing cartridges in a repeating firearm for loading into the chamber.
- **Muzzle:** The end of the barrel out of which the bullet comes.

Pistol: Synonym for a handgun that does not have a revolving cylinder.

Powder: Modern gun cartridges use "smokeless" powder that is relatively stable, of uniform quality, and leaves little residue when ignited. For centuries, "black powder" was used and was quite volatile (ignited at low temperature or shock), was composed of irregularly sized grains, and left a heavy residue after ignition, requiring frequent cleaning of bore.

Primer: A volatile substance that ignites when struck to detonate the powder in a cartridge. "Rimfire" cartridges have primer inside the base, while "centerfire" cartridges have primer in a hole in the middle of the base of the cartridge case.

Revolver: Handgun that has a cylinder with holes to contain the cartridges. The cylinder revolves to bring the cartridge into position to be fired. This is "single-action" when the hammer must be cocked before the trigger can fire the weapon. It is "double-action" when pulling the trigger both cocks and fires the gun.

Rifling: The spiral grooves cut inside a gun barrel that give the bullet a spinning motion. The metal between the grooves is called a "land".

Rimfire: The cartridge has the primer distributed around the periphery of the base.

Safety: A mechanism on an action to prevent firing of the gun.

Shotgun: A gun with a smoothbore that shoots cartridges that contain "shot" or small metal pellets (of lead or steel) as the projectiles.

Silencer: A device that fits over the muzzle of the barrel to muffle the sound of a gunshot. Most work by baffling the escape of gases.

Single-action: The hammer must be manually cocked before the trigger can be pulled to fire the gun.

Stock: A wood, metal, or plastic frame that holds the barrel and action and allows the gun to be held firmly.

Operation cycle of a firearm:

A series of mechanical or manually operated events that take place in all firearms during the firing of ammunition. These terms are used to describe with technical accuracy the manner in which the mechanism functions. This series of events is described as follows:

1. Cocking
2. Feeding
3. Loading
4. Locking
5. Firing
6. Unlocking
7. Extraction
8. Ejection

(**NOTE:** These events do not necessarily occur in the order described above.)

Classification of firearms

Modern firearms are manufactured in a variety of shapes and sizes to fit multiple purposes. These firearms can be classified on the basis of the following characteristics:

- Bore characteristics (smooth bore or rifled firearm)
- Loading mechanism (muzzle loader or breech loader)
- Handling mechanisms (handguns or shoulder weapons).

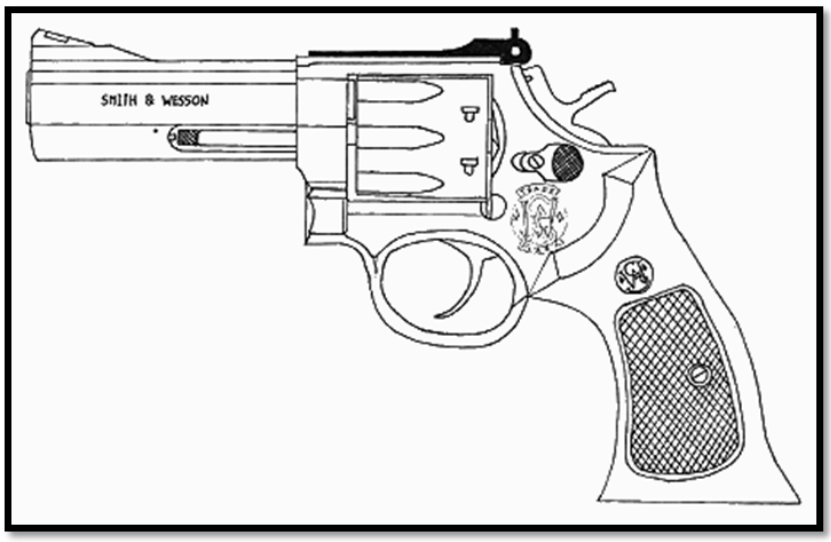
Handguns

From the very start, a handgun was conceived as a compact weapon for self-defense. Even though today there are handguns made specifically for target competition or hunting, most are still designed

with defense in mind. Thus, handguns are compact and easy to carry, therefore deemed dangerous and are controlled by law in most states. A handgun should be capable of firing a projectile accurately at a target. The energy delivered must be sufficient to quell any attack, yet be light enough so that the recoil generated does not wrest the gun from the shooter's hand; this is difficult in practice and there is no perfect choice, so many types of handguns are manufactured for different situations. The two most common defensive handguns are the double action **revolver** and the semiautomatic **pistol.**

Revolver

A revolver is less expensive, simpler in design and more reliable than semiautomatic pistols. It is easy to master but requires more effort to trigger the target. Revolvers seem to be more accurate than semiautomatics. On the other hand, revolvers are limited to six shots, are relatively slow to reload, the gap between barrel and cylinder makes them less efficient, and the trigger pull is greater. The anatomy of a representative double action revolver is shown below:

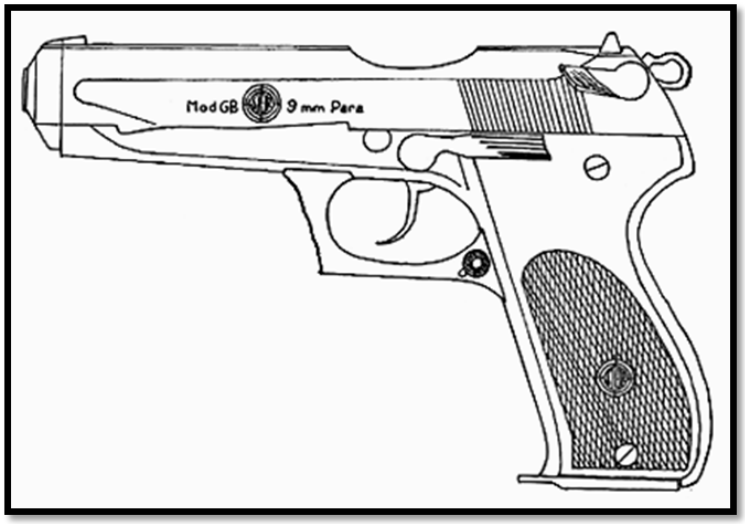


The ejector rod under the barrel is used to eject fired cartridges before reloading. Sights on a revolver are usually a blade in the front and a notch on the rear. The frame is the largest part, and all other pieces attach to it. Frames are usually made of blued or plated steel, stainless steel, or lightweight alloys. A revolver may weigh less than 1 lb to more than 4 lbs. The cylinder contains five or six holes for the cartridges and can be swung out for easy reloading. This must be a conscious act, so that no empty cartridge cases will be found at a crime scene unless the assailant stopped to reload.

There is a gap between cylinder and barrel to allow the cylinder to turn freely, but this also allows gases to escape laterally, which at close range may deposit gunshot residue on surrounding structures and allow the forensic pathologist to reconstruct the scene. The lockwork translates the trigger pull to rotation of the cylinder, cocking and fall of the hammer. If this is done in one motion of pulling the trigger, it is termed "double-action." Single-action revolvers (old Colts of "cowboys") require manual cocking of the hammer before the trigger is pulled. Different types of grips are employed; larger grips allow more accuracy, smaller grips provide.

Pistol

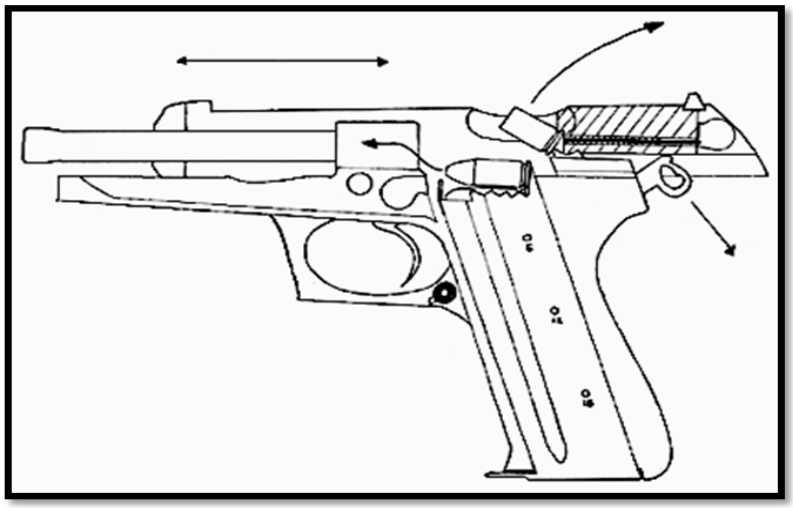
This is a more recent development than the revolver, originating late in the 19th century. The advantage of semiautomatics is the use of recoil generated by the fired cartridge to eject the empty cartridge case, load the next cartridge, and cock the hammer. This is more conducive to firing multiple shots, so many are designed to carry 15 to 19 rounds. Disadvantages include a more complicated mechanism; require more practice to use, and cartridge cases must be short to work well. Revolver cartridges are more powerful than semiautomatic cartridges for this last reason. The anatomy of a semiautomatic pistol is given below:



Choices of barrel length are limited. The barrel is normally hidden by the slide. The slide is able to move back along the axis of the barrel under tension from a spring. Since the cartridge base rests on the slide, the slide does just that under the force of recoil generated by the firing of the cartridge. As the slide and empty cartridge case are accelerating backwards, the case is struck by a stationary piece of metal that bumps it to the side. This is conveniently located next to a hole in the slide, so that the empty cartridge case continues its acceleration in a direction perpendicular to the pistol and into the air, landing from 2 to 20 feet from the fired gun.

The rearward- moving slide also cocks the hammer. After the case is clear the slide hits a stop and the spring tension starts it forward. The magazine spring is pushing on a column of rounds tight up against the bottom of the slide. As the slide comes back by the column of cartridges, it grabs the top one and pushes it forward and up a short ramp into the chamber where the slide locks it in place.

The slide is a key part to the operation of a semiautomatic:



The handle, or butt, is more important here because it contains the magazine holding the cartridges. Safety mechanisms prevent accidental firing. Some lock the hammer, while other designs lock the trigger. Even on open ground ejected cases may be difficult to find, as they typically roll into a hiding place such as grass or small depressions in the ground. Thus, ejected cases will virtually always be left behind at the scene, but must be searched for diligently.

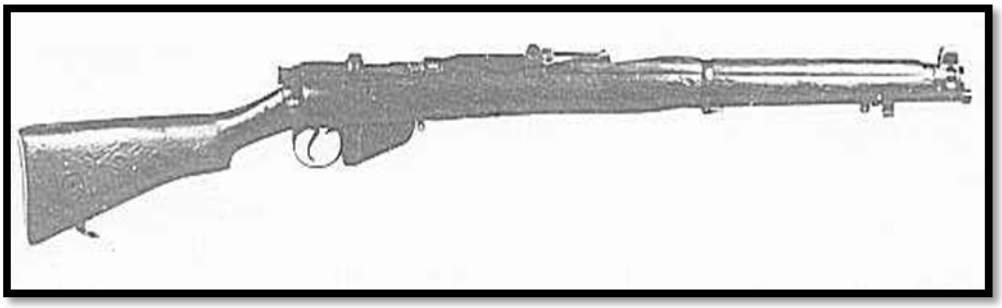
Shoulder weapons

A shoulder weapon is one where the firearm is supported by the shoulder or by the long arm. The two main examples of shoulder weapons are rifle and shotguns. A rifle is a shoulder weapon having a barrel that is 16 inches or more in length. A shotgun is a shoulder weapon having a barrel that is 18 inches or more in length. Rifles and shotguns have an overall length of 26 inches or greater and cannot be concealed on a person.

Rifles

Rifles differ from handguns in the length of the barrel and the presence of a butt stock. They are harder to carry, are poorly concealable, and more loosely regulated than handguns. However, they are much more accurate and shoot more powerful cartridges than handguns. Rifles may be manufactured as single shot, but most commonly are bolt action, used for large caliber hunting rifles. Military rifles are semiautomatic or automatic, having a detachable magazine holding 5 to 50 rounds. Pump action and lever action rifles, usually of lower caliber, have magazines below the barrel.

Rifle, Magazine Lee Enfield Mark 3 – 1907



Rifle, Springfield Armory M1903

Shotguns

Shotguns have a similar external appearance to rifles, but differ in the lack of rifling inside the barrel, which is the basis for their legal definition. A shotgun shell may contain one large projectile (called a slug), a few pellets of large shot, or many tiny pellets. Shotguns are available in single shot (break action), double barrel, pump action, and semiautomatic.

Shotgun, Winchester model 12-1912 pump action

Other types of firearms

- The single action revolver has remained popular for its historic appeal, reliable design, and uncanny balance. A single action Colt 45 is easier to shoot from the hip than a modern revolver, and is used almost exclusively in trick shooting.
- Semiautomatic versions of submachine guns (such as the Uzi) are classed as pistols for legal reasons. These often have the ability to hold 20 to 30 rounds, but are otherwise identical to

conventional handguns in similar caliber. The expense of such weapons precludes their use by most criminals, but they may be used by persons involved in organized crime, drug-dealing, and gangs.

Air guns, which use pneumatic pressure to fire a projectile, are generally known as "BB guns" and have been around for over 200 years. Three mechanisms are employed:

Air is pumped into a pressure chamber reservoir and released by trigger pull. A spring compression system is used to drive a piston to compress air (most "toys" are of this variety). A pressurized, carbon dioxide filled cartridge is attached.

Lastly, there has arisen a new group of handguns for hunting big game and long-range target competition that are nothing but single shot rifles with shortened barrels and no buttstock. These shoot rifle or hybrid rifle cartridges and deliver rifle energies.

18.3 LOADING AND FIRING MECHANISMS OF DIFFERENT FIREARMS

Muzzle Loader

Muzzle-loading muskets (smooth-bored long guns) were among the first small arms developed. The firearm was loaded through the muzzle with gunpowder, optionally some wadding and then a bullet (usually a solid lead ball, but musketeers could shoot stones when they ran out of bullets). Greatly improved muzzleloaders (usually rifled instead of smooth-bored) are manufactured today and have many enthusiasts, many of whom hunt large and small game with their guns. Muzzleloaders have to be manually reloaded after each shot; a skilled archer could fire multiple arrows faster than most early muskets could be reloaded and fired, although by the mid-18th century, when muzzleloaders became the standard small armament of the military, a well-drilled soldier could fire six rounds in a minute using prepared cartridges in his musket. Before then, effectiveness of muzzleloaders was hindered by both the low reloading speed and, before the firing mechanism was perfected, the very high risk posed by the firearm to the person attempting to fire it.

One interesting solution to the reloading problem was the "Roman Candle Gun" with superposed loads. This was a muzzleloader in which multiple charges and balls were loaded one on top of the other, with a small hole in each ball to allow the subsequent charge to be ignited after the one ahead of it was ignited. It was neither a very reliable nor popular firearm, but it enabled a form of "automatic" fire long before the advent of the machine gun.

Matchlock

Matchlocks were the first and simplest small arms firing mechanisms developed. Using the matchlock mechanism, the powder in the gun barrel was ignited by a piece of burning cord called a "match". The match was wedged into one end of an S-shaped piece of steel. As the trigger (often actually a lever) was pulled, the match was brought into the open end of a "touch hole" at the base of the gun barrel, which contained a very small quantity of gunpowder, igniting the main charge of gunpowder in the gun barrel. The match usually had to be relit after each firing.

