Physics With A Purpose: Forensic Science Applications

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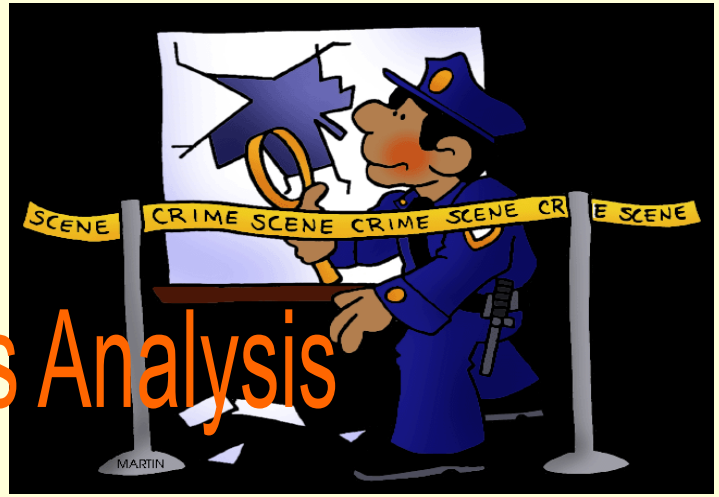
PDF of PowerPoint and Handouts Available At:

www.forensicscience-ed.com

Crime Scene Physics



Glass Analysis

BLoodstain Analysis

Accident Reconstruction

Analyzing Broken Glass

- Broken glass analysis is forensically important to the reconstruction of events in a criminal act
- Analysis can include:
  - The sequence of the fractures – order of events
  - The direction of the force which caused the fracture – did the break occur from the inside or outside
  - The identity (type) of a small piece of glass – soda lime glass, borosilicate, tempered, or lead crystal

Force on Glass: Analyzing Fractures

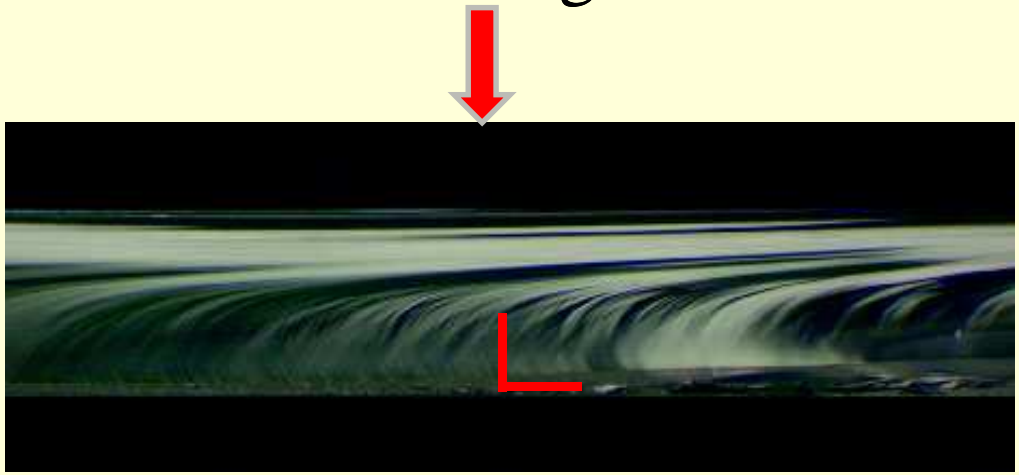
Bullet Traveling Through Glass: Analyze Entry vs. Exit

