STEREO MICROSCOPE:

Fig. 22 Stereo Microscope

Stereomicroscope is an optical magnifying instrument which offers three dimensional investigations of the samples. It is superior to two dimensional studies. The specimens are lit up utilizing spot lights. The examination is begun from low amplification to high amplification. The examination is done at the particular and pertinent zone. It utilizes two diverse optical way alongside two objectives and eyepieces. Stereomicroscope utilizes reflected light rather than transmitted light (Mann et al, 2013). The stereoscopic magnifying lens has endless utilizations in the document examiner’s work.

The best value of this instrument is its application to the most incessant issue submitted to the document analyst: the credibility or nonvalidity of signatures. The
fragile tremor of fraud because of gradually drawing instead of freely writing the signature is the most pervasive confirmation of phony which appears with clarity under amplification. The minute retracing, over-writings, or overlapping; the unnatural retouching or patching; the stops or lifts of the writing instrument at unlikely locations; the uneven, irregular ink distribution-characteristics of forged signatures which to the eye may appear to have natural, freely written, continuous lines—are revealed by the microscope to brand the signatures as bungling, sloppy failures. An examination through transmitted light will regularly demonstrate some of these components considerably. For this reason it is handier to put the archive on a case or table with a glass top having a light underneath it, or on a photographic contact printer. The base with sub stage mirror may obviously be joined to the magnifying lens for a transmitted light examination. A carbon paper or pencil diagram, or an indentation on the paper, which serves as the rule for a falsification by the tracing procedure can be seen unmistakably with the microscope notwithstanding when an endeavor has been made to eradicate it, where it may be difficult to identify with the unaided eye. Where there is an issue of whether a signature was fastened before or after the handwriting above it on an archive, the signature and the other written work will here and there meet or cover. In these cases it is frequently conceivable to figure out which was composed last through a microscopic investigation of sequence of intersecting strokes (David A. Black, 1952).

In this association it is well to note that a kind of optical deception regularly deceives the easygoing spectator, with or without the microscope. This is the impact that the darker line normally seems, by all accounts, to be "on top" (composed last), despite the fact that that may not really be the situation. The reason is that the darker line seems to have consistent, continuous edges since they are not darkened by the
lighter line, regardless of the fact that the last was composed last. Then again, the lighter line's edges appear to be spasmodic or intruded on the grounds that their perceivability is clouded by the darker line, notwithstanding when the lighter line was composed last. Since the common eyewitness will judge the request or arrangement of the strokes by the evident consistency of their edges, he might be hoodwinked where the lighter line was composed last. Notwithstanding intersecting ink strokes, the same kind of inquiry including pencil composing, typewriting, duplicates, elastic stamps, and different impressions can frequently be explained with the utilization of this magnifying lens.

As an additional illustration, where ink crosses naturally composed typewriting, the oil in the typewriting will frequently repulse the water of the ink. At the point when analyzed later, there will be a positive crevice or diminishing in the ink stroke where it crosses the typewriting. This is an unmistakable proof of the ink having been composed last (David A. Black, 1952).

MICROSCOPESPECTROPHOTOMETERS

![Fig. 24 Microspectrophotometers](image-url)
The UV-visible- NIR microspectrophotometer is an instrument used to gauge spectra of tiny samples or minute ranges on samples. Questioned Document Examination is the field that identifies with the scientific examination of documents, inks and papers. A standout amongst the most widely recognized assignments of the Questioned Document Expert is to figure out whether a suspect archive is unique. Regularly tests are done by correlation with other unique samples or by examination with standard reference materials. Questioned document examiners work with samples that range from historical treatises to currency to identification papers such as passports. Numerous sorts of tests are performed by the Questioned document expert. Microspectrophotometers are extensively utilized to examine the microscopic things such as micro printing on the currency notes. These systems can give pictures and spectra of minute components of questioned documents by UV-visible- NIR reflectance, transmission, fluorescence and Raman excitation. The visible part of the spectrum is imperative as it recognizes diverse shaded inks, papers and security highlights. The UV is essential as most of the chemicals utilized as a part of inks and papers have an UV dynamic component. Also, numerous security elements are just distinguishable in the ultraviolet region. The NIR area is imperative as a portion of the more up to date security highlights have spectral responses here. **UV-visible-NIR microspectrophotometers**, are used to analyze the dyes and pigments as well as the paper and many of the security features contained within such documents. The advantage of using microspectrophotometers is that they can be used to analyze even the smallest micro-printing and security features. This makes these instruments very useful for everything from forensic analysis to developing new ink and paper formulations. (http://www.microspectra.com/questioned documents)
UV-Vis-NIR, FTIR AND X-RAY FLUORESCENCE SPECTROMETRY

