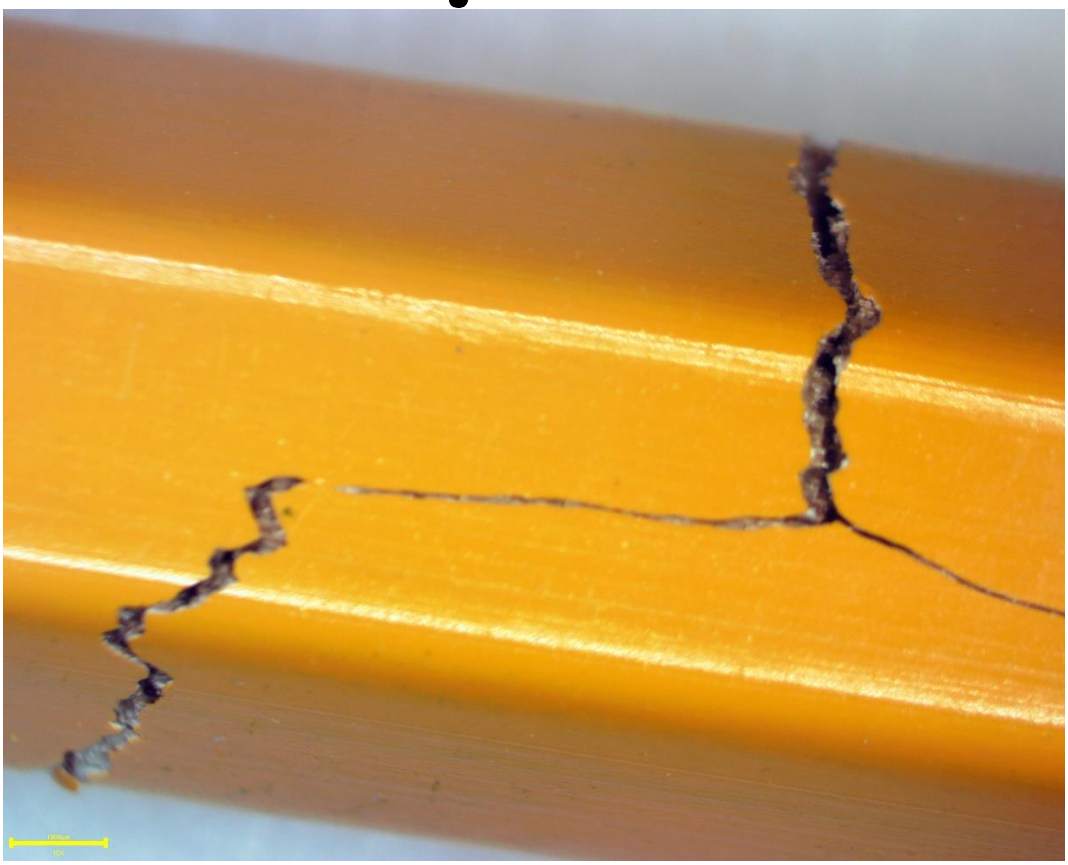
Washington State Patrol



Crime Laboratory Division

Materials Analysis
Physical Fit Training Manual

September 2023

TABLE OF CONTENTS

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This manual provides the outline for the Physical Fit training program. It is designed to provide the trainee with the scientific, technical and other specialized knowledge, skill, and experience required to perform independent casework under the Physical Fit subdiscipline as laid out in the Materials Analysis Technical Procedures (MATP).

1.2 MANUAL ORGANIZATION

This training manual consists of two chapters. One chapter covers the classification and properties of the types of materials encountered in this type of analysis. The other chapter covers the general casework aspects of this type of analysis.

Each chapter is organized into the following five parts:

- Objectives – a list of the goals for each chapter.
- Topic Areas – a list of subjects and vocabulary that will be covered during training
- Readings – the list of minimum required readings to complete the training.
- Study Questions – a series of questions to ensure comprehension and encourage discussion
- Practical Exercises – a set of hand-on activities to develop first-hand experience

1.3 QUALIFICATIONS

The trainee shall have successfully completed the Foundation Training Manual and the following chapters from the Instrument and Techniques Training Manual: Evidence Recovery, Imaging and Visualization, and Microscopy (Basic). A refresher of instruments and techniques may be considered if the trainee does not routinely use these techniques in the current authorized casework subdisciplines.

The trainer must be a qualified analyst in the Physical Fit subdiscipline. The trainer should have sufficient experience to cover the variety of possible evidence submissions, scenarios that are encountered, and courtroom testimony in the discipline. The trainer must have a thorough understanding of, and follow, the applicable subdiscipline procedures and the policies and procedures of the laboratory/division.

The trainer may delegate specific content to be taught by other instructors. Such instructors must have sufficient experience to cover the variety of possible evidence submissions and scenarios that are encountered in the area that they are going to instruct and a thorough understanding of the applicable procedures and policies of those topics. The technical lead shall approve the qualifications of any instructors.

1.4 TRAINING PLAN

A training plan will be developed and approved as outlined in the QOM.

