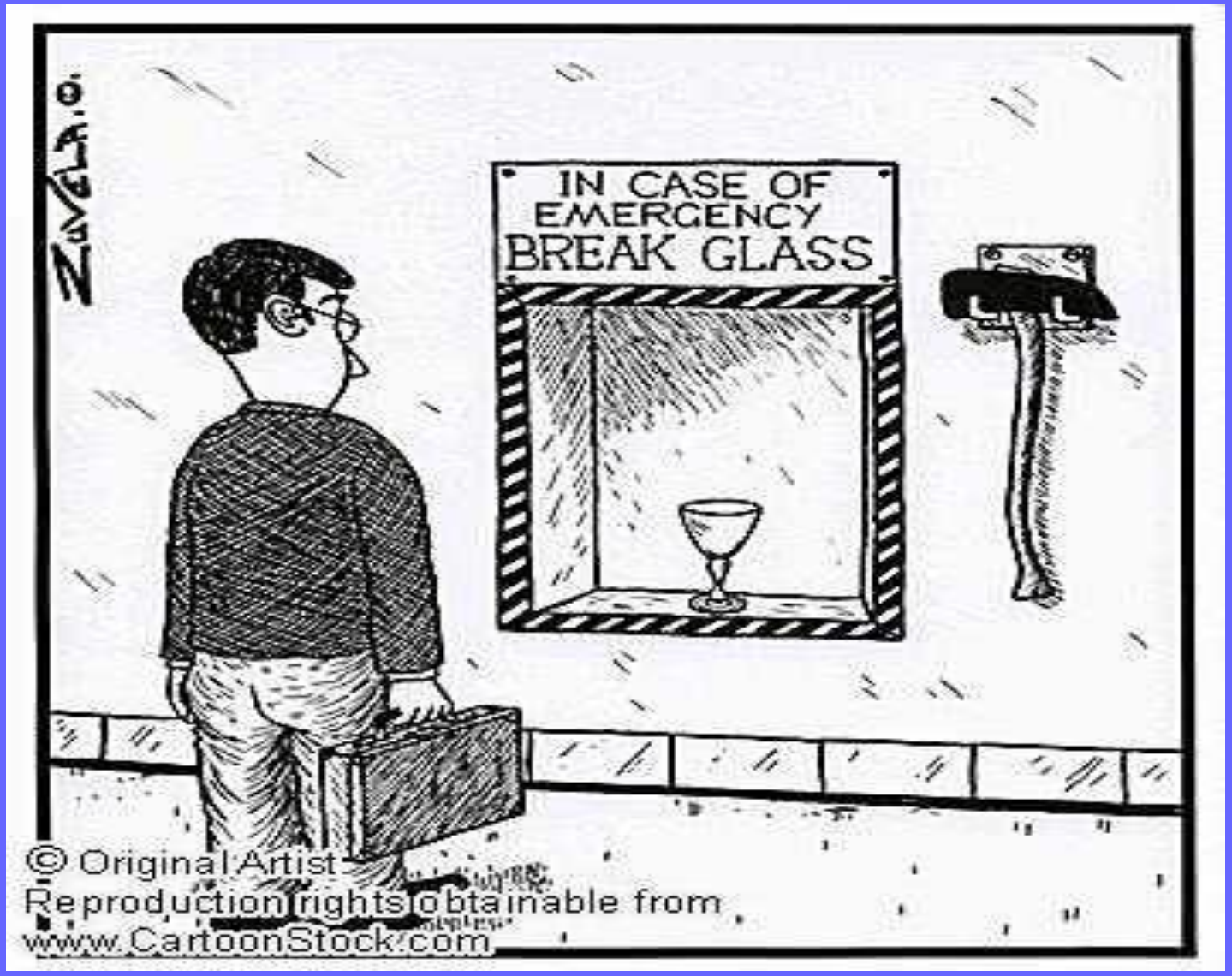
Forensic Analysis of Glass

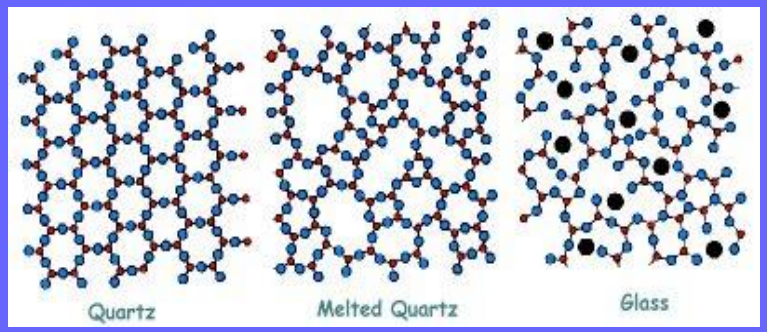
GLASS ANALYSIS



What is Glass?