F:\Videos\bullet - slow motion animation - YouTube.flv

Sequence Fractures for Multiple Breaks

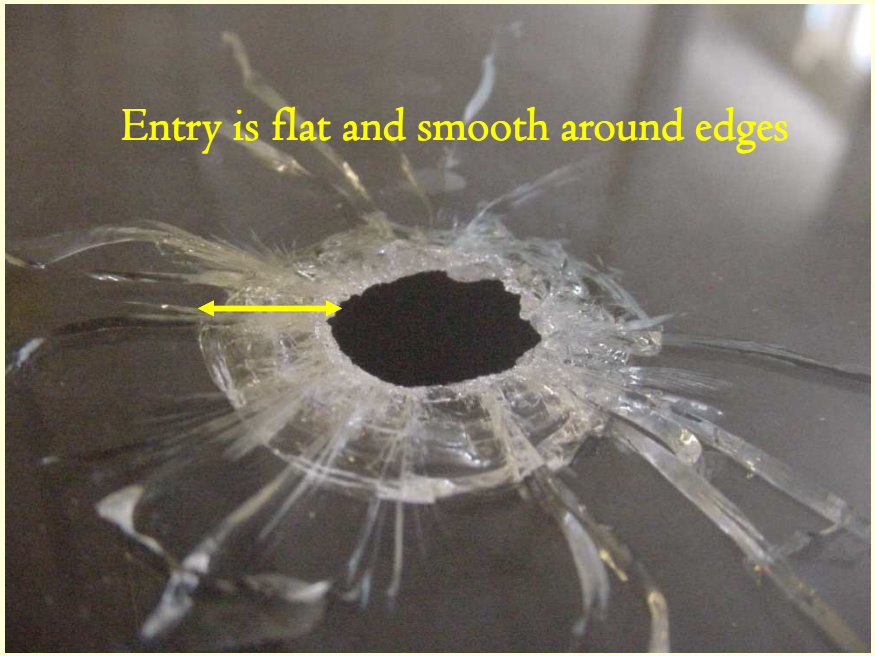
Determine Direction of Force

3R: Radial, Right, Reverse



Projectiles & Glass: Analyzing Entry and Exit

Projectile Movie



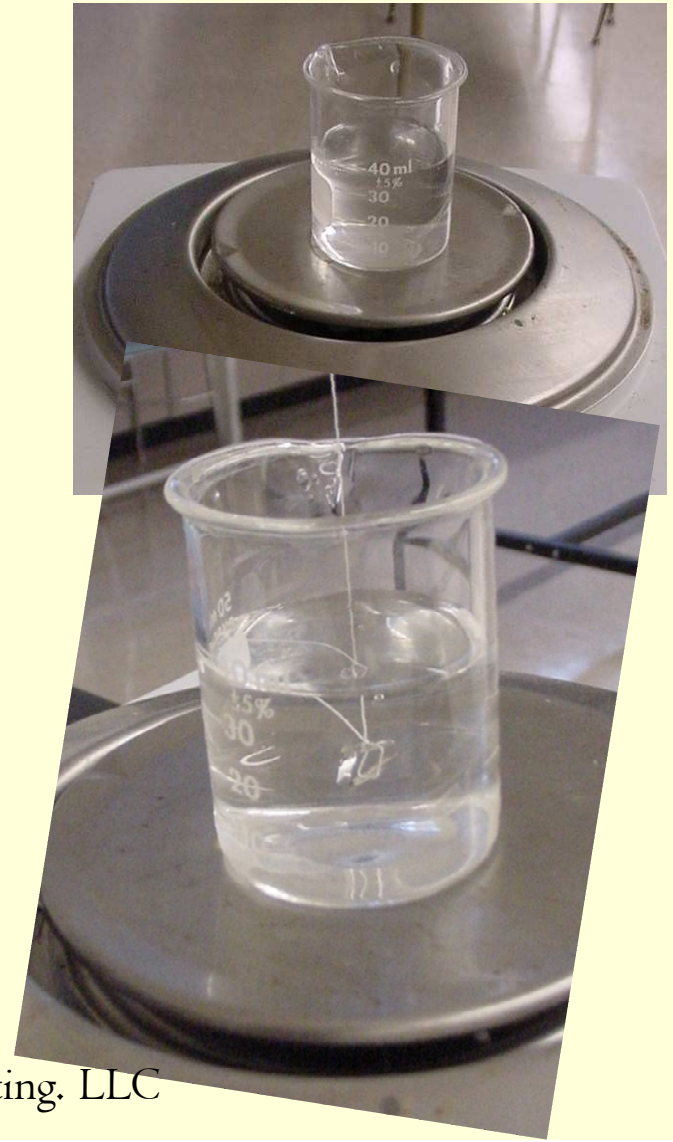
Class Characteristics of Glass

- Class characteristics of glass are limited because glass is so inert—difficult to dissolve in solvents
- Exception is the *Inductively Coupled Plasma Mass Spectrometer* (ICP/MS)—digests glass and performs elemental analysis to determine chemical composition
- ICP/MS in few crime labs and probably no high schools
- Old analytical techniques—look at class characteristics:
  - Physical appearance – size, shape, thickness
  - Color
  - Density
  - Refractive index

Measuring The Density Of A Small Piece of Glass

1. Mass the piece of glass.
2. Find Volume of glass.
   a. Tare beaker with water.
   b. Tie thread around glass.
   c. SUSPEND the glass in water.
   d. Take mass reading.
   e. Mass of water displaced =
      Volume of water displaced =
      Volume of piece of glass.
