



# PHYSICAL PROPERTIES: GLASS





# Physical vs. Chemical Properties

- The forensic scientist must constantly determine those properties that impart distinguishing characteristics to matter, giving it a unique identity.
- Physical properties such as weight, volume, color, boiling point, and melting point describe a substance without reference to any other substance.
- A chemical property describes the behavior of a substance when it reacts or combines with another substance.





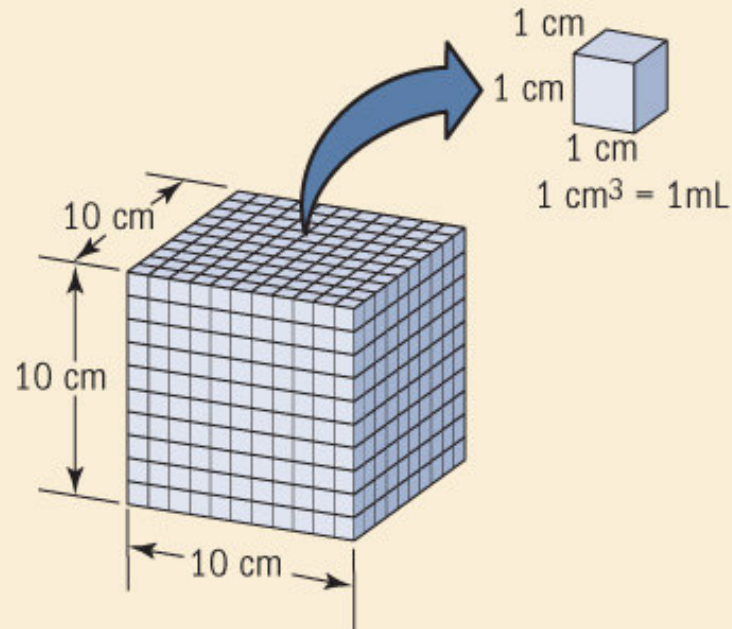
# Measurement System

- Scientists throughout the world use the metric system of measurement.
- The metric system has basic units of measurement for length, mass, and volume; they are the meter, gram, and liter, respectively.
- The following are common prefixes used in the metric system: deci, centi, milli, micro, nano, kilo, and mega.

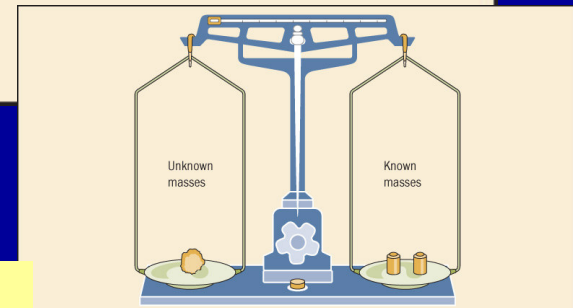




# Volume equivalencies in the metric system



$$1 \text{ liter (1 L)} = \begin{cases} 1,000 \text{ cm}^3 \\ 1,000 \text{ mL} \end{cases}$$





# Important Physical Properties

- Temperature is a measure of heat intensity, or the hotness or coldness of a substance.
  - In science, the most commonly used temperature scale is the Celsius scale. This scale is derived by assigning the freezing point of water a value of  $0^{\circ}\text{C}$  and its boiling point a value of  $100^{\circ}\text{C}$ .
- Weight is the force with which gravity attracts a body.
- Mass refers to the amount of matter an object contains independent of gravity.
  - The mass of an object is determined by comparison to the known mass of standard objects.





# Important Physical Properties

- Density is defined as the mass per unit volume. ( $D = M/V$ )
  - Density is an intensive property of matter, meaning it remains the same regardless of sample size.
  - It is considered a characteristic property of a substance and can be used as an aid in identification.





# Important Physical Properties

- Light waves travel in air at a constant velocity until they penetrate another medium, such as glass or water, at which point they are suddenly slowed, causing the rays to bend.
- The bending of light waves because of a change in velocity is called refraction.
- Refractive index is the ratio of the velocity of light in a vacuum to that in the medium under examination.





