Forensic Glass Analysis
Properties of Matter Review: Density

- Density is mass per unit of volume

\[ \text{Density} = \frac{\text{mass}}{\text{volume}} \]

- Is an intensive property of matter: remains the same regardless of the size of the object

- Observe whether an object floats, sinks or remains suspended in liquid to relate the object's density
Properties of Matter Review: Refractive Index

- Refraction: bending of light waves
- Refractive index: ratio of the speed of light in a vacuum to the speed of light in a medium (water)

\[ RI = \frac{\text{Velocity of light in a vacuum}}{\text{Velocity of light in a medium}} \]
Properties of Matter Review: States of Matter

- **Crystalline solids:** have a definite geometric form because of the orderly arrangement of atoms (particles)

- **Amorphous solids:** have atoms arranged randomly throughout the solid (glass)
Composition of Glass

- Made by melting sand, lime, and sodium oxide at very high temperature.
- Crystalline solids have a regular atomic structure.
- Glass is an amorphous solid and so has an irregular atomic structure.
- Therefore, glass breaks in a variety of fracture patterns.
TYPES OF GLASS

- Many types of glass
- Adding metal oxides yields different colors
- Different densities
- Refraction indexes
- These characteristics allow comparisons
- Fine glassware or leaded glass, substitute lead oxide for calcium oxide. This makes the glass denser.
Types of Glass

- Borosilicates: add boron oxide to sand
  - Ex: heat resistant Pyrex glass, car headlights
- Float glass: add sodium carbonate (soda) and calcium oxide (lime) to sand
  - Ex: windows, bottle glass
- Obsidian glass - volcanic glass
Types of Glass

- **Tempered glass: (safety glass)**
  - 3-5 times stronger than ordinary window glass
  - Goes through a rapid heating and cooling process
  - Does not shatter—fragments into small squares
  - Used on rear and sides of car windows

- **Laminated glass: (safety glass)**
  - Sandwiches a layer of plastic between 2 pieces of ordinary window glass
  - Car windshields
Density

- To compare density of glass fragments the FLOTATION METHOD is used...
  - Standard glass particle is immersed in a liquid (composed of bromofoam and bromobenzene)
  - Add chemicals above in measured quantities a little at a time to liquid until glass is suspended in the liquid
  - At the point the glass and the liquid both have the same density
  - Method allows for the smallest density differences to be detected
Refractive Index

- Snell’s Law – describes the behavior of light as it travels from one medium into a different medium. (remember physics)
- When a beam of light moves from one medium into another:
  - The speed changes
  - The direction bends
- **Refractive Index**—a tool used to study how light bends as it passes from one substance to another
- **Normal line** is perpendicular to the glass surface
Refractive Index

When a beam of light moves from less dense medium (air) into a more dense medium (water):

- Its speed **slows**, and
- Bends light **toward** the normal line

![Diagram showing refraction](image)
Refractive Index

When a beam of light moves from a more dense medium (glass) into a less dense medium (air):

- Its speed increases
- And bends light away from the normal line
Forensic Glass Analysis

- To compare glass fragments at the scene of a crime, a forensic scientist evaluates density and refractive index.
Using Glass Analysis at a Crime Scene

- Compare glass fragments on a suspect (person and/or vehicle) with the shattered glass remaining at the crime scene
- EX:
  - glass in a suspect's shoes matching the chips of glass from a broken window at a burglarized home
  - Compare headlight glass found at a hit and run to the headlight glass on suspect vehicle
Application of Refractive Index to Forensics

- Submersion method—
- used when glass fragments found at the crime scene are small
Application of Refractive Index to Forensics Submersion method continued.

- Place the glass fragment into different liquids of known refractive indexes.
- The glass fragment will seem to disappear when placed in a liquid of the same refractive index.

Index of refraction increasing
Becke Line—a halo-like effect appearing at the edges of a glass fragment when the reflective index of the glass and liquid are different.

If the line is inside the glass perimeter, the glass index is higher than the index of the liquid.

If the line is outside the glass perimeter, the glass index is lower.
Fracture Patterns in Broken Glass

- When glass is hit, it can stretch slightly.
- Being an amorphous solid, glass will not break into regular pieces with straight line fractures.
- When stretch to far it will fracture.
- Fracture patterns provide clues about the direction, side it was hit, rate, and sequence of the impacts.
How Glass Breaks

- The side of glass where the impact takes place, the surface is compressed or squeezed together. The opposite side of the glass (away from impact) stretches and is under tension.
- Glass is weaker under tension than under compression.
- It will break first on weaker side, the side opposite the strike, producing radial fractures.
Why Radial and Concentric Fractures Form

- Impacted glass is compressed on the side it is hit.
- It will stretch on the opposite side of the glass, and the tension there will radiate breaks in the glass outward from the point of impact.
- Then fractures form in the shape of concentric circles on the same side of the impact.
After primary radial fractures form, the secondary or concentric fractures form.
• Glass after an impact shows radial fractures (red) and concentric circle fractures (blue)
Bullet Fractures

- Combination of two or more types of glass, one hard and one soft.
- The softer layer makes the glass more elastic, so it can flex instead of shatter. Soft layer is the important layer.
  - As a bullet passes through glass, it pushes a cone shaped piece of glass out of the glass ahead of it.
  - The exit side of the hole is larger than the entrance side of the hole.
  - Radiating fracture lines from a subsequent shot will stop at the edge of the fracture lines already present in the glass.
The angles at which bullets enter window glass help locate the position of the shooter. Bits of the glass can fly backward (backscatter), creating trace evidence.
Multiple shots

- If several shots are fired through the glass, the order in which the shots were fired can be determined if enough of the glass is available or can be reconstructed.
- 1\textsuperscript{st} shot produces the first set of fracture lines.
- These lines set boundaries for further fracturing by following shots.
- Radiating fracture lines from 2\textsuperscript{nd} shot stop at the edge of fracture lines from 1\textsuperscript{st} shot.
Handling of Crime Scene Glass Samples

1. Identify and photograph any glass samples before moving them.
2. Collect the largest fragments that can be reasonably collected.
3. Identify the outside and inside surface of any glass.
4. If multiple panes are involved, make a diagram.
5. Note trace evidence such as skin, hair, blood, or fibers.
6. Package all materials collected to maintain the chain of custody.