GLASS ANALYSIS

- Fusion of sand (SiO_2), soda (Na_2CO_3) & lime (CaO) that produces a transparent solid when cooled.
- A 3D network of atoms which lacks the repeated, orderly arrangement typical of crystalline materials.



- Physical Properties: hard, elastic, brittle, non-conductor of electricity, density, refractive index, etc.
- Chemical: resistant to all but fluorine and very strong bases.

What Types of Glass Are There?

GLASS ANALYSIS

- The primary uses for glass are in windows, containers, light bulbs and eyewear.
- Borosilicate Glass (pyrex): 5% borax ($Na_2B_4O_7$) is added to resist breaking when heated or cooled.
- Colored Glass: metal oxides or colloidal iron (Fe) & sulfur (S) are added to change its color.
- Lead glass: Pb increases refractive index & density

What Types of Glass Are There?

GLASS ANALYSIS

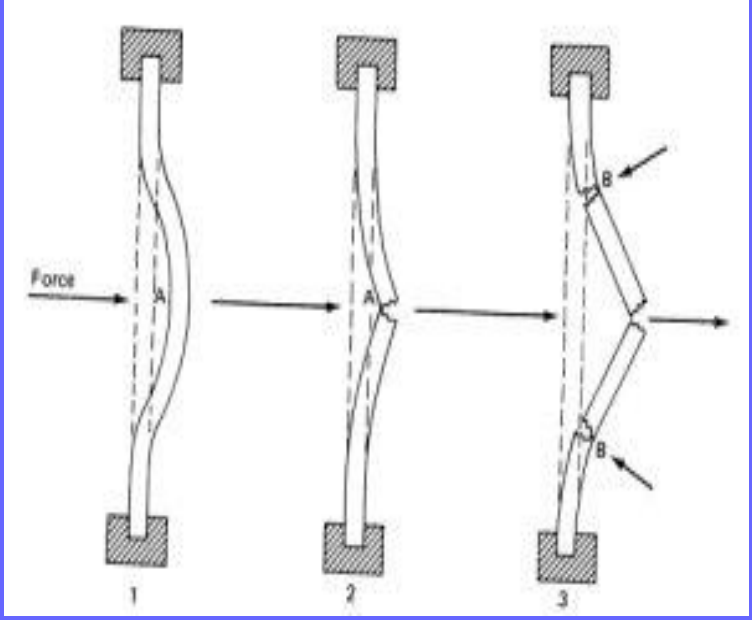
- Flat glass: made by a “float glass process”; molten glass is floated on a pool of tin while cooling. Commonly found in doors and windows.
- Laminated glass: used in windshields, two sheets of glass with plastic between them.
- Tempered safety glass: used in car side windows and designed to break into tiny pieces; potassium (K) replaces sodium (Na) on the surface.

How Do Glass Windows Break?

GLASS ANALYSIS

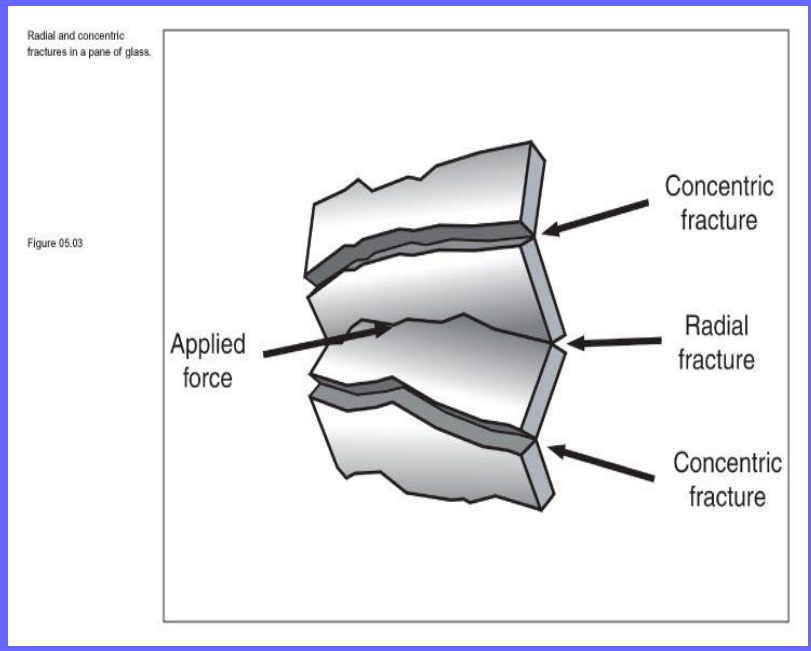
- Each force causes a deformation that may leave a visible mark or fracture the glass. This can be used to determine the direction and amount of force.