Trainees who demonstrate prior related training and experience may be able to progress through the training program at an accelerated pace or skip certain content based on an evaluation of the trainee. Adjustment of the training plan based upon the trainee's prior related training and/or experience will be left to the technical lead in consultation with the trainer and trainee's supervisor.

The trainee will maintain a notebook (and/or digital equivalent) throughout the duration of the training program and will record notes and observations for each study segment, including answers to study/discussion questions/exercises and documentation of completion of practical and competency

exercises. The training notebook should be maintained in a neat, organized, and up to date fashion during training. The training notebook shall be available for review upon request.

The trainee is encouraged to take outside courses in Physical Fit analysis when possible. Notes from such external training events shall be kept as part of the training records.

The trainer should create a learning environment that serves to continuously improve the subdiscipline. Such resources shall include, when feasible, the following:

- Knowledge of all applicable laboratory policies and procedures regarding this discipline
- Training and reference materials available internally and externally
- Organizations and courses that facilitate professional development
- Participation in research, local organization, give a poster presentation, etc.
- Participation in training events for other colleagues, law enforcement partners, etc.

The trainer will continuously evaluate the trainee throughout the training for the trainee's comprehension and competency in their knowledge, practical skills, and critical thinking skills. Training is progressive and continuously builds on and reinforces prior learning. Unacceptable training progress may occur during the course of the training. It is important that any such instances be openly and promptly addressed among the trainee, the trainer, the technical lead, and/or the trainee's supervisor, as appropriate. An appropriate course of action should be developed and implemented to move training progress back to acceptable status.

1.5 TRAINING KITS

Training kits have been created for all of the practical exercises and the mock casework. The technical lead will disperse the kits as needed for training.

1.6 TRAINING COMPLETION

In order to successfully complete this training program, the trainee must, after completion of all subject areas required based on the training plan, successfully complete a closed book written exam passed with 80%, a competency exam passed with a pass/fail, and an oral testimony exam with a pass/fail. The content of these exams will be overseen by the technical lead in consultation with the trainer and the trainee's supervisor. The competency exam will take the form of a mock case, which will include a draft report. The oral testimony exam may be either a full moot court or an oral examination of testimony type questions.

The completion of these steps will be documented on a training checklist worksheet that covers the dates completed and the trainers and/or instructors for the content and the exams. An example of a training checklist worksheet is provided at the end of this manual. Electronic versions may be developed and adapted as needed.

Upon satisfactory completion of the above exams, the trainee will be signed off to perform casework in accordance with the QOM. Supervised casework is optional and dependent on the trainee's repertoire of subdisciplines as well as performance on mock casework. The number of supervised case requests shall be determined by the technical lead in consultation with the trainer and the trainee's supervisor. Final approval for independent casework, technical review, and for conducting verifications will be determined by the technical lead in consultation with the trainer and the trainee's supervisor.

1.7 TRAINING RECORDS

Training records, including training IOCs and authorizations, will be maintained in accordance with the QOM. Individual scientists are strongly encouraged to maintain copies of their own training records and their training notebook(s).

1.8 QUALITY ASSURANCE

This training manual, including related umbrella documents where applicable, complies with the following external document:

- OSAC 2022-S-0015 (Registry Version) Standard Guide for Forensic Physical Fit Examination, OSAC Proposed Standard sent to ASTM for further development and publication (https://www.nist.gov/organization-scientific-area-committees-forensic-science/osac-registry).

1.9 SAFETY

Good chemical safety practices shall be employed.

Rigid and/or brittle materials may have sharp edges. They shall be handled with caution.

UV light can damage the eyes. Use UV blocking eye protection when working with UV light.

2 OVERVIEW OF PHYSICAL FIT AND MATERIALS

2.1 OBJECTIVES

- To familiarize the trainee with characteristics of different types of materials that may be submitted as evidence for physical fit analysis.
- To understand and articulate why some objects are not suitable for physical fit analysis.
- To familiarize the trainee with some of the possible classifications of different types of materials that may be submitted as evidence for physical fit analysis.
- To practice several methods which can be used to document a physical fit.

2.2 TOPIC AREAS

GENERAL

1. Physical Fit Terminology
    a. Individual characteristics
    b. Class characteristics
    c. Exclusionary differences
    d. Fractography
    e. Physical Fit Analysis
    f. Verification
2. Materials Terminology
    a. Classifications
        i. Glass
        ii. Metal
        iii. Skeletal Material
        iv. Synthetic Polymers
        v. Tape
        vi. Textiles
        vii. Wood and Paper
    b. How it's Made
        i. Manufacturing
        ii. Biology
    c. Separation Methods
        i. Direct
        ii. Indirect
    d. Relevant Features

GLASS

3. Types (based on end use)
    a. Container (e.g. bottles, jars)
    b. Flat (e.g. windows)
        i. Tempered
        ii. Non-tempered
    c. Laminated safety glass
4. Manufacturing (glass-forming processes)
    a. Blowing
    b. Casting (molding)
    c. Flat glass
        i. Float method
        ii. Rolled method

