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Study of Different Types of Printed Documents and Photocopied Documents and to Estimate the Type of Printers and Photocopiers Used

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ABSTRACT

Printed document examination is a subset of Forensic Science that deals with Questioned documents. The main objective of document examination is to analyse, compare and evaluate characteristics of printers in order to determine the type of printers and photo copiers used to identify whether the document has been forged or not . The individual characteristics that were analysed in this study are Borders, Edges, Edge Roughness, Ink and the Letter flow, drum marks and patches on letters were observed among the different types of printers .The primary goal of this study is to estimate the type of the printers and photocopiers used based on their characteristics. Thus, the total number of samples is 40 in which 15 samples from 7 models of photocopiers, 15 samples from 7 models of laser printers, 10 samples from 9 models of inkjet printers. All the samples are collected from different shops and different models in the location of kirumampakkam, Pondicherry. With the help of stereo microscope, Magnifier the sample were analysed and interpreted the class characteristics between one models to another. The borders, edges, patches, ink flow, and drum marks were shown differences in one to other samples. At the end of the study we can estimate the types of printers and photocopiers used to make the document.

Keywords: Printers, Photocopiers, Stereo Microscope, Printed document,

1. INTRODUCTION:

In Contemporary offices, Computers have replaced typewriters. These days, documents are typewritten on a computer so that errors can be fixed, and then they printed. Possibly on one of the multiple printers attached to the system using word processing software. The daisy wheel and dot matrix technologies were utilized by printers that were invented to imitate typewriters.

1.1 Questioned documents.

Questioned document is a branch of forensic science that deals with the interpretation of data i.e. typewritten; written, photocopied or printed document about its origin and authenticity of the obtained or collected data is called as Questioned document. In this study we are analysing the characteristics of collected printed and photocopied documents which is one of the 7 classes in questioned document.

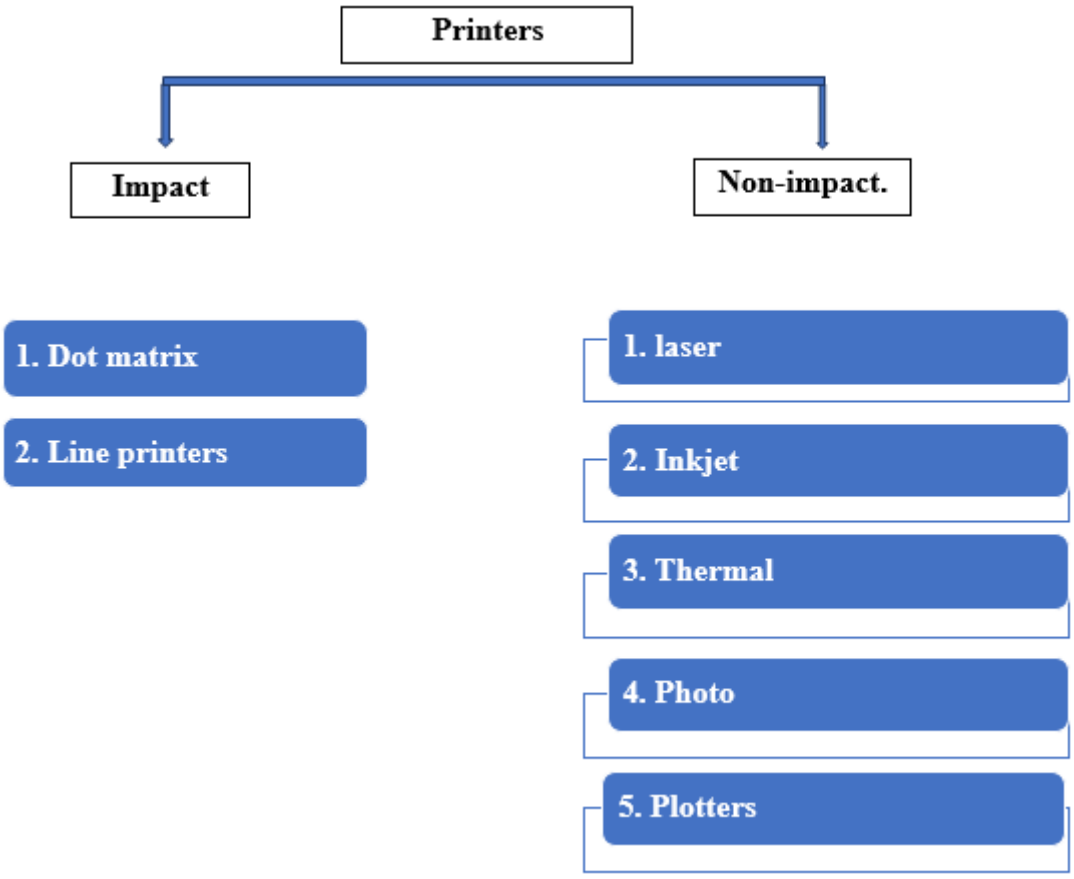
1.) Documents with questioned signature
2.) Documents with alleged fraudulent alterations.
3.) Holograph documents questioned or disputed
4.) Documents attacked on the question of their age or date.

5.) Documents attacked on the question of materials used in their productions
6.) Documents investigated on the question of type writing:
a.) With a view to ascertaining their source.
b.) With a view to determining the date.
7.) Documents or writing investigated because they identify some person through handwriting.
a.) Anonymous and disputed letters.
b.) Superscriptions, registrations and miscellaneous writing.