- Glass acts initially as an elastic surface and bends away when a force is applied. When the force increases beyond its tensile strength, it cracks.



How Does Glass Break?

GLASS ANALYSIS



- **Radial cracks form first and are propagated in short segments on the side opposite the force.**
- **Concentric cracks come later from continued pressure on the same side as the force applied.**

How Does Glass Break?

GLASS ANALYSIS

- Edges of broken pieces of glass will show rib (“stress”) marks.
- In a radial crack, the rib marks are perpendicular to unloaded side and parallel to loaded side. The arrow shows the side that received the impact.
- 3R rule:
  - Radial cracks give rib marks that make
  - Right angles on the
  - Reverse side from where the force was applied

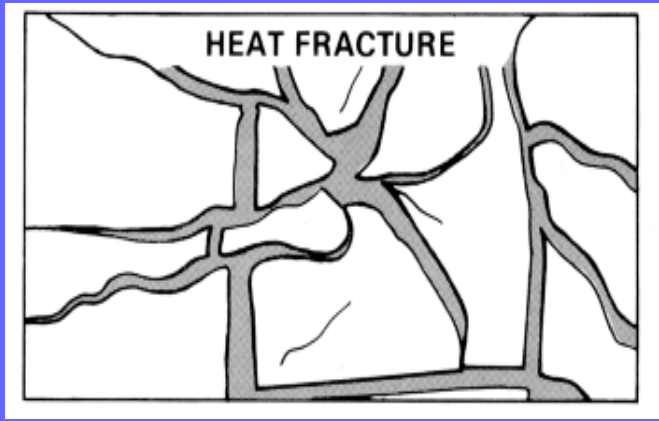
Exceptions To The Three R Rule

GLASS ANALYSIS

Tempered glass
- "dices" without forming ridges

Very small windows held tightly in frame
- can't bend or bulge appreciably

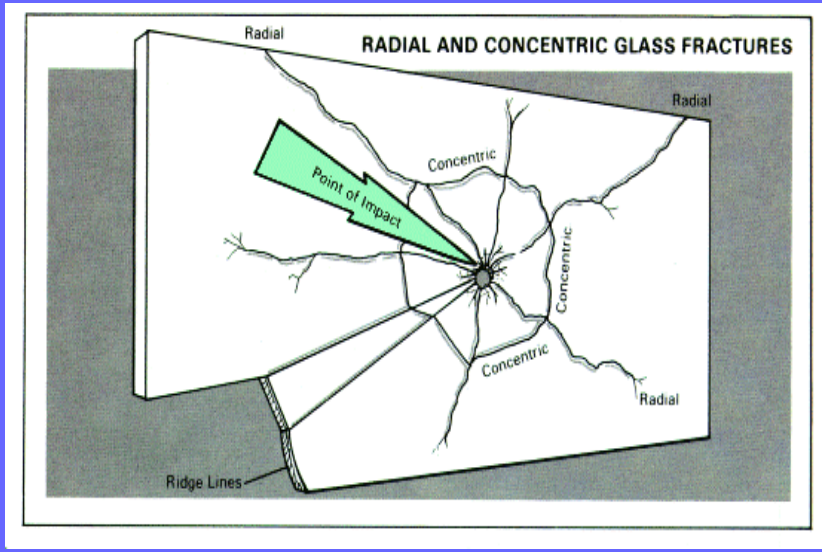
Windows broken by heat or explosion
- no "point of impact"
- curved, smooth edges at break points



Types of Fractures by Projectiles

GLASS ANALYSIS

- **Bullets are a projectile force (load) that can pass through glass.**
  - **Load side is the entrance side; unloaded side is the exit side.**
  - **Low-speed projectiles: rib marks may indicate where breaking force was applied**
  - **As the bullet's velocity increases, the central hole becomes smaller, cracking patterns become simpler, and the exit hole becomes wider than the entrance hole.**