3. Calculate density of the glass.

Window Glass	2.53-2.54 g/ml	(2.5)
Pyrex Glass	2.29-2.39 g/ml	(2.2)
Leaded Glass	2.65-2.92 g/ml	(2.8)



Refractive Index

- Refractive Index (RI) is the ratio of the velocity of light in a vacuum to it's velocity in a medium
- Equation: $RI = c/v_{medium}$ $c = 3 \times 10^8$ m/s
- As light passes from one medium to a different medium, it changes speed, causing it to bend or refract

The straw appears bent due to refraction of light

Glass ID Using Properties of Refraction

- If two transparent materials have the same RI, light will not refract as it passes from one to the other.

Solid is visible in air.

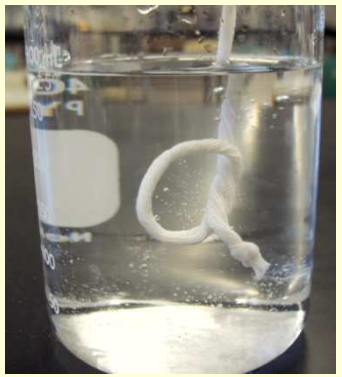
- If solid is placed in liquid with same RI, it will disappear.

Solid has same RI as liquid. Starts to disappear.

- Demonstrations of similar RI

  Ghost Crystals: cross-linked polyacrylamide

  Vegetable Oil and Pyrex



Solid immersed in liquid. Not visible.

Refractive Index Determination of a Small Glass Fragment

- Refractive index of small pieces of glass can be determined using commercially available liquids whose refractive indexes are known