# Important Physical Properties

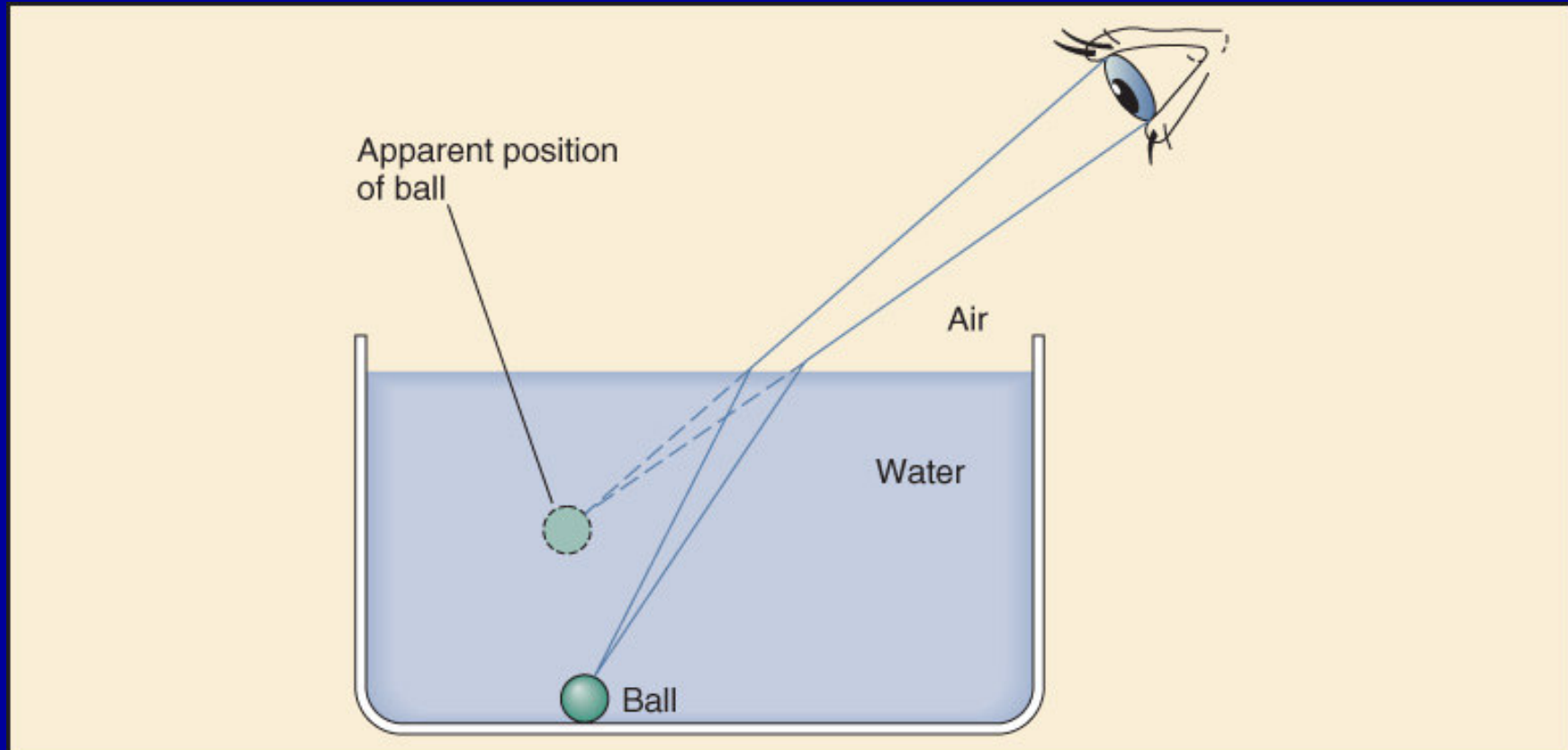
- For example, at 25°C the refractive index of water is 1.333.
- This means that light travels 1.333 times faster in a vacuum than it does in water.
- Like density, refractive index is an intensive property and will serve to characterize a substance.