1.2. Background of printers and printing technologies:

Charles Babbage created the first computer printer as a mechanically propelled device for his invention in the 19th century. The EP-101was created by the Japanese company, was the first electronic printer from Epson it was released in 1968. The mechanics from electric typewriters and the first commercial printers were typically Teletype equipment. The increased development of the faster speed was prompted by the demand for the modern computing systems. There were comparable daisy wheel systems in the 1980s. Line printers, which produced similar output to typewriters but more quickly, were followed by dot matrix printers, which combined text and visuals but produced a poor quality output.

1.3. Classification of printers.



1.3.1. Impact printers:

An Impact Printer refers to those printers where the printing heads touch the paper. This mechanism uses hammers or pins to strike against a ribbon and paper to print the text or image. A Character printer prints a single character at a time. They are low speed printers.

1.3.1.1. Dot matrix printers:

Dot matrix printers rely on fully formed characters; each character of the printer is capable of printing which represents by the letterforms. Dot matrix printers use a predetermined number of pins or wires to create prints on paper. In this, one or more vertical columns of pins or wires are used to form letters. Each pin leaves a little dot on the paper when it strikes an ink-coated ribbon and forces the ribbon's contact with the paper. These dots come together to create a letter which is known as dot matrix image

1.3.1.2. Line printers:

Before moving on to the next line of text, a line printer prints the full previous line. Line printers are still in use today. In the 1950s, the print speed of line printers is up to 600 lines per minute (lpm) & (about 10 pages per minute) were attained. Later, speeds reached as high as 1200 lpm. With speeds ranging from 150 to 2500 lines per minute.

In the present study we are going to analyse the samples of laser and inkjet printers.

1.3.2. Non-impact printers:

Compared to the impact printers, non-impact printers are more reserved, which is their primary advantage. Any kind of vibration or physical interference is less likely to have an impact on the printouts that are produced.

1.3.2.1. Laser printers:

A kind of electronic digital printing that uses a laser to scan a negatively charged drum to create text and graphics of the highest quality. This is a cutting-edge printing technique that results in high-quality output.

Working principle of laser printer:

- The computer sends millions of bytes of data to the printer. The printer's electrical circuit determines how to print the data correctly onto the paper.
- A high-voltage cable that provides something close by an electric charge is static.
- The photoreceptor is charged by the corona wire. Where a positive charge is added and extends evenly over the whole surface of the percussion instrument.
- In this period, the circuit becomes charged, in reality the image on the paper with the help of the laser beam doesn't move but it rebounds off the moving mirror, and it applies a scan to the drum that erases the positive charge that is over the drum when it hits it.
- Rather, it produces a negative charge region at this point; the blank area on the page progressively fills in with an image of the complete page.
- Section of the paper has a positive charge, and the black area has a negative charge.
- There are charges on it. Powdered ink (toner) is applied to the photoreceptor drum by an ink roller.
- A positive charge is applied to this toner, and it adheres to the negative charge. Present on the drum's component sections. The positive component of the ink does not attract any ink particles.

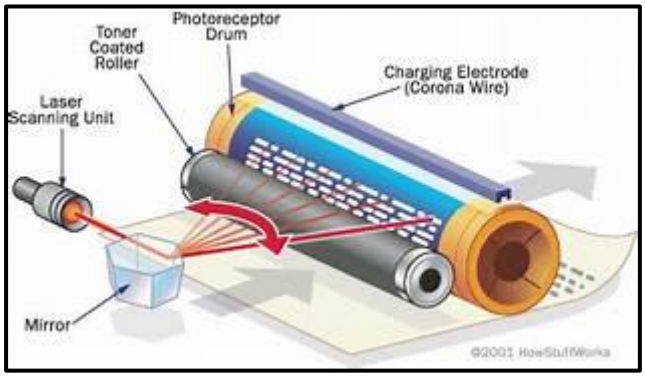


Figure 1: Laser printer

Disadvantage of laser printers:

The fact that a laser printer can only print on a particular kind of paper or print media is another drawback of laser printer. If you intend to get a laser printer for your photos. Their rapid speed prevents them from printing or transferring heat. Because laser printers print too quickly, so they need bright and soft paper.

1.3.2.2. Ink jet printers:

This type of printer uses ink droplets to replicate a computer image on paper surfaces. These are the most widely utilized printer types. The idea behind this printing technique was first widely established in the early 1950s, but it dates back to the 20th century. It ranges from small inexpensive consumer models to expensive professional machines.

Working principle of inkjet printers:

- Commercial printing is done using this technique to create and code items in packaging works. In this A high pressure pump is a technological device that guides liquid ink from a gun body through a reservoir and tiny nozzle, which results in producing a stream of droplets of ink. An electrical sound wave is produced by a crystal, which vibrates inside the gun body, resulting in the liquid stream to fragment into droplets on a regular basis.

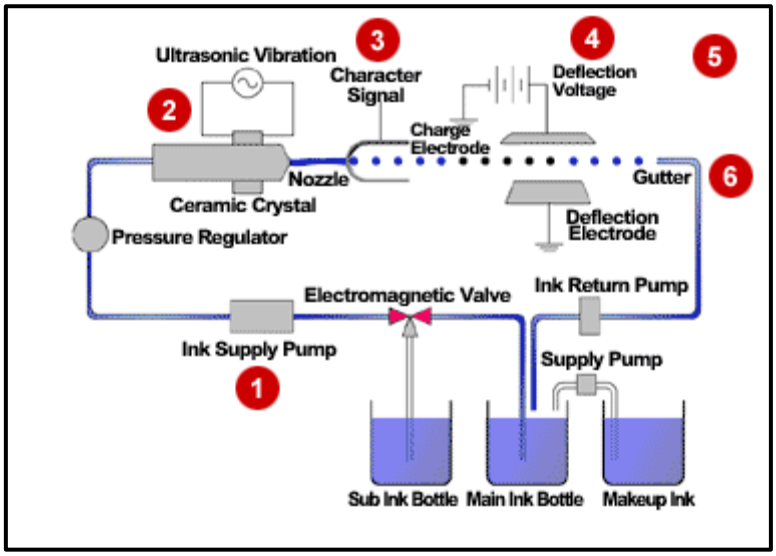


Figure 2: Inkjet Printer

Disadvantages of Inkjet printers:

- Print head is less durable and easily cause damage.
- The ink cartridges used are very expensive to replace.
- Less printing speed when compared to laser printers
- The ink used in inkjet printers is very resistant to water so it easily causes damage.

