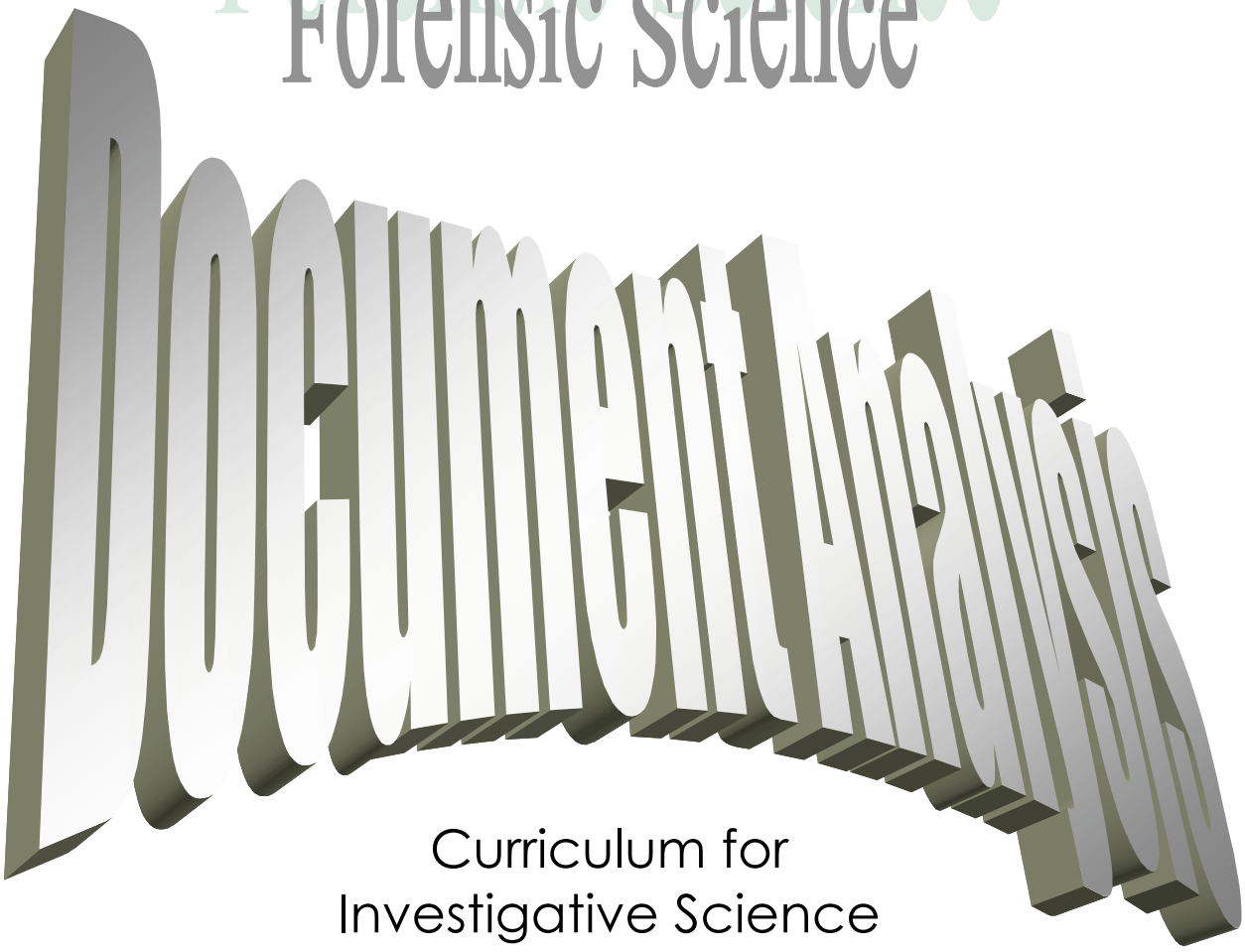
Forensic Science



Curriculum for
Investigative Science

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Research Experience for Teachers 2006
Department of Physics & Astronomy
University of Oklahoma
Norman, Oklahoma

Dates _____ 85 minute block periods Class _____

Document Analysis at a Glance

Day	Students will:	Duration
Handwriting	1) discover the difficulty in forgery 2) learn about document analysis 3) explore handwriting analysis (lab)	1) 5 minutes 2) 15-20 minutes 3) 45-50 minutes
Ink	1) discuss differences and similarities in ink 2) explore, microscopically, ink analysis (lab) 3) discover how infrared radiation is used in ink analysis (demo)	1) 10-15 minutes 2) 40-50minutes 3) 15-20 minutes
Ink	1) discover how infrared radiation is used to recognize obliterations (demo) 2) learn about chromatography 3) quantiatively measure retention factors (lab)	1) 15-20 minutes 2) 15-20 minutes 3) 45-50 minutes
Paper	1) learn about electromagnetic radiation 2) explore invisible/indented writing (lab) 3) view fluorescence of paper using UV light (demo)	1) 10-15 minutes 2) 40-50minutes 3) 15-20 minutes
Crime Scene	1) investigate and solve a hypothetical crime scenario	1) 45 minutes

Document Analysis at a Glance

Day	Students will:	Duration
Handwriting	1) discover the difficulty in forgery 2) learn about document analysis 3) explore handwriting analysis (lab-begin)	1) 5 minutes 2) 15-20 minutes 3) 25 minutes
Handwriting	1) explore handwriting analysis (lab-finish)	1) 30-45 minutes
Ink	1) discuss differences and similarities in ink 2) explore, microscopically, ink analysis (lab)	1) 10-15 minutes 2) 40-50minutes
Ink	1) discover how infrared radiation is used in ink analysis (demo) 2) discover how infrared radiation is used to recognize obliterations (demo)	1) 15-20 minutes 2) 15-20 minutes
Ink	1) learn about chromatography 2) quantitatively measure retention factors (lab-begin)	1) 15-20 minutes 2) 20-30 minutes
Ink	1) quantitatively measure retention factors (lab-finish)	1) 30-45 minutes
Paper	1) learn about electromagnetic radiation 2) explore invisible/indented writing (lab-begin)	1) 10-15 minutes 2) 20-30 minutes
Paper	1) explore invisible/indented writing (lab-finish) 2) view fluorescence of paper using UV light (demo)	1)15-20 minutes 2) 15-20 minutes
Crime Scene	1) investigate and solve a hypothetical crime scenario	1) 45 minutes

Collaborations

Special collaborators:

- ✓ Dr. David Von Minden, Forensics Chair, University of Central Oklahoma
- ✓ David Parrett, Forensic Document Examiner, Oklahoma County D.A.
- ✓ Sgt. Everett Baxter, Jr., Oklahoma City Police Department
- ✓ Douglas Perkins, Oklahoma State Bureau of Investigation
- ✓ Bob Post, Norman Police Department, Oklahoma
- ✓ Natalya Sebastian, student, Bishop McGuinness High School, Oklahoma
- ✓ Jordan Fritch, student, Bishop McGuinness High School, Oklahoma
- ✓ Aaron Hennen, student, Tecumseh High School, Oklahoma
- ✓ Emma Hunsaker, student, Norman High School, Oklahoma

University of Oklahoma collaborators:

- ✓ Caroline Hall, Project Manager
- ✓ Ernie Sanchez, Student Technician
- ✓ Kieran Mullen, Associate Professor of Physics
- ✓ Eric Abraham, Assistant Professor of Physics
- ✓ Matt Johnson, Associate Professor of Physics

RET Program University of Arkansas
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Forensic Science Unit
Document Analysis Module Lesson Plans

I. Rationale

Document evidence is one of the most common types of evidence found at a crime scene. Paper is involved in most crimes either directly (ransom notes, forged signatures, counterfeiting, etc.) or indirectly (receipts, signed legal documents, etc.). Furthermore, document analysis is not limited to just paper but anything that is used to convey a message. Document analysis employs many areas of investigation, such as handwriting and signature verification; characterizing papers, pigments, and inks; restoring erased and obliterated writing. Similar to fingerprinting, handwriting's distinctiveness make this type of evidence one of the few unique characteristics available to the investigator.

Within these lessons, students will investigate the fundamentals of handwriting, ink, and paper analysis. Students will use investigative techniques to identify a master forger, classify ink patterns and types, explore chromatography fundamentals, and discover the unique abilities of infrared and ultraviolet radiation to characterize paper. Students will experience using appropriate tools and apparatuses to collect data and practice safety procedures in all activities. In addition, students will utilize the scientific method to interpret data, recognize variables, derive hypotheses, and arrive at conclusions using document analysis techniques.