Wheellock

The wheellock action, a successor to the matchlock, predated the flintlock. Despite its many faults, the wheellock was a significant improvement over the matchlock in terms of both convenience and safety, since it eliminated the need to keep a smoldering match in proximity to loose gunpowder. It

operated using a small wheel much like that on cigarette lighters which was wound up with a key before use and which, when the trigger was pulled, spun against a flint, creating the shower of sparks that ignited the powder in the touch hole. Supposedly invented by Leonardo da Vinci, the Italian Renaissance man, the wheel lock action was an innovation that was not widely adopted.

Flintlock

The flintlock action was a major innovation in small arms design. The spark used to ignite the gunpowder in the touch hole was supplied by a sharpened piece of flint clamped in the jaws of a "cock" which, when released by the trigger, struck a piece of steel called the "frizzen" to create the necessary sparks. (The spring-loaded arm that holds a piece of flint or pyrite is referred to as a cock because of its resemblance to a rooster.) The cock had to be manually reset after each firing, and the flint had to be replaced periodically due to wear from striking the frizzen. The flintlock was widely used during the 18th and 19th centuries in both muskets and rifles.

Percussion cap

Percussion caps (caplock mechanisms), coming into wide service in the 19th century, were a dramatic improvement over flintlocks. With the percussion cap mechanism, the small primer charge of gunpowder used in all preceding small arms was replaced by a completely self-contained explosive charge contained in a small brass "cap". The cap was fastened to the touchhole of the gun (extended to form a "nipple") and ignited by the impact of the gun's "hammer". (The hammer is roughly the same as the cock found on flintlocks except that it doesn't clamp onto anything.) In the case of percussion caps the hammer was hollow on the end to fit around the cap in order to keep the cap from fragmenting and injuring the shooter.

Once struck, the flame from the cap in turn ignited the main charge of gunpowder, as with the flintlock, but there was no longer any need to charge the touchhole with gunpowder, and even better, the touch hole was no longer exposed to the elements. As a result, the percussion cap mechanism was considerably safer, far more weatherproof, and vastly more reliable (cloth-bound cartridges containing a premeasured charge of gunpowder and a ball had been in regular military service for many years, but the exposed gunpowder in the entry to the touch hole had long been a source of misfires). All muzzleloaders manufactured since the second half of the 19th century use percussion caps except those built as replicas of the flintlock or earlier small arms.

18.4 RANGE OF FIRE

The wounds have certain characteristics which permit their identification without difficulties, most of the times. The prominent features utilized for the purpose are- The wounds are circular or oval in most of the cases. Key hole wounds are also formed by wobbling bullets. The diameter of the entrance hole is, ordinarily slightly less than the diameter of the projectile creating the hole.

The edges are compressed inward – they are inverted. A contusion ring is found around the wound in most of the times. The ring is dark red to bluish-black depending upon its age. The dirt or wipe ring is not always present but whenever it is present, it is a sure sign of an entry wound. Burning of skin, flesh or singeing of hair is caused when the shot is fired from a close range. The scorched skin, when it is available, it identifies the entry wound. GSR deposits are from close range firing only. They also

identify the entrance wound whenever they are available. The presence of a muzzle impression around the wound. Sometimes the bullet carries the GSR in their flight from the ejecta, from the barrel fouling and deposit on the edges or inside the entrance hole.
Extraneous deposits around the wound are from the following sources- Propellant burned powder (smoke), semi burnt and unburnt propellant.
Primer residue.
Projectile, Cartridge Case and barrel material (from fouling and bore scraping). Intermediate targets.

The extent of extraneous deposit depends upon-

- The weapon.
- The ammunition.
- The range.
- The angle of fire.
- The target characteristics.

Pink coloration

If a shot is fired from a very close range or in contact with the skin, some carbon monoxide (produced in the combustion of propellants) gets absorbed in the skin and flesh. It gives a pink coloration to the skin around the wound which indicates firearm injury and injury from a close range.

Charring, Scorching, Burning

These are the effects of flame or hot gases produced in the combustion of propellants. The charring is caused when the shot is fired from a very close range. The size, shape and extent are characteristic of the firearm and range. The Charring is often confused with the Blackening, Tattooing, Dirt Ring or even with Contusion Ring. The Charring is different from Blackening. The later can be removed with a cotton swab moistened with spirit while the former cannot be removed in this way.

Blackening

The smoke deposits cause the blackening. The smoke particles are light. They do not travel afar. Therefore, smoke deposit i.e. blackening is limited to a short range. The colour of smoke is grey to black in black powder and light grey to dark grey in smokeless powder.

Tatooing

The tattooing is also known as peppering or stippling. It is the deposit of unburnt or semi-burnt powder particles under the skin. Tattooing, ordinarily, cannot be removed with a swab.

Dirt ring

Some projectile around the wound deposits the dirt ring. The materials come from- The projectile may carry grease on them. The dirt gets collected on the grease, which, in turn, gets deposited around

the wound. Deposit of soot/GSR present on bullet. The projectile picks up the soot/GSR from the powder ejecta which rush past the projectiles inside or outside the barrel.
Dirt due to intermediate target (clothes, mud walls etc.) or from the surface from which the projectile has ricocheted. In shotgun ammunition, the pellets and buckshots are rubbed with graphite. A small amount of graphite is carried by the projectiles, which they deposit around the entry hole. The lead bullets may also blacken the edges of the entry wound.

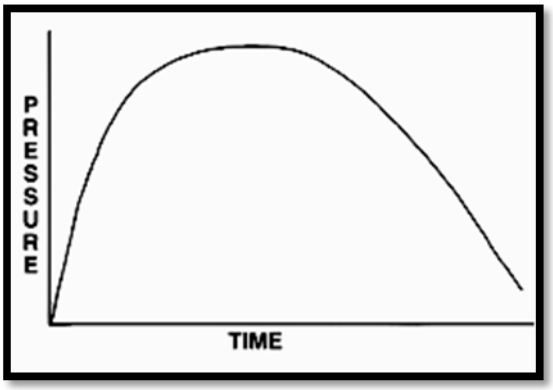
18.5 BALLISTICS

The term ballistics refers to the science of the travel of a projectile in flight. The flight path of a bullet includes; travel down the barrel (internal ballistics), path through the air (external ballistics), and path through a target (terminal ballistics). These are illustrated in this section.

18.5.1 Internal ballistics (within the barrel)

Bullets fired from a rifle will have more energy than similar bullets fired from a handgun. More powder can also be used in rifle cartridges because the bullet chambers can be designed to withstand greater pressures (70,000 psi for rifles vs. 40,000 psi for handgun chamber). Higher pressures require a bigger gun with more recoil that is slower to load and generates more heat that produces more wear on the metal. It is difficult in practice to measure the forces within a gun barrel, but the one easily measured parameter is the velocity with which the bullet exits the barrel (muzzle velocity).

The controlled expansion of gases from burning gunpowder generates pressure (force/area). The area here is the base of the bullet (equivalent to diameter of barrel) and is a constant. Therefore, the energy transmitted to the bullet (with a given mass) will depend upon mass times force times the time interval over which the force is applied. The last of these factors is a function of barrel length. Bullet travel through a gun barrel is characterized by increasing acceleration as the expanding gases push on it, but decreasing pressure in the barrel as the gas expands. Up to a point of diminishing pressure, the longer the barrel, the greater the acceleration of the bullet.



As the bullet traverses the barrel of the gun, some minor deformation occurs, called setback deformation. This results from minor (rarely major) imperfections or variations in rifling or tool marks. The effect upon the subsequent flight path of the bullet is usually insignificant.

18.5.2 External ballistics (flight of projectile in air)

The external ballistics of a bullet's path can be determined by several formulae, the simplest of which is:

Kinetic Energy **(KE) = 1/2 MV^2**

Velocity (V) is usually given in feet/second (fps) and mass (M) is given in pounds, derived from the weight (W) of the bullet in grains, divided by 7000 grains per pound times the acceleration of gravity (32 ft/sec) so that:

Kinetic Energy (KE) = $W(V)^2$ / (450,435) ft/lb

This is the bullet's energy as it leaves the muzzle, but the ballistic coefficient (BC) will determine the amount of KE delivered to the target as air resistance is encountered.

Forward motion of the bullet is also affected by drag (D), which is calculated as:

Drag (D) = $f(v/a)k\&pd^2v^2$

f(v/a) is a coefficient related to the ratio of the velocity of the bullet to the velocity of sound in the medium through which it travels. k is a constant for the shape of the bullet. &is a constant for yaw (deviation from linear flight). p is the density of the medium (tissue density is >800 times that of air). d is the diameter (caliber) of the bullet. v the velocity.

Thus, greater velocity, greater caliber, or denser tissue gives more drag.

The degree to which a bullet is slowed by drag is called retardation (r) given by the formula:

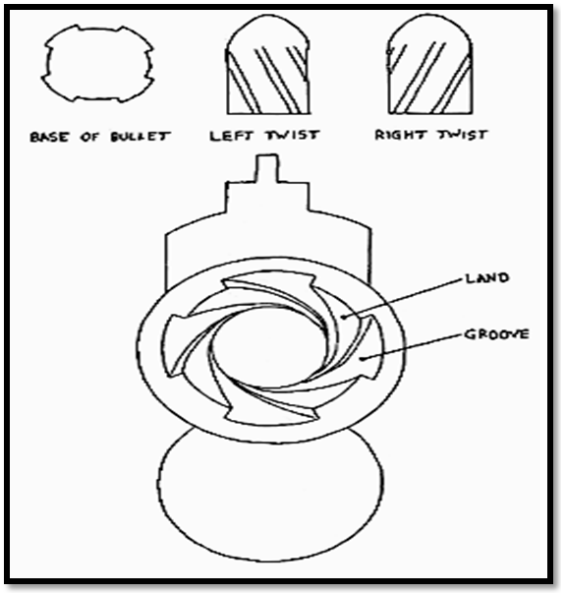
r = D / M

Drag is difficult to measure, so the Ballistic Coefficient (BC) is often used:

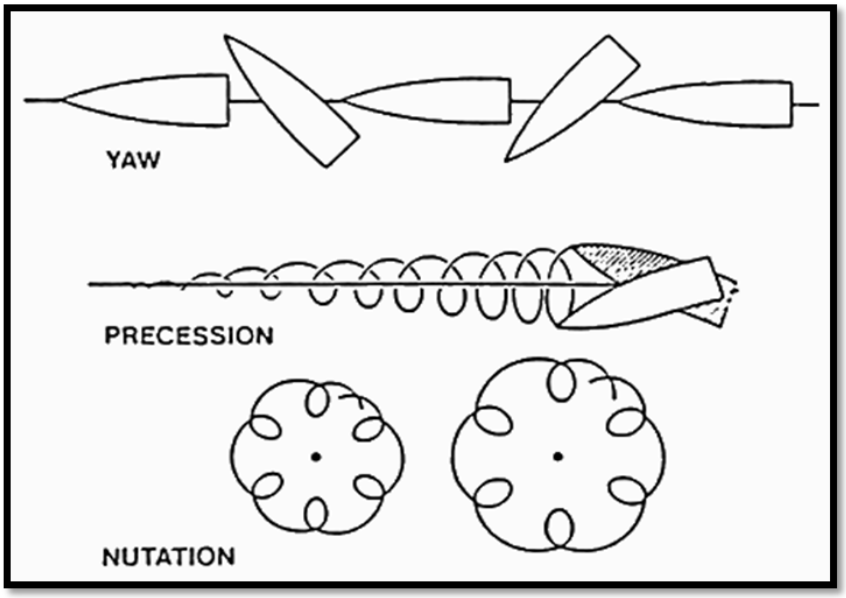
BC = SD / I

SD is the sectional density of the bullet, and I is a form factor for the bullet shape. Sectional density is calculated from the bullet mass (M) divided by the square of its diameter. The form factor value of I decreases with increasing pointedness of the bullet (a sphere would have the highest I value).

Since drag (D) is a function of velocity, it can be seen that for a bullet of a given mass (M), the greater the velocity, the greater the retardation. Drag is also influenced by bullet spin. The faster the spin, the less likely a bullet will "yaw" or turn sideways and tumble in its flight path through the air. Thus, increasing the twist of the rifling from 1 in 7 will impart greater spin than the typical 1 in 12 spiral (one turn in 12 inches of barrel).



Bullets do not typically follow a straight line to the target. Rotational forces are in effect that keep the bullet off a straight axis of flight. These rotational effects are diagrammed below:



Yaw refers to the rotation of the nose of the bullet away from the line of flight. Precession refers to rotation of the bullet around the center of mass. Nutation refers to small circular movement at the bullet tip. Yaw and precession decrease as the distance of the bullet from the barrel increases.

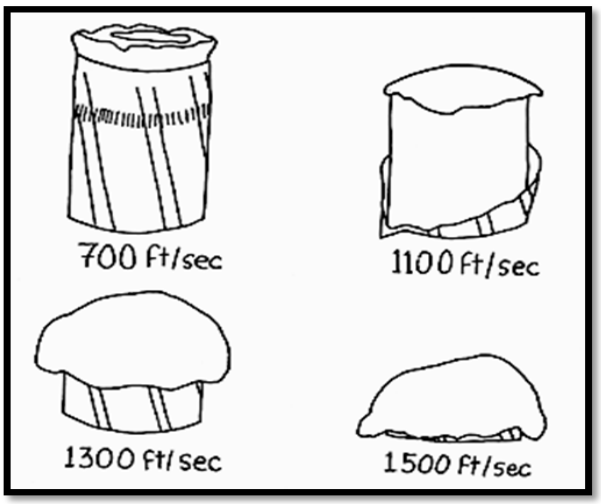
These formulae help in designing cartridges and bullets, given that a cartridge can be only so large to fit in a chamber, and given that the steel of the chamber can handle only so much pressure from increasing the amount of gunpowder, the kinetic energy for any given weapon is increased more easily by increasing bullet mass. Though the square of the velocity would increase KE much more, it is practically very difficult to increase velocity, which is dependent upon the amount of gunpowder burned. There is only so much gunpowder that can be burnt efficiently in a cartridge. Thus, cartridges designed for hunting big game animals use very large bullets.

To reduce air resistance, the ideal bullet would be a long, heavy needle, but such a projectile would go right through the target without dispersing any of its energy. Light spheres would be retarded the greatest and release more energy, but might not get to the target. A compromise for a good aerodynamic shape is a parabolic curve with low frontal area and wind-splitting shape. The best bullet composition is lead (Pb), which is of high density and is cheap to obtain. Its disadvantages are a tendency to soften at velocities >1000 fps, causing it to smear the barrel and decrease accuracy, and >2000 fps lead tends to melt completely. Alloying the lead (Pb) with a small amount of antimony (Sb) helps, but the real answer is to interface the lead bullet with the barrel through another metal soft enough to seal the bullet in the barrel but of high melting point. Copper (Cu) works best as this "jacket" material for lead.

Terminal ballistics (hitting the target)

The pattern of fractures may permit identification of the sequence and direction of fire. The presence of bone damage from an initial injury causes subsequent injuries to stop in the point of intersection with the previous wounds. In the skull, the fracture lines produced by a second gunshot stops at pre-existing fractures of the skull.

Yaw has a lot to do with the injury pattern of a bullet on the target, termed "terminal ballistics." A short, high velocity bullet begins to yaw more severely and rotate upon entering tissue. This causes more tissue to be displaced, increases drag, and imparts more of the KE to the target. A longer, heavier bullet might have more KE at a longer range when it hits the target, but it may penetrate so well that it exits the target with much of its KE remaining. Even a bullet with a low KE can impart significant tissue damage if it can be designed to give up all of the KE into the target, and the target is at short range (as with handguns). Despite yaw, an intact bullet that comes to rest in tissue generally has its long axis aligned along the path of the bullet track, though its final position may be either nose forward or base forward.



Bullets produce tissue damage in three ways:

Laceration and crushing - Tissue damage through laceration and crushing occurs along the path or "track" through the body that a projectile, or its fragments, may produce.