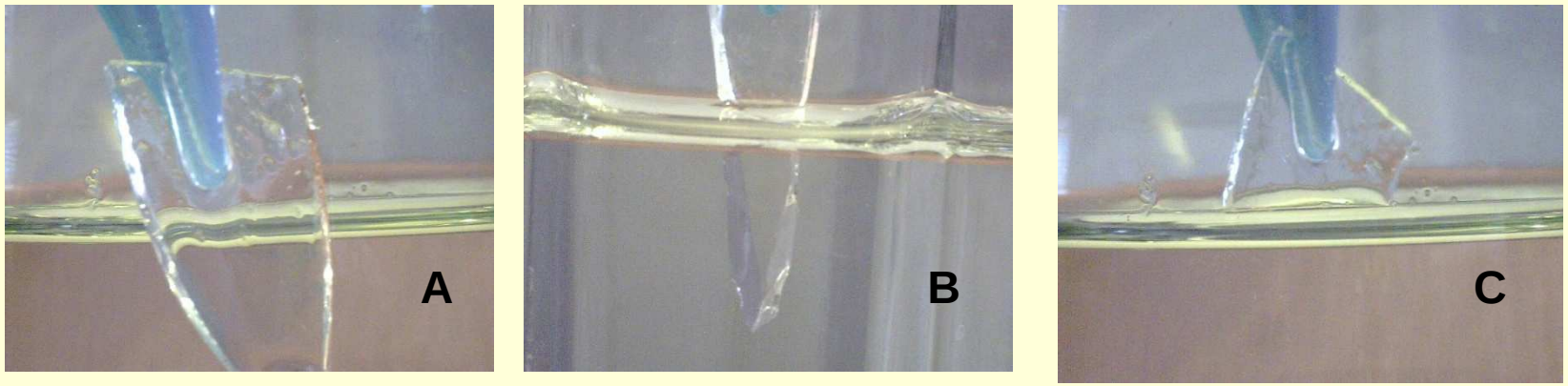


Photo A shows a small piece of Pyrex glass *not immersed* in a liquid.

Photo B shows the same piece of glass *immersed in water*.

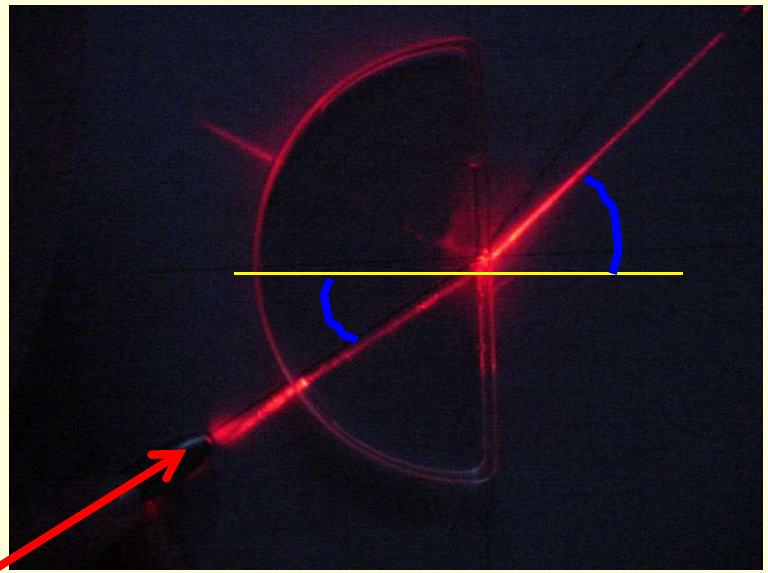
Photo C shows the piece *immersed in vegetable oil*. Pyrex and vegetable oil have similar indices of refraction as shown by the disappearance of the glass in the oil.

Refractive Index Determination of a Small Glass Fragment

Glass Type	RI
Window Glass (soda lime)	I.5I
Pyrex	I.47
Tempered Glass (auto)	I.52
Leaded Glass (29%-55%)	I.57-I.67
Liquid Medium	**RI**
Water	I.33
Vegetable Oil	I.47
Clove Oil	I.53

Measure the RI of Comparison Liquids

- Use plastic dishes filled with liquid to be tested
- Laser light or light box single beam through liquid at a given angle (30^0).
- Trace refracted beam.
- Calculate RI using Snell's Law