Contemporary inks contain numerous substances expecting to enhance ink qualities. Clearly, the most essential segment is the shading material, which comes as dyes, shades or their blend. Dyes are dissolvable in the fluid body of the ink, which is otherwise called the vehicle. Then again, shades are finely ground multi-sub-atomic granules that are insoluble in the vehicle. The vehicle, whose organization influences the streaming and drying attributes of the ink can comprise of oils, solvents and pitches (D. Djozan et. al, 2008). In regular examinations of inks, non-distractive scientific techniques, for example, microscopic and optical ones, are fundamentally useful. These strategies permit picked parameters of the ink to be portrayed, for example, its hues, glow and assimilation of radiation. Samples might be separated on the premise of transmission, reflection and fluorescence spectra acquired for inks stored on the surface of paper. Notwithstanding, with a specific end goal to distinguish the ink, it is important to decide its sort and arrangement, utilizing strategies for physico-chemical examination.

Among these techniques, thin layer chromatography and capillary electrophoresis are connected frequently. They are easy to utilize, require just a little measure of sample for examination, and in the meantime they are described by a high level of selectivity and repeatability of results. However, disengagement of the specimen from the substrate of the archive (i.e. the paper) by method of solvent extraction is vital, which prompts some harm to the analyzed record. UV-visible-near infrared Spectrophotometry (UV-Vis-NIR) and Fourier Transform Infrared Spectrometry (FTIR) can be additionally used to pen brand separation. Information of ink equations can decide the validness of a document, including age and nearness of any progressions to the document. (Daniela-Laura Feraru et. al, 2014)
X-ray fluorescence spectrometry as an explanatory system which investigates at the fundamental substance of a Small specimen and gives data about colors and fillers, is more delicate to higher nuclear weight components than SEM/EDX. However, the profundity of X-ray infiltration and in addition the beam diameter’s impact on the outcomes acquired for multilayer materials. Spectroscopic strategies, for example, Fourier transform infrared spectroscopy, X-ray fluorescence spectroscopy, UV-VIS spectroscopy and chromatography techniques was effectively connected in the investigation of inks. (H. Awab et. al, 2011)

VIDEO SPECTRAL COMPARATOR:

Non destructive examination of questioned documents is a priority in document examination. Video spectral comparator is one of the adaptable instruments which permits non destructive examination of document various instrumental parameters and furnishes moment results with less simpler use. The video spectral comparator is an imaging gadget which permits an analyst to scrutinize inks, helps us to see unseen securities and uncover alteration on a document. Light is a type of electromagnetic radiation, VSC works on this principle. The visible range is 400 nm-700 nm in the electromagnetic scale. At the point when the eyes see distinctive colors, it really sees diverse wavelengths of light. At the point when light is coordinated towards an entity, any one of 5 things may happen relying upon the emitted wavelengths and the structure of the entity.

• Reflection:- All the light or a part of it can be reflected off the object making it seem white (if white light is radiated) or lighter (if just particular wavelengths are discharged).

• Absorption: -. All or the greater part of the light can be consumed by the object. The object then seems dark or darker
• Reflection and Absorption:- A part of the light can be reflected, and part can be assimilated. It produces colours in the visible part of the spectrum.

• Transmission:- Light can be transmitted through the entity.

• Luminescence: - Light can strike the entity, be retained, and after that reemitted at a more longer wavelength.

Infrared (IR) and Ultra Violet (UV) radiations are not obvious to the human eye. In any case, each of the five specified impacts that happen in the visible part of the spectra likewise happen in the IR and UV portions. There can be an imperative distinction. The same entity that ingested light in the visible range and seemed dark, can now transmit radiant energy in the IR range and seem clear like a bit of glass. For example, the VSC5000 camera working in the IR segment of the range can catch a picture lying underneath a murky blue ink, like the way a X-Ray catches pictures of bones through skin (Sharma. R, 2014)

**ELECTROSTATIC DETECTION APPARATUS:**

Indented writing, or second page writing, is the impression from the writing instrument caught on sheets of paper beneath the one that contains the first written work. This regularly shows itself when stack of paper are utilized. Indented writing can be a wellspring of distinguishing proof in anonymous note cases and when medical records are associated with alterations. Frequently, addition in the writing on
a record or document can be uncovered by a impression that has been exchanged to
the page beneath. Indented writing on resulting pages may not be in concurrence with
what shows up on the surface of the archive. Writing observed to be out of position,
missing, or included afterwards can regularly be exhibited by recuperating and
safeguarding indented writing from different pages.

We have all perused mystery books or been subjected to TV and film plots
that have recuperation of indented writing as a clue. The technique to "peruse"
Indented composing is regularly recouped by one
of two techniques: Either photographically utilizing oblique light or by utilization of a
device generally alluded to as ESDA, short for Electro-static Detection Apparatus.