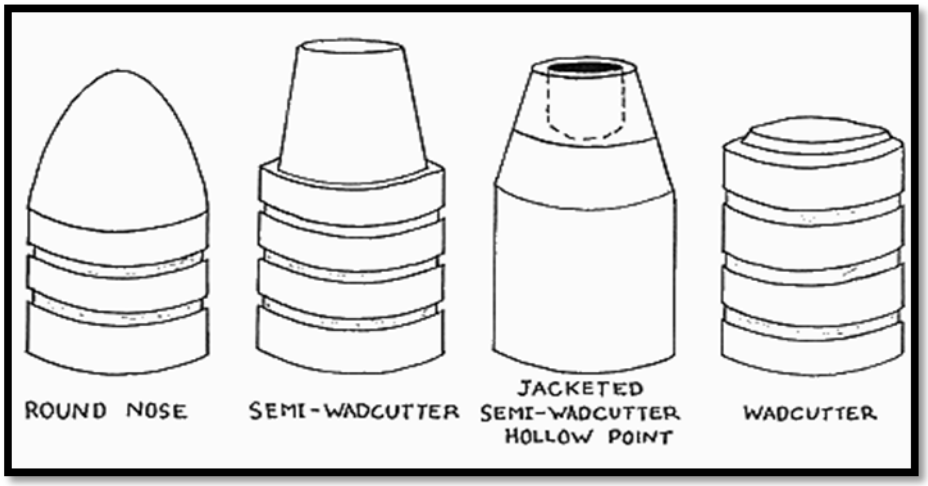
Cavitation - A "permanent" cavity is caused by the path (track) of the bullet itself with crushing of tissue, whereas a "temporary" cavity is formed by radial stretching around the bullet track from continued acceleration of the medium (air or tissue) in the wake of the bullet, causing the wound cavity to be stretched outward. For projectiles traveling at low velocity the permanent and temporary cavities are nearly the same, but at high velocity and with bullet yaw the temporary cavity becomes larger.

Shock waves - Shock waves compress the medium and travel ahead of the bullet, as well as to the sides, but these waves last only a few microseconds and do not cause profound destruction at low velocity. At high velocity, generated shock waves can reach up to 200 atmospheres of pressure. However, bone fracture from cavitation is an extremely rare event. The ballistic pressure wave from distant bullet impact can induce a concussive-like effect in humans, causing acute neurological symptoms.

The mathematics of wound ballistics, in reference to yaw of unstable projectiles, has been described. The model works well for non-deformable bullets. Experimental methods to demonstrate tissue damage have utilized materials with characteristics similar to human soft tissues and skin. Pigskin has been employed to provide an external layer to blocks of compounds such as ordnance gelatin or ballistic soap. Firing of bullets into these materials at various ranges is followed by direct visual inspection (cutting the block) or radiographic analysis (CT imaging) to determine the sizes and appearances of the cavity produced.

Bullet velocity and mass will affect the nature of wounding. Velocity is classified as low (<1000 fps), medium (1000 to 2000 fps), and high (>2000 fps). For example; an M-16 rifle (.223 cal) is designed to produce larger wounds with high velocity, lower mass bullets that tumble, cavitate, and release energy quickly upon striking the target. A hunting rifle (.308 cal or greater) would have a larger mass bullet to penetrate a greater depth to kill a large game animal at a longer distance. Bullet design is important in wounding potential. Military bullets have full metal jackets around the lead core.

Bullet shapes are diagrammed below:



The distance of the target from the muzzle plays a large role in wounding capacity, for most bullets fired from handguns have lost significant kinetic energy (KE) at 100 yards, while high-velocity military .308 rounds still have considerable KE even at 500 yards. **Military and hunting rifles are designed to deliver bullets with more KE at a greater distance than are handguns and shotguns.**

The type of tissue affects wounding potential, as well as the depth of penetration. Specific gravity (density) and elasticity are the major tissue factors. The higher the specific gravity, the greater the damage. The greater the elasticity, the lesser the damage. Thus, lung tissue of low density and high elasticity is damaged less than muscle with higher density but some elasticity. Liver, spleen, and brain have no elasticity and are easily injured, as is adipose tissue. Fluid-filled organs (bladder, heart, great vessels, bowel) can burst because of pressure waves generated. A bullet striking bone may cause fragmentation of bone and/or bullet, with numerous secondary missiles formed each producing additional wounding.

The speed at which a projectile must travel to penetrate skin is 163 fps and to break bone is 213 fps, both of which are quite low, so other factors are more important in producing damage. Designing a bullet for efficient transfer of energy to a particular target is not straightforward, for targets differ. To penetrate the thick hide and tough bone of an elephant, the bullet must be pointed, of small diameter, and durable enough to resist disintegration. However, such a bullet would penetrate most human tissues like a spear, doing little more damage than a knife wound. A bullet designed to damage human tissues would need some sort of "brakes" so that all the KE was transmitted to the target.

It is easier to design features that aid deceleration of a larger, slower moving bullet in tissues than a small, high velocity bullet. Such measures include shape modifications like round (round nose), flattened (wadcutter), or cupped (hollowpoint) bullet nose. Round nose bullets provide the least braking, are usually jacketed, and are useful mostly in low velocity handguns. The wadcutter design provides the most braking from shape alone, is not jacketed, and is used in low velocity handguns (often for target practice). A semi-wadcutter design is intermediate between the round nose and wadcutter and is useful at medium velocity. Hollowpoint bullet design facilitates turning the bullet "inside out" and flattening the front, referred to as "expansion." Expansion reliably occurs only at velocities exceeding 1200 fps, so is suited only to the highest velocity handguns.

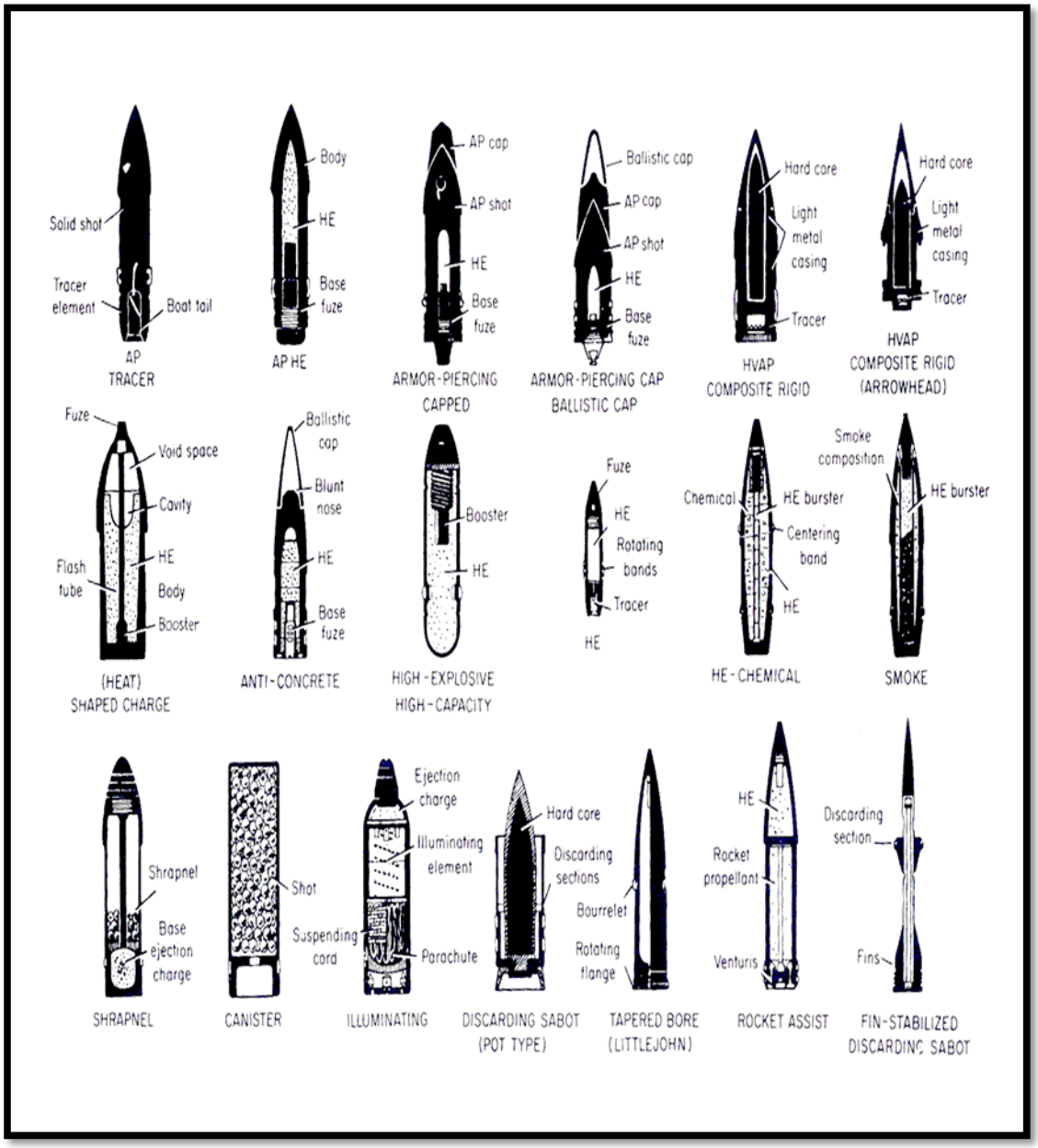
Wounding is an extremely complex situation with variables of bullet size, velocity, shape, spin, distance from muzzle to target, and nature of tissue. These factors are interrelated, and the wounding potential may be difficult to predict even under controlled test conditions. In an actual forensic case, few of the variables may be known, and it is up to the medical examiner to determine what can be known from examination of the evidence. Blood loss depends upon the size of the wound, the number and size of blood vessels damaged, and total body blood volume. A healthy 80 kg man has a blood volume of 4800 ml, and loss of 25% of this volume leads to incapacitation through diminished cardiac output and oxygenation.

The best approach to wound care is conservative. With simple punctures and no apparent tissue disruption, just irrigation and application of a dressing may suffice. So-called "high velocity" rounds are not necessarily more damaging because they are jacketed and the bullet is smaller in size. Variability in wounding from such rounds is potentially, but not often practically, a function of bullet yaw. A fully jacketed 7.62 mm military round creates a much smaller temporary and permanent cavity in tissue than a 7.62 mm civilian "hunting" round with a soft point tip, despite the fact that both are "high velocity" rounds. Treatment guidelines include the use of antibiotics if necessary and debridement of devitalized tissues when greater tissue disruption is apparent. It can be difficult to determine the extent of disruption and the amount of non-viable tissue, so reassessment of more disruptive wounds left open for 48 hours can be done.

18.6 MATCHING OF BULLETS AND CARTRIDGES

Bullets

Some of the various types of bullets are shown below:



Cartridges

Cartridge cases are generally made up of brass and contain a percussion cap, powder, and a bullet in one weatherproof package. The main advantage of a cartridge case is the effective and reliable sealing of high pressure gasses at the breech, as the gas pressure forces the cartridge case to expand outward, pressing it firmly against the inside of the gun barrel chamber. This prevents the leakage of hot gas which could injure the shooter.

In cartridge-firing firearms, a hammer (or a firing pin struck by the hammer) strikes the cartridge primer, which then ignites the gunpowder within. The primer charge is at the base of the cartridge, either within the rim (a "rimfire" cartridge) or in a small percussion cap embedded in the center of the base (a "centerfire" cartridge). As a rule, **centerfire cartridges are more powerful than rimfire cartridges**, operating at considerably higher pressures than rimfire cartridges. Centerfire cartridges are also safer, as a dropped rimfire cartridge has the potential to discharge if its rim strikes the

ground with sufficient force to ignite the primer. This is practically impossible with most centerfire cartridges. Nearly all contemporary firearms load cartridges directly into their breech end.

Some additionally or exclusively load from a magazine that holds multiple cartridges. A magazine is defined as a part of the firearm which exists to store ammunition and assist in its feeding by the action into the breech (such as through the rotation of a revolver's cylinder or by spring-loaded platforms in most pistol and rifle designs).

Handgun

These weapons are easily concealed but hard to aim accurately, especially in crime scenes. Most handgun shootings occur at less than 7 yards, but even so, most bullets miss their intended target. Usually, low caliber weapons are employed in crimes because they are cheaper and lighter to carry and easier to control when shooting. Tissue destruction can be increased at any caliber by use of hollow-point expanding bullets. Some law enforcement agencies have adopted such bullets because they are thought to have more "stopping power" at short range. Most handgun bullets, though, deliver less than 1000 ft/lb of KE. The maximum momentum transferred from different small arms projectiles, including large caliber rifles and shotguns, to an 80 kg body is only 0.01 to 0.18 m/s, negligible compared to the 1 to 2 m/s velocity of a pedestrian. Incapacitation of gunshot victims is primarily a function of the area of the body wounded. Immediate incapacitation may occur with gunshot wounds to the brain and upper cervical cord. Rapid incapacitation may occur with massive bleeding from major blood vessels or the heart.

The two major variables in handgun ballistics are diameter of the bullet and volume of gunpowder in the cartridge case. Cartridges of older design were limited by the pressures they could withstand, but advances in metallurgy have allowed doubling and tripling of the maximum pressures so that more KE can be generated.

Some of these are outlined in the table below to compare and contrast the ballistics.

Common Representative Handgun Cartridges							
Name	**Comment**	**Case Length**	**Case Diameter**	**Bullet Weight (grains)**	**Velocity (muzzle) in fps**	**Energy (muzzle) in ft lbs**	**Energy (at 100 yd) in ft-lbs**
.22 LR	for inexpensive guns, rimfire (R and A)	0.625	0.222	40	1060	100	75
.25 auto	small pocket gun (A only)	0.615	0.251	45	815	66	42
.380 auto	popular pocket auto (A only)	0.680	0.355	85	1000	189	140
9 mm	popular military	0.754	0.355	115	1155	391	241

para	handgun (A only)						
.38 special	popular police revolver (R only)	1.155	0.357	110	995	242	185
.357 SIG	popular police pistol (A only)	0.865	0.381	115	1550	614	N/A
.357 magnum	popular police and hunting revolver (R and A)	1.290	0.357	125	1450	583	330
.40 S&W	rimless police pistol (A only)	0.850	0.421	165	1150	484	342
10 mm	same projectile as .40 S&W (A only)	0.992	0.421	165	1425	744	N/A
.44 magnum	hunting revolver (R only)	1.290	0.430	180	1610	1036	551
.45 auto	popular military handgun (R and A)	0.898	0.451	185	1000	411	324
Colt .45	cowboy "sixgun" (R only)	1.285	0.452	225	920	423	352
.50 AE	Big game and metallic targets (A only)	1.285	0.540	325	1400	1415	930

Key: R=Revolver; A=Semi-Automatic; velocity in fps

Rifles

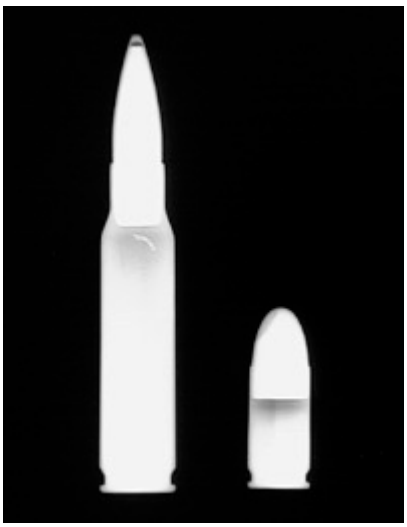
Many different cartridges are available using different loads and bullet designs. Some of these are outlined in the table below to compare and contrast the ballistics.