5. Separation
    a. Deform elastically until onset of cracking
    b. Fractures grow from origin of impact
    c. Crack development factors
        i. Glass type
        ii. Loading pressure
        iii. Impact type (i.e. high velocity, low velocity, thermal)
        iv. Humidity
6. Relevant Features
    a. “Click-Fit”
    b. Coatings
    c. Color
    d. Curvature
    e. Fluorescence face (i.e. surface)
    f. Hackle
    g. Mirror
    h. Mist
    i. Scratches
    j. Thickness
    k. Wallner lines

METAL

7. Types
    a. Single element
    b. Alloys
8. Manufacturing (Metal Fabrication Techniques)
    a. Forming
        i. Forging
        ii. Rolling
        iii. Extrusion
        iv. Drawing
    b. Casting
        i. Sand Casting
        ii. Die Casting
    c. Welding
9. Separation
    a. Broken
    b. Brittle
    c. Tool cut
10. Relevant Features
    a. Striations
    b. Coatings

SKELETAL MATERIAL

11. Types
    a. Bones
    b. Teeth
    c. Horns
    d. Antlers
    e. Shells
12. Biology
    a. Cartilage
    b. Dry bone (post-mortem)
    c. Endoskeletons

d. Exoskeletons
e. Fresh bone

13. Separation
    a. Low velocity impact
        i. Fresh bone
        ii. Dry bone
    b. High velocity impact
        i. Fresh bone
        ii. Dry bone
14. Relevant Features
    a. External compact bone patterns
    b. Internal trabecular bone patterns

SYNTHETIC POLYMERS

15. Rigid
    a. Types
        i. Rigid plastics (e.g. vehicle car parts)
        ii. Automotive paint chips
        iii. Closed-cell foams
    b. Separation
        i. Typically brittle fracture
        ii. Sources
    c. Relevant features
        i. Color
        ii. Contour
        iii. Curvature
        iv. Hackle marks
        v. Layer structure (including substrate when present)
        vi. Pre-existing scratches or cracks across the separation boundary
        vii. Surface Designs
        viii. Surface irregularities
        ix. Texture
        x. Three-dimensional structure
16. Flexible
    a. Types
        i. Plastic bags (e.g. garbage bags, sandwich bags)
        ii. Flexible plastic films (e.g. cling wrap, plastic packaging)
        iii. Some architectural paints
        iv. Open-cell foams
    b. Separation
        i. Typically ductile fracture
        ii. Tool cuts
    c. Relevant Features
        i. Class marks (e.g. striations, pigment bands, and interference colored bands)
        ii. Color
        iii. Construction (if applicable)
        iv. Contour
        v. Individual marks (e.g. fisheyes, arrowheads, streaks, tiger stripes, surface scratches)
        vi. Perforation pattern
        vii. Print
        viii. Size
        ix. Surface designs
        x. Surface irregularities
        xi. Texture

TAPE

17. Types (based on end-use)
    a. Duct
    b. Masking
    c. Office
    d. Packaging
    e. Strapping
18. Manufacturing Processes
    a. Single coated
    b. Double coated
    c. Reinforced
    d. Unsupported
19. Separation
    a. Tearing
    b. Cutting
    c. High impact event (e.g. explosion)
20. Relevant Features
    a. Calendering marks
    b. Color
    c. Construction features – including layers
    d. External marks or debris
    e. Fluorescence
    f. Lettering
    g. Luster (i.e. degree of gloss)
    h. Orientation
    i. Scrim weave and protruding fibers
    j. Shape
    k. Surface irregularities
    l. Surface textures
    m. Torn edge appearance (e.g. straight, angles, wavy, or patterned edges)

TEXTILES

21. Types (based on construction method)
    a. Fabrics
        i. Knit
        ii. Woven
        iii. Non-woven
    b. Cordage
        i. Twisted (laid) rope
        ii. Braided rope
    c. Carpet
        i. Yarns
        ii. Backing
        iii. Adhesive
22. Separation
    a. Cut
    b. Torn
23. Relevant Features
    a. Color
    b. Construction
    c. Damage (e.g. cut, torn)
    d. Patterns
    e. Selvedges
    f. Shape (e.g. round rug)
    g. Size

h. Stains
i. Stitched edges
j. Surface designs (e.g. screen printing)
k. Unusual stretching or contours
l. Yarn and fiber characteristics

WOOD AND PAPER

24. Wood and Paper Products (based on use)
    a. Common lumber (e.g. 2x4, 2x6)
    b. Specialty lumber (e.g. quarter sawn, veneer, burl)
    c. Engineered Wood (e.g. plywood, oriented strand board, laminate flooring)
    d. Copy paper
    e. Specialty papers
25. Separation Methods
    a. Broken
    b. Cut
    c. Sawn
    d. Torn
26. Relevant Features
    a. Coating (e.g. stained, painted)
    b. Color
    c. Fiber direction
    d. Grain orientation
    e. Growth rings
    f. Printing
    g. Ray Fleck
    h. Rays
    i. Relative location of heartwood and sapwood
    j. Wood knots