We have designed these lesson plans to be easily modified as needed by the instructor. It is our goal that teachers can decide to present all the material in one comprehensive package or just pull out specific activities/topics to use as mini-lessons or re-enforcers. In all of the activities, additional suggestions and time saving tips are included at the end.

II. Objectives

A. Cognitive Objectives:

Upon completion of this module, the student will be able to:

- Utilize the scientific method to analyze handwriting.
- Discover the twelve points to handwriting analysis.
- Use the scientific method to determine the differences and similarities between a varying styles of pens.
- Establish if the type of paper used has an effect on ink appearance.
- Employ the scientific method to discover about means of identifying indented writing.
- Determine means of document preservation.
- Discover the principles of chromatography.
- Formulate a testable hypothesis.

B. Skills and Performance Objectives:

Upon completion of this module, the student will be able to:

- Utilize appropriate tools in a laboratory setting (microscope, magnifying glass, etc.)
- Organize and report data in an appropriate method.
- Practice suitable safety methods.
- Make qualitative observations about various inks, papers, and handwritings.
- Use retention factors to quantitatively recognize the differences in inks.
- Use chromatography to compare ink pigments.
- Make qualitative observations about the separation of ink pigments.

- Present laboratory results with critique from peers.
- Use evidence, apply logic, and construct an argument for their proposed explanations.

III. Materials—see lab handouts for detailed information

- Note pads
- Magnifying glasses
- Ball point, gel, roller ball, felt tip pens (blue & black)
- Black markers
- Pencil
- Rulers
- Flashlights
- Transparency film
- Mirrors
- Iron filings
- Microscopes
- Paper—glossy photo, cardstock, photocopy
- Infrared source (heat lamp)
- Ultraviolet light source (black light)
- Infrared filters
- Digital camcorder (with night shot capability)
- Filter paper
- Cling wrap or parafilm
- Ethanol
- Deionized water
- Graduated cylinders
- Forceps
- Pipettes
- Scissors

IV. Instructional Procedure

A. Lesson One—Handwriting Analysis

- Opening
  1. Ask a student to volunteer to write their signature on the board
  2. Ask other students to volunteer to try to forge the signature on the board.
  3. Discuss the difficulty or ease in trying to mimic a signature. Have the class decide which forger was the best.
- Middle
  1. Presentation of the document analysis introduction.
  2. Activity: Handwriting Analysis laboratory activity
  3. During the activity (before testing hypothesis), present the Twelve Characteristics of Handwriting Analysis (transparency 1). Use the transparency and the 12 points to conduct a class discussion and to provide examples.
  4. Students should then complete the activity.
- Closing
  1. Have students summarize results and speculate on the possible forger.
  2. Present correct answer to activity.

B. Lesson Two—Ink Analysis

- Opening
  1. Show the class the Microscopic View of Ink Analysis. (transparency 2)
  2. Discuss the differences and similarities in the ink. Ask the students to predict which ink sample is from what type of pen (roller ball, gel, felt tip, ball point). Do not give the answers yet!
- Middle
  1. Activity: Ink Analysis—A Microscopic View laboratory activity
  2. Upon completion of the activity, show the transparency again and discuss. Provide the students with the correct answers.
- Closing
  1. Demonstration: Using Infrared Radiation in Ink Analysis

C. Lesson Three—Ink Analysis

- Opening
  1. Demonstration: Using Infrared Radiation to Recognize Obliterations.
  2. Presentation of obliterations and erasures.
- Middle
  1. Presentation of chromatography and retention factors. (transparency 3)
  2. Activity: Ink Chromatography.
- Closing
  1. Class discussion of laboratory results.

D. Lesson Four—Paper Analysis

- Opening
  1. Presentation of Electromagnetic Radiation (transparency 4)
- Middle
  1. Activity: Indented Writing laboratory activity
- Closing
  1. Demonstration: Fluorescence of Paper using Ultraviolet Radiation

E. Lesson Five—Crime Scenario

- Opening
  1. Presentation of crime scenario.
- Middle
  1. Students perform laboratory activities to solve the case.
- Closing
  1. Students prepare a written report and orally present their findings.

V. Demonstrations

A. Using Infrared Radiation in Ink Analysis

- Prep time: 15 minutes
- Demonstration time: 15 minutes
- This demonstration will show the students that some ink can reflect the invisible infrared light, while others will absorb the light. Some inks will be visible while others will not. Forensic document examiners use these tools to *analyze ink.*
- **Materials:**
  - Infrared (IR) filter—a 4x5" filter can be found at www.edmundoptics.com for about $14.
  - Black pens
    - **Reflect:** Sharpie, BIC Velocity Gel, Zebra Marathon. (Other pens may reflect as well, just test them.)
    - **Absorb:** Pilot Precise, Paper Mate Write Bros, Pentel Ever Gel (or others that you might test)
  - Video Camera with either night vision or night shot capability
  - Television
  - Heat lamp (IR light source)
  - Paper with suspicious note
- **Was it suicide or was it Murder?**
  - For the note, you will have to write out the first section in a reflective ink and the second section in ink that will absorb the IR.
  - **Instructions to the Class:** Kelly makes the mistake of telling some of Barbie's darkest secrets to Barbie's arch rival Theresa. Barbie is furious over the disclosers, and vows to get even. Many complications arise from this breach

of confidence. The next day Kelly is found hanging in her bathroom. A suicide note is found in the sink.
    - **Note:** "Dear Barbie, I am so sorry for betraying our friendship when I told Theresa about you and Ken. Please forgive me. I feel so badly about the pain that I've caused that I cannot deal with it any longer. Forgive me for what I must do. Goodbye."
- Set up the camera and television so the class can view the results. Next you will shine the IR source on to the suspicious document while holding the filter between the paper and the camera. You will then observe the reflection of some inks and absorbing of the others.
- The class will observe only the first section indicating that the second part was written by a different person using a different pen. This would hint that the first section was a true note of apology, and not part of a suicide note!

B. Using Infrared Radiation to Recognize Obliterations

- Prep time: 15 minutes
- Demonstration time: 15 minutes
- This demonstration will show the students that some ink can reflect the invisible infrared light, while others will absorb the light. Some inks will be visible while others will not. Forensic document examiners use these tools to observe *obliterated writing*.
- **Materials:**
    - Infrared (IR) filter—a 4x5" filter can be found at www.edmundoptics.com for about $14.
    - Black pens
        - **Reflect:** Sharpie, BIC Velocity Gel, Zebra Marathon. (Other pens may reflect as well, just test them.)
        - **Absorb:** Pilot Precise, Paper Mate Write Bros, Pentel Ever Gel (or others that you might test)
    - Video Camera with either night vision or night shot capacity
    - Television
    - Heat lamp (IR light source)
    - Paper with suspicious petition.
- **Who wrote it?**
    - **Petition:** Using the reflective ink pen write out the following petition.

"We the undersigned believe that Ms. Snodgrass is a big ugly dork who in unable to teach us anything. She is unfair and gives too many tests, and homework. SHE SHOULD BE FIRED!

Signed: Billy Jack Bubba Jones Redd Nekk Susie Que
Duddley Duwrite Betty Whoop Barney Fife Opie Taylor."

    - Obliterate four of the signatures by scribbling over them with an absorptive pen.
    - Set up the camera and television so the class can view the results. Next you will shine the IR source on to the suspicious document while holding the filter between the paper and the camera. When viewed through the camera, the students will still be able to read the names that were hidden!

C. Fluorescence of Paper using Ultraviolet Radiation

- Prep time: 10-15 minutes
- Demonstration time: 10-15 minutes

- This demonstration will show students that various types of paper will absorb or fluoresce under ultraviolet (UV) light, though they may appear the same under visible light.
- **Materials:**
  - Ultraviolet light source—most true black lights will work
  - Two sheets of paper—one that absorbs, one that fluoresces (suggestions include different brands of photocopy paper, cardstock, 100% cotton, etc.)
- **To will or not to will…that is the question!**
  - You will have to write out a holographic will (one that is hand written or typed, not witnessed or notarized).
  - **Will:** Page one will list several people receiving items of little value. On the second sheet a Snap-On Rollaway tool box goes to Jake Nekk. The farm, house in town, savings account, and certificates of deposit go to Jake's younger brother Bubba Nekk. It is signed by the deceased, Jupiter Nekk.
  - **Instructions to the Class:** Describe the nature of the will's contents, and that Jake contests it. Jake takes the will to a document specialist who examines it under ultraviolet light.
  - Turn out the lights and shine the UV light onto the two pages. The students should observe that the papers look different under the UV light. Ask the class what this may indicate. Is the will for real?