Representative Centerfire Rifle Cartridges

Cartridge	Bullet Type	Bullet Weight (grains)	Velocity (muzzle) in fps	Velocity (100 yds) in fps	Velocity (500 yds) in fps	Energy (muzzle) in ft-lbs	Energy (100 yds) in ft-lbs	Energy (500 yds)in ft-lbs
.22 hornet	H	46	2690	2042	841	740	426	72
.223 Rem*	J	55	3240	2759	1301	1282	929	207
.243 Win	P	100	2960	2697	1786	1945	1615	708
.30-30 Win	R	150	2390	1973	973	1902	1296	315
.308 Win*	J	150	2750	2743	1664	2468	1996	904
.30-06 Spr	P	180	2600	2398	1685	2701	2298	1135

Key: R=Round nose; P=Pointed; J=Jacketed; H=Hollow-point; S=Semi-pointed; Rem=Remington; Win=Winchester; Spr=Springfield; LR=Long Rifle; *=Military usage

The radiographic appearance of a .308 rifle cartridge and a 9 mm Luger handgun round are shown below to demonstrate the seating of the bullet in the casing.

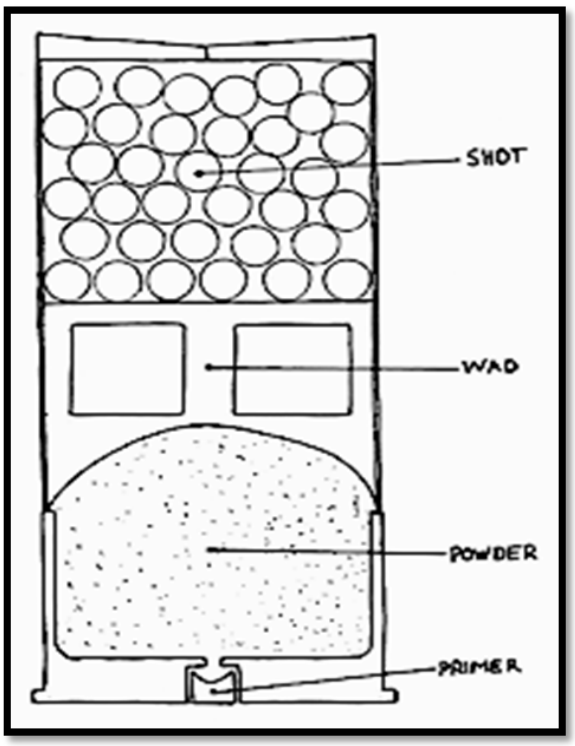


Shotguns

The type of shot, or pellets, used in the shotgun shell weight constant for a shell so that 1 oz of shot would equal either 9 pellets of double O buckshot or 410 pellets of #8 birdshot. A 00 or "double ought" pellet is essentially equivalent to a low velocity .38 handgun projectile. The spread of the

pellets as they leave the muzzle is determined by the "choke" or constriction of the barrel at the muzzle (from 0.003 to 0.04 inches). More choke means less spread. Full choke gives a 15 inch spread at 20 yards, while no choke gives a 30 inch spread at the same distance. A "sawed-off" shotgun has a very short barrel so that, not only can it be concealed more easily, but also it can spray the pellets out over a wide area, because there is no choke.

A shotgun shell is diagrammed below:



At close range (less than 4 feet), the pellets essentially act as one mass, and a typical shell would give the mass of pellets a muzzle velocity of 1300 fps and KE of 2100 ft/lb. At close range, an entrance wound would be about 1 inch diameter, and the wound cavity would contain wadding.

At intermediate range (4 to 12 feet) the entrance wound is up to 2 inches diameter, but the borders may show individual pellet markings. Wadding may be found near the surface of the wound.

Beyond 12 feet, choke, barrel length, and pellet size determine the wounding.

If the energy is divided between the pellets, it can be seen that fewer, larger pellets will carry more KE, but the spread may carry them away from the target. Pellets, being spherical, are poor projectiles, and most small pellets will not penetrate skin after 80 yards. Thus, close range wounds are severe, but at even relatively short distances, wounding may be minimal. Range is the most important factor, and can be estimated in over half of cases, as can the shot size used. A rifled slug fired from a shotgun may have a range of 800 yards.

Shotgun slugs can produce significant injury, because of the slug's size and mass. At close range, survival is rare. In treating shotgun injuries, it is necessary to remember that the plastic shell carrier

and the wadding (which may not appear on radiographs) can also cause tissue damage and may need to be found and removed.

The Polyshok Impact Reactive Projectile (IRP) is a form of shotgun ammunition with a lead bead core encased within a single, plastic projectile. The lead core is designed to disintegrate on impact so that lead fragments are distributed over a small area. This reduces the likelihood of exit or collateral damage on missed shots. This projectile produces a single entrance wound, and both plastic and lead components can be found within the wound, regardless of the range of fire. The single entrance wound with limited area of tissue damage suggests a shotgun slug, while the small lead fragments within the wound suggest small size shot pellets, but together these findings are characteristic for the IRP.

Matching of bullets and cartridges

The matching or comparison of bullets and cartridge cases are conducted on the basis of following traits which are either marked due their storage in the cartridge house of the firearm or made while firing the bullet, as it leaves the barrel. These marked features or class characteristics are given below:

i. The bullet base contains irregular press points or dimpled markings when the pressure delivered there in its acceleration.
ii. The bullet sides will bear the markings of the barrel interior rifling. These spiral lines, or striations, contain the microscopic imperfections of the gun from which it was fired and can be as specific as a fingerprint.
iii. The bullet nose carries information about the target, and recognizing these may give a clue to the injury rendered.
iv. The complete description of dimensions as measured (using vernier calipers for best results), shape, and appearance of surface.
v. Photography is inevitable.

Expansion of a semi-wadcutter or hollow-point bullet increases the frontal area and blunts the shape. The degree to which this happens depends upon the texture of the tissue impacted, the velocity at impact, and the softness of the bullet (usually quite constant). With the exceptions of lung and bone, tissue densities are relatively constant. Velocity is the most important factor.

No change in shape occurs until impact velocity achieves about 800 fps. Between 800 and 1000 fps a slight flattening of the bullet nose can be expected. Over 1000 fps real expansion starts to occur and by 1200 fps the nose is turned over to form a mushroom shape. An interesting artefact of impacts around 1000 fps is the tendency of the copper jacket to be shed from the lead. The jacket stops in the subcutaneous tissue and the bullet will continue to penetrate. This accounts for fragments of copper (with rifling marks) commonly seen as surgical specimens. At velocities approaching 1500 fps the bullet is transformed into a rounded ball of lead and copper. The above results are uniformly valid only in artificial media (such as ordnance gelatin) but correlate with human tissue.

The soft exposed lead nose on non-full metal-jacketed bullets can be imprinted with anything that is penetrated by the bullet. Wood, glass, fabric, plastic, or tissue may leave marks as well as fragments on the bullet tip. Bone struck by bullets may not only fragment the bone, but also split the bullet. Lead round nose bullets can penetrate deeply and strike bone at relatively high velocity and can be cleanly cut in half or shaved vertically. Full metal jacketed round nose bullets are less affected, but are often irregularly flattened upon striking bone. Bullets that come to rest in soft tissue without striking bone are often intact.

Intermediate targets such as; glass, wood, clothing, or even paper, may influence the path, shape, and fragmentation of projectiles. Such factors must be taken into account in the recovery of evidence. High velocity, jacketed bullets will be deflected much less.

Flattening of shotgun pellets may not necessarily indicate a close range contact with a target, as the pellets may be deformed on firing. Even pellets of air guns may show characteristic striations. Silencers used over the muzzle of a gun are often misaligned and can produce characteristic striations.

Examination of whole bullets in laboratory

i. If a bullet is recovered from the scene or from the body, it may be compared to bullets obtained by test-firing the suspected weapon. Test firing is done using similar ammunition. Bullets are marked on the nose at the 12 o'clock barrel position (called "index", "witness", or "reference" marks).
ii. Consecutive test bullets are then fired into a water tank, recovered, and juxtaposed with a comparison microscope to compare test bullets with the recovered evidence. Index marks help to align test bullets to determine reproducibility of markings. Photographs should be taken (a ruler or coin can be used to give scale and alignment).
iii. Comparison of bullets involves "class" and "individual" characteristics. These characteristics are based upon "striations" left on the bullet as it passes through the barrel.
iv. **Class characteristics** include the type of caliber and rifling, the angle of twist of rifling and the distance between the two lands or groves in determining its caliber.
v. Rifling pattern may turn to the right or left, with a given rate of twist.
vi. The number and depth of grooves can also vary.
vii. **Individual characteristics** are used to determine if a specific gun was used. The individual characteristics are based upon burrs or imperfections in the barrel, particularly the muzzle, that impart specific markings, or striation marks to fired bullets. If such markings are present, they may lead to a "determinative" identification.

- **Examination of striation marks on Bullets**

A system has also been described for identification of jacketed sporting rifle bullets using twelve parameters:

- Identification number

- Manufacturer
- Weight
- Diameter
- Cartridge
- Base design
- Length of bearing surface
- Color
- Shape
- Location and description of crimping cannelure
- Location and description of other cannelures
- Miscellaneous notes.

Such parameters may aid in narrowing the search for suspected weapons or ammunition. Optical devices for identification of bullets and tool marks include microscopes with cameras. Standard light microscopy has limits of resolution defined by magnification and illumination. Digital cameras are limited by number, color, and density of pixels detected. Confocal microscopy provides a means for obtaining information regarding depth in an image.

There are three results of comparison identification. Test fired and recovered bullets can:

(1) Be related to the same weapon;
(2) Be unrelated to the same weapon;
(3) Not be compared with this type of examination.

Conclusions should not be based upon probabilities in test firing. In many situations, however, the hospital pathologist as medical examiner will not be involved with test firing. The hospital pathology department may receive bullets or bullet fragments from patients. Such evidence should be clearly identified, with a "chain of custody" followed. The pathologist will dictate a report and release the evidence back to the authorities.

- **Examination of bullet fragments or bullet composition**

In many cases, recovered bullets will be too deformed for comparison studies. A method has been described for differentiation of bullets by spark source mass spectrometry (SSMS). This method makes use of the fact that the lead of bullets actually may contain up to 26 common elements, of which 12 can be used for differentiation. One of the commonest of these is antimony (1 to 2%). Unfortunately, the study also found that bullets within a box or lot do not have uniform composition, but there may be two or three distinct groups of bullets within a box. When analysis of the bullet lead is necessary, but a copper jacket is present, the copper may be most efficiently removed, without contamination of the lead, by use of concentrated nitric acid.

Detection of the type of bullet (jacketed or not) may be done by a dithiooxamide (rubeanic acid) test. This test detects copper and nickel, which may be components of jacketed ammunition, on the target.

The rubeanic acid forms a dark green precipitate in the presence of copper, pink or blue with nickel, and brown with cobalt. Blood and other materials on the target produced false negatives.

Bullet particles may also be detected in bone fragments from skeletal remains when no soft tissues remain. After determining that radiopaque particles are present, surfaces of the bone fragments containing the particles can be exposed by cutting. The surfaces can then be analyzed by SEM-EDA and by electron probe microanalysis to identify lead (Pb) and antimony (Sb). The electron probe technique aids in differentiating antimony from abundant calcium of bone. Detection of bullet lead has also been carried out with proton-induced X-ray emission (PIXE) analysis, even in a victim buried for several years. Even if an exit wound is present, a search for bullet fragments or jacket material should be done, with radiographs if necessary.

CHECK YOUR PROGRESS

1. Which of the following is not a method of classification of firearms?
   (1) Bore
   (2) Loading
   (3) Handling
   (4) Rifling

2. _____ refers to the rotation of the nose of the bullet away from the line of its flight.
3. The comparison identification of the test fired bullet with the sample bullet is done to relate it to a particular _____ of crime.
4. Write the correct order of the rings formed by the ejecta on the target
   1. Blackening
   2. Tattooing
   3. Dirt ring
   4. Charring
5. Write the correct order:
   1. Matchlock
   2. Flintlock
   3. Percussion
   4. Wheellock

Answers

1. d
2. Yaw
3. Firearm
4. dabc
5. adbc

18.7 SUMMARY

This module dealt with classification of modern firearms on the basis of their handling characteristics such as handguns and shoulder weapons. The estimation of the range of fire by studying different ring patterns formed by the ejecta on the target. The comparison examination of the fired bullet or spent cartridge case with the samples may positively conclude that the bullet or cartridge case was or not fired by a particular firearm. These examinations may also conclude that there are not sufficient individual microscopic marks of value on the bullet or cartridge case for identification purposes or that the condition of the firearm prevents the possibility of making identification.

UNIT-19 : MECHANISM OF FORMATION OF GUN SHOT RESIDUES

Structure

19.0 Introduction
19.1 Objectives
19.2. Formation of gun shot residues (GSR)
19.3. Methods of analysis of GSR
19.4 Summary

19.0 INTRODUCTION

Firing a weapon produces combustion of both the primer and powder of the cartridge. The residue of the combustion products are called gunshot residue (GSR). The gunshot residue can consist of both burned and unburned primer or powder components, and can be used to detect a fired cartridge. Gunshot residue may be found on the skin or clothing of the person who fired the gun, on an entrance wound of a victim, or on other target materials at the scene. The discharge of a firearm, particularly a revolver, can deposit residues even to persons at close proximity, so interpretations as to who fired the weapon should be made with caution.

19.1 OBJECTIVES

- Type of weapon used (e.g. shotgun, self-loading pistol)
- Manufacturer, make and model (even to know if it's a country made or home made gun)
- To estimate the range of fire
- To study the composition of various bullets/ pallets/ shots and their laboratory examination

19.2 FORMATION OF GUN SHOT RESIDUES (GSR)

All gun powders are designed to burn quickly to produce rapid expansion of gas in a confined space. In an explosion something gets very big very fast. The burning rate of gunpowder can be classified in three categories:

- Degressive (regressive) burning: gunpowder grains formed in flakes, balls, and sticks have a burning surface area that decreases continuously as the grains are consumed.
- Neutral burning: gunpowder grains that are single perforated and the burning surface area remains relatively constant.
- Progressive burning: gunpowder grains that are multi-perforated and rosettes that have a burning surface area that increases continuously as the grains are consumed.

Unburned gunpowders can have recognizable shapes, colors, and sizes of grains.

The major primer elements are lead (Pb), barium (Ba), or antimony (Sb). Usually, all three are present. Less common elements include aluminum (Al), sulfur (S), tin (Sn), calcium (Ca), potassium (K), chlorine (Cl), copper (Cu), strontium (Sr), zinc (Zn), titanium (Ti), or silicon (Si). A mercury-fulminate based primer may be found in ammunitions usually used.

Primer elements may be easier to detect in residues because they do not get as hot as the powder. So-called "lead free" ammunition may contain one or more elements including strontium (Sr), zinc (Zn), titanium (Ti), copper (Cu), antimony (Sb), aluminum (Al), or potassium (K). Both titanium and zinc are commonly used in paints and can be contaminants, but the appearance of particles containing them can be distinguished from gunshot residue by SEM. In addition, primer residues may adhere to fired bullets and gradually ablate through the path of the bullet. Thus, primer residue may be found in targets or wounds at considerable distance from the muzzle (up to 200 meters).

The cartridge case, bullet, bullet coating, and metal jacket also contain specific elements that can be detected. Virtually all cartridge cases are made of brass (70% copper and 30% zinc). A few have a nickel coating. Primer cases are of similar composition (Cu-Zn). Bullet cores are most often lead and antimony with a very few having a ferrous alloy core. Bullet jackets are usually brass (90% copper with 10% zinc), but some are a ferrous alloy and some are aluminum. Some bullet coatings may also contain nickel.

