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OF
BLOODSTAIN PATTERN ANALYSTS

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BALLISTIC TRAJECTORIES OF BLOOD

COMPUTER APPLICATIONS AND WORKSHOP

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COMPUTER MODELING BLOOD DROPLET TRAJECTORIES

Two different computer programs whose names are **DROPLETS** and **BACKTRACK** were created for the Bloodstain Analysis Course held in Ottawa in May 1989, by the RCMP and The departments of Physics and Mathematics of Carleton University. They are designed to run on an IBM PS/2 (AT) computer.

The first program called **DROPLETS**, was developed as an aid for teaching the physical laws that govern projectiles such as blood droplets. It simulates, on the video screen, the flight paths of individual blood droplets through the air before striking a vertical wall. This program takes into account the effect of air resistance on the path of different size droplets in addition to the gravitational force.

The computer calculates points along the path taken by the droplet and draws on the video screen a 3 - dimensional plot of this path.See figure 1. When the calculated position of the path of the droplet coincides with vertical wall, the computer then calculates the impact position and the speed and direction of the velocity of the droplet just before impact. This direction, denoted by the angles alpha and gamma degrees, along with the impact speed, are called the "impact values" or "impact parameters" and they determine the characteristic shape of the spot produced by the blood droplet as it strikes the wall.

The figure shows the computer display for five different sizes of droplets originating from a single point with all their directions and speeds the same. (i.e. 45 degrees above the horizontal and 800 cm/sec.) The effect of air resistance on the path of the drops is greater for smaller drops. This is apparent from the display where it is seen that the smaller droplets strike the wall at successively lower points. The top left window shows the drop # and the initial values for the direction and speed of the droplet. The top right window shows the calculated values of the parameters describing the impact of the droplet with the wall.

These "impact parameters" are important because the knowledge of these numbers enables one to calculate, using the Laws of Physics, the path of the droplet through the air before striking the wall. Thus if the investigator can examine the spot produced by the blood droplet and estimate reasonable values for the impact parameters it is possible to reconstruct, by calculation, the path followed by the droplet while travelling from the point of origin to the point of impact with the wall. The second computer program called **BACKTRACK** was created to perform such calculations.