VI. Crime Scenario

A. Prep time: 25-30 minutes

B. Activity time: 45-60 minutes

C. Materials

- Black pen/marker advertising "Goober's Garage"
- Generic black pen/marker
- UV light source (black light)
- Graduated cylinders (25 mL)
- Ethanol
- Deionized water
- Chromatography paper (filter paper)
- Pipette
- Copies of "Goober's" checks
- Paper—two varieties (photocopy paper, cardstock)
- Student materials

D. Teacher information:

1. Preparation of Crime Scenario
   - 5 copies of Goober's checks on cardstock paper
     - Original checks signed by Goober
     - Written with the black pen/marker advertising "Goober's Garage"
     - Returned as insufficiently funded
   - 5 copies of Goober's checks on photocopy paper
     - Copied and forged checks produced by Barney
     - Written with the generic black pen/marker
   - Copies of Crime Scenario for each laboratory group
   - Set up materials for the analysis

2. Present the students with the following scenario:

   "Barney worked for Goober's Garage for several months. One day he stole a checkbook from the garage office. He made several copies of the checks and replaced the checkbook in the office. That evening, Barney went on a check writing shopping spree around the neighboring town.

   Goober went about his usual business writing checks for home and the garage, using his company pens. But because Barney had drained most of his account, the checks Goober wrote were returned as insufficiently funded. Merchants and employees sent the bad checks to the District Attorney's office. The D.A. has accused Goober of writing fraudulent checks for personal gain.

   When Goober received his bank statement he quickly realized that something suspicious was going on. He suspected that someone stole his checks and forged his signature.

   Your task as a laboratory technician in the D.A.'s forensic document examiner's office is to help clear Goober's good name. But be sure to interpret the evidence using science, not intuition!"

   - Students will process the evidence using techniques and knowledge gained throughout the Document Analysis Module.
3. Suggested evidence and processing techniques:
   - Forged signature—handwriting analysis
   - Copied checks--fluorescence using ultraviolet radiation
   - Copied checks and Goober's Garage pen--chromatography
4. Expected results
   - Goober's signature and the forged signature should not match.
   - One set of checks will fluoresce and the others will not.
   - Chromatography will differentiate between Goober's Garage pen and the pen used in the forged checks.
   - Conclusion—Goober did not write one set of checks and should not be held liable for the monetary damage produced by the copied checks.

Forensic Science
Document Analysis Lecture Materials

I. Introduction to Document Analysis

A. Why would a forensic scientist be interested in a piece of paper?

1. Paper is involved in most crimes
   a. Directly—ransom notes in a kidnapping case, suicide notes, forged signatures on checks, etc.
   b. Indirectly—hotel registries, receipts, signed legal documents, etc.
2. Furthermore, document analysis is not limited to paper
   a. Anything that is used to convey a written message can be analyzed
   b. Walls, mirrors, envelopes, notepads, floors, etc.

B. What is a Forensic Document Examiner?

1. The application of analytical techniques to questions concerning documents is called forensic document examination.
2. Examination consists of the analysis and comparison of handwriting, typewriting, photocopies, papers, inks, and other documents with known materials in order to establish authenticity and detect alterations.
3. It is estimated that on the North American continent there are less than 1,000 qualified forensic document examiners.
4. Crimes in which a forensic document examiner is utilized:
   - Hate crimes
   - Threats
   - Kidnappings
   - Sexual assault
   - Robbery
   - Homicide
   - Suicide
   - Counterfeiting
   - Sports/celebrity autographs
   - Narcotics
5. The role of the forensic document examiner:
   - Preserve all questioned documents in its original quality
   - Handwriting and handprinting comparison
   - Detection of:
     - Forgery
     - Indented writing
     - Alterations
     - Obliterated writing
     - Erasures
   - Rubber stamps
   - Charred and/or soaked paper
   - Ink and paper analysis
   - Typewriters, elements, ribbons, and correcting ribbons
   - Copy machines
   - Computers and printers

C. What a Forensic Document Examiner Can Not Do…

1. Identify a person who traces a signature.

2. Determine if the writer is male or female.
3. Determine a writer's age.
4. Determine whether a writer is right or left handed.
5. Determine personality (pseudoscience called graphology).

II. Analysis of Handwriting

A. Similar to fingerprinting, handwriting's distinctiveness make this type of evidence one of the few unique characteristics available to the investigator.

B. To determine whether a signature/writing is authentic, a document examiner will usually examine 12 characteristics:

1. **Line quality**: Are the lines smooth, free flowing, and rhythmic, or shaky, nervous, and wavering?
2. **Spacing of words and letters:** Examine the average amount of space between words and letter formation.
3. **Ratio of relative height, width, and size of letters:** What are the overall height, width, and size of the letters?
4. **Pen lifts and separations:** Check if the writer stops to form new letters and begin words. Forgeries may have pen lifts in unusual places (e.g. in the writing of a single letter).
5. **Connecting strokes:** Compare how capital letters are connected to lowercase letters and how strokes connect between letters and words.
6. **Beginning and ending strokes:** Are the strokes straight, curled, long, or short? Are they made on the upstroke or downstroke?
7. **Unusual letter formation:** Look for unusual letter formations (e.g. letters with tails).
8. **Shading or pen pressure:** Check for pressure on the downward and upward strokes.
9. **Slant:** Does the writing slant to the left or right, or is it straight up and down? Are some letters consistently slanted more or less than others?
10. **Baseline habits:** Does the writing tend to follow a straight line, move downward, or move upward? Is it above or below the line?
11. **Flourishes or embellishments:** Are there any fancy letters?
12. **Placement of diacritics:** Check the crossing of t's, dotting of i's and j's, or any other letters or punctuation marks.

III. Ink Analysis

A. Paper Chromatography—an analytical technique for separating mixtures and identifying compounds that are colored.

1. Chromatography Process:
   a. A small spot of the sample is applied to a strip of chromatography paper or filter paper about one centimeter from the base. This sample is adsorbed onto the paper and may form interactions with it.
   b. The paper is then dipped in to a suitable solvent, such as ethanol and/or water and placed in a sealed container.
   c. As the solvent rises through the paper it meets and dissolves the sample mixture, which will then travel up the paper with the solvent.

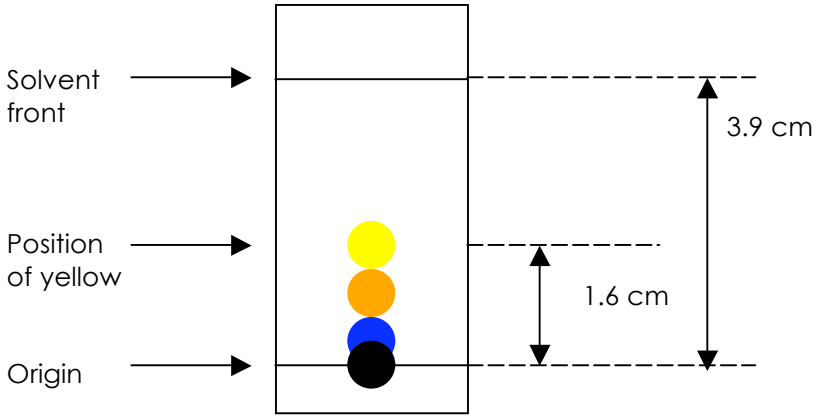
d. The process is complete when the solvent is near the top of the piece of filter paper.
e. Use a pencil to mark where the solvent front has stopped.
f. Paper chromatography takes anywhere from several minutes to several hours.