1.3.2.3. Thermal printers:

The thermal printer work as similar to the fax machines which places the print head on a heating element (semiconductor) and heat the print head, and then comes to contact to the thermal paper to print the desired image. Heating causes a chemical reaction in the film that forms the image

1.4. Photo copiers (Xeroxed documents):

It indicates that a Xerox machine was used to duplicate or reproduce the original one. The word Xerox is an American English (copy) is a British English. Powdered ink is electrically transferred to paper and results in producing an image that closely mimics the original document**.**

Working principle of photocopier:

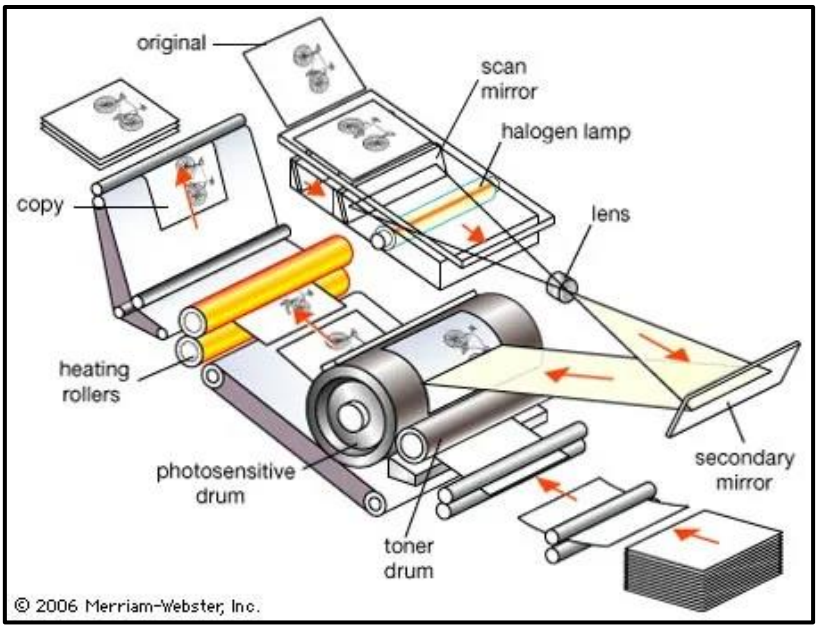


Figure 3: Photocopier

2. AIM AND OBJECTIVES:

2.1 AIM

To study different types of printed and photocopied documents is done to estimate the different types of printers and photocopiers used and the individual characteristics of the printers and photocopiers have been studied. These findings can aid in identifying issues in civil and criminal proceedings, leading to more accurate and objective conclusions.

2.2 OBJECTIVES

1. Identifying the letter characteristics of printed documents using hand magnifier and Stereomicroscope.
2. Identifying letter characteristics of photocopied documents by hand magnifier and Stereomicroscope.

3. REVIEW OF LITERATURE:

1. **A comparative study of different printed documents to estimate the type of printer used-** by Noronha SJ, Basheer SZ, Vijay MN, Alnajjar A, Sharma BK, and Singh. (SJ, 2017).

- The increased usage of printers in document creation as opposed to handwritten documents and the counterfeiting of documents printed by various printers have made printer examination in questioned documents necessary in the modern day.
- The purpose of this study is to determine the specific way that each printer prints papers by looking at the printed documents. The results obtained indicate a clear diversity in the document properties with regard to character formation and types of ink.
- This demonstrates that the suggested type is a helpful tool for differentiating printed papers produced by various printer types. Three types of printers were investigated for the analysis i.e. Dot matrix, Laser, and Inkjet.
- As a result, the research mentioned above can be used in the area of Forensic Questioned document analysis, which includes examining the variation of documents.

2. **Detecting documents forged by printing and copying by**- Shize Shan, Nasir Memon, xiangwei Kong, Dalian University of Technology, Ganjingzi District, Dalian, China, Polytechnic School of Engineering, New York University, New York City, USA. (Shang, 2014)

- This paper outlines a technique for differentiating papers generated by three frequently used document generation devices: electrostatic copiers, laser printers, and inkjet printers,
- Based on characteristics taken from the characters in the papers, the suggested method can differentiate between documents created by these sources. That's why it can also be applied to identify papers that have been altered using a combination of these sources.
- We identify the signatures produced by the various physical and technical processes involved in each form of printing by analyzing the features of electrostatic copiers and laser inkjet printers. We estimated the features of noise energy, contour roughness, and average gradient based on the study of these signatures.
- As far as we are aware, this is the first effort to differentiate between documents created by laser and inkjet printers.

3. Forensic analysis and anonymization of printed documents by – Timo Richter, Stephan Escher, Dagmer Schonfeld, Thorsten Strufe, TU Dresden, Dresden, Germany. (Timo Richter, 2018).