Modern gunpowder, or **"smokeless"** powder, can contain nitrocellulose, which is virtually always present, along with other compounds containing nitrate or nitrogen. One of these compounds, diphenylamine (used as a stabilizer in the powder), can be detected using reagents containing sulfuric acid. Modern gunpowders are also described as **"single-base"** when the basic ingredient is nitrocellulose and as **"double-base"** when there is additionally 1 to 40% nitroglycerine added. These two can be differentiated using a mass spectrometer.

In the physical examination of the scene or body for evidence of gunshot residue, it must be remembered that lead residues may mimic gunshot residue. Lead residues may be found up to 30 feet from the muzzle, and are always present on the opposite side of a penetrated target. Such a situation has been reported when an intermediate target (glass) was present. Though the amount of residue deposited tends to decrease with increasing range of fire, the actual deposits can be highly variable for ranges up to 20 cm.

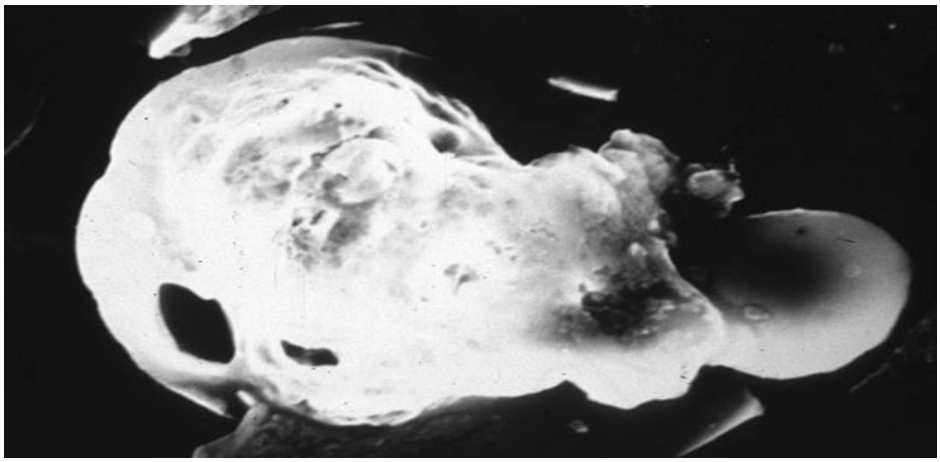
19.3 METHODS OF ANALYSIS OF GSR

The major methods for detection of primer residues are analytical and qualitative. Analytical methods include atomic absorption spectrophotometry **(AAS)** and inductively coupled plasma-atomic emission spectrometry **(ICP-AES).** Scanning electron microscopy with energy dispersive analysis **(SEM-EDA)** and atomic force microscopy **(AFM)** are used to identify the primer residue qualitatively. For these methods, samples must be obtained from the skin surfaces of a victim at the scene. Delay in obtaining residues, movement, or washing of the body prior to autopsy will diminish or destroy gunshot residues.

The method of collection for residue is quite simple and easily carried out in the field directly onto the gummed surface of a chuck, or holder, applied to the surface (skin or other material) to be tested. The chuck, with the residue on the surface, can be directly prepared for examination in the SEM device. A polyvinyl-alcohol (PVAL) collection method has been developed that has the advantage of preserving the topical distribution of gunshot residues as well as sampling of other trace materials such as blood.

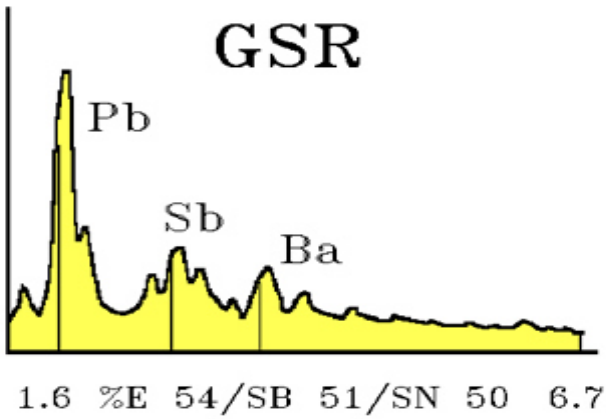
A major advantage of this method is that SEM can reveal the actual surface details of the particles examined, for comparison with known examples of gunshot residue, and pictures can be taken. The large particles of partially burned powder and the spheres of residue can be distinguished from contaminant materials.

Scanning Electron Micrograph of GSR



An X-ray analyzer can be beamed directly onto the particles, so that the energy dispersive pattern (EDX) can be generated, giving the elemental composition of the particles. (Nesbitt et al, 1976) A computer program to speed up the search for GSR particles by SEM has been described (Tillman, 1987)

Diagram of the SEM-EDX pattern of GSR



It should be remembered that any hand or body part that was close to the fired weapon might have residue appearing consistent with having fired the weapon. Clothing should always be retained on the body up to autopsy, as this may modify entrance wounds, need examination for gunshot residues, or aid in interpretation of the scene.

Gunshot residue analysis requires careful evaluation. Contamination or transfer of GSR to the body may cause false positives by mishandling, or when GSR heavily contaminates the body from previous shooting. However, the number of particles from secondary environmental contamination is low. False negatives result from washing of the hands (when this area is sampled) or by victim wearing gloves. A rifle or shotgun may not deposit GSR on hands.

SEM may also have usefulness for examination of bullets, as embedded materials from the target such as bone fragments may aid in reconstruction of the scene. SEM has been used to study tool marks made by the firing pin impressions in the primers of spent cartridges. Such findings could be useful to determine which gun was used to fire the cartridge. SEM could reveal clearly all-surface detail in the impression and that 50% of shotgun impressions and 75% of rifle impressions could be positively identified on the basis of four or more individual characteristics, given similar class characteristics.

Gas chromatography has been used to identify gun oils in targets, and was very sensitive, even with stored specimens.

It may be difficult to both find and determine the nature of gunshot wounds in a decomposed body. Determination of the range may be particularly difficult. Extreme care should be taken to avoid misinterpretation of the wounds and artifacts.

Other Examinations:

Latent fingerprints may be detectable on cartridges and expended shell casings. Such fingerprints, called latent because they are transferred via a substance on the skin ridges to an object. On a gun, such substances could include cleaning solvents or gun oils. Usually, the substances consist of perspiration mixed with oils from sebaceous glands. Conditions of increased temperature and low humidity decrease the persistence of fingerprints. Brass retains the fingerprints better than nickel-plated materials.

Each firearm sold (other than black powder weapons) has a manufacturer's serial number stamped into it, which may be used to identify the weapon. Registration of firearms provides a way of tracing gun ownership. However, attempts may be made to obliterate registration numbers by grinding or filing the metal.

CHECK YOUR PROGRESS

1. Which of the following set of techniques can be used to examine gunshot residue?
   a) AAS, SEM, EDX

b) HPLC, GC
c) TLC, Electrophoresis
d) None

2. Which of the following are the major elements present in primer?
   a) Pb, Ba, Sb
   b) Ca, K, Sr
   c) Cu, P, S
   d) None
3. The smokeless double base powder contains:
   a) Nitroglycerine
   b) Nitrocellulose
   c) Both (a) and (b)
   d) None of the above

Answers

1. a
2. a
3. c

19.4 SUMMARY

The discharge of a firearm results in not only the ejection of the intended projectiles but also secondary ejecta. These secondary materials include partially combusted and unburned propellant, the combustion products of both the propellant and the primer, and matter derived from the barrel, cartridge case and projectile(s). When a gun is fired, these materials form a heterogeneous cloud of finely divided particles, known collectively as gunshot residues (GSRs). These residues settle on all nearby surfaces. These include the insides of the barrel and cartridge; where exposed, the hand(s), clothes, hair and face of the shooter; and the target (provided that it was sufficiently close to the firearm when it was fired).

SUGGESTED READINGS

1. Gaur's, Firearms
2. Jerry Lannacci, Access Device Fraud and Related Financial Crimes
3. C D Duncan, Advanced Crime Scene Photography
4. Wayne A Petheric, Forensic Criminology
5. Frank Bolz, The Counter terrorism Handbook
6. Ronald J Burke, International Terrorism and Threats to Security
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11. Tom Mason, Forensic Psychiatry
12. Toga, Brain Mapping the Methods
13. Kaufman Marc J., Brain Imaging in Substance Abuse, Research Clinical and Forensic Applications
14. Solomon M Fulero, Forensic Psychology
15. Tony Sammes, Forensic Computing, A Practitioners Guide
16. David R Ashbaugh, Quantitative Qualitative Friction Ridge Analysis

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Certificate Course in Forensic Science

CFS-03

FORENSIC PHYSICS, BALLISTICS DIGITAL FORENSIC AND SPECIAL TOPICS

Block

6

DIGITAL FORENSICS AND SPECIAL TOPICS

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UNIT - 20 : COMPUTER FORENSICS AND CYBER CRIME

Structure

20.0 Introduction
20.1 Objectives
20.2 What is a Computer?
20.3 Cyber crimes and their type
20.4 What is computer forensics?
20.5 Steps involved in investigating a cyber / computer crime
  20.5.1. Search and seizure
  20.5.2. Seizing evidence
  20.5.3. Evidence handling
  20.5.4. Forensic Imaging
  20.5.5. Data recovery
  20.5.6. Forensic Analysis / Examination
20.6. Computer scanners
20.7 Software piracy
20.8 Counterfeit currency
20.9 Summary

20.0 INTRODUCTION

Computer Forensics deals with the preservation, identification, extraction, and documentation of computer evidence. The field is relatively new to the private sector but it has been the mainstay of technology related investigations and intelligence gathering in law enforcement and military agencies since the mid−1980s.

Like any other forensic science, computer forensics involves the use of sophisticated technology tools and procedures that must be followed to guarantee the accuracy of the preservation of evidence and the accuracy of results concerning computer evidence processing.
The evidences required for investigation purposes:

- All physical evidence (computer, peripherals, notepads, documentation, etc.)
- Visual output on the monitor
- Printed evidence on a printer
- Printed evidence on a plotter
- Film recorder (magnetic representations)

20.1 OBJECTIVE

This unit deals with the need and purpose to consider the complaint or the initial reason for conducting an investigation.
Some typical reasons that may warrant an investigation include but are not limited to:

- Internet usage exceeds norm

- Using e−mail inappropriately
- Use of Internet, e−mail, or PC in a non−work−related manner
- Theft of information
- Violation of security policies or procedures
- Intellectual property infractions
- Electronic tampering

This unit reviews the typical reasons for investigation and lists some questions to help determine what facts or circumstances surround each reason.

20.2 WHAT IS A COMPUTER?

A computer is a programmable machine designed to sequentially and automatically carry out a sequence of arithmetic or logical operations. The particular sequence of operations can be changed readily, allowing the computer to solve more than one kind of problem.

A computer consists of some form of memory for data storage, at least one element that carries out arithmetic and logic operations, and a sequencing and control element that can change the order of operations based on the information that is stored. Peripheral devices allow information to be entered from an external source, and allow the results of operations to be sent out. A computer's processing unit executes series of instructions that make it read, manipulate and then store data.

A computer has two aspects: Hardware and Software.

Hardware: An electronic component or any sub-component of the same. Hardware can be seen, touched or felt. There can be several hardware components as follows:

Central components

- Central Processing Unit (CPU)
- Main Memory Unit (MMU)
- Arithmetic Logical Unit (ALU)

Peripheral Components

1. Visual Display Unit (VDU) or Monitor
2. Key Board/Mouse
3. Hard Disk Drive (HDD), Floppy Disc Drive (FDD)
4. Compact Disk (CD) Reader/Writer

5. DVD reader/writer
6. Printer, Scanner
7. Web Camera
8. Graph Plotter
9. Speaker, Sound Boxes etc.

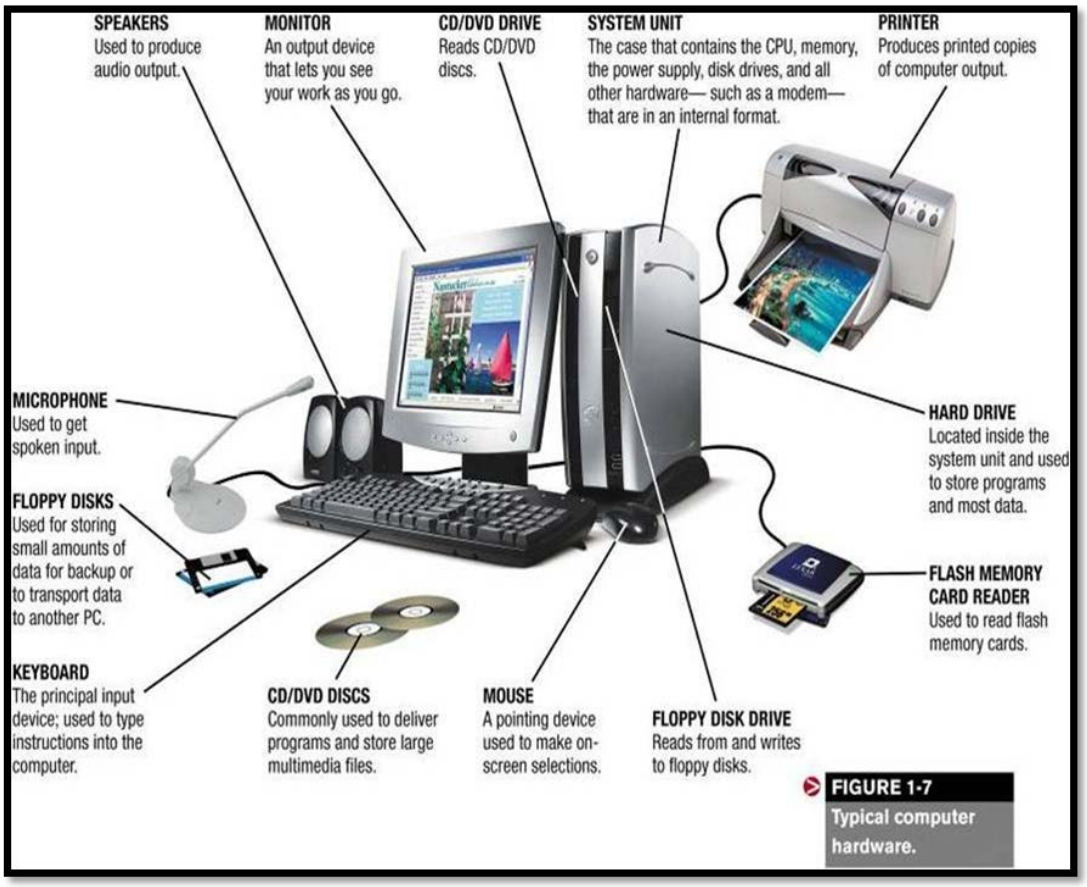


Fig: Parts of computer

Software: A set of instructions that makes the hardware work to the user's choice. Software cannot be seen or touched. It is a program designed to perform a particular task on the computer. The computer understands it in digital (binary- 0 and 1 form).

Computer Program: A set of instructions logically placed to perform a given task is a program.

Software System: A set of one or more programs to perform several related tasks is a software system. A software system has two parts viz. data and programs.

Software Package: A software system that takes care of every aspect of a system.

Operating System (OS): A software package that activates hardware (computer) and makes the hardware ready for use. Examples of OS:

1. DOS
2. UNIX
3. WINDOWS (95, 98, 2000, NT, XP, 2003, 7)
4. LINUX

Systems Software: A group of software that comes along with hardware and it is not user dependent.