2.3 READINGS

GENERAL

1. Current Physical Fit chapter from the Materials Analysis Technical Procedures (MATP).
2. OSAC 2022-S-0015 (Registry Version) Standard Guide for Forensic Physical Fit Examination, OSAC Proposed Standard sent to ASTM for further development and publication (https://www.nist.gov/organization-scientific-area-committees-forensic-science/osac-registry).
3. Brooks E, Prusinowski M, Gross S, and Trejos T **(2020)** "Forensic physical fits in the trace evidence discipline: A review" *Forensic Science International* 313: article 110349.
4. Callister WD **(2007)** *Materials Science and Engineering – An Introduction, 7th Edition*, John Wiley & Sons, Inc. [Read sections 1.4 Classification of Materials (chapter 1, pp 5-11), 8.2 Fundamentals of Fracture (chapter 8, pp 208-209), 8.3 Ductile Fracture (chapter 8, pp 209-211), and 8.4 Brittle Fracture (chapter 8, pp 211-215)].
5. Katterwe HW **(2005)** "Fracture matching and repetitive experiments: a contribution of validation" *AFTE Journal* 37(3): 229–241.

GLASS

6. Baca AC, Thornton JI, and Tulleners FA **(2016)** "Determination of fracture patterns in glass and glassy polymers" *Journal of Forensic Sciences* 61(S1): S92-S101.

7. Copley GJ **(2001)** "The composition and manufacture of glass and its domestic and industrial applications" in Brian Caddy (Ed.) *Forensic Examination of Glass and Paint* (chapter 2, pp 27-46) London, UK: Taylor & Francis.
8. Hamer PS **(2001)** "Microscopic techniques for glass examination" in B Caddy (Ed.) *Forensic Examination of Glass and Paint* (chapter 3, pp 47-64) London, UK: Taylor & Francis [Read sections 3.1 Introduction (pp 47-49), 3.3 Surface Examination (pp 50-51), and 3.4 Surface Luminescence (pp 51-52)].
9. Koons RD, Buscaglia J, Bottrell M, and Miller ET **(2002)** "Forensic glass comparisons" in R Saferstein (Ed.) *Forensic Science Handbook, Volume 1, 2nd Edition* (chapter 4, pp 161-213) Englewood Cliffs, NJ: Prentice Hall [Read subsections Glass Products (pp 169-173), Glass Fractures (pp173-177), The Mechanical Fit (pp 179-180), Identification of Glass (pp 180-181), Color (pp 181-182), Surface Features (p 182), Flatness (pp 182-183), and Fluorescence (pp 184-185)].
10. Quinn GD **(2020)** *Fractography of Ceramics and Glasses*, NIST Special Publication 960-16e3, September 2020 [Read chapter 5, focus on the basic terminology, ignore the processes and math].
11. Thornton JI **(2001)** "Interpretation of physical aspects of glass evidence" in Brian Caddy (Ed.) *Forensic Examination of Glass and Paint* (chapter 6, pp 97-122) London, UK: Taylor & Francis.

METAL

12. Callister WD **(2007)** *Materials Science and Engineering – An Introduction, 7th Edition*, John Wiley & Sons, Inc. [Read section Fabrication of Metals (chapter 11, pp 382-387)].
13. Finkelstein N, Volkov N, Novoselsky Y, and Tsach T **(2015)** "A physical match of a metallic chip found on a bold cutters' blade" *Journal of Forensic Sciences* 60(3): 787-789.
14. Garcia Y **(2012)** "A fracture match in a police-involved shooting investigation" *AFTE Journal* 44(2): 182-183.
15. Karim G **(2004)** "A pattern-fit identification of severed exhaust tailpipe sections in a homicide case" *AFTE Journal* 36(1): 65-66.
16. McKinstry EA **(1998)** "Fracture match – A case study" *AFTE Journal* 30(2): 343-344.
17. Ogle RR and Mitosinka GT **(1974)** "The identification of cut multistranded wires" *Journal of Forensic Sciences* 19(4): 865-867.
18. Streine KM **(2010)** "Striated marks encountered while attempting a physical fracture match" *AFTE Journal* 42(3): 293-294.

SKELETAL MATERIAL

19. Collings AJ and Brown K **(2020)** "Reconstruction and physical fit analysis of fragmented skeletal remains using 3D imaging and printing" *Forensic Science International: Reports* 2: article 100114.
20. Langley L **(2021)** "Why animals developed four types of skeletons" electronically downloaded on 28Aug2023 from National Geographic at https://www.nationalgeographic.com/animals/article/why-animals-developed-four-types-of-skeletons.
21. Steadman DW **(2003)** "Introducing forensic anthropology" in DW Steadman (Ed.) *Hard Evidence: Case Studies in Forensic Anthropology* (chapter 1, pp 1-22) Englewood Cliffs, NJ: Prentice Hall [Read subsection A Foundation in Skeletal Biology (pp 3-4)].