- The analysis of document colour tracking dots, an extrinsic signature seen in almost all colour laser printers, is presented in this research.
- From a printer forensic perspective, it was suggested to reuse it forensically in conjunction with the current passive printer forensic methods. The attributes and information content are mostly unknown; hence reusability analysis techniques were investigated.
- The supplied Dot Extraction, Decoding, and Anonymization Toolkit might be used to retrieve the known information and generate an anonymization pattern.

4. Identification of printing process using HSV colour space by – Haritha Dasari, Chakaravarthy Bhagvati, Dept. Of Computer and Information Sciences, University Of Hyderabad, Hyderabad, India. (Haritha Dasari, 2006)

- This paper explains how to determine the printing process that creates a document by using image processing techniques.

- Colour image processing is used to examine the features of the various non-impact printing techniques employed by photocopiers, inkjet, and laser printers.
- Preliminary research suggests that they have the potential to replicate the outcomes typically acquired by document examiners using chemical analysis or a microscope.

5. Forensic discrimination of the photocopy and printer toners 1.the development of an infrared spectral library- by Rena A Merrill, Edward G Bartick, J Hollis Taylor III. Analytical and Bio analytical chemistry 376 (8), 1272-1278, 2003

- Microscopical reflection –absorption by infrared spectroscopy (R-A-IR) was used as a viable technique of analysing polymer resins contained in dry, black, photocopy and printed toners.
- Ninety eight groups were established based on spectral characteristics of toners.

6. Particle emission characteristics of office printers-by Congrong He, Lidia Morawska, Len Taplin.

- Particle emission characteristics were studied using TSI SMPS. The monitoring of particle emission from large open plan office showed that particle generated by (p=0.01) affect the sub micrometer particle number done. Out of 62 printers in office, four classes were divided.

1. Non- emitters
2. Low emitters
3. Medium emitters
4. High emitters

7. Analysis of laser printer and photocopier toners by spectral properties and chemo metrics -by Neha Varma, Raj Kumar, Vishal sharma. Spectrochimica Acta part A: Molecular and Bio molecular Spectroscopy 196,40-48, 2018

- Qualitative and Quantitative analysis for laser and Xeroxed toner printers using UV-Vis spectroscopy in 100 black toner samples and caused 99.59 % of pair wise discrimination and 99.84% pair wise discrimination.

4. MATERIALS AND METHODOLOGY.

4.1. INSTRUMENTS USED:

- Stereomicroscope
- Optical magnifier of 5x and 7x magnification.

4.2. SAMPLE SIZE:

- 40 samples
- 15 samples of 7 models of laser printers
- 10 samples from 9 models of inkjet printers
- 15 samples from 7 models of photocopiers.

SAMPLE – 1: Laser Printer –Canon IR 3570.
SAMPLE – 2: Laser Printer –BrothersL5600DN
SAMPLE – 3: Laser Printer –Conica MINOLTA
SAMPLE – 4: Laser Printer –Conica L50
SAMPLE – 5: Laser Printer – Canon IR 2870
SAMPLE – 6: Laser Printer - Canon 6255
SAMPLE – 7: Laser Printer - Kyocera32121
SAMPLE – 8: Inkjet Printer – Canon G3000
SAMPLE – 9: Inkjet Printer – Canon G670

SAMPLE – 10: Inkjet Printer – Brother T820DW
SAMPLE – 11: Inkjet Printer – Canon G2020
SAMPLE – 12: Inkjet Printer – Epson L32210
SAMPLE – 13: Inkjet Printer – Epson L805
SAMPLE – 14: Inkjet Printer – Epson 205
SAMPLE – 15: Inkjet Printer – Canon 2020 GD
SAMPLE – 16: Inkjet Printer – Epson 3210
SAMPLE – 17: Xerox – Brother T820DW
SAMPLE – 18: Xerox – Canon IR 3045
SAMPLE – 19: Xerox – Canon 3245
SAMPLE – 20: Xerox – Conica 250
SAMPLE – 21: Xerox – Canon IR 3025
SAMPLE – 22: Xerox – Canon 6255
SAMPLE – 23: Xerox – Canon 3015

4.3. METHODS

4.3.2. STEREOMICROSCOPE.

An optical magnifier with a low amplification capacity is called a stereo model. Instead of using a single optical path, it makes use of two. The eyes have a relatively distinct review edge because of the two targets and two eyepieces. In essence, the left and right eyes perceive the same object in different ways. A three-dimensional image is produced by these two distinct points of view. It is ideal for examining the surfaces of robust materials because of this feature. It also lends itself easily to categorization and dissection. It makes use of light that the object ordinarily reflects.