Nowadays all the Forensic Science Laboratories utilize ESDA to detect
Indented writing from suspect pages was to rub a delicate lead pencil or carbon paper
over the surface of the record. It may seem interesting but, this strategy is one
approach to demolish or crush what may be an important proof and ought to serve as a
notice against novice examinations. Indented composing is regularly recouped by one

Nowadays all the Forensic Science Laboratories utilize ESDA to detect
Indented writing might be developed three, four, or considerably more pages underneath the first written work. Normally a
preparatory examination of the submitted report is first embraced just to dispense
those archives which are not suitable for the recovery of indented writings.
Documents, if treated with ninhydrin for examination of fingerprints or have been
soaked with liquids regularly fall into this category. Thick cardboard mediums are
generally incongruent with ESDA.

The archive to be prepared may be humidified somewhat on the off chance
that it has been kept in, or had as its source, a dry environment. This will help the
electro-static charge create. An inside page from a stack of paper is a case of such a
situation. In more moist atmospheres a few hours introduction to typical room air would fill this same need. Most reports presented to ordinary room conditions where the air is normally sticky don't require preconditioning.

The page associated with bearing indentations is secured with a Mylar material which is then pulled into firm contact with the paper by a vacuum drawn through a permeable bronze plate. This serves to affix the document and Mylar covering to the plate. The Mylar covering counteracts harm to the original document. The paper and Mylar are then subjected to a high voltage static charge by waving an electrically charged "wand" over the archive's surface.

This result in a variably accused surface of the heavier static charge staying inside any impressions, even those that are minute top to bottom. Dark toner (like that utilized as a part of dry-procedure photocopy machines), is then sprinkled over the cellophane surface utilizing minutely estimated glass globules as a transporter, or by moistening utilizing a clouding chamber set over the paper to be examined. The toner is firmly pulled in to electricity produced via friction and is held on the Mylar surface as per the measure of remaining static charge present at any given surface point. The areas of the paper containing the higher static electric charge hold more noteworthy segments of the dark toner resulting in the deposit of the toner aligned with the indentations in the paper.

These indentations are photographed and they are safeguarded by placing a clear plastic sheet which has adhesive over on the cellophane while it is still held set by the vacuum of the ESDA. In the event if the recouped indented writing is of a sufficiently high quality, it might even serve as a strategy to partner some individual to questioned document utilizing the penmanship as a part of the indentations for correlation with known penmanship.
Advantages:

- ESDA is non-destructive equipment for the examination of Questioned documents.
- The original document remains undestroyed throughout the process.
- ESDA has a great degree of sensitivity towards recovery of indentations, therefore if the indentations are not revealed by other techniques may be definitely revealed using ESDA (http://www.questioneddocuments.com)

THIN LAYER CHROMATOGRAPHY:

Fig. 26. Apparatus of Thin Layer Chromatography

Thin Layer Chromatography (TLC) is so widely used that it has become an essential technique for analysts and research workers. In 1935, Izmailov and Shraiber described the basic principle underlying the process and used it for separation of plant extracts. Later on it was Stahl in 1958 who is mainly credited with bringing out the work on preparing plates and separation of wide variety of compounds.
In thin layer chromatography the separation is carried on a glass or plastic plate which is coated with thin uniform layer of finely divided inert adsorbent such as silica gel or alumina. The plates are activated; the solution of the sample in a volatile solvent is applied by using a capillary tube or micropipette to spot keeping 1-2 cm from the bottom of TLC plate. The position of the sample spot is indicated by marking a origin line on the plate with the lead pencil. When the spot has dried, the plate is placed vertically in a suitable tank with its lower edge immersed in selected mobile phase. The solvent rises by capillary action, resolving the sample mixture into discrete spots. At the end of the run the solvent is allowed to evaporate from the plate and the separated spots are located and identified by various physical and chemical methods. This is the basic principle underlying the process of Thin Layer Chromatography. This principle is used in the examination of Inks and Dyes.

Using a blunt hypodermic needle, about ten plugs of ink is taken out from the written line or a signature. The controlled sample of the paper is also treated in the similar manner. Transfer both the samples in the different glass vails and add a drop of solvent which is very much suitable to dissolve the ink which is extracted from the questioned document. Allow 15 minutes to completely dissolve. Note and record the colour of the ink before spotting it on the chromatogram. Spot the ink samples on the chromatogram and allow it to dry before respoting. After sported ink is dried, place the chromatogram in the developing chamber which has been previously equilibrated for 15 minutes with 100 ml of solvent system. Later the plates are placed in the solvent chamber for the solute and solvent to run (Saferstein. R, 2011).