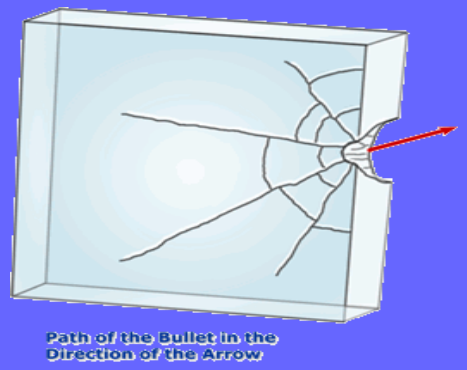


Fractures by Projectiles

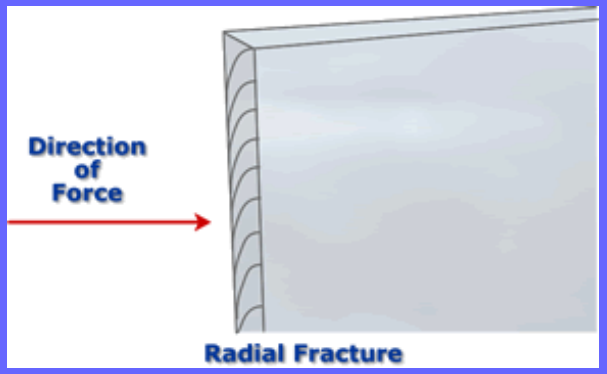
GLASS ANALYSIS

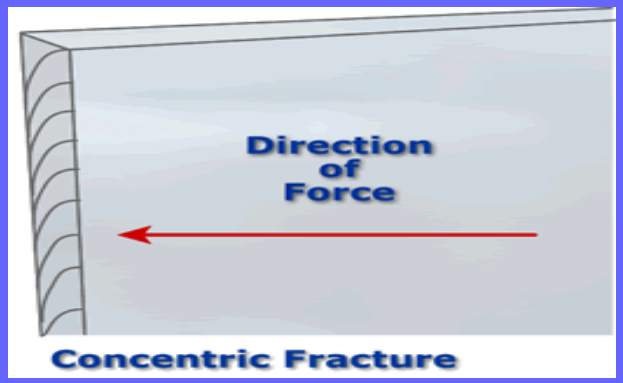
Which side was the bullet fired from?

Exit (unloaded) side is **wider** than entry (load) side.



- Stress lines on the glass edge of **radial** cracks form a **right** angle on the **reverse** side from the force.
- Stress lines on the glass edge of **concentric** cracks form a **right angle** on the **same side** as the force.

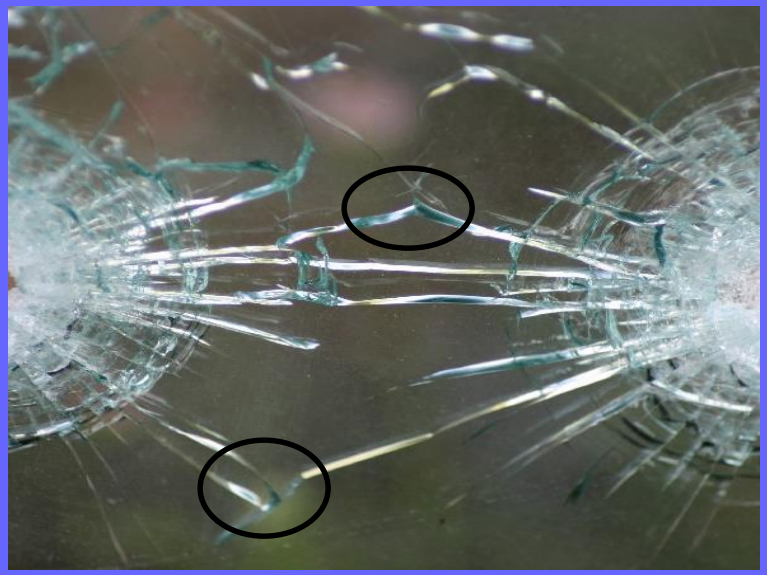




Which Bullet Hole Was First?

GLASS ANALYSIS

- The sequence of impacts can be determined since crack propagation is stopped by earlier cracks.



In the figure above, which impact occurred first?