BLOODSTAIN PATTERN ANALYSIS WITH A PC COMPUTER

The program **BACKTRACK** grew out of the Bloodstain Analysis Course[#] held in Ottawa by the Royal Canadian Mounted Police and Carleton University in May 1982 and more recently in May 1990. This program accepts as input the six impact parameters for each single droplet stain. With these parameters and using the Laws of Physics the computer can reconstruct the trajectory which corresponds to the path through space for the droplet.
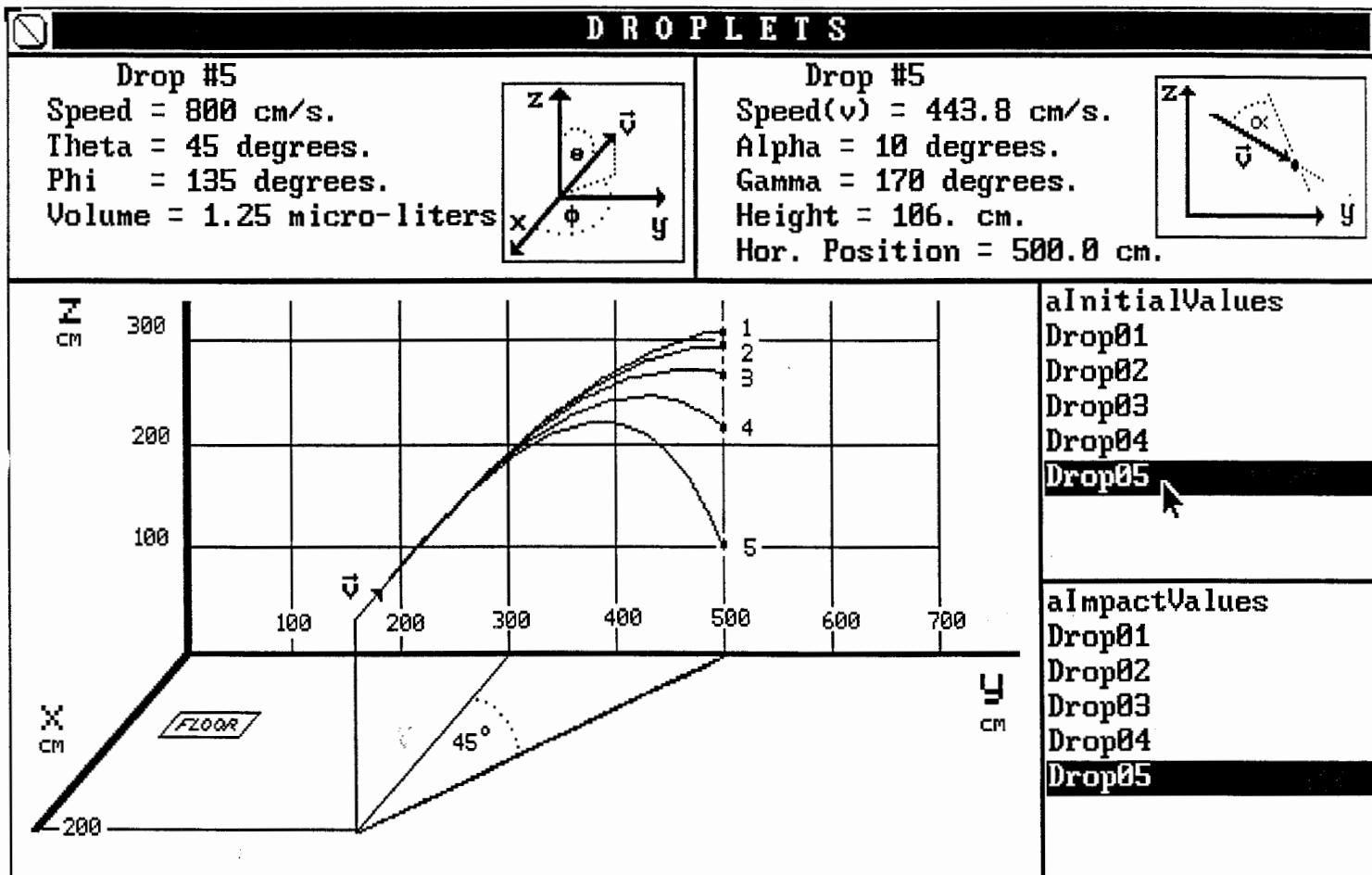
The six impact parameters are,

1. The droplet volume in microliters.(1 microliter of water = 1milligram).

2. The glancing angle gamma in degrees.

3. The impact angle alpha in degrees.

4. The impact speed in centimeters per second.

5. The height in centimeters (Z - coordinate).

6. The horizontal position in centimeters (Y - coordinate

- This talk will report on an experiment using fresh blood donated by a volunteer to produce a bloodstain pattern under controlled conditions in the llaboratory. An analysis of the data done with the program **BACKTRACK** will be presented

- A technique was developed to obtain the dry weight of each droplet used in the analysis. The volume of the droplets were then calculated using the dry to wet ratios which were measured for the two diifferent blood samples along with their densities. The volumes ranged from .05 to 4 microliters (.05 to 4 milligrams approximately).

- The angle alpha for each drop was determined from the shape of the droplet stain.The ratio of the width to the length of a stain was equated to the sin of the angle alpha..

- The angle gamma is the angle between the vertical plumb line and the major axis of the stain

The instructors were Professor Kenneth Hardy of the Mathematics department and and Alfred L. Carter of the Physics department.