2. Science behind Paper Chromatography:
   a. The solvent moves up the paper by capillary action, which occurs as a result of the attraction of the solvent molecules to the paper and to one another.
   b. Different compounds in the sample mixture travel at different rates due to differences in solubility in the solvent and due to differences in their attraction to the fibers in the paper.
   c. Any substance that reacts or bonds with the paper cannot be measured using this technique.
   d. This method has been largely replaced by thin layer chromatography (TLC) in the laboratory environment.
3. Retention Factor
   a. Retention is a measure of the speed at which a substance moves in a chromatographic system.
   b. In paper chromatography, the retention is expressed as the retention factor R_f; the run length of the compound relative to the run length of the solvent front:

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

   c. The retention of a substance often differs considerably between experiments and laboratories.
      i. Since these factors are difficult to keep constant from experiment to experiment, relative R_f values are generally considered.
      ii. Relative R_f means that you compare the R_f values of compounds ran at the same conditions.

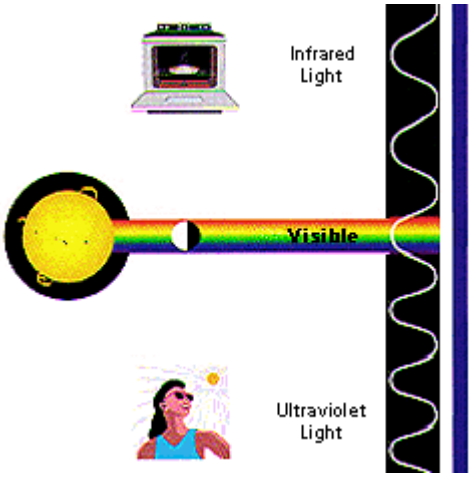
Using the yellow as the compound of interest:



$$R_f = \frac{1.6 \text{ cm}}{3.9 \text{ cm}} = 0.41$$

4. How Forensic Scientists use Chromatography
   a. The retention factor of a substance differs between experiments and laboratories due to variations of the solvent, the paper, temperature, and the setup. Forensic document examiners compare the retention factor of the test compound to that of one or more standard compounds in a reference textbook under absolutely identical conditions.
   b. Forensic scientists utilized other methods of chromatography to analyze unknown mixtures, compounds, drugs, dye composition of fibers, etc.
   c. Other types of chromatography: thin-layer, gas, liquid, ion exchange, affinity, fast protein liquid, high performance liquid, size exclusion, countercurrent,
5. Obliterations—removal of writing by physical or chemical means.
   a. Common methods include physically erasing with a rubber eraser, scraping ink off the document's surface, and writing over the words with darker ink (scratching out). This can cause changes in the paper.
   b. Forgers also use chemical methods to obliterate words, such as strong oxidizing agents (chlorine or sodium hypochlorite). These chemicals can make ink become colorless.

B. Electromagnetic Radiation (EM)—the full range of frequencies, from radio waves to gamma rays, that characterizes light.
   1. Radio waves, visible light, X-rays, and all the other parts of the electromagnetic spectrum are fundamentally the same thing, electromagnetic radiation.
   2. Two types of radiation are commonly used as analysis tools by forensic document examiners.
      a. Infrared radiation (IR)
      b. Ultraviolet radiation (UV)



(Courtesy of NASA's Imagine the Universe
http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html)

3. Infrared radiation—radiation whose wavelengths are longer than the red end of the visible spectrum but shorter than microwaves
    a. Approximately between 750 nm and 1mm
    b. Often associated with heat because it makes our skin feel warm
    c. Most of the IR of the EM can not reach the surface of the Earth
    d. Used in ink analysis and detection of deletions and erasures.
    e. The discovery of infrared radiation is attributed to William Herschel, an astronomer in the early 19th century. He used a prism to refract light from the sun and detected the infrared through an increase in the temperature recorded on a thermometer.
4. Ultraviolet radiation—wavelengths shorter than the violet end of visible light
    a. Approximately between 380 nm and 31 nm
    b. The sun is one source of UV radiation.
    c. Because of the shorter wavelength, UV radiation has greater energy that visible or IR (you notice this because sunlight produces sunburns!)
    d. Used in detection of alterations and obliterations.
    e. In 1801, the German physicist Johann Wilhelm Ritter used silver chloride, a light-sensitive chemical, to show that there was a type of invisible light beyond violet, which he called chemical rays.

IV. Paper Analysis

A. Indented writing—impressions left under the paper that has been written on
    1. Method of rubbing indented writing with a soft pencil is the worst thing to do! Remember the role of the document examiner is to preserve the condition of the document.
    2. Oblique lighting will enhance indentations.
    3. Electrostatic detection apparatus (ESDA)—used to "develop" indented writing using plastic to cover the document, powdered toner, and electrostatic charge. The image is then photographed.
B. Fluorescence—many papers today are coated with optical brighteners that make them fluoresce or look very white under UV light. This coating may be disturbed when forgers try to erase or obliterate information on the document.

For additional information:

- ✓ http://imagine.gsfc.nasa.gov/docs/science/know_l1/emspectrum.html
- ✓ http://qdewill.com/labtour.htm
- ✓ http://orgchem.colorado.edu/hndbksupport/TLC/TLC.html
- ✓ http://en.wikipedia.org
- ✓ www.forensic-documents.com
- ✓ www.fbi.gov/hq/lab/fsc/backissu/april2000/swgdoc1.htm
- ✓ Deslich, Barbara and John Funkhouser. Forensic Science for High School. Kendall/Hunt Publishing Company. Dubugue, Iowa. 2006. Student edition: ISBN 0-7575-1825-7; Teacher edition: ISBN 0-7575-1824-9