## Light is refracted when it travels obliquely from one medium to another



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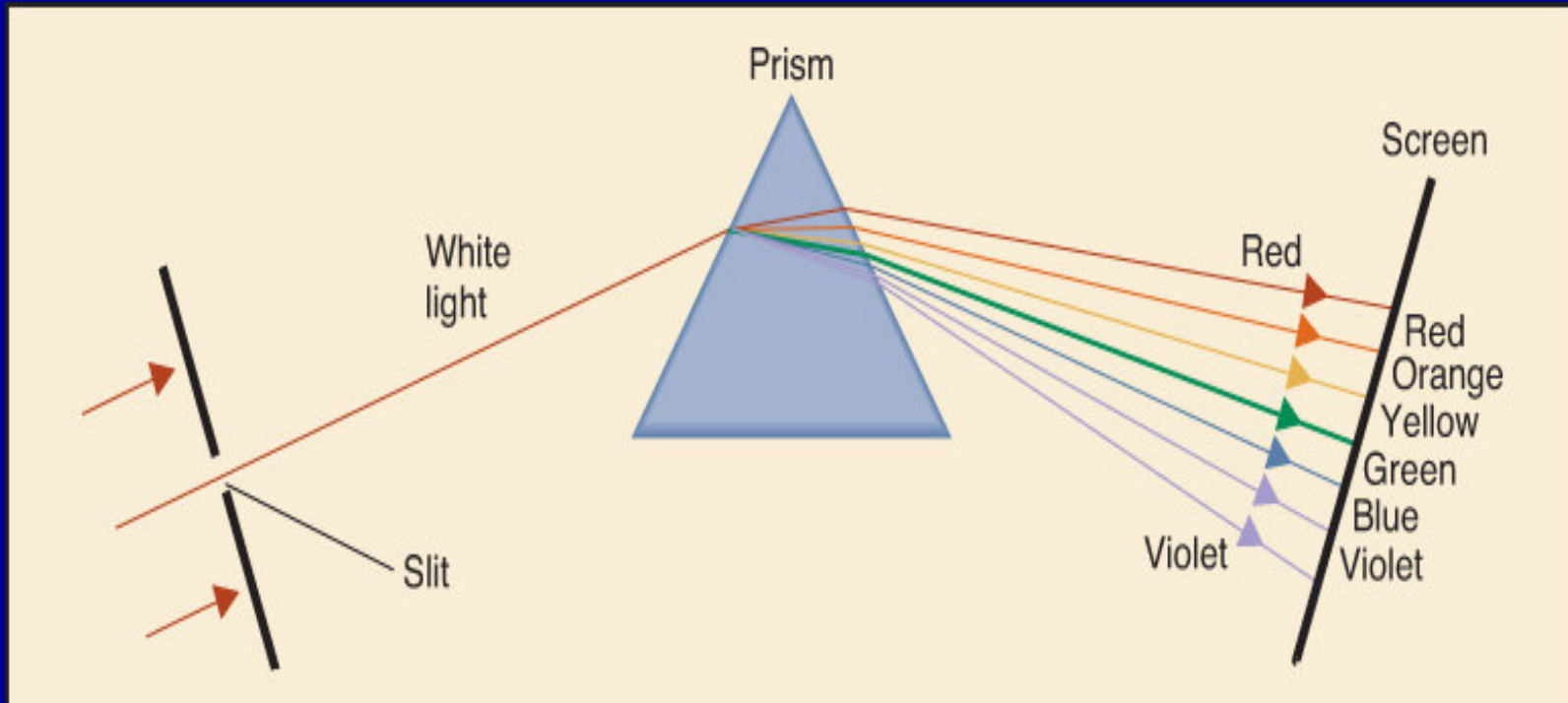
# Refractive Index = R.I.

$$\text{R.I.} = \frac{\text{Velocity of light in vacuum}}{\text{Velocity of light in medium}}$$





# Dispersion of light in glass prism





# Glass Fragments

- Glass is a hard, brittle, amorphous substance that is composed of silicon oxides mixed with various metal oxides.
- Amorphous solids have their atoms arranged randomly, unlike crystals.
- Tempered glass is stronger than normal glass due to rapid heating and cooling.
- Laminated glass found in car windshields has a layer of plastic between two pieces of ordinary window glass.