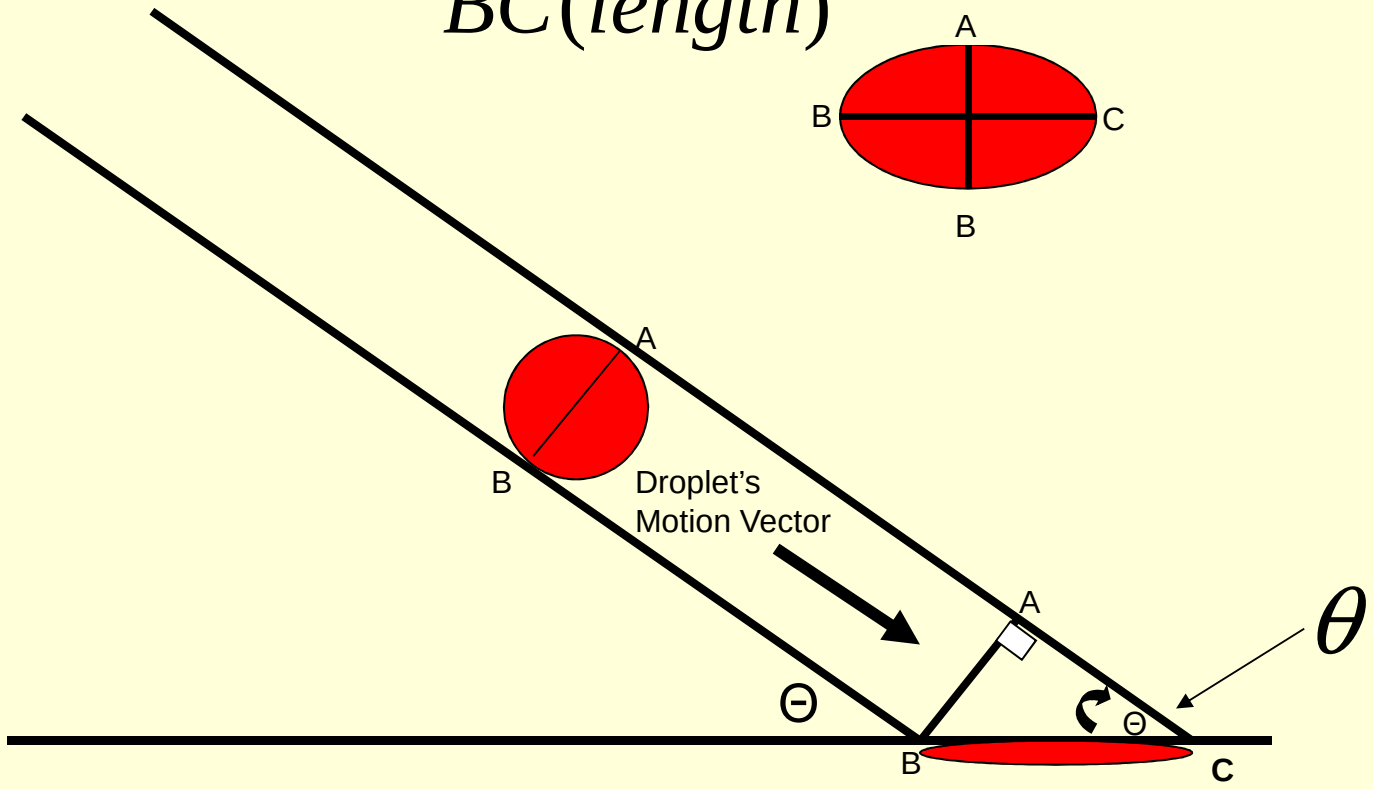
$$n_I = n_2(\sin \theta_2) / \sin \theta_I \qquad n_2 = 1.00 \text{ (air)}$$

Projectile Motion: Blood In Flight

- Blood in flight obeys laws of gravity
- Impact spatter due to blunt force trauma
- Use trigonometry to locate position of source

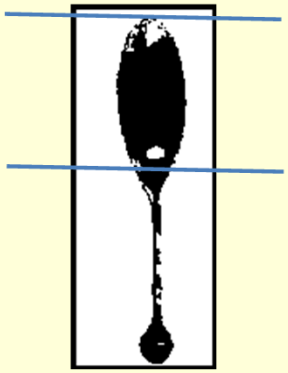
Analyzing the Motion of a Blood Droplet

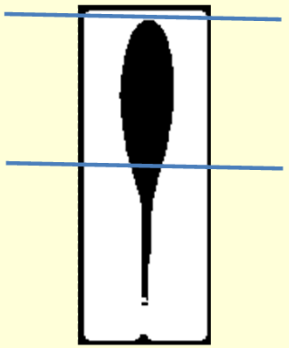
$$\theta = \sin^{-1} \frac{AB(width)}{BC(length)}$$



Calculating Impact Angle

- Impact Angle (θ) = $(\sin^{-1})$ width/length
- Practice Sheet.