1 My son came home late.

2 My son came home late.

3 My son came home late.

4 My son came home late.


Dave
yellow
grass
Evil

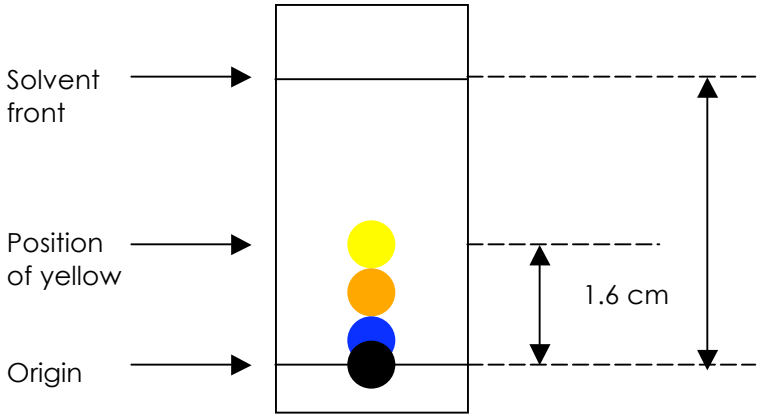
Ball point

Felt tip

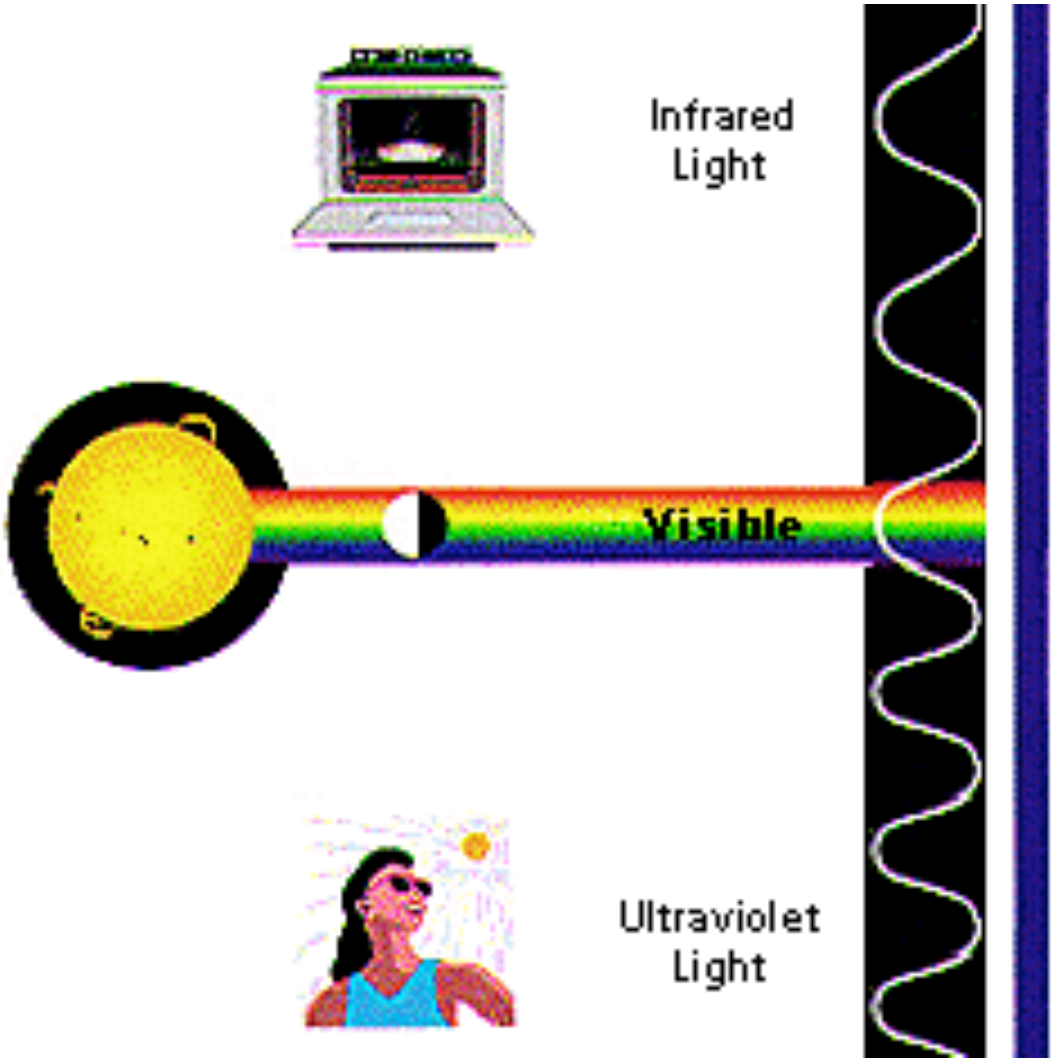
Roller ball

Gel

Using the yellow as the compound of interest:



$$R_f = \frac{1.6\ cm}{3.9\ cm} = 0.41$$


Infrared
Light
Visible
Ultraviolet
Light

Name _____ Date _____

Goober's Garage
1492 W. Main
Hicksville, OK 12345

_____Date

Pay to the Order of _____ $

_____Dollars

Hicksville Savings & Loan
123 E. Main
Hicksville, OK 12345

For_____ _____

13522849173071 748735982113

Goober's Garage
1492 W. Main
Hicksville, OK 12345

_____Date

Pay to the Order of _____ $

_____Dollars

Hicksville Savings & Loan
123 E. Main
Hicksville, OK 12345

For_____ _____

13522849173071 748735982113

Name _____ Date _____

Document Analysis
Crime Scenario

Background:

Barney worked for Goober's Garage for several months. One day he stole a checkbook from the garage office. He made several copies of the checks and replaced the checkbook in the office. That evening, Barney went on a check writing shopping spree around the neighboring town.

Goober went about his usual business writing checks for home and the garage, using his company pens. But because Barney had drained most of his account, the checks Goober wrote were returned as insufficiently funded. Merchants and employees sent the bad checks to the District Attorney's office. The D.A. has accused Goober of writing fraudulent checks for personal gain.

When Goober received his bank statement he quickly realized that something suspicious was going on. He suspected that someone stole his checks and forged his signature.

Your task as a laboratory technician in the D.A.'s forensic document examiner's office is to help clear Goober's good name. But be sure to interpret the evidence using science, not intuition!

Procedure:

Use the knowledge gained and any materials from the Document Analysis Unit to process the evidence. Take careful notes of the test(s) you perform and write down all observations. Practice appropriate safety procedures in all experiments.

Report:

Once you have exhausted all possible test(s) to perform on the evidence, write a brief summary of your results indicating what evidence was analyzed, how it was processed, methods you took to preserve the integrity of the document, and any conclusions that were made.

Name _____ Date _____

Teacher Suggestions &Expected Results:

- Prep time: 25-30 minutes
- Activity time: 45-60 minutes
- Preparation of Crime Scenario
    - 5 copies of Goober's checks on cardstock paper
        - Original checks signed by Goober
        - Written with the black pen/marker advertising "Goober's Garage"
        - Returned as insufficiently funded
    - 5 copies of Goober's checks on photocopy paper
        - Copied and forged checks produced by Barney
        - Written with the generic black pen/marker
    - Copies of Crime Scenario for each laboratory group
- Suggested evidence and processing techniques:
    - Forged signature—handwriting analysis
    - Copied checks--fluorescence using ultraviolet radiation
    - Copied checks and Goober's Garage pen--chromatography
- Expected results
    - Goober's signature and the forged signature should not match.
    - One set of checks will fluoresce and the others will not.
    - Chromatography will differentiate between Goober's Garage pen and the pen used in the forged checks.
    - Conclusion—Goober did not write one set of checks and should not be held liable for the monetary damage produced by the copied checks.

Name _____ Date _____

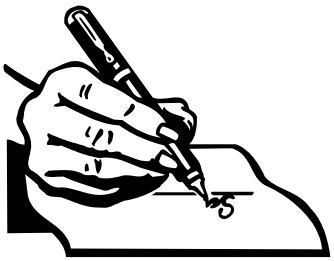
Handwriting Analysis
Laboratory Activity

Purpose/Objectives: The student will…

- Utilize the scientific method to analyze handwriting.
- Discover the twelve points to handwriting analysis.

Materials:

- Freehand Simulation Forgery sheet
- Magnifying glass
- Pencil
- Ruler



Safety: Practice appropriate safety procedures.

(1) Problem: How are handwriting forgeries detected?
Procedure: Eleven of the signatures in each row on the Freehand Simulation Forgery worksheet were prepared by the actual person. One signature in each row is made by a master forger. Find the two forgeries by making note of the individual characteristics that don't fit! You may use any appropriate tools as necessary. Include qualitative and quantitative observations about each signature.

(2) Initial Observations: Make observations about individual characteristics.

1	A
2	B
3	C
4	D
5	E
6	F
7	G
8	H
9	I
10	J
11	K
12	L

Name _____ Date _____

(3) Hypothesis: Which signature in each column is the forgery and why?

_____

_____

_____

(4) Test: Use the twelve characteristics to analyze each of the handwritings.

- **Line quality**: Are the lines smooth, free flowing, and rhythmic, or shaky, nervous, and wavering?
- **Spacing of words and letters:** Examine the average amount of space between words and letter formation.
- **Ratio of relative height, width, and size of letters:** What are the overall height, width, and size of the letters?
- **Pen lifts and separations:** Check the writer stops to form new letters and begin words. Forgeries may have pen lifts in unusual places (e.g. in the writing of a single letter).
- **Connecting strokes:** Compare how capital letters are connected to lowercase letters and how strokes connect between letters and words.
- **Beginning and ending strokes:** Are the strokes straight, curled, long, or short? Are they made on the upstroke or downstroke?
- **Unusual letter formation:** Look for unusual letter formations (e.g. letters with tails).
- **Shading or pen pressure:** Check for pressure on the downward and upward strokes.
- **Slant:** Does the writing slant to the left or right, or is it straight up and down? Are some letters consistently slanted more or less than others?
- **Baseline habits:** Does the writing tend to follow a straight line, move downward, or move upward? Is it above or below the line?
- **Flourishes or embellishments:** Are there any fancy letters?
- **Placement of diacritics:** Check the crossing of t's, dotting of i's and j's, or any other letters or punctuation marks.

Secondary Observations: Use the following space to make qualitative and quantitative observations about each signature. Use the twelve characteristics as guidelines.

1	A
2	B
3	C
4	D
5	E

Name _____ Date _____

6	F
7	G
8	H
9	I
10	J
11	K
12	L

Analysis: Revaluate your hypothesis. Did you hypothesis change? You may need to retest a new hypothesis at this point.

_____

_____

_____

(5) Conclusion: Which signature are the forgeries? Explain citing evidence.

_____

_____

_____

Name _____ Date _____

Teacher Suggestions and Expected Results:

Prep time: 5-10 minutes
Lab time: 45-50 minutes

- Before the students get to the testing portion of the activity, present the Handwriting Analysis transparency. Use the transparency as an example to go over the twelve handwriting characteristics in more detail.
- Students might feel frustrated at times during this activity. It may be beneficial to have the students work in groups. Furthermore, guide them through this activity if they are struggling. Point out specific details.
- If you do have the students work in groups, provide each student with a copy of the Freehand Simulation Forgery.
- You could use this activity just to teach students about the scientific method.