# Glass Fragments

- For the forensic scientist, the problem of glass comparison is one that depends on the need to find and measure those properties that will associate one glass fragment with another while minimizing or eliminating other sources.
- To compare glass fragments, a forensic scientist evaluates two important physical properties: density and refractive index.

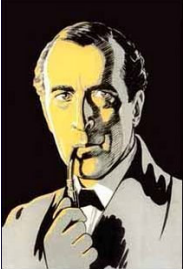




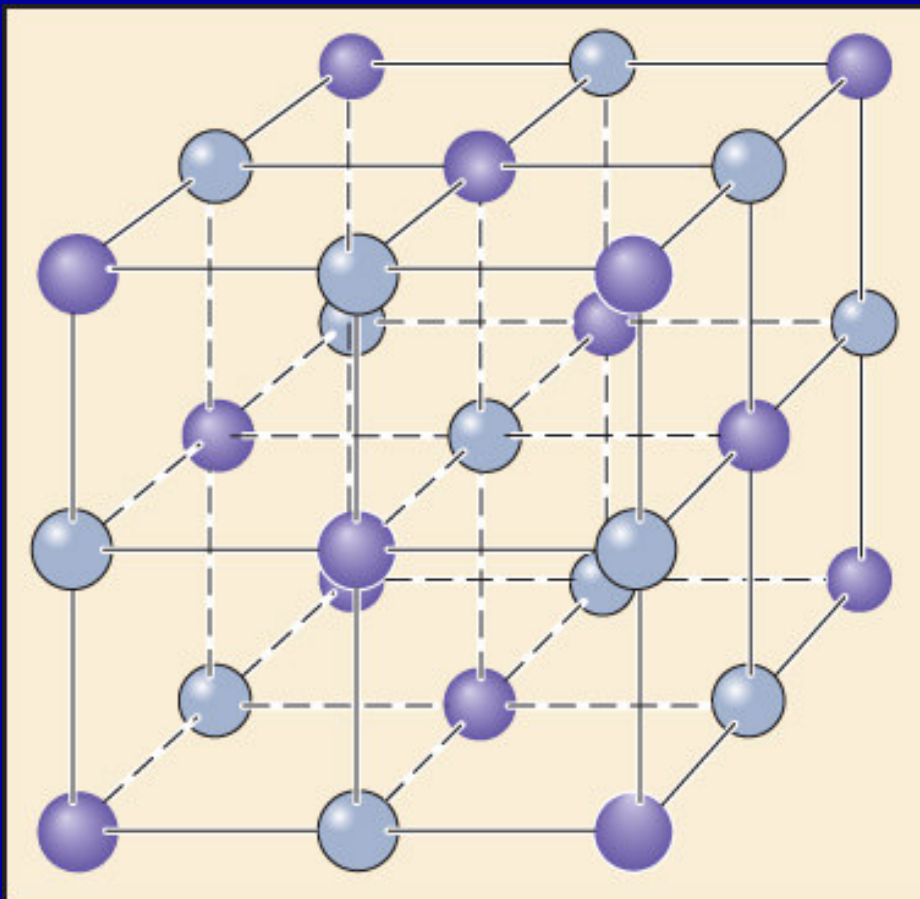
# Flotation method

- Is a precise and rapid method for comparing glass densities.
- A glass particle is immersed in a liquid.
- The density of the liquid is adjusted by addition of small amounts of an appropriate liquid until the glass chip remains suspended in liquid
- At this point, the glass will have the same density as the liquid medium
- The other pieces of glass will remain sink, or float.