Application Software: Software that solves a given problem of a user. Application software are developed using a suite of systems software.

20.3 CYBER CRIMES AND THEIR TYPES

Cyber crime refers to any crime that involves a computer and a network. The computer may have been used in the commission of a crime, or it may be the target. Internet crime refers to criminal exploitation of the internet. Such crimes may threaten a nation's security and finances. Issues surrounding this type of crime have become high-profile, particularly those surrounding cracking, copyright infringement, child pornography, and child grooming. There are also problems of privacy when confidential information is lost or intercepted, lawfully or otherwise.

Computer crime encompasses a broad range of activities. Generally, however, it may be divided into two categories as follows:

- Crimes that target computers directly.
- Crimes facilitated by computer networks or devices, the primary target of which is independent of the computer network or device.

Crimes that primarily target computer networks or devices include:

- **Computer viruses**
- Denial-of-service attacks
- Malware (malicious code)
  - Few examples of crimes that use computer networks or devices to advance other ends include:
  - Cyber stalking
  - Defamation
  - Email spoofing
  - Internet time thefts
  - Fraud and identity theft
  - Information warfare
  - Phishing scams
  - Data didling
  - Salami attacks
  - Denial of service attacks
  - Logic bombs
  - Spam mails
  - Computer Fraud
  - Unauthorized access
  - Viruses, worms and Trojan attacks
  - Computer vandalism

- Sabotage
- Cyber squatting
- Altering, destroying, suppressing, or stealing output, usually to conceal unauthorized transactions: this is difficult to detect;
- Altering or deleting stored data;
- Altering or misusing existing system tools or software packages, or altering or writing code for fraudulent purposes.
- Obscenity or pornographic content etc.

(a) Hacking

Hacking with computer system as defined under **section 66 of IT Act 2000** as:

(1) Whoever with the intent to cause or knowing that he is likely to cause wrongful loss or damage to the public or any person destroys or deletes or alters any information residing in a computer resource or diminishes its value or utility or affects it injuriously by any means, commits hack:

(2) Whoever commits hacking shall be punished with imprisonment up to three years, or with fine which may extend upto two lakh rupees, or with both.

(b) Unauthorized access

IT Act provides against unauthorized access to computer material as follows:

(1) A person is guilty of an offence if

(a) He causes a computer to perform any function with intent to secure access to any program or data held in any computer;

(b) The access he intends to secure is unauthorized; and

(c) If he knows at the time when he causes the computer to perform the function that that is the case.

(2) The intent a person has to have to commit an offence under this section need not be directed at

(a) Any particular program or data;

(b) A program or data of any particular kind; or

(c) A program or data held in any particular computer.

(3) A person guilty of an offence under this section shall be liable on summary conviction to imprisonment for a term not exceeding six months or to a fine not exceeding level 5 on the standard scale or to both.

(c) Computer viruses and security

Computer viruses are malicious lines of code or software program that are usually developed with intent of causing damages or to obtain unauthorized access to confidential files present on a computer. The affect of a virus attack will result in identity theft, as the hacker might use those credit card details and personal banking credentials. A lot of computer viruses when executed will begin multiplying itself and start to spread across multiple files, finally resulting in a halt or crash. Usually, Viruses don’t come separate, as they will come embodied with other files when you are

downloading or data sharing. Some of the commonly prevailing computer viruses are as follows:

Resident Viruses

These viruses will reside on the RAM memory situated in the CPU, and will damage or corrupt all those files and programs available on that system.

Direct Action Viruses

These kinds of viruses will affect the documents in the folder or directory and replicate them again in the same place where it is located in. The execution of the virus is triggered when the system is booted every time.

Security or prevention of spread of computer viruses

- Keeping system free from buds, worms and harmful viruses that harms your data stored by continual scanning is the entry-level prevention. Some hackers also use virus programs to hack details from your PC, which gets the needful data from the system or can even destroy the file by changing the file format or can duplicate more files to create confusion on finding the original one. Turn on firewall to alert you on suspect over any harmful sites, data download and access over insecure data on the Internet. Protect system and Internet mailing accounts with strong password; changing your password frequently helps to protect your account from virus attacks. Before you download any files from the net check if they are free from virus or bugs.
- Update Anti-virus software, as they are more important to cross check your PC for new threats on scanning your system.
- **Keep backup of your data.** Most of the virus stays hidden in the Booting system causing a failure to start up your system. Format the system with new OS and has to be secured with updated latest anti-virus software.

20.4 WHAT IS COMPUTER FORENSICS?

Computer forensics is a branch of digital forensic science pertaining to legal evidence found in computers and digital storage media. The goal of computer forensics is to examine digital media in a forensically sound manner with the aim of identifying, preserving, recovering, analyzing and presenting facts and opinions about the information for the legal procedures and for trials in courts of law.

Although it is most often associated with the investigation of a wide variety of computer, computer forensics may also be used in civil proceedings. The discipline involves similar techniques and principles to data recovery, but with additional guidelines and practices designed to create a legal audit trail.

20.5 STEPS INVOLVED IN INVESTIGATION OF A CYBER / COMPUTER CRIME

20.5.1. Search and Seizure:

Search and seizure of digital evidence is the first process that is often disputed. If it can be shown that this step was not completed properly, the defense or prosecution's evidence may not be admitted. An illegal search and seizure or improper methodology employed during search and seizure can negatively affect the admissibility of the evidence. Traditional, non-digital instances of search and seizure contentions have been evaluated by courts from precedents. In contrast, the digital cases are still emerging as the technology is created, resulting in few precedents to apply. As such, the methods law enforcement entities use with computer crime investigations becomes the issue. Currently, there are no rigid standards, and the guidelines and recommendations differ between law enforcement sources.

A unique issue with computer forensics search and seizure centers on the source of the item(s) in the warrant or in verbal/written affirmation, when a warrant is not needed (e.g., open view resulting in a search and seizure). For instance, when a computer has the power turned off, the data in volatile media storage, for technical purposes, is virtually impossible to reconstruct. In pre-digital crimes, electricity was not a major factor in the ability to execute a proper search and seizure.

20.5.2. Seizing Evidence

General guidelines concerning the seizing of evidence are provided as follows:

- Consult with the investigating officer to determine the necessary equipment to take to the scene.
- Review the legal authority to seize the evidence, ensuring any restrictions are noted. If necessary during the execution of the seizure, obtain additional authority for evidence outside the scope of the search.
- When it is impractical to remove the evidence from the scene, the evidence items should be copied or imaged according to local procedures.
- All suspects, witnesses, and by-standers should be removed from the proximity of digital evidence, ensuring that the above individuals are not in possession of potential evidence.
- Solicit information from potential suspects, witnesses, LAN administrators, etc. to ascertain knowledge of the system to be seized (e.g., password(s), operating system(s), and screen name, email address.
- Scene should be searched systematically and thoroughly for evidence.
- Searchers should be able to recognize the different types of evidence.

20.5.3. Evidence Handling

If the computer is turned off, do not turn on the computer. A computer forensic specialist should be consulted when available.

- Before powering down a computer, consider the potential of encryption software being installed on the computer or as part of the operating system. If present, appropriate forensic methods should be utilized to capture the encrypted data before the computer is powered down.

- Assess the power need for devices with volatile memory and follow agency policy for the handling of those devices.
- Document the condition of the evidence.
- Take legible photographs (screen, computer front and back, and area around the computer to be seized) and/or make a sketch of the computer connections and surrounding area.
- Appropriately document the connection of the external components.
- Note and document any pre-existing damage to the evidence.

Networked computer

- Workstations: remove the power connector from the back of the computer. Place evidence tape over the power plug connector on the back of the computer.

Note: Any network computer can be used for file sharing and those systems should follow normal shut down procedures.

Servers

- A determination should be made as to the extent of data that should be seized.
- Capture volatile data if necessary.
- If shutdown is necessary, use the appropriate commands.
- Each piece of evidence should be protected from change and a chain-of-custody maintained as determined by agency policy.

Packaging of evidence:

- Plastic/paper bags or sleeves.
- Computer case sealed with evidence tape over case access points and power connector.
- Devices with volatile memory should be packaged appropriately to allow for power to be maintained to the device.

Specific care should be taken with the transportation of digital evidence material, to avoid physical damage, vibration, and the effects of magnetic fields, electrical static, and large variations of temperature and humidity.

Equipment Preparation

"Equipment" refers to the non-evidentiary hardware and software the examiner utilizes to conduct the forensic imaging or analysis of the evidence.

- Equipment must be monitored and documented to ensure proper performance is maintained.
- Only suitable and properly operating equipment shall be employed.
- The manufacturer's operation manual and other relevant documentation for each piece of equipment should be accessible.
- Analysis/Imaging software should be validated prior to use.

20.5.4. Forensic Imaging

Before start analyzing the questioned hard disk drive for legal purposes the hard disk should be imaged (copied) for maintain its integrity and the analysis should then be done on the copy of the original questioned disk made thereby. The original disk should be placed back in the case exhibit box for future use in the court of law during the case's trial. The following steps are to be taken at the time of imaging the hard disk.

- Document the current condition of evidence.
- Precautions should be taken to prevent exposure to evidence that may be contaminated with dangerous substances or hazardous materials. All items submitted for forensic examination should be examined for the integrity of their packaging. Any deficiency in the packaging, which may compromise the received value of the examination, should be documented. Consideration should be given if the deficiency in packaging warrants the refusal to conduct the examination. Any exceptions between the inventory and the actual evidence by the examiner should be documented. Hardware or software write blockers are to be used to prevent the evidence from being modified. Methods of acquiring evidence should be forensically sound and verifiable. Forensic image(s) should be captured using hardware/software that is capable of capturing a "bit stream" image of the original media. Digital Evidence submitted for examination should be maintained in such a way that the integrity of the data is preserved. Properly prepared media should be used when making forensic copies to insure no mingling of data from different cases.
- Forensic image(s) should be archived to media and maintained consistent with departmental policy and applicable laws.

20.5.5. Data Recovery

Data recovery refers to the process of recovering data from a hard drive, removable disk, or other type of electronic storage media such as, a backup tape drive, server, database, flash memory, etc. when the data is no longer accessible via normal means.

There are many ways to store data: hard drives, removable disks, CDs or DVDs just to name a few. No matter how reliable these storage products might be, any mechanical or electronic device can fail to function normally. In addition, there are many non-failure-related causes of lost or inaccessible data, such as accidentally deleting files, formatting/repartitioning a disk, or a forgotten password. Sometimes disaster strikes and a storage device might physically be unusable, such as in the case of a fire, a spill or other damage. When normal methods for accessing data fail, data recovery is the process we use to regain safe, reliable access to that data.

How to recover the lost data

Data recovery can be a simple process in many cases but may requires exhaustive, detailed work to recover the data in some cases. Any data recovery case typically involves the following process for recovering the lost data:

1. **Evaluate** the media and provide an initial determination of the extent of the damage, potential for recovery, and work involved to recover the data.

2. **Estimate** how much work will be involved, how much data can be recovered, what steps will need to be taken, and what the cost will be to recover the data.

3. **Image** any data that may be accessible to safe location if the media in question is actually physically functional when it is received. Using this process increases the chances for a complete recovery and preserves the original media in case further access is required.

4. **Repair** any electrical or physical damage that may be preventing the media from accessing the data.

5. **Recover** the data through software processes that work with the raw data on the disk or drive.

6. **Analyze** the recovered data to be sure it is intact and usable and then provide a **report** of the results of the recovery (what data was recovered, what was the cause of the data loss, etc).

7. **Return** the restored data on media of your choice as soon as possible.

20.5.6. Forensic Analysis/Examination

Examiner should review documentation provided by the requestor to determine the processes necessary to complete the examination and ascertain legal authority to perform the requested examination. Examples of such authority include: consent to search by owner, search warrant, or other legal authority.

Consideration should be given to the following before commencing any examination:

- The urgency and priority of the requestor's need for information
- The other types of forensic examination, which may need to be carried out on the evidentiary item.
- Which items offer the best choice of target data in terms of evidentiary value.

  An examination strategy should be agreed upon and documented between the requestor and examiner. Conducting an examination on the original evidence media should be avoided if possible. Examinations should be conducted on forensic copies or via forensic image files.

  Appropriate controls and standards should be used during the examination procedure.

  Examination of the media should be completed logically and systematically consistent with the agency's SOPs.

Computer Forensics in catching the criminal:

Computer forensic science is relatively new discipline that has the potential to greatly affect specific types of investigations and prosecutions. Computer forensics is the science of acquiring, retrieving, preserving, and presenting data that has been processed electronically and stored on computer media. As a greater number of people now make use of computers, more and more information of all kinds is being stored on them. This includes information that is of significant importance to an organization's clientele or that has a bearing on a civil or criminal case, such as evidence of financial fraud, embezzlement, wrongful employment termination, sexual harassment, theft, arson, workers compensation fraud, age or sex discrimination, child pornography, theft of trade secrets, or marital

infidelity, to name a few. Computer forensic science is different from the traditional forensic disciplines. To begin, the tools and techniques required are easily available to anyone seeking to conduct a computer forensic investigation. In contrast to traditional forensic analysis, there is commonly the requirement that computer examinations are performed at virtually any physical location, not just in a controlled environment. Rather than producing conclusions requiring expert interpretation, computer forensic science produces direct information and data that may play a significant role in the apprehension or conviction of cyber criminals.

The acquisition of digital evidence begins when information and/or physical items are collected or stored in anticipation of being examined. The term “evidence” implies that the courts recognize the collector of evidence and that the process of collecting is also understood to be a legal process, appropriate for evidence collection in the locality in which it is taking place. A data objector physical item only becomes evidence when so deemed by a law enforcement official or designee.

20.6 COMPUTER SCANNERS

A scanner is a device that captures images from photographic prints, posters, magazine pages, and similar sources for computer editing and display. Very high-resolution scanners are used for scanning for high-resolution printing, but lower resolution scanners are adequate for capturing images for computer display. Scanners come in flatbed, hand-held, feed-in types and for scanning black-and-white or color. Scanners usually come with software, such as Adobe's Photoshop product, that lets the user to resize and modify a captured image.

The basic principle of a scanner is to analyze an image and process it in some way. Image and text capture (optical character recognition or OCR) allow saving information to a file on the computer. One can then alter or enhance the image and print it out or use it on web page. Scanners have become an important part of the home office over the last few years. Scanner technology is everywhere and used in many ways. There are following types of scanners used nowadays:

- **Flatbed scanners**

  It is also called desktop scanners, are the most versatile and most common of all scanners. A flatbed scanner is usually composed of a glass pane, under which there is a bright light (often xenonorcold cathode fluorescent), which illuminates the pane, and a moving optical array. A flatbed scanner typically contains three rows (arrays) of sensors with red, green, and blue filters, as shown below (Figure.1).

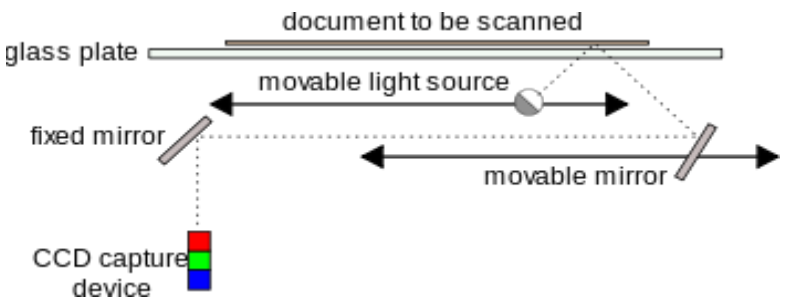


Figure.1

- **Sheet-fed scanners**

  These are similar to flatbed scanners except the document is moved and the scan head is immobile. A sheet-fed scanner looks a lot like a small portable printer.