Putting it Back Together Again?

GLASS ANALYSIS

- Examiners can fit together two or more pieces of glass that were broken from the same object.
- Because glass is amorphous, no two glass objects will break the same way.

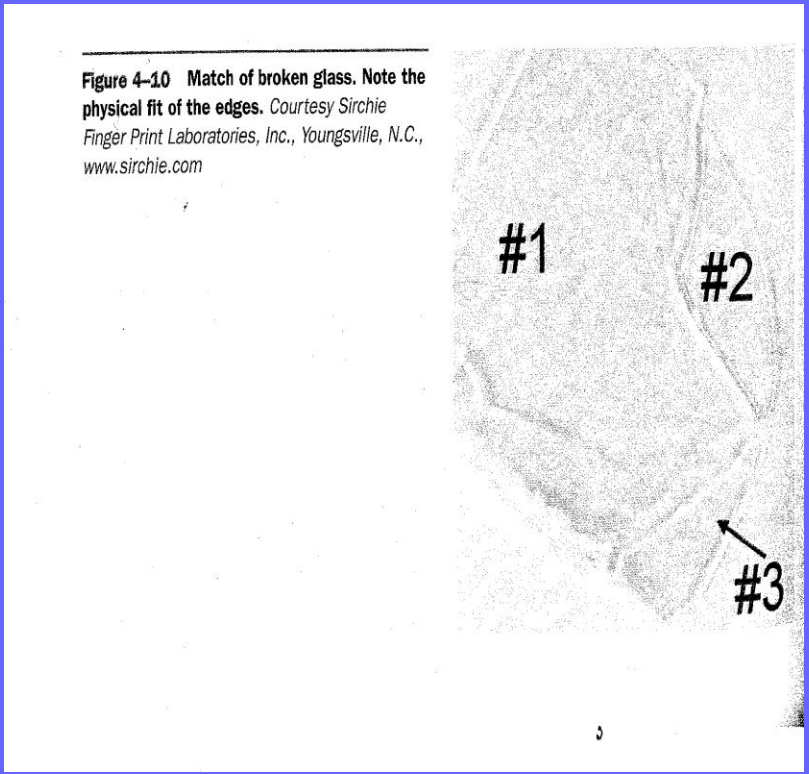
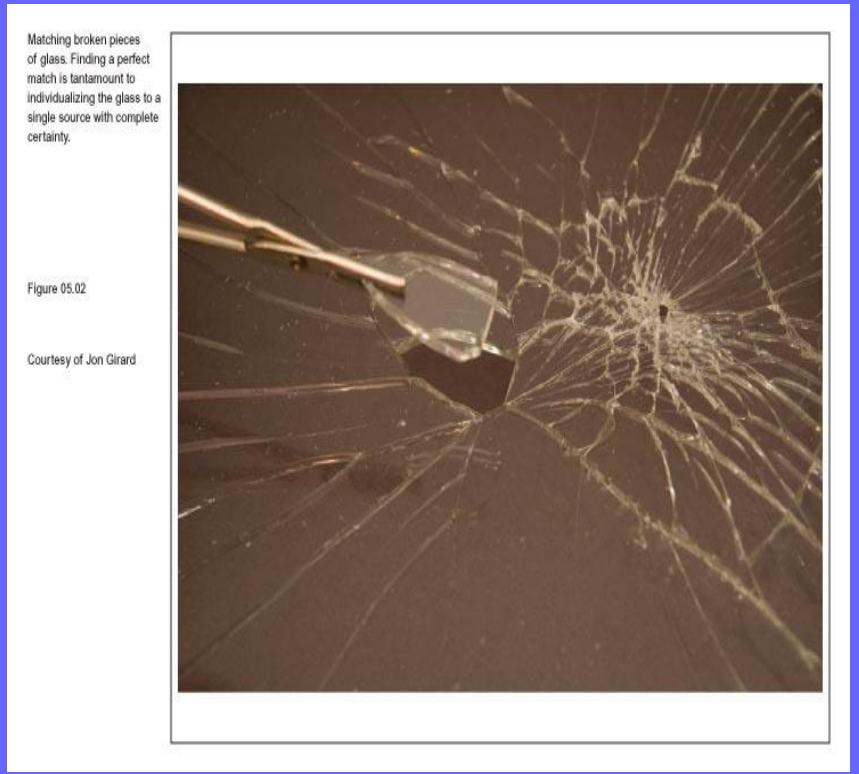


Figure 4–10 Match of broken glass. Note the physical fit of the edges. *Courtesy Sirchie Finger Print Laboratories, Inc., Youngsville, N.C., www.sirchie.com*



Matching broken pieces of glass. Finding a perfect match is tantamount to individualizing the glass to a single source with complete certainty.