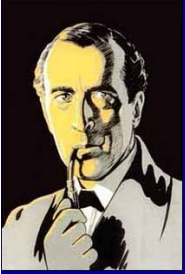


# Sodium Chloride structure



Crystalline solids have definite geometric forms because of the orderly arrangement of their atoms.





# Refractive Index method

- Crystalline solids have definite geometric forms because of the orderly arrangement of their atoms.
- These solids refract a beam of light in two different light-ray components.
- This results in double refraction.
- Birefringence is the numerical difference between these two refractive indices.
  - Not all solids are crystalline in nature. For example, glass has a random arrangement of atoms to form an amorphous or non-crystalline solid.







# Polarizing Microscope-PLM Manufactured by Leitz company



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# Immersion Method

- The flotation and the immersion methods are best used to determine a glass fragment's density and refractive index, respectively.
- The latter involves immersing a glass particle in a liquid medium whose refractive index is varied until it is equal to that of the glass particle.
- At this point, known as the match point, the Becke line disappears and minimum contrast between liquid and particle is observed.
- The Becke line is a bright halo near the border of a particle that is immersed in a liquid of a different refractive index.





# Double Refraction

- Splitting of light rays into two or three ways when it passes thru crystalline solids – uni-axial and bi-axial crystals
- Use polarizing microscope to detect double refraction
- Transparent Calcite crystals are cut appropriately to use as polarizers and analyzers in PLM (Polarizing Light Microscopy)





# Analyzing Cracks

- The penetration of window glass by a projectile, whether it is a bullet or a stone, produces cracks which radiate outward (radial fractures) and encircle the hole (concentric fractures).
- By analyzing the radial and concentric fracture patterns in glass, the forensic scientist can determine the direction of impact.

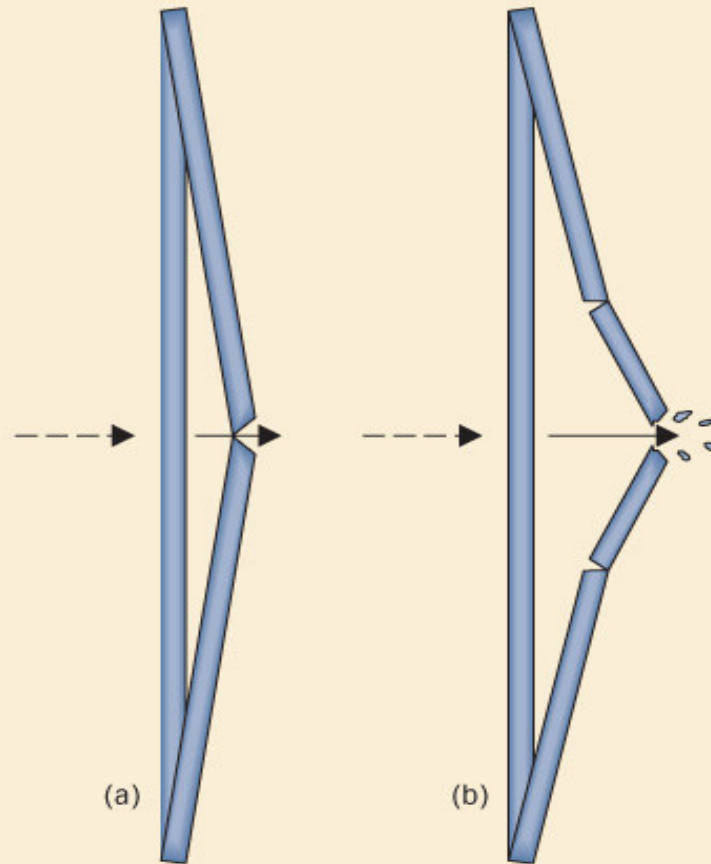
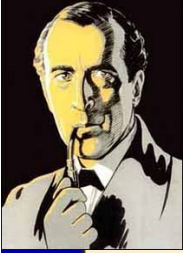




# Analyzing Cracks

- A high-velocity projectile such as a bullet often leaves a hole that is wider at the exit side, and hence its examination is important in determining the direction of impact.
- The direction of impact can also be accomplished by applying the 3R Rule: *Radial* cracks form a *Right* angle on the *Reverse* side of the force.
- The sequence of impacts when there have been successive penetrations of glass is frequently possible to determine because a fracture always terminates at an existing line of fracture.