SYNTHETIC POLYMERS

22. Castle DA, Gibbons B, and Hamer PS **(1994)** "Physical methods for examining and comparing transparent plastic bags and cling films" *Journal of the Forensic Science Society* 34(1): 61-68.
23. Callister WD **(2007)** *Materials Science and Engineering – An Introduction, 7th Edition*, John Wiley & Sons, Inc. [Read sections 14.9 Thermoplastic and Thermosetting Polymers (chapter 14, pp 506-507) and 15.5 Fracture of Polymers (chapter 15, pp 532-533)].
24. Ryland S and Houck MM **(2001)** "Only circumstantial evidence" in MM Houck (Ed.) *Mute Witnesses, Trace Evidence Analysis* (chapter 6, 117-137) San Diego, CA; Academic Press.
25. Pierce DS **(1990)** "Identifiable markings on plastics" *Journal of Forensic Identification* 40(2): 51-59.
26. Van Hoven HA and Fraysier HD **(1983)** "The matching of automotive paint chips by surface striation alignment" *Journal of Forensic Sciences* 28(2): 463-467.
27. Von Bremen UG and Blunt LKR **(1983)** "Physical comparison of plastic garbage bags and sandwich bags" *Journal of Forensic Sciences* 28(3):644-654.
28. Zugibe FT and Costello JT **(1986)** "The jigsaw puzzle identification of a hit and run automobile" *Journal of Forensics Sciences* 31(1): 329-332.

TAPE

29. Berry **(2003)** "Tapes Manufacturing" electronically downloaded on August 29, 2023 from https://www.berryglobal.com/en/capabilities/capability-item/tapes-manufacturing.
30. Can-Do National Tape **(2023)** "Tape 101" electronically downloaded on August 29, 2023 from https://www.can-dotape.com/adhesive-tape-consultant/tape-101/.
31. Pressure Sensitive Tape Council **(2023)** "Why tape?" electronically downloaded on August 2, 2023 from https://pstc.org/why-tape/.
32. Prusinowski M, Andrews Z, Neumann C, and Trejos Tatiana **(2023)** "Assessing significant factors that can influence physical fit examinations – Part I. Physical fits of torn and cut duct tapes" *Forensic Science International* 343: article 111567.
33. Smith JM **(2007)** "Forensic examination of pressure sensitive tape" in RD Blackledge (Ed.) *Forensic Analysis on the Cutting Edge* (chapter 12, pp 291-332) Hoboken, NY: John Wiley & Sons, Inc. [Read sections 12.1-12.9, 12.10 intro, 12.10.1-12.10.3]
34. Weimar B **(2008)** "Physical match examinations of adhesive PVC-tapes: improvement of the conclusiveness by heat treatment" *AFTE Journal* 40(3): 300–302.

TEXTILES

35. Laux DL **(1984)** "Identification of a rope by means of a physical match between the cut ends" *Journal of Forensic Sciences* 29(4):1246-1248.
36. McKenna HA, Hearle JWS, and O'Hear N **(2004)** *Handbook of Fibre Rope Technology*, Boca Raton, FL; Taylor and Francis Group, LLC – CRC [Read Chapter 3 Rope Structures (pp 75-100)].
37. Taupin JM and Cwiklik C **(2011)** *Scientific Protocols for Forensic Examination of Clothing*, Boca Raton, FL; Taylor and Francis Group, LLC – CRC [Read sections 3.7 Fabric (pp 24-28), 6.2 Damage Categories (pp 98-101), 6.5 Cuts (pp 105-108), 6.6 Tears (pp108-110), and 6.10 Physical Fit (p 114)].

38. Wiggins KG **(2018)** "Ropes and cordages" in J Robertson, C Roux, and KG Wiggins (Eds.) *Forensic Examination of Fibres, 3rd Edition* (chapter 3, pp 89-98) Boca Raton, FL; Taylor and Francis Group, LLC – CRC [Read sections 3.2 Terminology (p 90), 3.3 Structure of Rope (pp 90-91), 3.4 Sample Handling and Identification (p 91), 3.4.4 Markers and Colour Comparison (pp 95-96), and 3.4.5 Other Points of Comparison (p 96)].

WOOD AND PAPER

39. Dixon KC **(1983)** "Positive identification of torn matches with emphasis on crosscut and torn fiber comparisons" *Journal of Forensic Sciences* 28(2): 351-359.

40. Deskera **(2023)** "Paper Manufacturing: The Role of Additives" electronically downloaded on 20Aug2023 from https://www.deskera.com/blog/paper-manufacturing-the-role-of-additives/.

41. Deskera **(2023)** "Paper Manufacturing Process: How Paper is Made?" electronically downloaded on 20Aug2023 from https://www.deskera.com/blog/paper-manufacturing-process-how-paper-is-made/.

42. Funk HJ **(1968)** "Comparison of paper matches" *Journal of Forensic Sciences* 13(1): 137-143.

43. Gerhart FJ and Ward DC **(1986)** "Paper match comparisons by submersion" *Journal of Forensic Sciences* 31(4): 1450-1454.