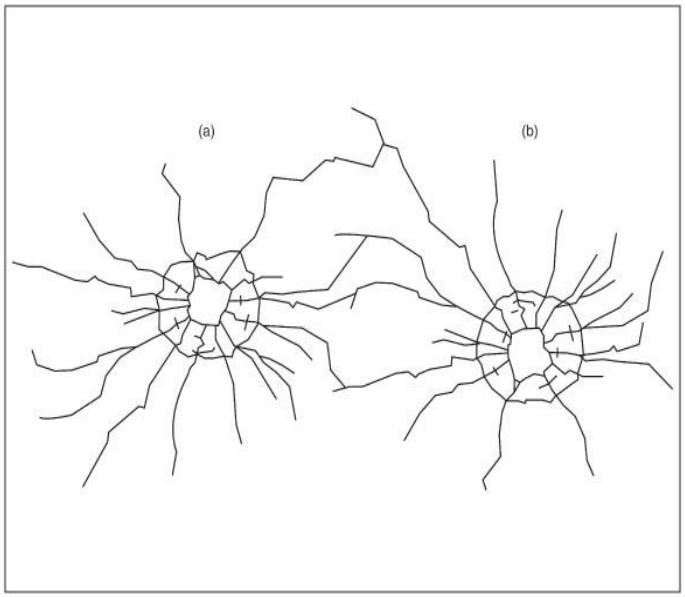
Figure 05.02

Courtesy of Jon Girard

Learning Check

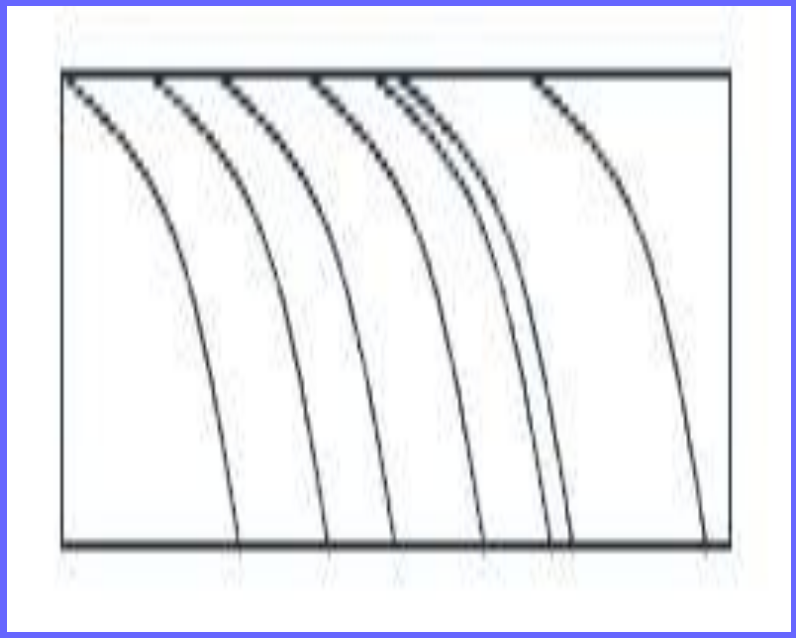
GLASS ANALYSIS

In the figure below & left, which impact occurred first?



Two bullet holes in a piece of glass. The formation of the left hole (a) preceded the formation of the right hole (b).

Figure 05.05



In the figure above & right, from which side did the impact occur?

Glass Transfer Evidence

GLASS ANALYSIS

- When glass objects are broken, glass flies backward from all parts of the object where cracks appear not just from point of impact.
- This creates a shower of minute glass particles and a transfer of evidence.
- Glass fragment comparison depends finding and measuring properties that will associate one glass fragment with another while eliminating other sources.

Collection of Glass Samples

GLASS ANALYSIS

- The glass fragments should be packaged in boxes to avoid further breakage.
- If evidence is to be examined for glass fragments, it should be taken whole and each item individually wrapped in paper and boxed.
- If even the remotest possibility exists that glass fragments may be pieced together, every effort must be made to collect all glass fragments.
- Submit glass evidence along with a representative sample of each type of glass from the crime scene.