The solvent is observed as it moved from the place of origin and stopped at a point and it was marked as Solvent Front which was found to be at a distance of 10cms. The plates were removed as soon as the solvent reached the solvent front. The
colour obtained due to dyes present in inks was noted and their distance from origin was measured and later the $R_f$ values of each spot was calculated by the following formula.

$$R_f = \frac{\text{Distance traveled by the solute from the point of origin}}{\text{Distance traveled by the solvent system from the point of origin}}$$

Examination and differentiation of inks is a major task for a forensic expert. Various inks are used to commit forgeries such as additions, alterations, anonymous letters, forged cheques, birth certificates etc. Such forgeries can be detected with the help of Thin Layer Chromatography by comparing the $R_f$ values of ink on the questioned document with the standard ink sample. If the $R_f$ values matches then it can be concluded that the ink on the Questioned Document and standard sample of ink are one and the same.

**HIGH PERFORMANCE THIN LAYER CHROMATOGRAPHY**

![Fig. 27 Equipments of High Performance Thin Layer Chromatography](image)

The High Performance Thin Layer Chromatography regularly known as HPTLC is a refined form of thin layer chromatography. It includes the same hypothetical theory of thin layer chromatography wherein substances are isolated on
the premise on their differential migration in an system of two phases on extraordinary kind of plates. By and large, plates of 20*20 cm or 5*7.5 cm size having 100-250mm adsorbent thickness are utilized. Silica gel having a pore size 6mm with fluorescent pointer is a coat material. The essential distinction amongst TLC and HPTLC plates is the molecule size of coated materials. An enhanced TLC strategy, i.e. High Performance Thin Layer Chromatography (HPTLC), was introduced in the mid 2010s. Senior et al, Neumann and Margot, Neumann et al exhibited the likelihood of recovering quantitative information from HPTLC chromatograms. Hence, factual procedures can be connected on information interpretation and this significantly enhances the precision of distinguishing and separation of pen inks taking into account HPTLC Technique (Loong Chuen Lee et. al, 2014)

From the minute that a writing ink is connected to paper material, the chemical composition of ink starts to experience changes. Different physical and chemical forms happen, for example, the evaporation of solvent; spreading of ink, paper erosion and so forth. Current inks are the blends of different components to give diverse physical and chemical properties to ink, for example, colorants (colors or shades), Solvent, surfactants, humectants, biocides, fungicides, buffering operators and pitches. Current strategies for the examination, distinguishing proof and correlation of inks on paper incorporate a wide assortment of procedures, extending from optical examination, microscopic and spectroscopic investigations of the ink. A few methods require destruction of the sample by mechanical or chemical expulsion of ink from paper. Different types of chromatography, for example: column, paper, thin layer, gas and liquid chromatography have proved to be most significant in analyzing ink segments.
Crimes related to forgery are increasing with the increase in the paper work in out society. Any deletion, addition or alteration in the document dependably includes the utilization of writing instrument, such as, ballpoint pens. Thus, there is an obvious need to build up a quick and precise ink examination convention to take care of this issue. The segregation force of high performance thin layer chromatography (HPTLC) method can be utilized for investigating ballpoint pen inks. Ink samples on paper are extricated utilizing methanol and are isolated by means of a solvent mixture of ethyl acetate, methanol and distilled water (70: 35: 30, v/v/v) (Loong Chuen Lee et. al, 2014).

HIGH PERFORMANCE LIQUID CHROMATATOGRAFY

Fig.28 Equipments of High Performance Liquid Chromatography

Liquid Chromatography, like TLC, uses a solid stationary phase and a liquid mobile phase. The principle differences are that liquid Chromatography uses a column to contain the stationary packing, a pump to transport the solvent, and a detector to produce a spectrum of the separated samples. The form of Liquid Chromatography used today for analysis is “High Performance Liquid Chromatography (which has also been termed “High Pressure”), with the same acronym. Like HPTLC, High
Performance Liquid Chromatography uses smaller particles in the stationary phase which produces greater column efficiency. In its column packing, High Performance Liquid Chromatography uses many of the same sorbents used on thin layer chromatography plates. Solvent choices for Liquid Chromatography can often be made quickly and easily by first testing samples with High Performance, Thin Later Chromatography. HPLC is particularly useful for separating thermally fragile, non volatile substances, including high molecular weight molecules. For ink analysis, HPLC generally offers great sensitivity HPLC equipments includes

- A reservoir into which the mobile phase (liquid) is placed.
- A pump, which forces the liquid phase through the system.
- And injector, were sample analytes are introduced.
- A separation column where the chromatographic partitioning and separation of components of the sample take place.
- A detector for analyzing the separated components as they emerge from the column in the effluent (and/or a fraction collector for capturing the separated components)

Common detectors are mass spectrometers, and fluorescence or absorbance spectrometers. For ink analysis, the later are most useful when multi wavelength detectors are used (Richard. L. Brunelle, 2003).