ANSWER KEY

INITIAL OBSERVATIONS: Answers will vary. Because this is an initial observation, students may not find a lot of detail to observe. They may repeat information, for example: #6 looks like #1, #7 looks like #1, etc.

HYPOTHESIS: Answers will vary. Look for explanations and justification.

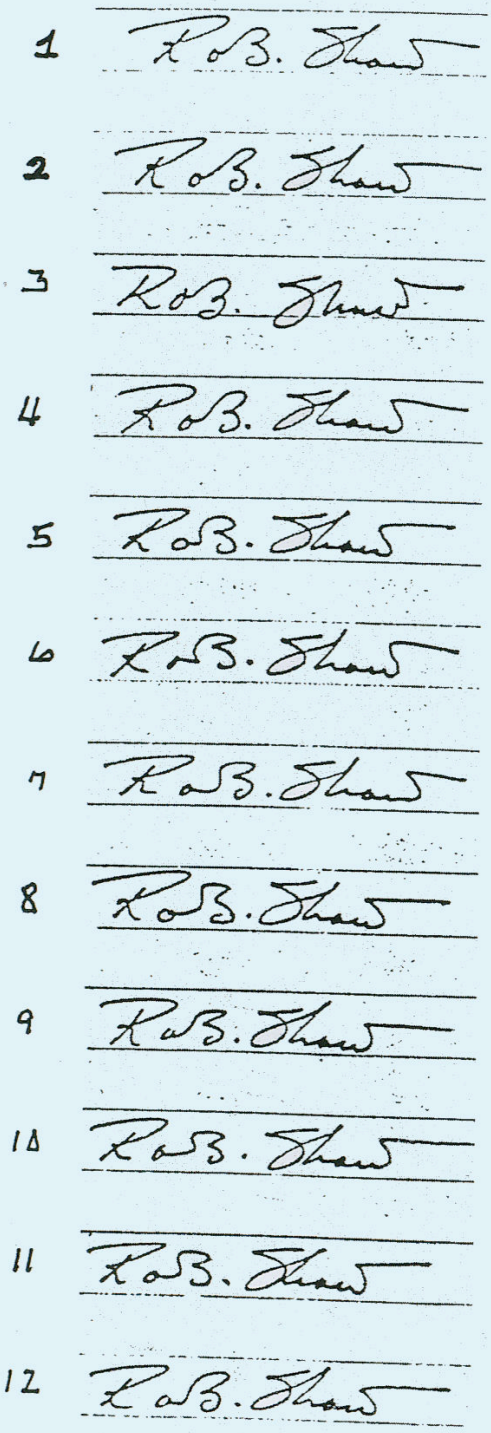
SECONDARY OBSERVATIONS: Answers will vary but should include more detail than in the first observation. Students should mention specifics, for example: A-L had an embellishment for the dot on the "I".

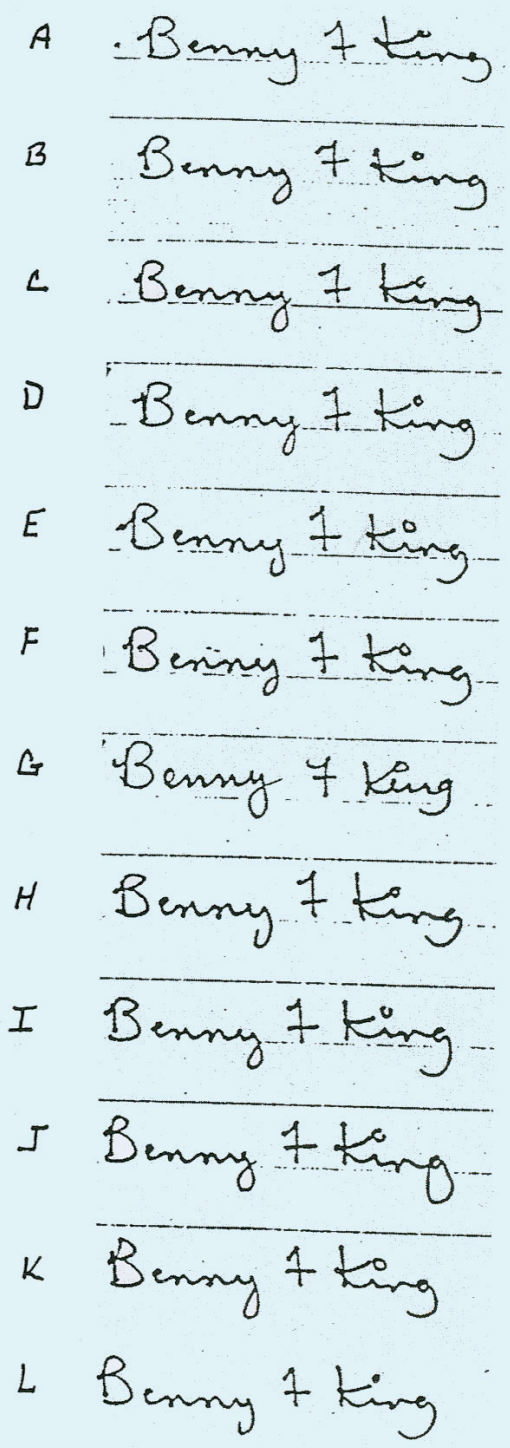
ANALYSIS: Answers will vary and may or may not be different from the initial hypothesis.

CONCLUSION: Answers key for the Freehand Simulation Forgery is included. #3 and G are the forgeries.

FREEHAND SIMULATION FORGERY

Eleven of the signatures in each row were prepared by the real person. One signature in each row is a forgery. Find the two forgeries and make note of the individual characteristics that don't fit that tipped you off.