44. Hathaway RA **(1994)** "Physical wood match of broken pool cue stick" *AFTE Journal* 26(3): 185–186.

45. Hoadley RB **(1990)** *Identifying Wood, Accurate Results with Simple Tools*, Newtown, CN: The Taunton Press, Inc. [Read "The Structure of Wood Plants: Gross Anatomical Features (chapter 2, pp 7-13).

46. Meier E **(2015)** *Wood! Identifying and Using Hundreds of Woods Worldwide*, The Wood Database [Read "Foundations: What is Wood" (chapter 1, pp 1-6) and "A Closer Look: Identifying Wood" (chapter 3, pp 15-24)].

47. Townshend DG **(1981)** "Examination of tree stumps" *AFTE Journal* 13 (4): 32–36.

2.4 STUDY QUESTIONS

GENERAL

1. Use the on-line OSAC Lexicon to define and give examples of the following terms:
   a. Class
   b. Class characteristic (interdisciplinary version)
   c. Classification (interdisciplinary version)
   d. Exclusionary difference
2. Use the OSAC 2022-S-0015 document to define and give examples of the following terms:
   a. Individual characteristics
   b. Fractography
   c. Physical fit
   d. Verification
3. What is the difference between a direct and an indirect physical fit? Give examples.
4. Explain the difference in material deformation between a ductile fracture and a brittle fracture.

GLASS

5. Define the following terms:
    a. Ceramic
    b. “Click-Fit”
    c. Frost lines
    d. Glass
    e. Hackle marks
    f. Wallner lines
6. Describe the different types of glass based on their manufacturing (end use).
7. What is the source of the fluorescence on flat glass?
8. What are the four factors that affect how glass may crack?
9. How can you distinguish a thermal fracture from an impact fracture in flat (i.e. not tempered) glass?

METAL

10. Define the following terms and include examples:
    a. Metal
    b. Metal alloy
    c. Metal fabrication
11. Briefly describe the major categories of metal fabrication techniques.
12. What is the difference between a tool mark exam and a physical fit exam?

SKELETAL MATERIAL

13. Define the following terms:
    a. Skeletal material
    b. External compact bone
    c. Internal trabecular bone
14. What is the difference between wet bone and dry bone, and provide an example of when each may be encountered in casework.
15. Give some examples of human and animal skeletal materials besides bones.

SYNTHETIC POLYMERS

16. Use the on-line OSAC Lexicon to define the term “plastic”.
17. Define synthetic polymers.
18. Give examples of “rigid” and “flexible” synthetic polymers.
19. What are some examples of non-synthetic polymers?
20. Give some examples of external factors that commonly cause fracture in rigid polymers?

TAPE

21. Use the on-line OSAC Lexicon to define and give examples of the following terms:
    a. Calendering (Trace Materials version)
    b. Calendering marks
    c. Pressure sensitive tape

22. What are the different types of pressure sensitive tape based on end use?
23. What is the difference between pressure sensitive tape and non-pressure sensitive tape? Give examples of non-pressure sensitive tapes.
24. Define MOPP and BOPP and explain their importance to physical fit analysis.
25. List different descriptive features of duct tape that can be used in side-by-side comparisons.

TEXTILES

26. Define textile and give examples.
27. What are the three types of fabrics based on construction?
28. What is the difference between laid and plaited rope?
29. What are marker yarns (aka house markers)?
30. How do you distinguish cut versus torn pieces of fabric?

WOOD AND PAPER

31. Define the following terms related to wood:
    a. Wood
    b. Grain
    c. Growth Rings
    d. Heartwood
    e. Knots
    f. Pores
    g. Ray Fleck
    h. Sapwood
32. Give examples of types of engineered wood products.

2.5 PRACTICAL EXERCISES

GENERAL

1. Assess each item of the provided materials for suitability for a physical fit analysis. Include class and individual characteristics, comments on separation method as appropriate, any limitations, and statement of suitability to attempt a physical fit analysis.

GLASS

2. Observe glass breakage – Flat Glass
    a. Take **safety precautions** not to cut yourself or send glass fragments flying (e.g. protective eyewear, worker gloves).
    b. Take a documentary image of a piece of flat glass (not tempered).
    c. Place a piece of flat glass between several layers of cloth or paper (old denim jeans work well). Break the glass with a hammer.
    d. Observe the broken pieces for mirror, mist, hackle marks, and Wallner lines. Depending on the size of the glass, you may need to work with a stereomicroscope.
    e. Slide the pieces against each other and notice the “click” fit that can be felt by your fingers/hand when the edges are aligned.
    f. Take notes and document your observations with imaging, and sketching if appropriate.

3. Observe glass fluorescence – Tempered Glass
    a. Take **safety precautions** not to damage your eyes when working with the UV light (e.g. UV specific protective eyewear).
    b. Observe the provided diced pieces of glass with short wave UV light on black paper in a dark room. Orient all of the provided diced pieces of glass with the fluorescent face up.
    c. Turn off the UV light and attempt to physically align the pieces.
    d. Observe the frost lines on the sides of the pieces under a stereomicroscope.
    e. Take notes and document your observations with imaging, and sketching if appropriate.
4. Observe mold marks in glass – Container Glass
    a. Take **safety precautions** not to cut yourself.
    b. Observe the provided broken pieces of a glass bottle for mold marks. Depending on the size of the glass, you may need to work with a stereomicroscope.
    c. Take notes and document your observations with imaging, and sketching if appropriate.