Forensic Examination of Glass

GLASS ANALYSIS

- Goals in examining glass evidence:
  - Determine the types of glass at the scene
  - Determine how the glass was fractured
  - Use physical characteristics to classify it
  - Individualize the glass to a source

- Compare physical and chemical characteristics:
  - Optical properties: color and refractive index
  - Non-optical properties: surface wear, striations from manufacturing, thickness, surface film or dirt, hardness, density
  - Chemical properties: additives or trace elements

Optical Properties of Glass

GLASS ANALYSIS

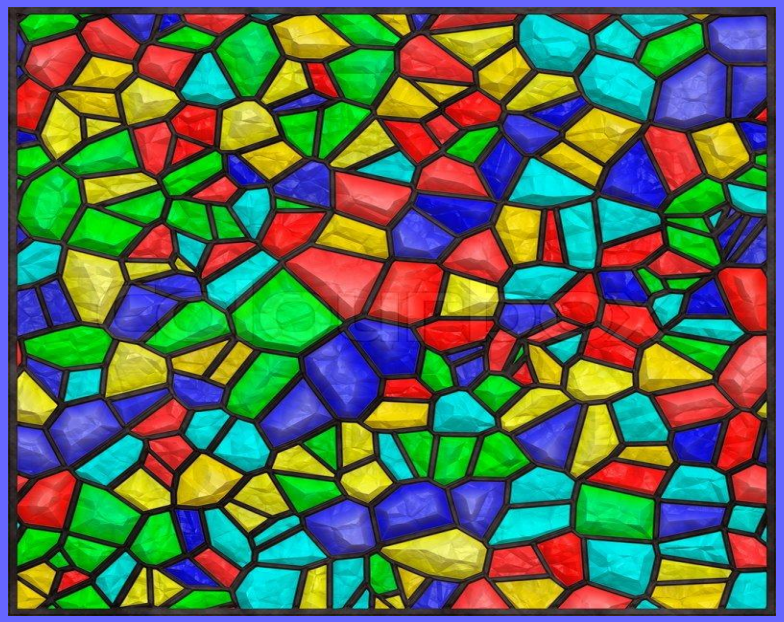
Make side-by-side comparisons using similar-sized fragments.

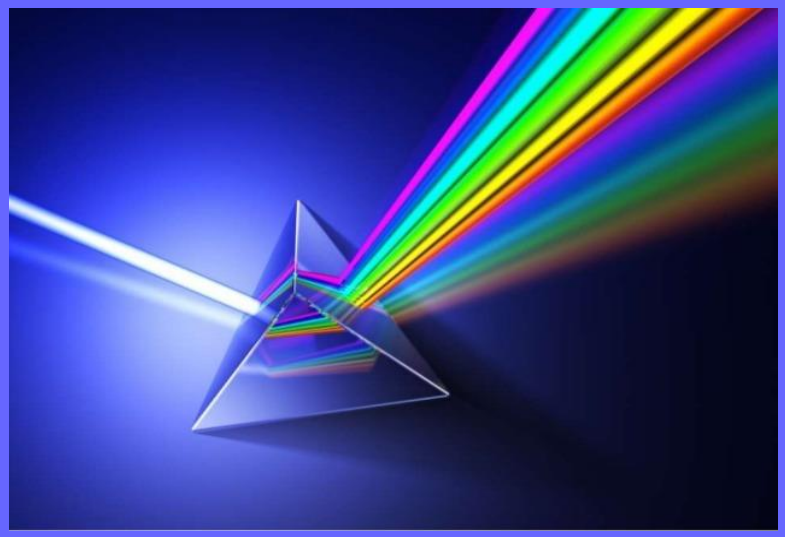
Place samples on a white surface using natural light.

Use both fluorescent and incandescent light to determine the glass's color.

Visual color analysis is very subjective.

Dyes and pigments can be almost impossible to extract.