A number of azo, anthraquinone and sulphonated dyes have been analyzed by HPLC. Liquid partition, absorption, adsorption and ion-exchange techniques were used with a variety of supports and eluents and UV detection at 254 nm. Ball-point pens inks have been compared by HPLC on silica with UV and Visible detection. Samples were punched put of pen strokes on paper with hallow needle, extracted and analyzed. Dyes in ink are detected by their absorption in the visible region of the
spectrum while UV detection located other components such as resins, viscosity adjusters, givcol, lipids and preservatives. The technique was also used on inks from tip pens. (Saferstein. R, 2011)

FOURIER TRANSFORM INFRARED MICROSCOPY

Fig. 29 Equipment of Fourier Transform Infrared Microscope

While visible spectroscopy measures colour of an sample, Infrared Spectroscopy audits particular characteristics of a specimen's molecular structure, FTIR can give an absorbance "unique finger print" of a sample. IR spectroscopy is based upon the capacity of specific substance’s absorption of IR radiations by associations of an IR beam with a molecular obligation of the anlyte. Absorption happens when the molecular bond has a vibrational recurrence equivalent to (synchronous with) the IR beam. Fourier Transform Infrared Spectroscopy has today practically supplanted the more seasoned dispersive IR methods. FTIR utilizes a beam splitter to make two source beams. A moving mirror changes the way distinction between the two beams and delivers a pattern. The PC then uses the numerical
procedure of Fourier Transform convert the time domain into frequency domain. FTIR can also be coupled with Attenuated Total Reflectance (ATR) and Diffuse Reflectance (DRIFTS) (Richard. L. Brunelle, 2003).

FT-IR is highly utilized in affirming the genuineness of archives in business exchange. Questioned document examiners utilize a wide exhibit of logical methods to help with their examinations running from first-line visual investigation devices to cutting edge analytical instrumentation.

The Fourier Transform infrared (FT-IR) microscope, a backbone of the forensic laboratory, is outstandingly appropriate for investigation of the inks, toners, and papers of false archives since it consolidates standard visible light microscopy with non-destructive molecular spectroscopy examination.

Ink investigation is one of the essential angles in forensic document examinations to decide the credibility or legitimacy of a document therefore it is very much necessary to have exact and judicous ink examination procedure. Because of the widespread use of Ballpoint pens they may be easily associated with the crimes such as alteration, obliteration, additions etc in the documents. Ballpoint pen is comprised of plastic packaging which houses the ink repository and a ball which is consistently covered with the ink. In the demonstration of writing the ball turns and in the long run exchanges the ink onto the paper. Any examination and investigation performed on an questioned document must mull over the restricted measure of ink accessible on the document. Thus, and for reasons of safeguarding the integrity of the questioned document, non-destructive tecniues must always be considered first over the destructive ones (Ellen. D, 2006, Brunell. R.l, 2003). And therefore FTIR is the commonly employed technology in the forensic examination of inks (Mustafa Kamil et. al. 2015)
Advantages of FT-IR

• FTIR is a non-destructive method
• It gives an exact estimation technique which requires no outside adjustment
• It can build speed, gathering an output each second
• It has more prominent optical throughput
• It is mechanically straightforward with one and only moving part

(www.revbase.com)

RAMAN SPECTROSCOPY

Spectroscopy is the investigation of communication of electromagnetic radiation with matter. Spectroscopic strategies can be based on phenomenon of emission, absorption, fluorescence and scattering. Diverse spectroscopic techniques are widely utilized for the portrayal of an extensive variety of samples of scientific interest. Raman spectroscopy was named in the honor of its innovator, C.V. Raman, who, alongside K.S. Krishnan, published the primary paper on this technique. Raman spectroscopy (RS) is an adaptable technique for examination of an extensive variety of forensic samples. (Bumbrah GS et. al, 2015).

We can utilize Raman spectroscopy to get chemical and structural data that helps us see more about the materials we investigate. This data can be gathered from a variety of points on or in a specimen, and can be visually represented in the form of pictures (1D, 2D or 3D) delineating any of the parameters which can be uncovered utilizing Raman (http://www.renishaw.com).