COMPUTER DISPLAY SHOWING FIVE DROPLETS


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┌─────────────────────────────────────────────────────────────────────────────┐
│ ◇                         D R O P L E T S                                     │
├─────────────────────────────────────────────────────────────────────────────┤
│    Drop #5                          Drop #5                                   │
│  Speed = 800 cm/s.                Speed(v) = 443.8 cm/s.                      │
│  Theta = 45 degrees.              Alpha = 10 degrees.                         │
│  Phi   = 135 degrees.             Gamma = 170 degrees.                        │
│  Volume = 1.25 micro-liters       Height = 106. cm.                          │
│                                   Hor. Position = 500.0 cm.                   │
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A slightly edited version of the computer display for the program DROPLETS showing 5 different droplets projected from the same point with the same speeds and the same directions but with different sizes. The droplet volumes are 20, 10, 5, 2..5 and 1.25 microliters for droplets 1 to 5 respectively.
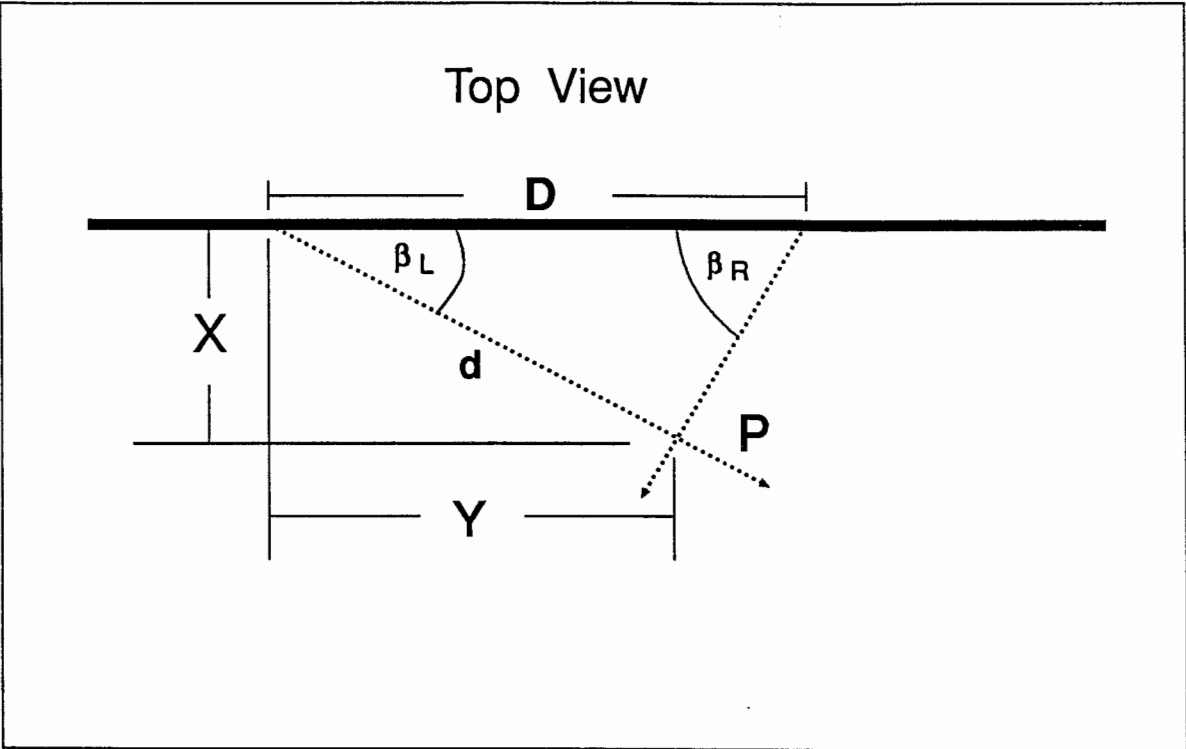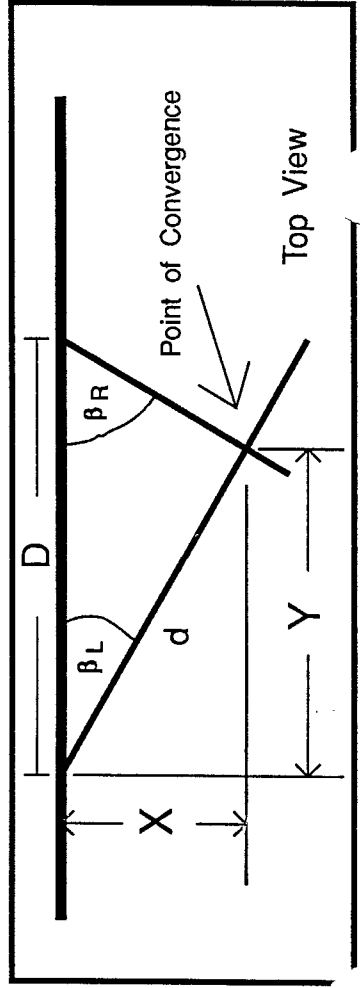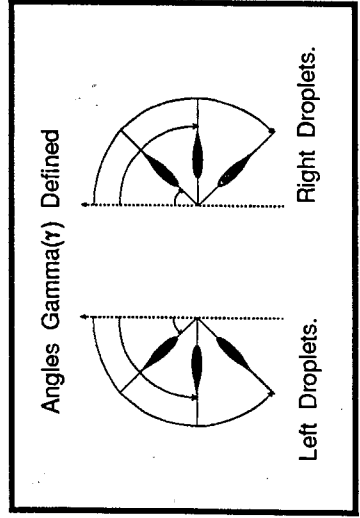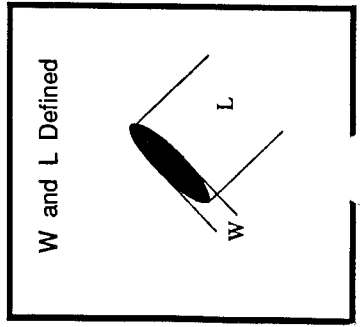
Top View