Figure 4: Stereomicroscope

5. RESULTS AND CONCLUSION:

5.1. MICROSCOPIC OBSERVATION TABLE:

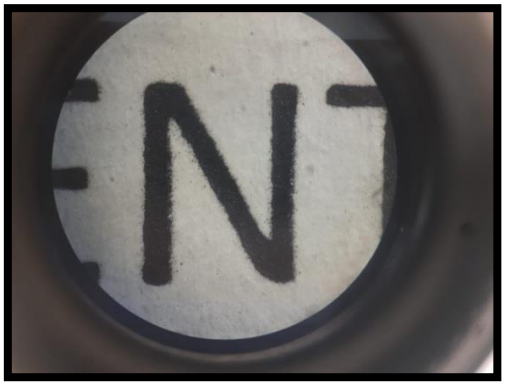
SI.No.	Type of printer	Model	Observed characters.	Marks
1.	Laser Printer	Canon IR 357O	White patches, Shivered borders, Blended finishing.	More satellite marks
2.	Laser printer	BrothersL5600DN	More white patches, White patches present only in top of letters and words, No sharp edges and the prints are missing.	-
3.	Laser printer	Conica MINOLTA 195	Shivered borders, Non white patches, Edges are little sharper.	-
4.	Laser printer	Conica L50	Proper borders, Non white patches, Several ink scatters.	Very less satellite marks observed
5.	Laser printer	Canon IR 2870	Several white patches, Uneven borders.	-
6.	Laser printer	Canon 6255	Letters are lean, No white patches, Even borders.	Less satellite marks
7.	Laser printer	Kyocera 32121	Uneven borders, Sharp edges on letters.	Several drum marks and Satellite marks
8.	Inkjet printer	Canon G3000	Blunt edges, Un uniform ink flow,	Roller marks well observed and no satellites formed.
9.	Inkjet printer	Canon G670	White patches, Even edges, Improper ink flow.	Roller marks are observed.
10.	Inkjet printer	Brother T820DW	No white patches, Edges are smudged due to ink overloaded.	-
11.	Inkjet printer	Canon G2020	Vertical lined patches, Even borders.	Few satellites
12.	Inkjet printer	Epson L3210	Less white patches, Shaggy borders, Improper starting and ending.	-
13.	Inkjet	Epson L805	White horizontal line due to	Several drum marks

	printer		**malfunctioning,** **Borders are very worse.**	
14.	Inkjet printer	**Epson 205**	**No white patches,** **Borders are scattered,**	-
15.	Inkjet printer	**Canon 2020 GD**	**More white patches,** **Uneven borders,** **Vertical roller marks.**	-
16.	Inkjet printer	**Epson3210**	**White patches,** **Black scattered line due to malfunctioning,** **Blunt edges an uneven borders.**	-
17.	Xerox	**Brother T820DW**	**Ink scattered on full document and poor ink quality,** **Many white linear lines on letters** **Smashed letters with white patches**	**Roller defect seen**
18.	Xerox	**Canon IR 3205**	**Uneven printing with full of white patches** **Edges are blunt.**	**Very few drum marks and satellite marks.**
19.	Xerox	**Canon 3245**	**Shattered letters,** **White lines across the line of letters.** **Blunt edges.**	-
20.	Xerox	**Conica 250**	**Light and dark letters printed** **Bottom tip of the letters are imprinted** **White patches**	-
21.	Xerox	**Canon IR3025**	**White patches in tip of every letters,** **Ink scattered around and on the letters,** **Smooth and incomplete borders.**	**Drum marks are more and less satellites.**
22.	Xerox	**Canon 6255**	**Less white patches,** **Blunt edges,** **Poor ink flow,** **Smooth borders.**	**Few drum marks and Satellites.**
23.	Xerox	**Canon 3015**	**White patches around letters,**	**Drum marks present in and around the letters.**

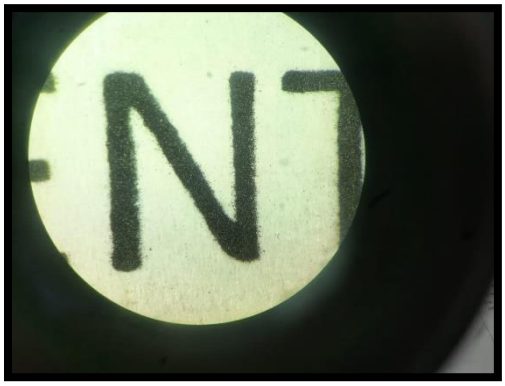
			Unclear borders, Poor ink flow, Blunt edges.	

1.2.MICROSCOPIC OBSERVATION (LASER PRINTER)

1.2.1. Sample 1.



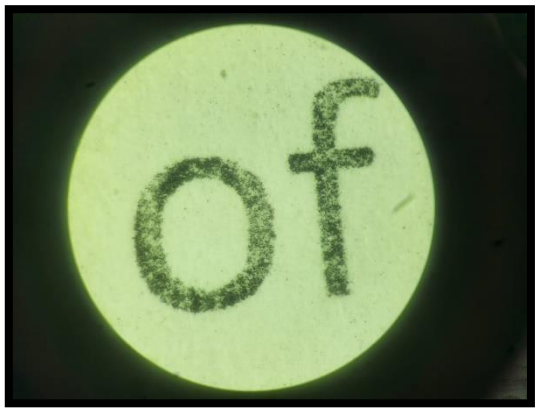
Canon IR 3570 without light.



Canon IR 3570 with light.

1.2.2. Sample 2.

Brother L5600 Dn without light.



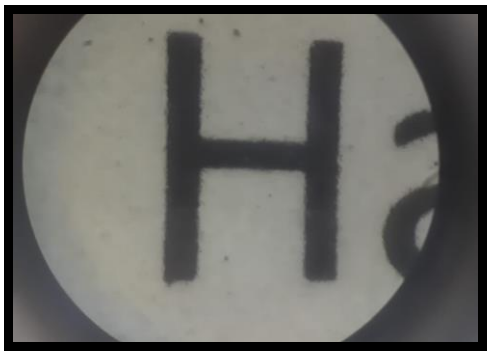
Brother L5600 Dn with light.