The techniques for executing imitation and modification of documents are turning out to be progressively more advanced. Forensic examinations of questioned documents routinely include physical and chemical investigation of inks. Raman
spectroscopy is an extremely appealing method for ink examination since it consolidates substance selectivity effortlessly, quick investigation can be done and it doesn't require sample preparation nor destroys the document. Nonetheless, a few restrictions of this system incorporate low sensitivity and the mind-boggling phenomenon of fluorescence, which can be reduced by resonance Raman spectroscopy (Andre' Braz et. al. 2013). Raman Spectroscopy comprises of illuminating samples with a monochromatic laser beam which collaborates with the atoms initiating a scattered light. The light that is scattered with an alternate recurrence than the incident photons (inelastic scattering) is enrolled to build a Raman spectrum that is trademark to the molecular structure, permitting its recognition. As it is known that inks are blends of obscure components, molecular characterization of all particular ink segments utilizing RS can be a hard assignment sometimes. Examination includes looking at the example of the spectra, and contrasts in band positions (nearness or nonappearance at particular shift values), band intensities (expansive or sharp) and relative intensities of contiguous groups. (E. Smith et. al, 2005)

In document examination, examiner is keen on analyzing inks and dyes in that. Raman spectroscopy can act as a wonderful phenomenon in the examination of document without destroying it. (Thomas Andermann, 2001)

**Advantages**

- Non-contacting and non-destructive, Sample can be investigated many a times without any damage.

- If you can utilize an optical microscope to focus onto the region to be examined, you can utilize a Raman microscope to gather its Raman spectra on the grounds that no sample preparation is required.
• Much Raman examination utilizes visible and near-visible light. It is, therefore, easy to gather the substance rich data notwithstanding whether the specimen is fixed inside a transparent container (e.g. vial or capillary tube), or inside a cell with a survey window. (http://www.renishaw.fr/).

![Fig. 30 White light and Raman image of crossing inks. The Raman image shows that two different inks were used to form the figure 4 and reveals their deposition order.](image)

**DIGITAL HYPERSPECTRUM EQUIPMENT AND SOFTWARE FOR FORENSIC DOCUMENT EXAMINERS**

Hyper-spectrum image is 4D information assortment that comprise of optical spectra for each point of image. In fact the Hyperspectrum can be measured either by filtering every point of an article with spectrometer or by recording arrangement of the pictures taken at narrow spectral band. In forensic document examination the hyper-spectrum is reflection (or/and radiance) spectral information set measured at every point of a questioned archive. The hyperspectrum prepared with advanced software uncovers substantially more data about the image when contrasted with Video Spectral Comparator (VSC) method or single point spectrum estimation. For instance, if one is to think about comparing (unbiased distinguish) distinctive inks in
one document, then processing is done in such a way, to uncover extraordinary spectral signatures in each and every part of the document. Every ink has novel spectral signature. This signature is so distinctive that it does not appear similar for same ink however for old drawn and new drawn lines, since inks spectral elements are subject of moderate transient changes. Hyperspectral information processor can reveal those signatures and bring the outcome into simple justifiable type of the 2D/3D image. Hyperspectral imaging was observed to be the most capable apparatus to see obliterated works, for instance, graphite, printer, ink and blended destructions. In obliteration it can be recognized which line was drawn the first or, to be specific, is it conceivable to settle traditional forensic "line sequence" issue with hyper-spectrum approach. ForensicXP is the main full computerized scientific imaging spectrograph available. It's principle is similar to that of conventional video spectral comparator, the instrument depends on most recent 4D hyper-spectrum digital technology and executes hand off completely modernized operation for questioned document handling. Best of all is that you can complete your examination work speedier, more precise and at division of the cost of the contender frameworks. Autonomous fruitfully utilization of hyperspectral imaging to see obliterated compositions was accounted by Oak Ridge Institute for Science and Education-FBI Laboratory Research Division (Hina Ayub et. al. 2006).
ADVANTAGES:

• Nondestructive examination of QuestionedDocument in nearness of apparently equivalent yet physically diverse components

• High-resolution hyperspectrum imaging at IR-VIS-UV spectral range. Compelling 16 bit imaging. Full range measured at every archive point.

• Spectral imaging of absorption, reflectance, transmittance and fluorescence of Questioned Document can be done utilizing hyper-spectral method

• Powerful up to x40 Zoom optics for both microscopic and macroscopic objects.

• Unlimited size record in "Auto Stitch" method of operation

• Advanced on-line computerized 4D hyper-spectral picture preparing for direct examination of documents for their innovation and line sequence indications

• 3D perception programming for cutting edge investigation of measured components in questioned document. A profitable device intended for pen
pressure investigation and line sequence determination (www.Hyperspectrum in Forensic Document Examination Spectral unwrap to 3D and 3D reptrs.com).