The top view showing the analysis of two droplet stains.
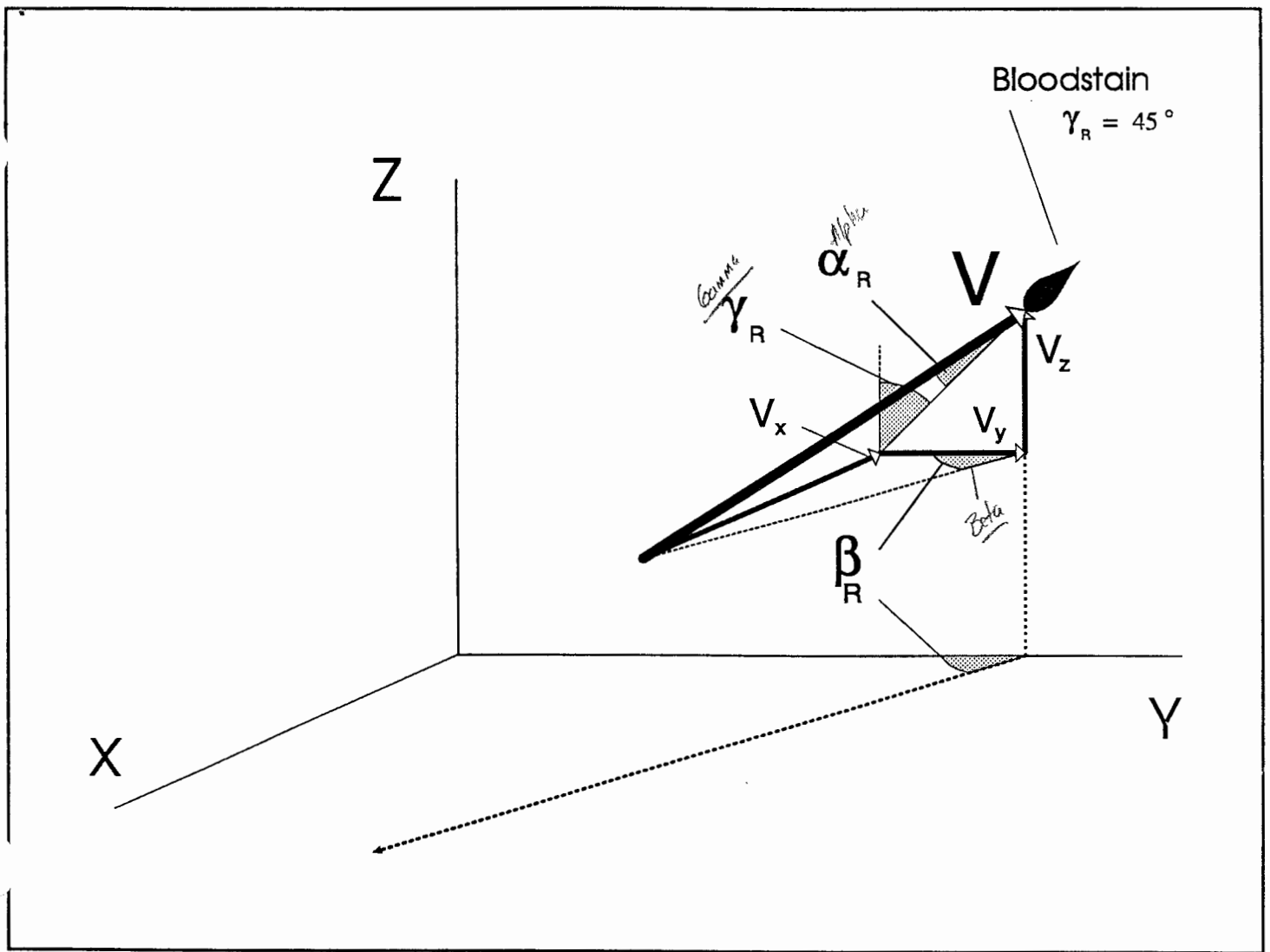
The impact velocity and its relationship to the impact angles.