- Blood Drop A: W/L=0.9cm/2cm 27^0

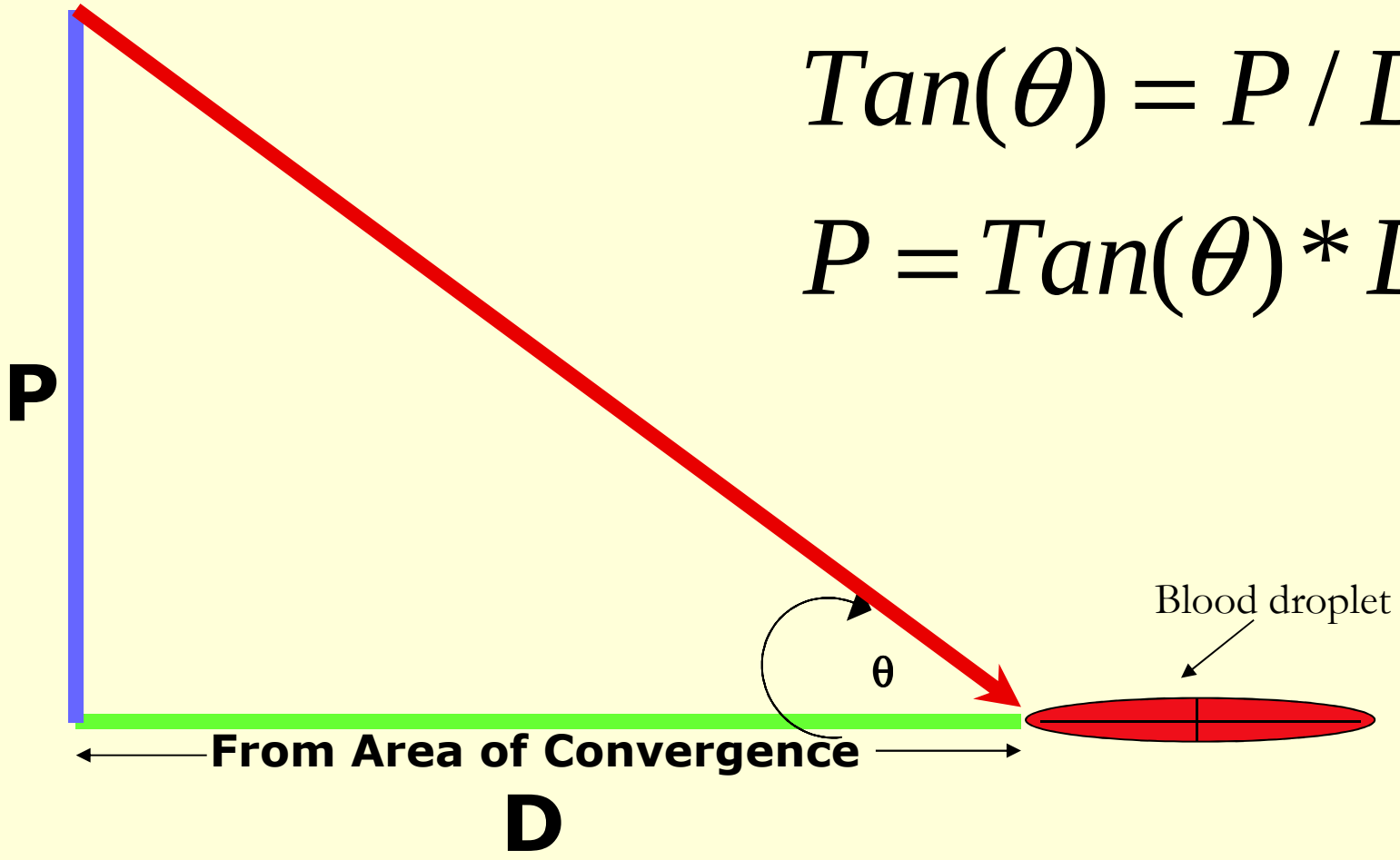
  Blood Drop B: W/L=1.2cm/1.9cm 39^0

  Blood Drop C: W/L=0.7cm/2cm 20^0

Finding the Third Dimension

$$Tan(\theta) = P / D$$