METAL

5. Watch the following videos.
    a. How Wrenches Are Made? (https://www.youtube.com/watch?app=desktop&v=WQucXJrKRDY)
    b. Pocket Knives – How It's Made (https://www.youtube.com/watch?v=VlRK0VNUccI)
    c. How Are Electrical Cable and Wires Made? (https://www.youtube.com/watch?v=rWO_Wvlqc_w)
6. You will be provided with a piece of wire that has pieces of tape evenly spaced across the length of the wire. Note that each piece of tape has a number and the different directions marked as A or B. Use a tool (e.g. wire clippers, tin snips) to cut the provided wire between each piece of tape. Compare known "matching" ends and known "non-matching" ends under a stereomicroscope. Is a single wire suitable for physical fit analysis (i.e. could you ever determine if a physical fit is present or not)? Take notes and document your observations with imaging, and sketching if appropriate.
7. Repeat the previous exercise with the provided cable of wires rather than the single wire. Are the wires in the cable suitable for physical fit analysis? Keep the cut pieces for the exercise in synthetic polymers, which will ask the same question only for the polymer portion of the cable.

SKELETAL MATERIAL

8. Watch the video "Forensic Anthropology: Assessing Damage" with, Sheila Nightingale (https://www.youtube.com/watch?v=6jhB2IwK9T4).

SYNTHETIC POLYMERS

9. Watch the following videos.
    a. How It Is Made – Plastic Bags (https://www.youtube.com/watch?v=Pp2RDu9fw6o)
    b. Car Headlights – How It's Made (https://www.youtube.com/watch?v=KoBfqvSZN7c)
10. Using the cable pieces from exercise 7 (Metals), compare the polymer portion of the known "corresponding" ends and known "non-corresponding" ends under a stereomicroscope. Are the polymer portions alone suitable for physical fit analysis (i.e. could you ever determine if a physical fit is present or not)? Take notes and document your observations with imaging, and sketching if appropriate.
11. Compare known "corresponding" ends and known "non-corresponding" ends of consecutive black garbage bags. Use a light box to observe the ends for die striations and pigment granules. Take notes and document your observations with imaging, and sketching if appropriate.

12. Compare known “corresponding” ends and known “non-corresponding” ends of consecutive clear bags or cling film. Use a light box and polarized sheets to observe the film orientation. Take notes and document your observations with imaging, and sketching if appropriate.
13. Group the different pieces of lens plastic by class characteristics. Take notes and document your observations with imaging, and sketching if appropriate.

TAPE

14. Watch the following videos.
    a. Adhesive Tape How It’s Made (https://www.youtube.com/watch?v=d9ykCVb9rKg)
    b. Why Is Duct Tape So Strong? (https://www.youtube.com/watch?v=yEMAVDYdj40)
15. Hand tear two pieces from each of the provided duct tape samples. Place each piece on a clean, large glass slide or on a piece of laser transparency film. Observe the samples for manufacturing characteristics visually and with a stereomicroscope. Include features from Figure 6 of Prusinowski et al, 2023. Take notes and document your observations with imaging.
16. Observe the different pieces of office tape on the provided envelope with short wave and long wave UV light. Take safety precautions not to damage your eyes when working with the UV light (e.g. UV specific protective eyewear). Take notes and document your observations with imaging.
17. Remove multiple consecutive pieces of office tape from each of two dispensers. Compare the edge contour from “corresponding” and “non-corresponding” ends. Are tape pieces cut with a dispenser suitable for a physical fit analysis?
18. Perform pairwise comparisons of the ends of each of the different pieces of provided packaging tape under cross pols using a stereomicroscope. Take notes and document your observations with imaging.

TEXTILES

19. Assess the provided fabric pieces for suitability to attempt a physical fit analysis. Include classification of the fabric construction, other class characteristics, and individual characteristics. Include conclusions if cut or torn where feasible. Take notes and document your observations with imaging, and sketching if appropriate.

WOOD AND PAPER

20. Watch the following videos:
    a. Frank Miller Lumber Quartersawing Process (https://www.youtube.com/watch?v=vbaXWmEiS98)
    b. What is QUARTER SAWN Lumber? (https://www.youtube.com/watch?v=U2GM_hZW1LA)
    c. How Paper Is Made (https://www.youtube.com/watch?v=WDE37DQ0GiA)
21. Examine the provided broken pool stick or broken broom. Prepare silicone cast (e.g. Mikrosil, Accutrans) and compare original surface to casted surface under stereo or with a firearms comparison microscope if possible. Take notes and document your observations with imaging, and sketching if appropriate.
22. Examine the provided pieces of sawn lumber pieces. Align the pieces based on wood grain. Take notes and document your observations with imaging, and sketching if appropriate.
23. Examine a shredded paper document and attempt to align the pieces. Take notes and document your observations with imaging, and sketching if appropriate.