- **Handheld scanners**

  Handheld scanners use the same basic technology as a flatbed scanner, but rely on the user to move them instead of a motorized belt. This type of scanner typically does not provide good image quality. However, it can be useful for quickly capturing text.

- **Drum scanners**

  The drum scanners are used by the publishing industry to capture incredibly detailed images. They use a technology called a photomultiplier tube (PMT). In PMT, the document to be scanned is mounted on a glass cylinder. At the center of the cylinder is a sensor that splits light bounced from the document into three beams. Each beam is sent through a color filter into a photomultiplier tube where the light is changed into an electrical signal.

  Some of the leading companies dealing in manufacture and retail of computer scanners are: Epson, HP, Microtek, Canon etc.

20.7 SOFTWARE PIRACY

Software piracy is the illegal distribution and / or reproduction of computer software or its application for business or personal use. For instance, anything that we don't buy doesn't belong to us, similarly, the software or its applications that is not purchased or that requires a license for its user to operate it doesn't entitle us to use it for our personal or professional means.

Yet, there are several such people who do not buy the software or its application but claim to be the licensed users and enjoy its application and functions. There are also people who purchase the license to use a software or its application but on a single computer, and can't put copies on other machines or pass that software along to colleagues. Software piracy is illegal and punishable by law all over the world.

Some common piracy methods are:

Licensed user duplication for unlicensed users.

When someone copies software without buying the appropriate number of licenses, it is copyright infringement. Each of these activities is a form of software piracy, such as:An individual copying software for a friend, A business underreporting the number of computers using the software, Including copies of any copyright fonts when sending files.

Illegal Internet distribution

When ordering software over the Internet one needs to be over cautious. Many resellers with Internet storefronts or those who sell from auction sites knowingly distribute copies of software illegally.

Estimates reveal that, as much as 90% of software sold over Internet auction sites is gray market. So, if the pricing seems too good to be true, it probably is.

Illegal use of a software or its application over a network

Some Web sites promise prospects free software downloads. These sites are distributing software illegally. There is also no guarantee that the software is secure or will work properly when installed.

Distributing specialized education versions to unauthorized markets

For this reason many software companies create special versions of its software to meet the needs of the education market. These versions are clearly labeled to avoid confusion with other market segments. Duplication of these specialized versions for distribution to other markets is prohibited.

Making counterfeit copies for sale

While software laws differ from nation to nation, this particular infringement is illegal in most countries. Obscure exceptions might exist for uncommon circumstances in certain countries, such as modification of a program for benefit of the disabled, but in general, duplicating software for the purpose of selling it is the classic definition of software piracy.

Hard-disk loading

Another form of software piracy is selling a computer system with illegal software already installed. Generally, the buyer does not receive manuals, license agreements, or even the CDs or diskettes containing the original program.

Internet sharing

Software that is neither freeware nor shareware cannot be legally disseminated online. However, many software programs are readily available over P2P (peer to peer) networks, via binary newsgroups or in chat rooms.

Tampering with the copyright of any software, including freeware

Even freeware can be the subject of software piracy, when the copyright is illegally changed or the program is illegally modified then redistributed. The redistributed product does not require an original price tag to qualify as pirated software.

Arguably, the most controversial form of software piracy relates to what many people consider simple 'personal use' - buying a software program, and then installing it on more than one personal machine. Some software licenses prohibit this, a restriction that many consumers see as corporate greed, especially where 'non-optional' programs such as operating systems are concerned. In many cases this has aligned otherwise law-abiding citizens with hackers and crackers when they seek ways around the specific copyright security provisions that they see as unfairly restrictive.

20.8 COUNTERFEIT CURRENCY

Counterfeiting of currency is as old as genuine. It is said that “Counterfeiting is an offence never committed by accident, or by ignorance, nor in the heat of passion, nor in extremity of poverty. It is a

crime expertly designed by one possessing technical skill and lays out substantial sums for equipment". Improved methods of photography and printing processes, advent of computer technology has made it easier and quicker for counterfeiting.

Production of Government Currency Notes

The Government currency notes are printed at Currency Note Press at Nasik and Bank Note Press at Dewas.

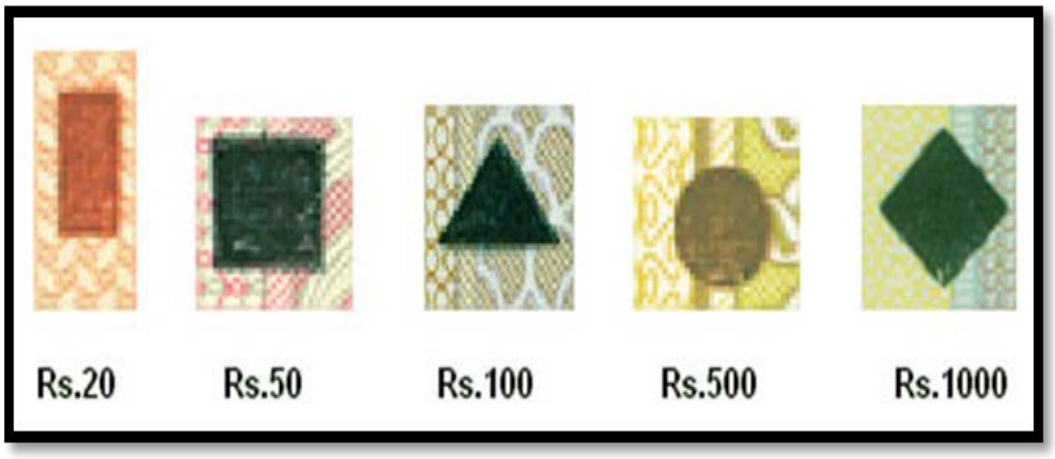
The Mahatma Gandhi series-1996 banknotes contain the following special features:

Latent Image: The vertical band next to the (right side) Mahatma Gandhi's portrait contains a latent image, showing the denominational value 20, 50, 100, 500 or 1000 as the case may be. The value can be seen only when the banknote is held horizontally and light allowed to fall on it at 45°; otherwise this feature appears only as a vertical band.

Security thread: Rs.10, Rs.20 and Rs.50 notes contain fully embedded security thread. Rs.100, Rs.500 and Rs.1000 banknotes contain windowed security thread. This thread is partially exposed and partially embedded. When held against light, this thread can be seen as one continuous line. Other than on Rs.1000 banknotes, this thread contains the words 'Bharat' in the Devanagari script and 'RBI' appearing alternately. The security thread of the Rs.1000 banknote contains the inscription 'Bharat' in the Devanagari script, '1000' and 'RBI'.

Micro letterings: This feature appears between the vertical band and Mahatma Gandhi portrait. It contains the word 'RBI' in Rs.10. Notes of Rs.20 and above also contains the denominational value of the banknotes. This feature can be seen well under a magnifying glass.

Identification mark: A special intaglio feature (raised printing) has been introduced on the left of the watermark window, on the obverse (front) on all banknotes except Rs.10/- banknote. This feature is in different shapes for various denominations (Rs.20-Vertical Rectangle, Rs.50-Square, Rs.100-Triangle, Rs.500-Circle, Rs.1000-Diamond) and helps the visually impaired to identify the denomination.



(i) **Intaglio Printing:** The portrait of Mahatma Gandhi, Reserve Bank seal, Guarantee and promise clause, Ashoka Pillar Emblem and RBI Governor's signature are printed in intaglio i.e. in raised prints in Rs.20, Rs.50, Rs.100, Rs.500 and Rs.1000 banknotes.

(ii) **Fluorescence:** The number panels of the banknotes are printed in fluorescent ink. The banknotes also have optical fibres. Both can be seen when the banknotes are exposed to ultra-violet lamp.

(iii) **Optically Variable Ink:** The numeral 500 & 1000 on the Rs.500 [revised color scheme of mild yellow, mauve and brown] and Rs.1000 banknotes are printed in Optically Variable Ink viz., a color-shifting ink. The color of these numerals appears green when the banknotes are held flat but would change to blue when the banknotes are held at an angle.

(iv) **Watermark:** The banknotes contain the Mahatma Gandhi watermark with a light and shade effect and multi-directional lines in the watermark window. A genuine note is crisp and thin. The notes are printed on optical fiber paper. Fake notes are printed on thick paper make of bamboo pulp. If it is a Xeroxed note the colour and print look faded. The presence of 'Intaglio" on the denomination i.e.1000,500,100,50, 20 ,10 or 5 (the embossed print that enables the blind to touch and know the denomination of the currency).The chemical 'omran' is used to print in 'Intaglio', which looks bright. Intaglio will be missing in counterfeit notes. Look at the note against the light, for the fine and shining 'security band' on the right side of 'Intaglio' look for the faint water mark of 'Mahatma Gandhi' .

(v) For a genuine currency note, the number panel will be regular and when scrutinized against ultra violet rays, the letters printed with fluorescent ink shine. For a fake note the security band will be rough and prominent Number panel will be irregular. The numbers are comparatively smaller as compared to the original notes.

There should be 10 people following "Mahatma Gandhi". Shadow/Umbrella whichever term can be used must be present above the head of the last 3 person following the lead which is being distinguished with an identification mark through red circle.

CHECK YOUR PROGRESS

1. Match the following identification marks with their respective currency denomination.

Identification mark		Currency note	
a)	rectangle	i)	50
b)	circle	ii)	100
c)	square	iii)	20
d)	triangle	iv)	1000
e)	diamond	v)	500

2. Which of the following is not a type of computer scanner?
   a) Flatbed
   b) Sheet fed
   c) Floor mat
   d) Drum scanner
3. What is the full form VIRUS?
4. A set of instructions logically placed to perform a given task is called a:
   a) System protocol
   b) Computer program
   c) Software system
   d) Operating system
5. Hacking with computer system is defined under which section of IT Act 2000?
   a) 60

b) 62

c) 64

d) 66

Answers

1. a-iii, b-v, c-i, d-ii, e-iv
2. c
3. Vital Information Resource Under Siege
4. b
5. d

20.9 SUMMARY

Computer forensics has become a vital tool in providing evidence in cases such as computer misuse and attacks against computer systems as well as more traditional crimes such as murders, money laundering, drugs, abuse and frauds. The internet, networks, e-commerce, home users, portable devices and automated systems present a range of opportunities for committing criminal activity unauthorized in workplace. Computers and other electronic devices are being used increasingly to commit, enable or support unwanted activity perpetrated against individuals, organizers, or assets.

The use of computer and allied electronic devices such as scanners, printers, magnetic inks and laser pointers are also being widely used by malingerers to forge currency notes and coins which in turn impedes the economy of the country.

UNIT - 21 : POLYGRAPH

Structure

21.0 Introduction
21.1 Objectives
21.2 Truth and deception
21.3 Psychology of lying
21.4 Principles of lie-detection
21.5 Summary

21.0 INTRODUCTION

Polygraph is also known as a **Lie Detector** device, derived from Greek words 'poly' means 'many' and 'graph' means 'writing'. It is an instrument that measures and records several physiological parameters such as blood pressure, pulse rate, respiration, and galvanic skin response. It was invented in 1921 by Dr. John A. Larson of the University of California and first applied in law enforcement work by the Berkeley Police Department under its nationally renowned police chief August Vollmer. In India, polygraph test is used as a means to interrogate the suspect to reveal the truth. It is a substitute to third degree torture methods of interrogation.

21.1 OBJECTIVES

The objective of this module is to study

- the importance of polygraph test
- legality of polygraph test as an evidence in the court of law in India.

21.2 TRUTH AND DECEPTION

The polygraph test starts with a pre-test interview to gain some preliminary information, which will later be used for 'control questions' (CQ). Then the expert will explain how the polygraph is supposed to work, emphasizing that it can detect lies and that it is important to answer truthfully. Some of the questions asked are 'irrelevant' (RQ) such as "Is your name Rameshwar?" Then there are the 'relevant questions' that are related to the crime case in question. For example: "Were you present at the scene of crime on 4th Jan.'12". These two different types of questions alternate. The questions are in multiple choices and the subject is rated on how he/she reacts to the correct answer. The test is passed if the physiological response during the test shows that the subject has reacted strongly to the guilty information, then it is likely that he/she knows the facts relevant to the case.
As the subject is asked these series of questions related to the case in hand, he/she is supposed to answer in either 'Yes' or 'No'. It is believed that deceptive answers (lie) will show physiological responses that can be differentiated from those associated with non-deceptive answers (truth). However, this kind of interrogation style would sometimes elicit a nervous response from innocent suspects. And they give positive test blamelessly. Therefore, the examiner first fits a subject with sensors to measure respiration, heart rate and blood pressure, and perspiration, which the polygraph records using pens on graph paper. And then asks a series of questions, including control questions

that are designed to provoke anxiety and denial. Later, another examiner compares these answers with answers pertaining to the matter at hand. This is known as numerical CQ testing. One examiner scores the test while also noting subject's observable physical responses, such as: eye or hand movements, expression, and voice etc.

21.3 PSYCHOLOGY OF LYING

Lying is morally wrong and is always discouraged, but it comes naturally to human beings. There are different types of lies such as: fabrication of facts or truth or deceiving (incomplete truth), a noble lie, a lie-to-children etc. There are different reasons why people lie. One of which could be fear of being convicted by the court of law for the wrongful doings or fabrication of truth. Also sometimes people lie to prevent social disgrace and hatred from near and dear ones.

Some people also suffer from a disorder known as **compulsive lying**. These people, known as chronic liars, acquire a habit of lying and they tend to lie in any and every situation. Lying comes naturally to them and they find it almost difficult to tell the truth. Compulsive lying is a disorder that develops from early adolescence and one must keep an eye out for signs of compulsive lying. It should also be noted that chronic liars may always pass lie-detection test as whatever answers they will give whether truth or false will give a graph showing answers to be ‘true’ always. For such people, it is necessary to take pre-test with control questions with positive answers for reference. One must accept the universal truth that people will continue to lie, whether it is right or wrong, particularly in cases pertaining to any legal action against them. With this test we only try to take advantage of their ability to spin stories which will show them as innocent. As the subject tries to concoct a fabricated story of real facts his physiological parameters such as his pulse rate, heart beat, blood pressure and galvanic skin response will start to show deflection from the normal curve. It is then that we say he is lying.

21.4 PRINCIPLES OF LIE-DETECTION

The discipline of polygraphy is based on the principle that by recording involuntary physiological changes in the subject, the polygraph yields data that can be interpreted to determine whether the subject is telling the truth or not. It is based on the principle of detecting anxiety. When a person is stressed, his body shows physiological signs, which can be measured by polygraph device. As the person, at the moment of lie, subconsciously and irrespective of its will, desire and efforts cannot constrain and supervise physiological reactions, which sharply amplify. The person whether wants it or not give out the truthful information about him, irrespective of his will and desire. Thus the person can keep an invariable look, seem easy, is direct look in the face, smile, laugh, assert, that he speaks the truth and not to give a sign in any way that he is lying, but to constrain activity of the brain and physiological reactions because they are not under his control. Scientific studies claim that polygraph results are approximately 90 percent accurate.

POINTTO REMEMBER

Article 20(3) of the Indian Constitution states - "No person accused of any offence shall be compelled to be a witness against himself."