$$P = Tan(\theta) * D$$



Projectile Motion: Blood In Flight

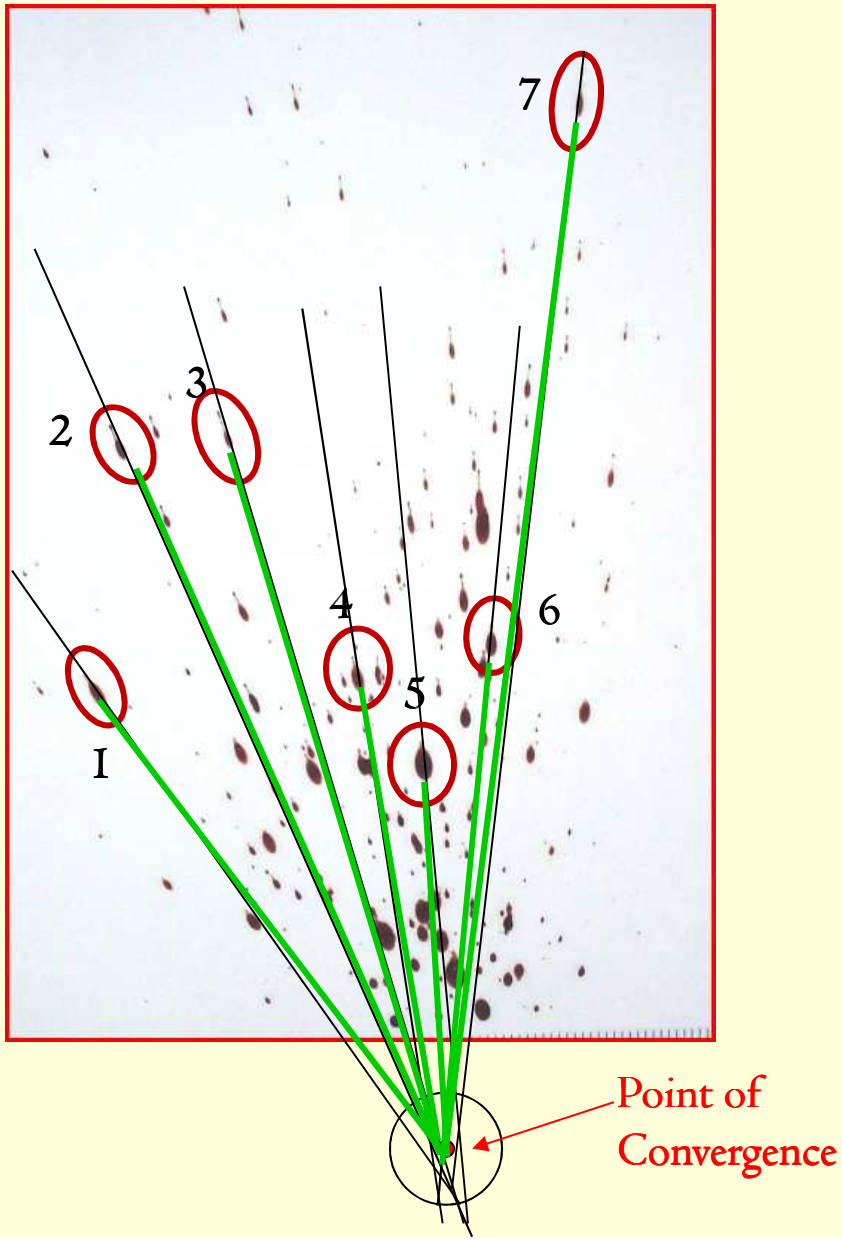
Impact Angles

1. 2/5 24^0
2. 1.5/4 22^0
3. 1/3 20^0
4. 2/4.5 26^0
5. 3/6 30^0
6. 2/4 30^0
7. 1/4 14^0