3 EVIDENTIARY SIGNIFICANCE AND MOCK CASEWORK

3.1 OBJECTIVES

- The trainee will be able to understand and articulate why some objects do not lend themselves well to a physical fit.
- To review the various studies that support physical fit analyses.
- To develop an understanding of the significance and limitations of Physical Fit exams
- To demonstrate the ability to perform and document Physical Fit casework
- To ensure appropriate report writing and court testimony skills for Physical Fit casework

3.2 TOPIC AREAS

1. Assessment of Submitted Evidence
2. Technical Manual Requirements
3. Report Wording
4. Court Testimony

3.3 READINGS

1. Current Physical Fit chapter from the Materials Analysis Technical Procedures (MATP).
2. OSAC 2022-S-0015 (Registry Version) Standard Guide for Forensic Physical Fit Examination, OSAC Proposed Standard sent to ASTM for further development and publication (https://www.nist.gov/organization-scientific-area-committees-forensic-science/osac-registry).
3. Bradley MJ, Keagy RL, Gauntt JM, Mehltretter AH, Lowe PC, and Wright DM **(2011) "**A validation study for vinyl electrical tape end matches" *Journal of Forensic Sciences* 56(3): 606-611.
4. Bradley MJ, Keagy RL, Lowe PC, Rickenbach MP, Wright DM, and LeBeau MA **(2006)** "A validation study for duct tape end matches" *Journal of Forensic Sciences* 51(3): 504-508.
5. Christensen AM and Sylvester AD **(2008)** "Physical matches of bone, shell, and tooth fragments: A validation study" *Journal of Forensic Sciences* 53(3): 694-698.
6. Claytor LK and Davis AL **(2010)** "A validation of fracture matching through the microscopic examination of the fractured surfaces of hacksaw blades" *AFTE Journal* 42(4): 323-334.
7. McCabe KR, Tulleners FA, Braun JV, Currie G, and Gorecho EN **(2013)** "A quantitative analysis of torn and cut duct tape physical end matching" *Journal of Forensic Sciences* 58(S1): S34-S42.
8. Orench JA **(2005)** "A validation study of fracture matching metal specimens failed in tension" *AFTE Journal* 37(2): 142-149.
9. Prusinowski M, Brooks E, and Trejos Tatiana **(2020)** "Development and validation of a systematic approach for the quantitative assessment of the quality of duct tape physical fits" *Forensic Science International* 307: article 110103.
10. Prusinowski M, Brooks E, Neumann C, and Trejos Tatiana **(2023)** "Forensic interlaboratory evaluations of a systematic method for examining, documenting, and interpreting duct tape physical fits" *Forensic Chemistry* 34: article 100487.
11. Tsach T, Wiesner S, and Shor Y **(2007)** "Empirical proof of physical match: Systematic research with tensile machine" *Forensic Science International* 166: 77-83.

3.4 STUDY QUESTIONS

1. How many points of comparison, if any, are needed to call two juxtaposed items a physical fit?
2. How would you document a physical fit in your notes?
3. What conclusions may be reached from a physical fit analysis?
4. What information should be included in your notes?
5. What information should be included in a report?
6. Explain physical fit analysis to a jury.
7. Explain the scientific support (i.e. validation studies) for physical fit analysis to a jury.

3.5 PRACTICAL EXERCISES

1. Review at least 5 case files. A representative file from each analyst should be included in the mix. Note the wording of observations and the images taken. Note how the conclusion(s) and any verifications were documented.
2. Work at least 3 mock cases as if they were real cases, including following the Technical Manual requirements and preparation of a draft report. These cases should be realistic in the type of evidence submitted. At least one of the mock cases should include:
   a. A rigid material (e.g. rigid synthetic polymer, glass, metal, wood)
   b. A flexible material (e.g. flexible synthetic polymer, textile, tape)
   c. A material that was separated by a method that can be replicated (e.g. sawn pieces of lumber, office tape cut with the same dispenser)
   d. A comparison that results in a “physical fit” conclusion
   e. A comparison that results in a “no physical fit” conclusion
3. Perform at least 3 practice technical reviews. These reviews may be on copies of active case files prior to the actual case files undergoing technical review by a qualified analyst or on mock case files created for this exercise.
4. Discuss with your trainer and other analysts any unusual casework they have had. Document your conversation with notes.
5. Discuss with your trainer and other analysts any court testimony experiences they have had. Document your conversations with notes.
6. Observe court testimony if possible. Document your observations with notes.
7. Participate in an oral practice session to practice giving verbal answers to court type questions for this subdiscipline. Documentation will include a written list of questions asked provided by your trainer after the practice session.

4 PHYSICAL FIT TRAINING CHECKLIST

Trainer Name: **Trainee Name:**	Trainee Initials/Date	Trainer Initials/Date	Time for Completion
1. Introduction			
Materials on Isilon Drive			
2. Review of Materials			
Reading			
Study Questions			
Exercises			
3. Evidentiary Significance and Mock Casework			
Reading			
Study Questions			
Exercises			
Written Test			
Competency Exam			
Oral Testimony Exam			