1.2.3. Sample 3.

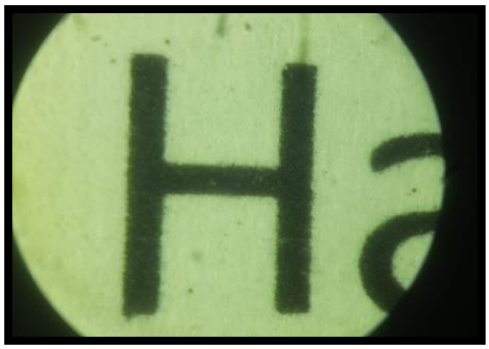
Conica Minolta without light

Conica Minolta 195 with light

1.2.4. Sample 4.



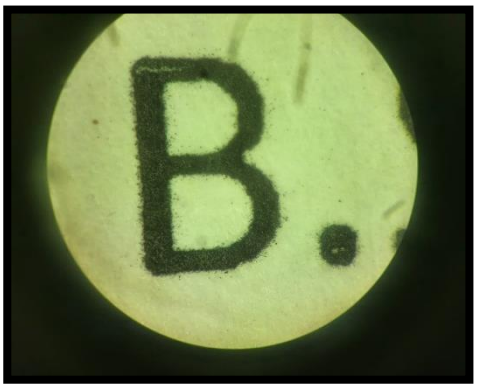
Conica l50 without light



Conica l50 with light

1.2.5. Sample 5.

Canon IR 2870 without light



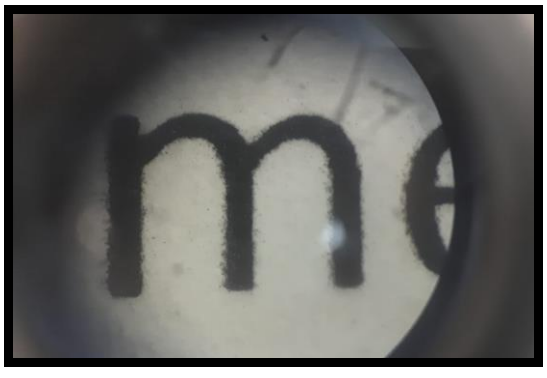
Canon IR 2870 with light

1.2.6. Sample 6.

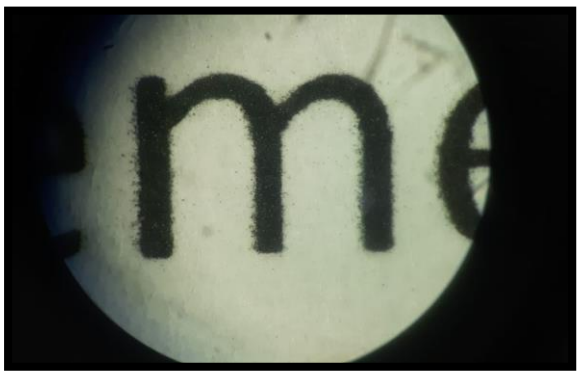
Canon 6255 without light

Canon 6255 with light

1.2.7. Sample 7.



Kyocera 32121 without light

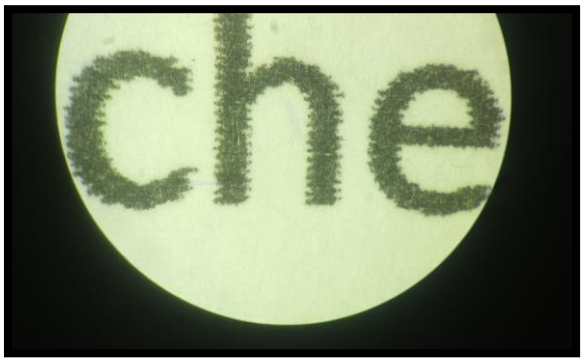


Kyocera 32121 with light

1.3.MICROSCOIC IMAGES (INKJET PRINTER)

1.3.1. Sample 8.

Epson 3210 without light



Epson 3210 with light

1.3.2. Sample 9.

Canon 2020 GD without light

Canon 2020 GD with light

1.3.3. Sample 10.

Epson 205 without light

Epson 205 without light

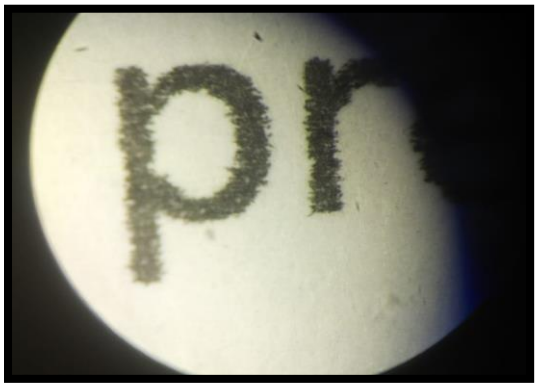
1.3.4. Sample 11.

Epson 1805 without light

Epson 1805 with light

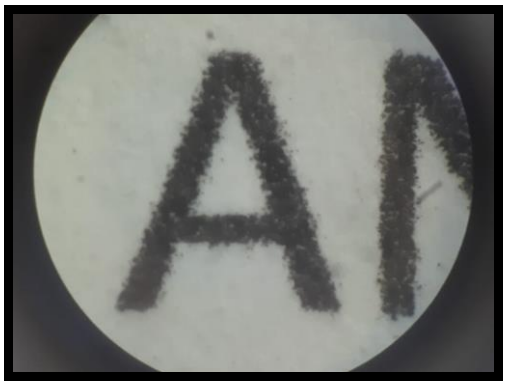
1.3.5. Sample 12.

Epson L3210 without light



Epson L3210 with light

1.3.6. Sample 13.



Canon G2020 without light

Canon G2020 with light.

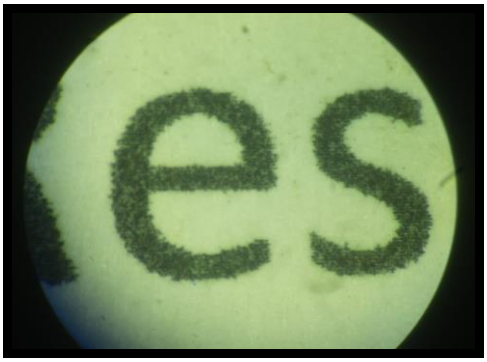
1.3.7. Sample 14.