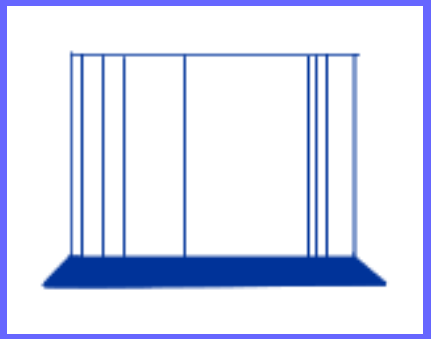


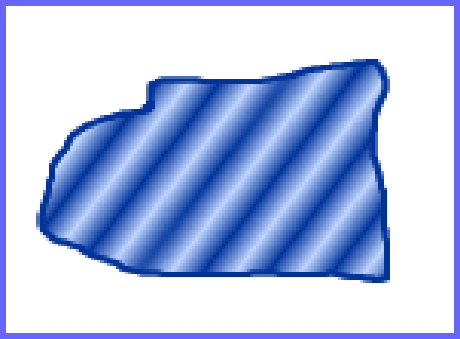


Nonoptical Physical Properties of Glass

GLASS ANALYSIS

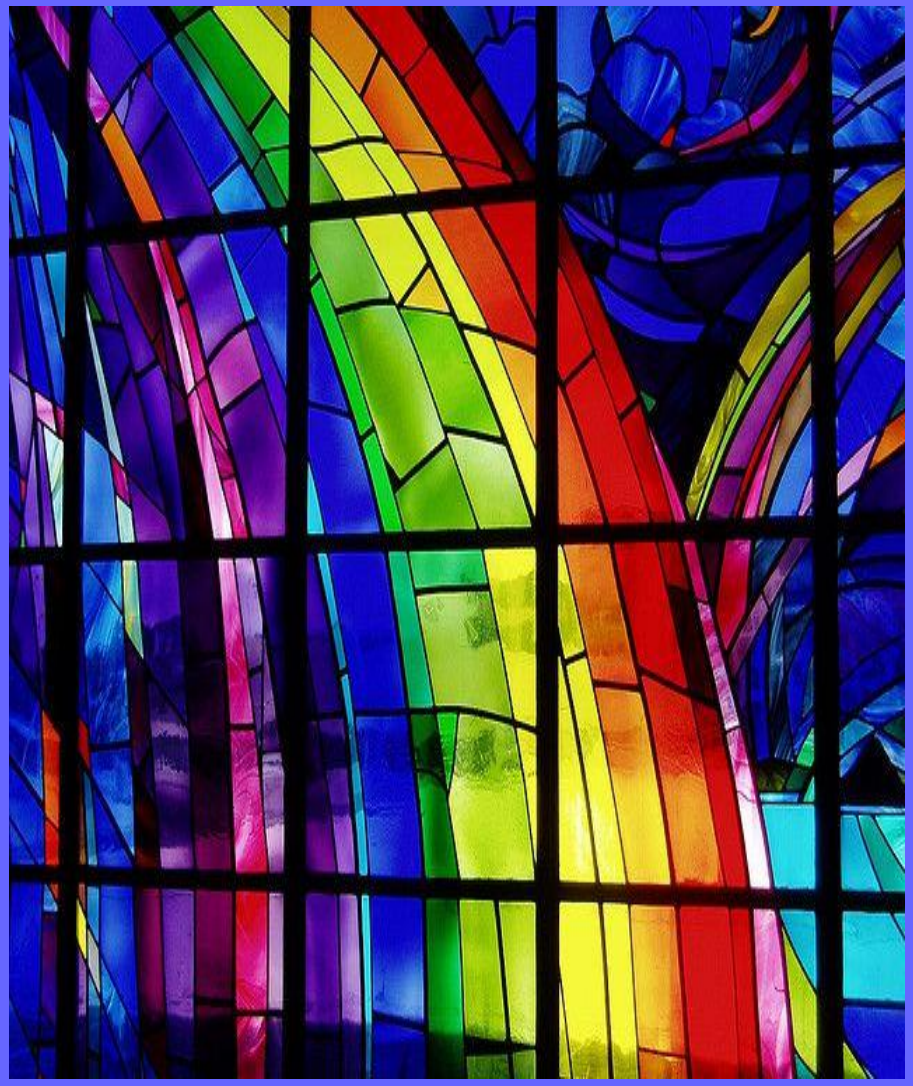
- Surface striations and markings
  - Rollers leave parallel ream marks on sheet glass
  - Markings may indicate the glass's orientation when pieces are missing
  - Surface scratches, etchings, and other markings may also be used to individualize evidence
- Other Properties
  - Hardness=5-6 on Mohs scale; use a scratch test.
  - Determinations of curvature can distinguish flat glass from container, decorative, or ophthalmic.





Thank You For Your Attention!

GLASS ANALYSIS



- Comments
  &
  Questions