Fig. 32 Decipherment of the Digits in the Document

Fig. 33 Forensic 3D digital image that resulted from questioned document measured with ForensicXP and processed with 4D hyper-spectrum processor.
Docubox Dragon have extensive variety of utility in field of biology, chemistry, fingerprints, handwriting and signature, and printed archives, confirmation of legitimacy of passports, discovery of fake cash, secret writings, and so on. It is a smaller box which is associated with a modernized computer framework. It comprises of 14 distinctive light sources with 20X zoom and a CCD IR delicate shading camera. It chips away at PIA-5, 6 programming. There are 2 sorts of filters likewise exciting filter and barrier filter. It utilizes different light hotspot for different purposes, The record to be examined in Docubox dragon, is kept in chamber then relying on the necessity of the Forensic Document Expert (FDE) different lights are utilized. The picture of the record can be observed on the computer screen (Mann et al, 2013)

Light Sources (variable force of the light):

- UV- Illumination ranging from 254 nm- 365 nm which is widely used in the examination of security marks, obliterations, inks, security threads.
- IR Lumiecence: with condenser, for recognizing contrasts in inks or pencil leads, distinguishing between the intial and secondary entries in the documents, mechanical and concoction deletions
- Infrared: for recognizing contrasts in inks or pencil leads, perfect for examination of printing inks
- Side light /IR selectable: for recognizable proof of mechanical deletions, inkless stamps, mechanical altering of photos, Intaglio printing, OVI/OVD, and so on.
- Transmitted light 2 x 50W: for distinguishing proof of mechanical eradication, transmitted light securities, watermarks, security strings

**PYROLYSIS GAS CHROMATOGRAPHY- MASS SPECTROMETRY**

Capillary Gas Chromatography coupled to a Mass Spectrometer [Gohlke, 1959] offers the upside of portraying small samples of complex blends through partition along the GC column and sequential examination in the MS. The premise of the GC partition is the dissemination of the specimen between two phases contained inside the column. One of these stages is a stationary fluid, perhaps covered on a bed of particles with huge surface area. The other is a gas that permeates through the column and conveys sample particles. The specimen must be unpredictably volatile and thermally steady. In view of their distinctive adsorption, dispersion and warm properties, the components of the specimen are parceled between the transporter gas and the nonvolatile stage and elute differently on a specific column.

The favored ionization strategy for GC/MS is Electron Impact (EI), where an electron beam delivered by a filament is quickened and impacts perpendicularly with
the specimen, subsequently inciting ionization through collaboration with the molecules. The disintegrated pattern of a given particle is extraordinary and reproducible, permitting its ID through library seek. Most GCs are combined with a quadrupole mass analyzer comprising of four electrically leading, parallel poles (Céline Weyermann, 2005).

Pyrolysis Gas Chromatography-Mass Spectrometry (GC-MS) identification of polymer constituents in a aqueous ink scattering is probably followed. The portrayal of ink on paper is of significance for dating and looking at questioned ink sections in forensic archive examination. The determination of the age of a pen stroke on paper is a fundamental subject in questioned document examination. Ink dating might be performed on a relative or outright scale. Relative in that an ink is contrasted with the reference passages in the same document, and outright is that no such references exist for examination (J'urgen H. B'ugler et. al, 2005).

Pyrolysis gas chromatography (GC), and pyrolysis gas chromatography/mass spectrometry (GC/MS) have been utilized widely as a part of forensic science labs for the in distinguishing complicated samples. Most of the times this technique is used in analysis of paints in the hit n run cases by vehicles. Experts have utilized pyrolysis GC to inspect cellulose items, for instance, wood, bark, paper etc, and a large number of them have utilized the strategy to take a gander at colors, coatings, and inks. Investigation of an assortment of photocopies from various makers of photocopying instruments can be resolved. Segments of the printed paper are pyrolyzed, and the pyrolysates are examined by GC/MS. Particular contrasts are noted to be reliant on the kind of toner material utilized as a part of the photocopying procedure of every make of copier. Peaks are selected and distinguished by their mass spectra to demonstrate the substance contrasts in toner material (E. J. Demand et. al, 1986).
Pyrograms and mass spectral information are exhibited for the toner material, toner on paper, and clear paper for subtraction from the pyrograms of toner material on paper.

GC is an effective scientific strategy fit for isolating complex blend of unstable natural substance. Notwithstanding it is not specifically pertinent to the examination of such non-unpredictable substances as gums in inks or sizing materials in paper (Maciej. J. Bogusz, 2011).