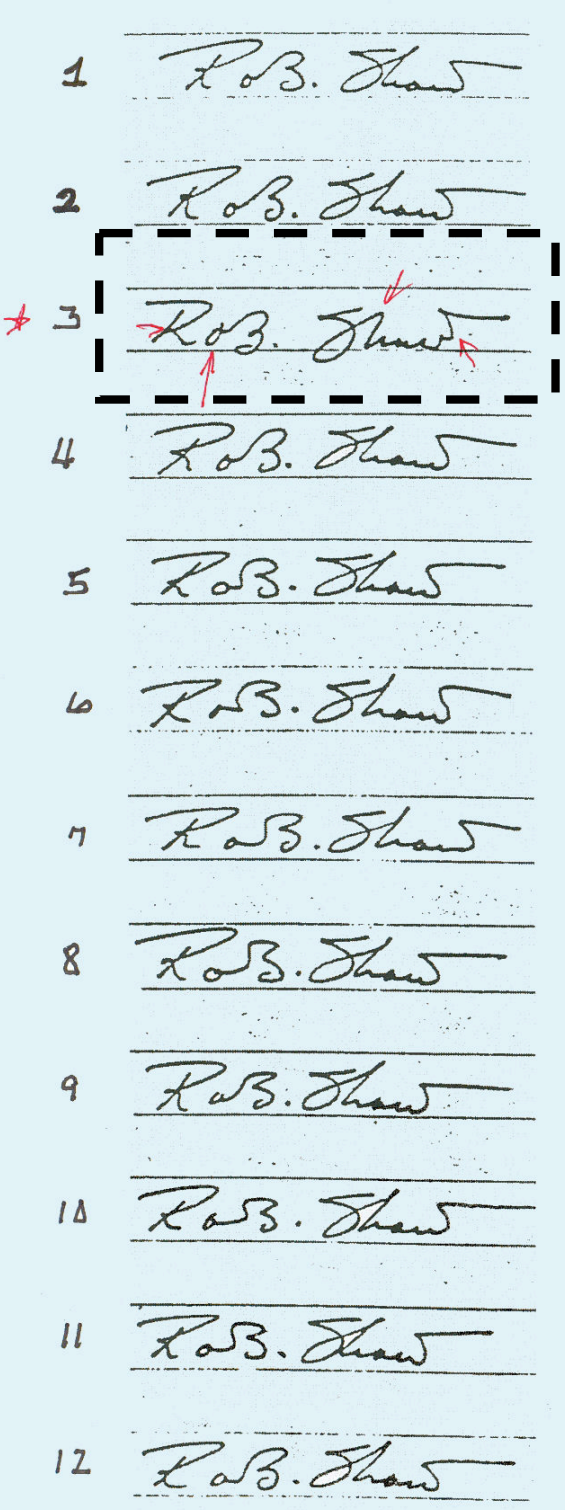


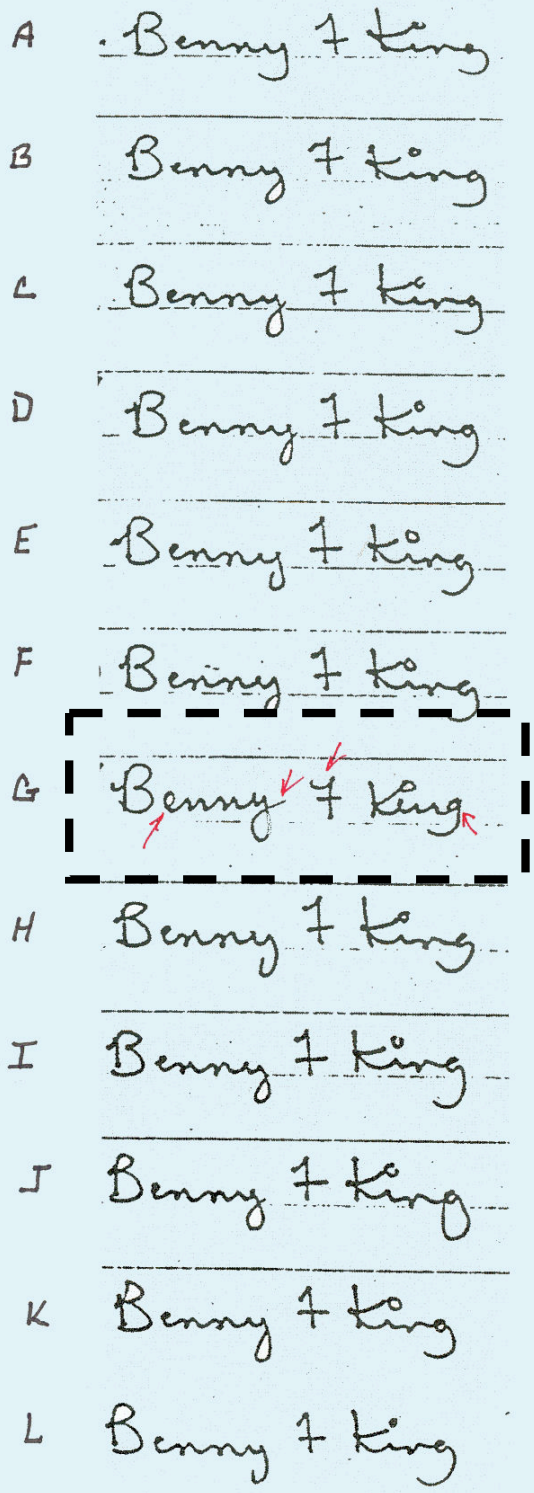


Answer Key

FREEHAND SIMULATION FORGERY

Eleven of the signatures in each row were prepared by the real person. One signature in each row is a forgery. Find the two forgeries and make note of the individual characteristics that don't fit that tipped you off.





Name _____ Date_____

Ink Analysis: A Microscopic View
Laboratory Activity

Purpose/ objectives: Students will:

- Use the scientific method to determine the differences and similarities between varying styles of pens.
- Use appropriate tools in scientific inquiry.
- Determine if the type of paper used has an effect on ink appearance.

Hypothesis: Examine the various samples of writings from 10 different pens used on 3 types of paper. Form a hypothesis as to which pen was used to write each sample. Give the evidence to support your prediction.

_____

_____

_____

_____

Materials:

- 3 different types of paper with 10 different numbered words written in blue and black ink
- 3 X magnifier or microscope
- 2 unmarked pens, 1 black 1 blue

Procedure, Part one:

1) You have 3 different pieces of paper. On each sheet there 10 numbered words written with 10 different pens.
2) Use the magnifier or microscope to examine each writing sample. Create a data table listing the characteristics of the sample indicating the differences and similarities of each.

Analysis:

Using the numbered samples, answer the following:

1) Which samples were written with the ball point? Give evidence.

_____

_____

2) What words were made with the gel? What caused that choice to be made?

_____

_____

3) The felt tip was used on which words? Why?

_____

_____

4) On which samples was the roller point used? Cite evidence.

_____

_____

5) Did the type of paper make a difference in the inks appearances? If yes, explain.

_____

_____

_____

Procedure, Part two:

1) Ask the instructor to check your analysis results. Reexamine any errors and correct mistakes.
2) Using the unmarked pens, write a word with each.

Black pen	Blue pen

3) Use the magnifier, or microscope and previous knowledge to determine what style of pen was used. Make your predictions below.

Black_____ **Blue**_____

Conclusion: Support your answers to number 3.

_____

_____

_____

Name _____ Date_____

Ink Analysis: A Microscopic View
Teacher Suggestions and Expected Results:
Prep time; 10-15 minutes to set-up materials
Lab time: 40-50 minutes

- Students will examine 10 different pens on 3 different papers to determine if there is a difference in the inks, and the surfaces used.
  - Students will examine 10 different pens:
    - Black ink: 2-ball point, 1-gel, 1-roller point, 1-felt tip
    - Blue ink: 2-ballpoint, 1-gel, 1-roller point, 1-felt tip
  - Each pen will be used on 3 different types of paper:
    - Card stock
    - Glossy photo printer
    - Copy paper
  - Instructor will number each pen, and its container.
  - On each sheet write the number of the pen and any random word.
  - Using the magnifier or microscope the student will examine each sample noting the similarities and differences.
  - Based on their observations students will predict the type of pen used, and cite the evidence for that decision.
  - Instructor will check each student's answers and have them reexamine those that are incorrect.
  - Using the 2 unmarked pens (black & blue) students will write a word, and determine what type of pen was used.
  - Use the overhead transparency to show the differences between the various pens.
  - Suggested pens:

BLACK
Pilot Precise roller ball
Pentel Energel gel
Pentel R.S.V.P ball point
Zebra Marathon gel roller ball
Paper Mate Flair felt tip
Paper Mate Write Bros ball point
BIC Velocity gel

BLUE
Pilot G2 gel
Paper Mate Write Bros ball point
BIC Round Stick ball point
Pilot Precise roller ball
Paper Mate Flair felt tip

Answer Key

Hypothesis: Answers will vary. Check for student explanations.
Data table: Answers will vary. Check student's notes. Notes should include observations on texture, ink density, stroke endings, stroke crossovers, ink penetration. Expected answers:

- Ball Point: low ink density, paper fibers are visible, not smooth, end strokes more tapered crossovers difficult to notice.
- Felt tip: moderate ink density, paper fibers filled in, smooth stroke endings, crossovers not visible, full ink penetration.
- Roller ball: similar to felt tip but with better ink penetration, thinner lines than felt tip, crossovers barely noticeable.

- Gel Pen: highest ink density, best ink penetration, rounded stroke endings, crossovers visible, somewhat of a metallic appearance.

Analysis: Answers will vary. Check for inaccuracies, and compare with your results.
Procedure 3: Answers will vary. Check with your results.
Conclusion: Answers will vary. Check for explanations.

Name _____ Date _____

Ink Analysis: Chromatography
Laboratory Activity

Purpose/Objectives: The student will…

- Discover the principles of chromatography.
- Make qualitative observations about the separation of ink pigments.
- Use retention factors to quantitatively recognize the differences in inks.
- Use chromatography to compare ink pigments.

Hypothesis: Are all inks of the same color the same? Is ink matter or a mixture? How can scientists differentiate between different inks? Answer the previous questions for your hypothesis. Be sure to elaborate and explain.

_____

_____

_____

_____

Materials:

- Black ink pens or markers
- 25 mL graduated cylinders
- 50 mL beaker
- Filter paper (cut into strips)
- Ethanol
- Deionized water
- Cling wrap (cut into small squares)
- Pipettes
- Forceps
- Ruler
- Pencil

Safety: Wear goggles for eye protection. Do not breathe the ethanol vapors. Do not use matches or burners around the ethanol. Dispose of the chemicals in the proper receptacle as designated by your instructor.

Procedure: Read this Procedure First. Then read the next section called Observations. You will need to "SET UP" your DATA TABLE before starting the lab.