Brother T820 DW without light

Brother T820 DW with light

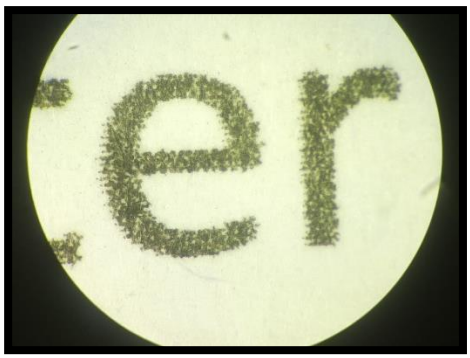
1.3.8. Sample 15.

Canon G670 without light



Canon G670 with light

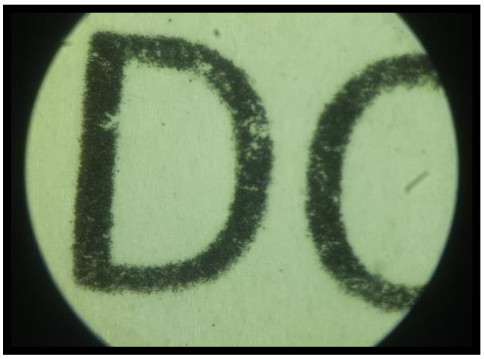
1.3.9. Sample 16.

Canon G3000 without light **Canon G3000 with light**

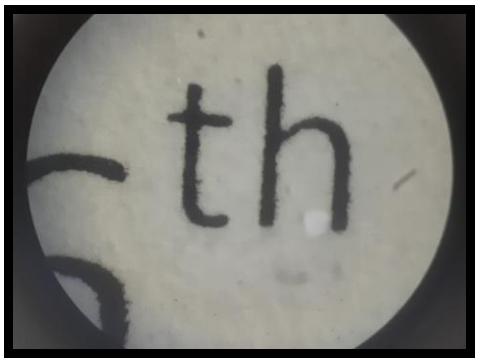
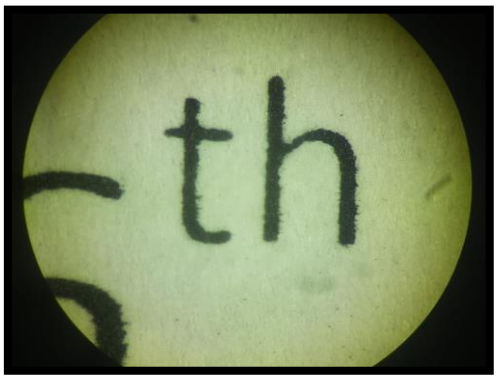
1.4.MICROSCOPIC IMAGES (PHOTOCOPIERS)

1.4.1. Sample 17.

Canon 3015 without light **Canon 3015 with light**

1.4.2. Sample 18.

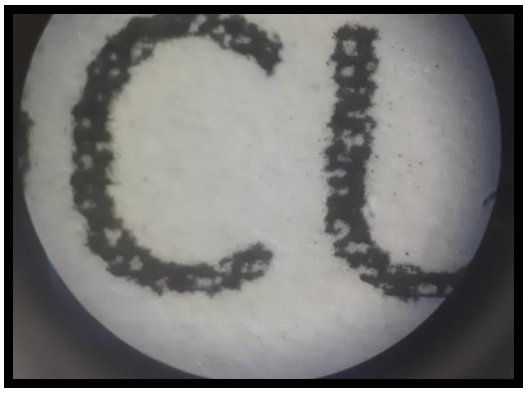



Canon 6255 without light **Canon 6255 with light**

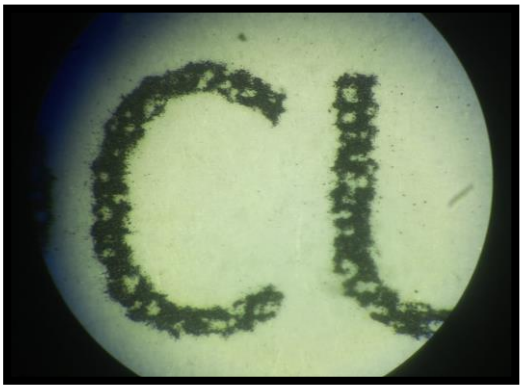
1.4.3. Sample 19.