Two Droplet Analysis Sheet

A	B	C	D	E	F	G	H	I	X	Y
					Alpha α	Tan(β)	β	d		
Drop #	Separation D	Width W	Length L	Gamma γ	$Sin^{-1}(C/D)$	$Tan\,F\,/\,Sin\,E$	$Tan^{-1}\,G$	$\dfrac{B \cdot Sin(\beta_R)}{Sin(\beta_L + \beta_R)}$	$I * Sin(\beta_L)$	$I * Cos(\beta_L)$
1L				γ_L	α_L		β_L			
1R				γ_R	α_R		β_R			
2L				γ_L	α_L		β_L			
2R				γ_R	α_R		β_R			
3L				γ_L	α_L		β_L			
3R				γ_R	α_R		β_R			
4L				γ_L	α_L		β_L			
4R				γ_R	α_R		β_R			

W and L Defined

Figure 1.

Angles Gamma(γ) Defined

Left Droplets.   Right Droplets.

Figure 2.

Point of Convergence

Top View

Figure 3.   ® A.L. Carter and E.J. Podwo   May 9 1990.

TWO DROPLET ANALYSIS SHEET
INSTRUCTIONS

Column A: Choose two droplet stains that are separated horizontally by a couple of feet or more. The left droplet stain should have a gamma value between zero and 180 degrees measured counterclockwise and the right droplet stain a similar angle but measured clockwise. See figure 2 at the bottom of the sheet.

Column B: With a plumb line, draw a vertical line at the location of each droplet stain. With a spirit level, measure the horizontal distance **D** between the two vertical lines. Record this value of **D** in column **B**.

Column C and D: Record the width (W) and length (L) for the two stains, (figure 1).

Column E: Record the value of the angle gamma for each stain, (figure 2).

Column F: Calculate the ratios of W/L for each droplet and then the arcsine of these ratios and record the results in column F.

Column G: Calculate the tangent of the entries in column F and divide these results by the sine of the corresponding entries in column E and record the answers in column G.

Column H: Compute the arctangent of the entries in column G and record these answers in column H. These are the angles β_L and β_R.

Column I: Multiply the entry in column B by the sine of β_R and then divide by the sine of the angle obtained by adding β_L and β_R and record this answer in column I. This is the distance **d** shown in figure 3.

Column X: This is the X coordinate of the point of convergence and is computed by multiplying the entry in column I by the sine of the angle β_L, (figure 3).

Column Y: This is the Y coordinate of the point of convergence and is computed by multiplying the entry in column I by the cosine of the angle equal β_L, (figure 3).

A.L. Carter and E.J. Podworny,
Ottawa, April 1990.