$\tan \theta = P/D$

D (point to stain)

1. 11 cm
2. 15 cm
3. 14.5 cm
4. 9.3 cm
5. 7.3 cm
6. 9.7 cm
7. 20.6 cm



$P = D (\tan \theta)$

1. 4.9 cm
2. 6.1 cm
3. 5.3 cm
4. 4.5 cm
5. 4.2 cm
6. 5.6 cm
7. 5.1 cm

Conclusion:

The source was 4.2 to 6.1 cm above the Point of Convergence

Accident Reconstruction

To determine the speed of the vehicle—Use coefficient of friction (drag factor) & length of skid marks.

- $W = E_k$ (Work Done = Δ Kinetic Energy)
- $F_f d = E_k$ (Work is done by braking—friction)
- $\mu mgd = \frac{1}{2} mv^2$
- $\mu \cancel{m} gd = \frac{1}{2} \cancel{m} v^2$
- $v^2 = 2\mu gd$

  v = speed (s)

  μ = drag factor (f)

  $s^2 = 2fgd$ (d in feet, s in mi/hr, g in ft/s^2)

Accident Reconstruction

Simplifying the equation and dealing with units:

- $s^2 = 2fd(\cancel{ft}) \left(\frac{1 mile}{5280 \cancel{ft}}\right) \times 32 \frac{\cancel{ft}}{\cancel{sec^2}} \times \frac{1 mile}{5280 \cancel{ft}} \times \frac{3600^2 \cancel{sec^2}}{1 hr^2}$

- $s^2 = 29.75(miles^2/hr^2)df$

$$s = \sqrt{30\ df}$$

$s = \sqrt{30df}$ Accident Reconstruc

Determining "f"

a. Drag Sled—force of friction between tire and road surface.

   Determine weight of drag sled. Use formula $f = F_f/F_g$

b. Test Skids. Use car to lay down skids, note speed at start of skid.

   Measure length of all 4 skids. Use $f = s^2/30d$

Actual Skid

a. Find d_{ave} by measuring all 4 skidmarks.

b. Use the "f" found by one or both of the methods above.

c. Calculate the speed (s) going into the skid.

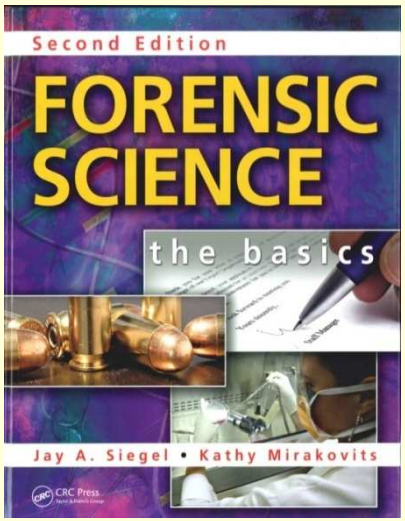
Test Skids

Thank You—Questions?

- Contact Information: Kathy Mirakovits
  www.forensicscience-ed.com
- Forensic Science Workshops Summer 2012

Atlanta, GA	June 12-15
Portland, OR	June 26-29
LTU (Southfield, MI)	July 9-13
IUPUI (Indianapolis)	July 17-20
Portage, MI	July 30-Aug 3

- Textbook? www.crcpress/com



Supplies for Activities

My recommendations for supplies:

1. Blood Spatter Kits from Wards Natural Science
   Introduction to Blood Spatter Analysis: 36 V 0047
   Advanced Techniques in Blood Spatter Analysis. 36 V 0048
   Simulated Drip & Projected Blood. 37 V 5310
   Simulated Transfer Blood. 37V5311

2. Glass Analysis from Wards Natural Science
   Forensic Analysis of Glass. 36 V 6240

3. Accident Investigation & Drag Sled. 36 V 6268 & 15 V 6268