Canon IR 3205 without light **Canon IR 3205 with light**

1.4.4. Sample 20.



Canon IR 3250 without light



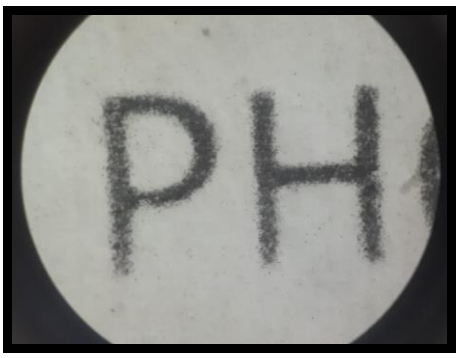
Canon IR 3250 with light

1.4.5. Sample 21.

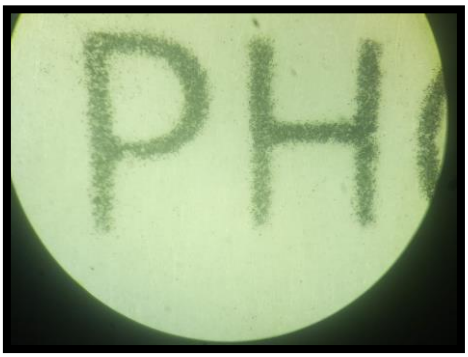
Canon 3245 without light

Canon 3245 with light

1.4.6. Sample 22.

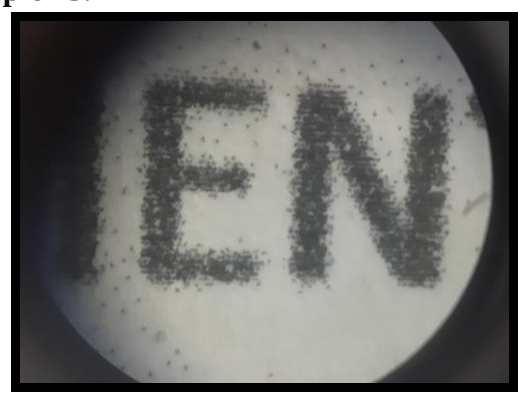


Conica 250 without light

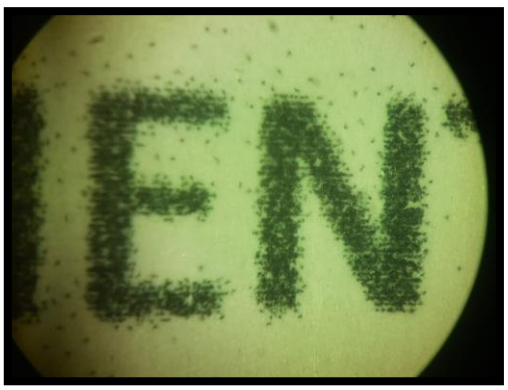


Conica 250 with light

1.4.7. Sample 23.



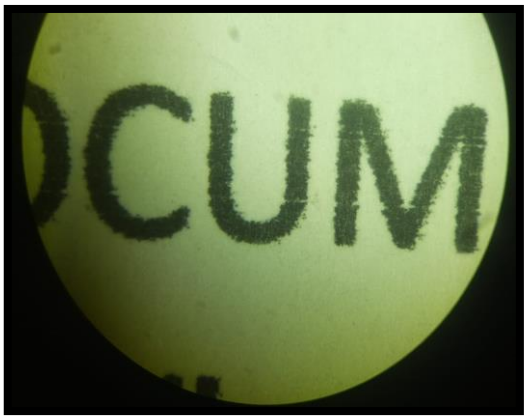
Brother T820 DW without light



Brother T820 DW with light

1.5.MICROSCOPIC COMPARATIVE IMAGES OF ALL THREE SAMPLES

Canon IR 2870 laser printer



Brother T820DW Inkjet Printer

Canon IR 3205 Xerox

- From all three images we can see the drastic changes in these samples in their **Letter formation, Edge contrast , Edge roughness and its ink flow**
- All these characters show a differentiation and uniqueness in its each sample and it can be easily differentiable from one another.
- The Quality of the letter formation in all three samples is one of the best solutions for giving opinion in documentation related disputes.

5.3. DISCUSSION

5.3.1. LASER PRINTER DOCUMENT:

- **Resolution**: The laser printer produces letters with a better resolution and sharper, when compared to inkjet printer.
- **Edge Contrast:** The letters' edges are more furnished and sharp
- **Edge Roughness:** when compared to the inkjet printer samples, the letters' edges contrast better.
- **Ink flow:** The letter’s continuity and ink depositions give them a smooth border and thickness because of increased ink spray.

5.3.2. INKJET PRINTER DOCUMENT:

- **Resolution:** The clarity and resolution of the letters produced by the inkjet printer are lesser than the laser printer.
- **Edge contrast:** There is less contrast and a hint of smudging at the edges of the letters.

- **Edge Roughness:** The letters' edges are jammed and irregular, and they look worse at increased magnification.
- **Uniformity of the printed character and Ink flow:** Blotting of the ink on the paper indicates that the ink had been sprayed. The amount of ink on the paper is not continued and certain letters have more ink in those locations than others. Uneven inking resulted in dark spots in certain places.

5.3.3. PHOTOCOPIED DOCUMENT:

- **Resolution:** Resolution of the letter is not better when compared to other two printed documents.
- **Edge Roughness:** Edges are improperly completed with white patches on the letters and
- **Edge contrast:** No letters are completed with sharp and proper edges
- **Ink flow and letter continuity:** The ink flow is uneven and the ink is about to scattered on the letters in and around, and many drum marks are present in the margins of the page.

6. CONCLUSION:

- The findings of this study may be utilized as supporting documentation or in criminal investigations. By identifying the printer, law enforcement agencies may essentially follow the characters of false documents to the suspected printer, which will identify the owner or suspect.
- Since most passports and other government documents are generated using laser printers and Inkjet printer, this study can be used in protection of forging of such document analysis to screen for forgeries. A more accurate and detailed determination can be availed by the investigators if a microscopic analysis of the letter formation is done by the experts.
- These days, banknotes and checks also have a certain printing method for their text; therefore, to verify their legitimacy, they should be microscopically compared to the standards that are provided from their own field and try to match the characters of questioned with the standards
- This study can also be used to examine the documents that have been edited or forged. Documents that have any changes, additions, or deletions made to their text are frequently vulnerable to forgery.
- When a document is forged, it is possible to determine whether the printing methods used are consistent by comparing the text of the allegedly altered document with the original.
- If the printing methods are the same, then the individual attributes are being contrasted. As a result, the outcome allows one to focus in on the specific kind of suspected printer.

7. REFERENCES:

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