**INDUCTIVE COUPLE PLASM- MASS SPECTROMETRY**

ICP-MS is a kind of mass spectrometry that is an exceedingly delicate and precise strategy, ready to quickly gauge trace elements at low fixations (beneath one section for every billion). So as to utilize this strategy, the samples should be in a gaseous state or in solution. Solids can be examined after a pre-treatment step, such as, microwave assimilation. ICP-MS is a moderately complex expository procedure that contrasts marginally starting with one machine then onto the next, however it is applicable to clarify quickly what for the most part happens to the samples that are examined. In the first place, the solution under investigation is brought into an ionized area that changes over the specimen into a vaporized made out of fine droplets with a size substandard compared to 10 μm. The recently framed droplets are blended with a transporter gas of argon and after that directed towards the plasma that is made out of positive particles and electrons. At the point when the droplets go into the plasma, the specimen vaporized is desolvated and the high temperature of the argon plasma (7000–8000K) results in ionized particle of the drops. At that point, an atomization procedure happens that produces single particles that will be ionized by the high vitality of the plasma. In this last stride, electrons are catapulted from the analyte atoms and, subsequently, positive particles are made. The positive particles are then dissected in the mass spectrometry framework. The cat ions travel through a mass...
analyzer and afterward land at a ion detector. With this procedure, the particles are isolated by mass-to-charge (m/z) proportions and are at last counted (Moteaa Mohamed Anwar El-Deftar, 2014).

The investigation of questioned documents in a forensic Laboratory customarily concentrates on the visual examination of the physical properties of the paper, for example, brightness and thickness. Changes in the paper making process have made visual separation of various sorts of paper troublesome which has expanded the examination elemental investigation of paper. Inductively coupled plasma-mass spectrometry (ICP-MS) has been utilized to create elemental profiles for paper specimens; this method is costly and not broadly accessible for legal research facilities. ICP-MS has been shown to be an intense procedure for the era of component profiles for paper tests. Of the procedures before utilized for component investigation of paper, ICP-MS has the least location limits for most components, which is useful because of the trace element fixations in paper tests (Emily Riddell, 2013).

NEUTRON ACTIVATION ANALYSIS:

The main utilization of NAA to analyze papers utilizing their elemental composition was accounted for by Brunelle et al. (1971). In this study, 600 paper tests from 10 distinct makers were examined for 23 components, and it was found that specific components, for example, Na, Mn, Ag and Cu have a high occurrence over paper samples while Ta, As and Sb were less found. These outcomes demonstrated that paper is generally homogeneous with respect to its trace element dissemination. The exerts exhibited that paper samples from various producers could be recognized by subjective and quantitative tests. Schlesinger and Settle (1971) additionally utilized NAA to decide the elemental composition of 120 paper samples from nine diverse
makes. The eight components that were most of the times recognized were Al, Na, Mn, Ti, Sb, Sc, Cr and Cl. Notwithstanding, a substantial intra-test variety was found for the elemental concentrations (> 20% for 5 components), in this way, constraining their value for segregation purposes. Moreover, Blanchard and Harisson in 1978 utilized NAA to decide the natural structure of five paper tests that were home made and prepared with clay fillers of known composition. Despite the fact that the specimens were effectively segregated by mud fingerprints, the outcomes just connected to papers with critical clay substance (Blanchard and Harisson, 1978). Despite the great affectability of the NAA procedure for elemental composition, with recognition limits in the parts-per-billion territory (ppb), the lack of absence of openness to an nuclear reactor makes this system unyielding for use by most scientific labs (McGaw et al., 2009) (Moteaa Mohamed Anwar El-Deftar, 2014).

CEDAR-FOX

This is software developed by CEDAR, the Center of Excellence for Document Analysis and Recognition at the University at Buffalo for the recognition and comparison of handwriting. CEDAR-FOX has capacities for collaboration with the document expert to experience handling steps, for example, extricating areas of inters from the scanned document, deciding lines and expressions of content, perceive printed components. The last objective is to compare two specimens of composing with decide the log-probability proportion under the indictment and barrier theories. It can likewise be utilized to compare the signatures. The software, which is secured by a United States Patent can be authorized from Cedar tech, Inc. writer identification is the assignment to figure out if two transcribed samples are composed by the same author or not. By utilizing a set of measurements, Cedar Fox can relate a measure of certainty whether two documents are composed by the same individual or by various
people. Cedar Fox permits you to choose either the whole report or a specific region of an archive for comparison. The examination depends on large scale highlights (which gauge worldwide qualities, such as incline, connectivity, and so forth.), miniaturized scale highlights (which depend on individual character shapes), and style highlights (e.g., states of character sets, or bigrams). Two unique methods of author confirmation are accessible: (i) comparison of questioned document with a single known document and (ii) comparison of questioned document against "different known" documents. Here the software gains from the known records about the writer’s propensities. No less than four known documents must be accessible to utilize this mode. The errand of recognizing the client is part into two sections, (Web Source)

1. Document processing and Feature extraction
   - Image Processing
   - System Utilities

2. Document Comparison
   - Searching
   - Handwriting Recognition
   - Legibility and Readability Analysis