1) Cut the filter paper into thin strips so that they will fit in the graduated cylinder.
2) Measure approximately 1-2 cm from the bottom of the filter paper and use the pencil to make a horizontal line. This is the origin line.
3) Using the black ink, make a single dot in the center of the origin.
4) In the graduated cylinder, add 2.5 mL of ethanol and 2.5 mL of water.
5) Use the forceps to gently place the filter paper strip into the graduated cylinder. The origin line should be at the bottom. Make sure the ink is not below the liquid line.
6) Cover the graduated cylinder with the cling wrap.
7) Wait approximately 15-30 minutes. Use the forceps to remove the filter paper and place on the laboratory countertop. Make observations.
8) Use the pencil to mark where the solvent front is located (near the top of the filter paper). Use the ruler to measure the distance between the origin and the solvent front. Record
9) Use the ruler to measure the distance between the origin and the center of each color pigment on the filter paper. Record

10) Repeat the procedure for each black pen.

Observations: On a separate sheet of paper, complete the following:

- Qualitatively, draw each strip of filter paper. Be sure to use colored pencils or markers and to label the writing utensil.
- Make a data table with the measurements of the distance between (a) origin and solvent front and (b) origin and center of the each colored pigment. Be sure to record the writing utensil. Repeat for each ink.

Analysis & Conclusions:

1) Using the following information and the data collected, calculate the retention factors (R_f) of each color pigment. Show your work on a separate sheet of paper. Be sure to label the type of pen and the color pigment.

$$R_f = \frac{\text{distance moved by color pigment}}{\text{distance moved by solvent front}}$$

2) Did each ink produce the same chromatography print? Elaborate.

_____

_____

_____

3) Do you think forensic document examiners could use chromatography to differentiate between inks? Explain.

_____

_____

_____

4) Revisit your hypothesis and comment on any changes. Make a statement about what you learned in this activity.

_____

_____

_____

Extension & Application

- Your job as a forensic laboratory technician is to analyze ink found on suspicious documents. You receive a ransom note in a high profile case. Use the following information and the knowledge gained from this laboratory activity to deduce which of the previous writing utensils could be responsible for making the note. This information will help detectives find the criminals!
- Since you work with the original document, you must strive to preserve the document in its original condition. Use scissors to cut a small portion of the ink, like from the dot from an "I" or a period. Place the cutting into a beaker with 2 mL of ethanol. Wait until the ink has bled into the ethanol. Then use a

pipette to extract a few drops of the ethanol/ink mixture. Place one drop on a strip of filter paper and then follow the remaining laboratory procedure.
- Write a short report on which ink could have been used to write the ransom note. Be sure to cite your data and give explanations.

Teachers Suggestions & Expected Results:
- Prep time: 10-15 minutes
- Activity time: 45-50 minutes
- Use black non-permanent markers for this activity. Vis-à-vis® works really well! However, Sharpies® does not work well, due to the bonding of the ink with the filter paper. Furthermore, regular black ink doesn't separate very well with this level of chromatography.
- Ethanol can be disposed of by pouring it down the drain with running water.
- For the extension and application, you will need to provide the students will a ransom note written in one of the black markers used in the laboratory activity. **NOTE:** "If you ever want to see your precious Chihuahua again, leave $1,000 in unmarked bills in the bowling alley locker #143 on Tuesday by 1:00 pm. Tell no one or the dog dies!"

ANSWER KEY

HYPOTHESIS: Answers will vary but may include that inks of the same color are not alike; ink is a mixture that can be physical separated into its constituent components; scientists use chromatography to separate inks and differentiate between inks.

OBSERVATIONS: Students should draw, color, and label the chromatography strips produced in the activity. Students should produce a data table that has the measurements of (a) origin to solvent front and (b) origin to center of EACH colored pigment.

ANALYSIS: Answers will vary but may include…
1) See student calculations for verification.
2) Each ink should have produced different chromatography strips because they are composed of different ink combinations.
3) Forensic document examiners can use chromatography to differentiate between inks because inks are mixtures and therefore inks are not made up of the same amounts or types of pigments. Forensic document examiners may use higher level/different types of chromatography to produce more differentiated results.
4) Answers will vary but should address their initial hypothesis and other information they gained during this experience.

Name _____ Date_____

Indented Writing
Laboratory Activity

Purpose/ objectives: Students will:

- Employ the scientific method.
- Utilize appropriate tools.
- Discover means of document preservation.

Problem: You are a detective examining the motel room of a bank robbery suspect. You discover a note pad by the telephone. You must find if there are any impressions of a previous note on the pad and what the message might be. You can not destroy or damage the document.

Materials per student:

- Note pad
- Magnifier
- Ball point pen
- Ruler
- Flashlight
- Quarter sheet of transparency film
- Mirror
- Iron filings

Procedure 1:

1) Using the note pad, write a bank robber's type of message (keep it school appropriate).
2) Remove the note and hide it until the appropriate time to reveal the actual message.
3) Pass the note pad to your lab partner to investigate.

Hypothesis: Examine your partner's note pad and the various materials available. Predict what item(s) will allow you to discover the indented writing. Then give reasons for making that choice.

_____

_____

_____

_____

Procedure 2:

1) Test your prediction.
2) Were you able to discover the message?

_____

3) If you were not able to read the message, reexamine the materials and form a new hypothesis to be tested. Test again.

_____

_____

_____

Name _____ Date_____

Conclusion:

4) Obtain the original note from your partner and, compare it with your pad. Does it match the original? Explain your answer.

_____

_____

_____

_____

5) Attach the original note to this sheet.

Name _____ Date_____

Ink Analysis: A Microscopic View

Teacher Suggestions and Expected Results:
Prep time; 10-15 minutes to set-up materials
Lab time: 40-50 minutes

- **Materials**
  - 10 Pens: 5-Black, 5-Blue
  - 3 different papers: glossy photo printer paper, card stock, copy paper
  - 3X magnifier or low power microscope
  - 2 unmarked pens: 1-black, 1-blue
- Students will examine 10 different pens on 3 different papers to determine if there is a difference in the inks, and the surfaces used.
- Students will examine 10 different pens:
  - Black ink: 2-ball point, 1-gel, 1-roller point, 1-felt tip
  - Blue ink: 2-ballpoint, 1-gel, 1-roller point, 1-felt tip
- Each pen will be used on 3 different types of paper:
  - Card stock
  - Glossy photo printer
  - Copy paper
- Instructor will number each pen, and its container.
- On each sheet write the number of the pen and any random word.
- Using the magnifier or microscope the student will examine each sample noting the similarities and differences.
- Based on their observations students will predict the type of pen used, and cite the evidence for that decision.
- Instructor will check each student's answers, and have them reexamine those that are incorrect.
- Using the 2 unmarked pens (black & blue) students will write a word, and determine what type of pen was used.
- Suggested pens:

BLACK
Pilot Precise roller ball
Pentel Energel gel
Pentel R.S.V.P ball point
Zebra Marathon gel roller ball
Paper Mate Flair felt tip
Paper Mate Write Bros ball point
BIC Velocity gel

BLUE
Pilot G2 gel
Paper Mate Write Bros ball point
BIC Round Stick ball point
Pilot Precise roller ball
Paper Mate Flair felt tip

Answer Key

Hypothesis: Answers will vary. Check for student explanations.

Data table: Answers will vary. Check student's notes.

Analysis: Answers will vary. Check for inaccuracies, and compare with your results.

Procedure 3: Answers will vary. Check with your results.

Conclusion: Answers will vary. Check for explanations.

Name _____ Date_____

Indented writing
Teacher Suggestions and Expected Results:

Prep time: 10 minutes
Lab time: 30-45 minutes
Materials

- Note pad
- Magnifier
- Ball point pen
- Ruler
- Iron filings
- Flashlight
- Quarter sheet of transparency film
- Mirror

- Students will examine the properties of the different materials for use in recovering the message. Then they will predict which item/material they believe will develop the words.
- They will explain why they chose that item.
- The students will then test their hypothesis. If it did not recover the note they will revaluate the materials, and form a new hypothesis.
- Students will conclude by attaching the actual note to their answer sheet.

Answer key

Hypothesis: Answers will vary, depending on item selected. Check for student explanations.

Conclusion: Answers should match the original note.

Name _____ Date_____