CHECK YOUR PROGRESS

1. The test used to elicit truth by measuring GSR (Galvanic Skin Response) is:
    a) Narco analysis
    b) Truth serum test
    c) Lie-detection
    d) Brain mapping
2. Which of the following is not measured in Polygraphy?
    a) Pulse rate
    b) GSR
    c) Blood Pressure
    d) Muscle movements
3. Polygraph test is considered as:
    a) Corroborative evidence
    b) Physical evidence
    c) Transient evidence
    d) All of the above

Answers

1. c
2. d
3. a

21.5 SUMMARY

Polygraph evidence was admissible in civil cases, however, and it was also used widely in law enforcement, government, and industry. In India, polygraph test is used a means to interrogate the suspect to reveal the truth. It is a substitute to third degree torture methods of interrogation. Therefore, it alone may not be conclusive to prove the guilt of the suspect, hence; police has to further probe the investigation by finding concrete and conclusive evidences to prove his guilt. It may only be used a lead in the investigation and cannot be considered as the sole evidence against any individual to cause the basis of his conviction.

UNIT - 22 : NARCO ANALYSIS

Structure

22.0 Introduction
22.1 Objectives
22.2 Narco Analysis Test
22.3 Hypnosis
22.4 Importance and limitations
22.5 Legal aspects of narco-analysis
22.6 Summary

22.0 INTRODUCTION

The term ‘Narco’ of **narco analysis** is derived from Greek word ‘nark’ means ‘anesthesia’ or ‘torpor’. This test is used to describe a diagnostic and psychotherapeutic technique that uses psychotropic drugs, particularly barbiturates, to induce a stupor in which mental elements with strong associated affects come to the surface, where the therapist can exploit them.

22.1 OBJECTIVES

The objective of this module is to study the importance of narco analysis and its legality as an evidence in the court of law in India. It deals with the administration of a chemical drug into the blood stream of the suspect to elicit truth.

22.2 NARCO ANALYSIS TESY

It is done by suppressing the subject's imagination to concoct stories or lies by making him semi-conscious. In this state, it becomes difficult for him to lie and his answers would be restricted to facts he is already aware of. Dr. William Bleckwenn first documented this application in 1930. Narco Analysis is an interrogative technique used in place of torturous third degree methods.

A **‘truth serum’** is used to inject intravenously into the subject to make him sub-conscious for narco analysis. The drugs used for this purpose are **Sodium Pentothal** or **Sodium Amytal**. The dose is dependent on the person's sex, age, health and physical condition. However, an excess dose can result in a person going into coma, or even death. The subjects who are unwilling to provide information otherwise are subjected to narco analysis to elicit truth. The subject once administered with the drug is not in a position to speak up on his own but can answer specific and simple questions when asked. The answers are believed to be spontaneous and true as a semi-conscious person is unable to manipulate the answers.

22.3 HYPNOSIS

When the drug (sodium pentothal) is administered intravenously, the subject ordinarily descends into anaesthesia in four stages, namely:

(i) Awakening stage
(ii) Hypnotic stage
(iii) Sedative stage
(iv) Anaesthetic stage

The drug is prepared by mixing 3g of Sodium Pentothal or Sodium Amytal in 3000 ml. of distilled water. A relatively lighter dose of sodium pentothal is injected to induce the `hypnotic stage' and the questioning is conducted during the same. The hypnotic stage is maintained for the required period by controlling the rate of administration of the drug. This causes the subject to enter into a hypnotic trance and he becomes less inhibited. It induces the subject to divulge information, which he would not have revealed in conscious awareness.

The personnel involved in conducting narco analysis interview include a forensic psychologist, an anaesthesiologist, a psychiatrist, a general physician or other medical staff and a language interpreter if needed. The entire test is video-graphed for subsequent scrutiny.

In India, this technique has been administered either inside forensic science laboratories or in the operation theatres of recognized hospitals. While a psychiatrist and general physician perform the preliminary function of gauging whether the subject is mentally and physically fit to undergo the test, the anesthesiologist supervises the intravenous administration of the drug. It is the **forensic psychologist** who actually conducts the questioning. Since the tests are meant to aid investigation efforts, the forensic psychologist needs to closely co-operate with the I.O in order to frame appropriate questions.

22.4 IMPORTANCE AND LIMITATIONS

The narco analysis in today’s time can be used to substitute the third degree methods of interrogation used by the police to elicit truth. Since, it is based on the principle that during the `hypnotic stage' the subject is unable to willfully suppress the memories associated with the relevant facts. Thus, it has been urged that drug-induced revelations can help to narrow down investigation procedures, thereby saving public resources. This would not only save resources and time of the police department but will also give the benefit of doubt to the innocents under suspicion or doubt.

One of the limitations of this test is that it does not give an absolute success rate and there is always the possibility that the subject will not reveal any relevant information. Some studies have shown that most of the drug-induced revelations are not related to the relevant facts and they are more likely to be in the nature of inconsequential information about the subjects' personal lives. It takes great

skill on part of the interrogators to extract and identify information, which could eventually prove to be useful. Secondly, while some persons are able to retain their ability to deceive even in the hypnotic state, others can become extremely suggestible to questioning. This is especially worrying, since investigators who are under pressure to deliver results could frame questions in a manner that prompts incriminatory responses. Thirdly, there are people who are malingers i.e. they fake amnesia and will not have impaired memory even after administration of drug.

22.5 LEGAL ASPECTS OF NARCO ANALYSIS

Generally acceptable scientific evidence, which is to be acceptable to courts of law and scientific community, is known as "Forensic" evidence. Such evidence must satisfy the test of admissibility according to the Indian Evidence Act, 1872.

This test has come under increasing criticism from the public and the media, yet it is steadily being mainstreamed into investigations, court hearings, and laboratories in India. However, it raises serious scientific, legal, and ethical questions. It refers to the process of psychotherapy conducted on a subject by inducing a sleep-like state with the aid of barbiturates or other drugs. In a spate of high profile cases, such as those of the Nithari killers, Aarushi-Hemraj double murder case and the Mumbai train blasts, suspects have been whisked away to undergo an interview drugged with the sodium pentothal.

Article 20 (3) of the Indian Constitution embody this privilege read as, “No person accused of any offence shall be compelled to be a witness against himself.” According to scientists and researchers, the potential to replace, or work in tandem, with other methods of interrogation narco analysis can be used to give possible head-way to the dead-end investigation. And that the police department should then look for the physical evidences based on the revelation from these tests. This is to not prove guilt of accused but to give lead to the Investigating Officer in an otherwise dead-end case. Our judiciary must take these into consideration.

Things to know

“Memory is a man’s real possession…In nothing else is he rich, in nothing else is he poor. Crime wave deceives, criminal mind perceives and criminal soul conceives.” – Alexander Smith

CHECK YOUR PROGRESS

1. Name the stage in which the suspect is asked questions relevant to the crime after administering narco drug.
   a) awakening
   b) hypnotic
   c) sedative
   d) anesthetic

2. The drug usually used to cause hypnosis in the subject during the narco analysis is:
   a) sodium chloride
   b) sodium barbital
   c) sodium pentothal
   d) sodium carbonate
3. Narco analysis is based on the principle that the victim is unable to willfully suppress his _____ associated with the relevant facts of crime.
   a) memories
   b) will
   c) ideas
   d) None

Answers

1. b
2. c
3. a

22.6. SUMMARY

This test is used to elicit truth from subjects who are unwilling to provide information. Here, the drug is injected intravenously into the subject to make him sub-conscious for narco analysis. He is then subjected to a series of questions related to the scene of crime. The answers are believed to be spontaneous and true as a semi-conscious person is unable to manipulate the answers.

UNIT - 23 : BRAIN FINGERPRINTING

Structure

23.0 Introduction

23.1 Objectives

23.2 Concept and significance of Brain Fingerprinting

23.3 Future and Legal aspect of brain fingerprinting

23.4 Summary

23.0 INTRODUCTION

The word **'brain fingerprinting'** is borrowed from the study of brain and the nervous system called Neuroscience. The brain fingerprinting is also known as P- 300 wave test or the Brain Mapping test. It was developed by Dr. Lawrence Farwell first in 1991 and flourished as an aid to scientific investigations in early 2000.

It is a process of detecting whether an individual is familiar with certain information by way of measuring activity in the brain that is triggered by exposure to selected stimuli. This test consists of examining and measuring event-related potentials i.e. electrical wave forms or electroencephalograph (EEG) emitted by the brain after it has absorbed an external event. This EEG measurement is the recognition of specific patterns of electrical brain activity in a subject that are indicative of certain cognitive mental activities that occur when a person is exposed to a stimulus in the form of an image or a concept expressed in words. The measurement of the cognitive brain activity allows the examiner to ascertain whether the subject recognized stimuli to which he/she was exposed.

23.1 OBJECTIVES

The objective of this module is to study the importance of brain fingerprinting and its legality as evidence in the court of law in India. This module deals with the resultant EEG (electroencephalogram) of the suspect to prove whether he knows the truth about a certain facts relevant to the case investigation.

23.2 CONCEPT AND SIGNIFICANCE OF BRAIN FINGERPRINTING

The brain fingerprinting is conducted by attaching electrodes to the scalp of the subject, which measure the emission of the said wave components. The test needs to be conducted in an insulated and air-conditioned room in order to prevent distortions arising out of weather conditions. In brain-wave fingerprinting, the accused is first interviewed and interrogated to find out whether he is concealing any information. The person to be tested wears a special headband with electronic sensors

that measure the EEG from several locations on the scalp. The subject views stimuli consisting of words, phrases, or pictures presented on a computer screen. Stimuli are of three types:

1) **Irrelevant stimuli :** that are irrelevant to the investigated situation and to the test subject
2) **Target stimuli :** that are relevant to the investigated situation and are known to the subject
3) **Probe stimuli :** that are relevant to the investigated situation and that the subject denies knowing.

Probes contain information that is known only to the perpetrator and investigators, and not to the general public or to an innocent suspect who was not at the scene of the crime. Before the test, the scientist identifies the targets to the subject, and makes sure that he/she knows these relevant stimuli. Then sensors are attached to the subject's head and the person is seated before a computer monitor. He is then shown certain images or made to hear certain sounds. The sensors monitor electrical activity in the brain and register P300 waves, which are generated only if the subject has connection with the stimulus i.e. picture or sound. The subject is not asked any questions. A MERMER (Memory and Encoding Related Multifaceted Electro Encephalographic Response) is initiated in the accused when his brain recognizes noteworthy information pertaining to the crime. These stimuli are called the 'target stimuli'. In a nutshell, Brain finger printing test matches information stored in the brain with information from the crime scene. Studies have shown that an innocent suspect's brain would not have stored or recorded certain information, which an actual perpetrator's brain would have stored.

This test also requires effective collaboration between the investigators and the examiner, most importantly for designing the stimuli or probes. Ascertaining the subject's familiarity with the probes can help in detecting deception or to gather useful information. The test subject is exposed to auditory or visual stimuli (words, sounds, pictures, videos) that are relevant to the facts being investigated alongside other irrelevant words and pictures. Even if the `probes' are prepared by an examiner who is thoroughly familiar with all aspects of the facts being investigated, there is always a chance that a subject may have had prior exposure to the probes.

A **limitation** would be any prior exposure to the details of scene of crime, for example, in the aftermath of crimes that receive considerable media-attention the subject can be exposed to the test stimuli in many ways. Such exposure could occur by way of reading about the crime in newspapers or magazines, watching television, listening to the radio or by word of mouth. A possibility of prior exposure to the stimuli may also arise if the investigators unintentionally reveal crucial facts about the crime to the subject before conducting the test. The subject could also be familiar with the content of the material probes for several other reasons.

Another significant **limitation** is that even if the tests demonstrate familiarity with the probes, there is no conclusive guidance about the actual nature of the subject's involvement in the crime being investigated. For instance a by-stander who witnessed a murder or robbery could potentially be implicated as an accused if the test reveals that the said person was familiar with the information related to the same. Furthermore, in cases of amnesia or `memory-hardening' on part of the subject, the tests could be blatantly misleading.

Dr. Lawrence Farwell opines that it is important for a suspect to have knowledge of the **'salient features of the crime scene'** to be accused of being involved in it in person.

Neuroscience is an attempt to read brain and mind. No body can explain the complete functioning of brain because there is fundamental uncertainty about the mind of others. Neuro-imaging is a process which records different patterns of brain images taken under varying circumstances that may relate with different future behaviors and conditions. Through the help of computer assisted tomography (CAT) the structure of living brain may be revealed. Through positron emission tomography (PET) and magnetic resonance imaging (MRI) different parts of brain functions may be studied.

23.3 FUTURE AND LEGAL ASPECT OF BRAIN FINGERPRINTING

Brain fingerprinting proves to be a good recourse in cases where criminals prove to be a hard nut to crack. To procure evidence, the investigating teams generally end up by adopting unfair and illegal means. In spite of adopting unfair means, it is fruitful to rely on science. With the advance scientific discoveries, working with their experts, the investigating officer can read the mind of suspect and dig out concealed information and evidence.

The whole neuro law is based on brain science which moreover Indian Constitution have permitted legislative system to take necessary steps in making law for justice through science. According to the Constitution of India, Part IV-A, it shall be the fundamental duties of every citizen of India to develop the scientific temper, humanism the spirit of inquiry and reform; that has brought volcano in present day administration of criminal justice system. The search for effective aids to interrogation is probably as old as man's need to obtain authentic and truth information. Development of new tools of investigation has led to the emergence of scientific tools of interrogation like Brain fingerprinting. Such tests are a result of advances in science but they often raise doubt regarding basic human rights and about their reliability.

There is an important difference between the **`P300 waves test'** that has been used by Forensic Science Laboratories in India and the **`Brain Fingerprinting'** technique. Dr. Lawrence Farwell has argued that the P300 wave component is not an isolated sensory brain effect but it is part of a longer response that continues to take place after the initial P300 stimulus has occurred. This extended response bears a correlation with the cognitive processing that takes place slightly beyond the P300 wave and continues in the range of 300-800 milliseconds after the exposure to the stimulus. This extended brain wave component has been named as the MERMER (Memory-and-Encoding-Related-Multifaceted-Electroencephalographic Response) effect. This test can also be used as corroborative evidence and can only additionally be used in accordance with other vital physical evidences.

CHECK YOUR PROGRESS

1. The brain fingerprinting technique is based on the electrical signals given out from which of the following wave?

   (a) P 30

(b) P 300

(c) T 20

(d) PT 30

2. Which of the following is the most recent method of interrogating suspects?

(a) Narco analysis

(b) Polygraph

(c) Brain fingerprinting

(d) Third degree methods

3. The test subject is exposed to which of the following stimuli relevant to the scene of crime.

(a) Visual

(b) Auditory

(c) Verbal questioning

(d) Both (a) and (b)

Answers

1. b
2. c
3. d

23.4 SUMMARY

In this study the sensors are attached to the subject's head and the person is seated before a computer monitor. He is then shown certain images or made to hear certain sounds. The sensors monitor electrical activity in the brain and register P300 waves, which are generated only if the subject has connection with the stimulus i.e. picture or sound. The subject is neither asked any questions nor does he speaks any answers. He is exposed to certain known and unknown pictures and sounds and the relative pattern (in the form of electro gram) is recorded for the same. It is this graph that shows deviation from the normal wave pattern for any crime scene information that subject might know.

SUGGESTED READINGS

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2. B. Lal & R. Chandra, Cross-Examination of Handwriting Expert with Modern Techniques,10
3. Prof. (Dr.) Vimala Veeraghavan, Handbook of Forensic Psychology,
4. Ram Ahuja, Criminology
5. Dr. M.P. Goutam, Analysis of Plant Poisons
6. Dr. R.K. Tewari, Computer Crime and Computer Forensic
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8. Alastair Ruffell, Geo Forensics
9. Glen, Handbook for Sound Engineers
10. Alexander Lerch, An Introduction to Audio Content Analysis
11. V N Sehgal & Prof. Surinder Nath, Forensic Science & Its Related Issues 12
12. Dr Anu Singhla & Ankit Srivastwa, Forensic Science For Criminal Justice System