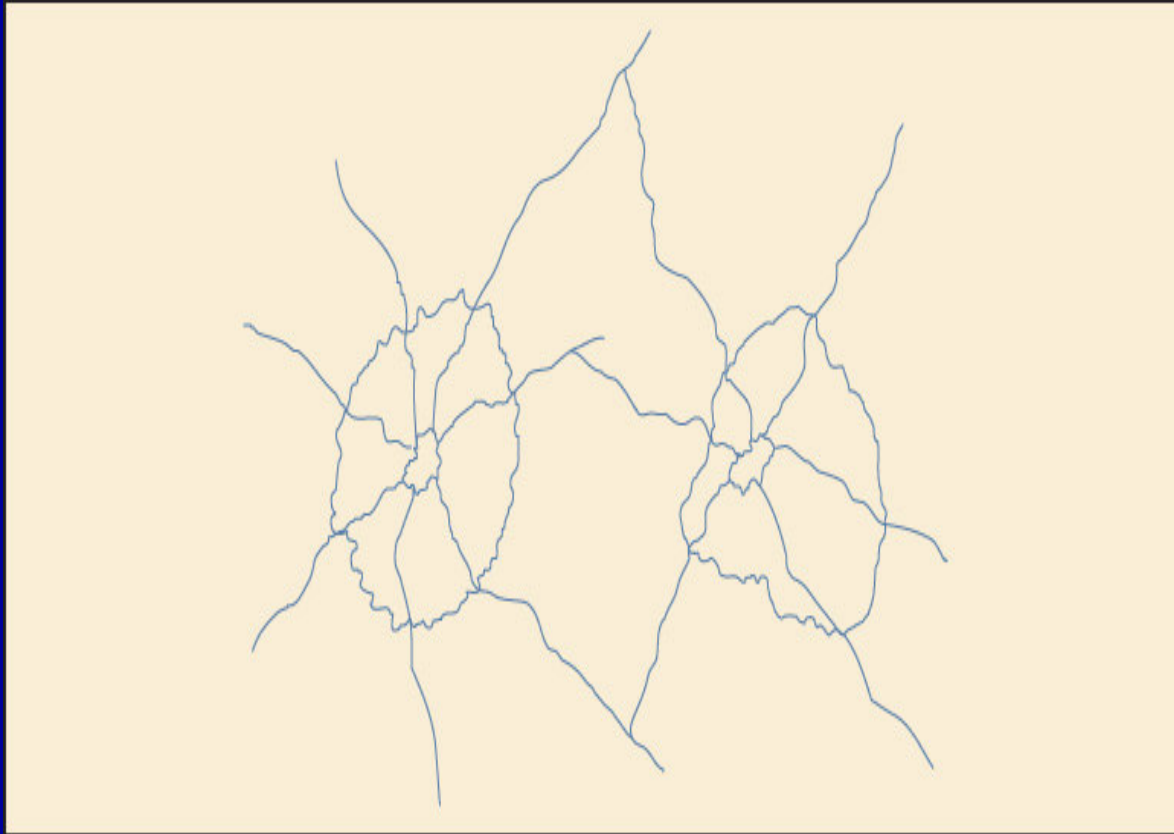


**Production of radial and concentric fractures in glass. (a) Radial cracks are formed first, commencing on the side of the glass opposite to the destructive force. (b) Concentric cracks occur afterward, starting on the same side as the force.**





# Two holes in glass – one later than the other



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