# Four Workshops on Forensics and Mathematics 

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## INTRODUCTION

The labs following this introduction and a compendium of suggestions on creating materials for the labs depict four situations that a coroner may be called upon to investigate. Although they are totally fictional, they are based on cases or a compendium of cases actually investigated by Pat.

At the end of the laboratory description is a reference to chapters Pat, Carl, and Josef's book, Forensische Mathematik für den Unterricht, published in the bk teachware Series, "Support in Learning". If you prefer an English version of a particular reference, the unedited English manuscript pages can be obtained by e-mailing either Pat or Carl at the addresses given above.

The plan for this workshop is to divide the participants into groups of three or four, preferably three, teachers. During the first session the teachers will construct the scene for their students to investigate. This will be a busy time. The team will create materials or use materials that are supplied to them to construct the scene. They will also make up the answer sheet that will be used to check their students investigative work. Since each crime scene involves giving an approximate range for a person's height from the length of their stride, the activity in chapter 1 of the book will be a joint project. As a class you will gather data. The analysis of the data and conclusions will be done by each team. For the rest of the activities used in the lab project, each team is on its own.

During the second part of the workshop one member of each team will remain at the scene that the team has created. This person will evaluate Coroner's Scene Investigating (CSI) team's analysis of the scene. The remaining members of the team will visit one of the other coroner's scenes. There they will, under the watchful eye of the evaluator, perform their investigation and analysis. The investigators will write up their report and turn it in to the evaluator.

If time permits, the evaluator will become an investigator and one of the investigators will become an evaluator and a new Coroner's Scene will be investigated and analyzed.

## SUPPLY AND EQUIPMENT SUGGESTIONS

## Footprints

Ideally, each team should have three or four "footprints" laid out at the scene to simulate evidence left behind at the scene. We made the prints that you will be given by taking a pair of shoes and pressing the soles of the shoes in muddy ground. We then placed the shoes on a piece of poster board and pushed down leaving a muddy print on the poster board. We cut out a rectangle the size of a piece of paper around each footprint after the print had dried and photocopied the print, making four prints (two left and two right) for each team. The team will decide how tall the person who "donated" the prints should be and lay them out at the Coroner's Scene. Recall, in the text, the students did an activity to show that there is no correlation between shoe size and height. Only stride length matters.

## Blood Spatters

We recommend water soluble poster paint for making blood spatters. You may have to dilute it a little. Experiment! The nice thing about poster paint is that it can be rather easily washed off of smooth walls, clothing, and skin. It is also non toxic.

To create the spatters, we found that the brushes we will give you (round, about 1 to $11 / 2$ cm in diameter) worked well. You need to experiment with making spatters. We did not get it to work on the first try. We needed to thin the poster paint a little and then dip the brush into the paint so that all of the bristles were covered. We then attached the poster board to the wall with plastic sheeting behind to catch any stray spatters. Standing off to the side and back a few feet, we aimed towards the board and flicked our wrist. Practice until you can get a few good elliptical shaped spatters to use for your "crime scene."

## "Body" Temperature

This is the toughest one to do realistically since it is unlikely, although fortunate, that you will have a corpse to use for your lab. We use a container of warm water that is close to the body temperature you are given for the victim. Place the temperature probe in the water for a half hour and record the temperature at five minute intervals. If you have a temperature probe that is connected to a TI calculator with appropriate software, you can record the temperature at more frequent intervals for a shorter time. The goal is to have enough data points to do an exponential regression that will enable the students to project back to the time, $\mathrm{T}_{1}$, when the curve passes through the point ( $\mathrm{T}_{1}, 98.6$ ), or if you are using a Celsius scale ( $\mathrm{T}_{1}, 37$ ). Obviously, the cooling process of the water is not the same as that of the human body, but the mathematical procedure for the processes is identical.

## Pedestrian Struck

This is another hard one to duplicate. There are many variables to take into account and, in general it is not a good formula for an accurate estimate of the speed of the vehicle that hit the pedestrian. In addition to speed, one needs to take into account the size and weight of the vehicle, the angle at which the pedestrian was struck, the location on the vehicle that struck the pedestrian, the size of the pedestrian, and many other variables.

What we do is have a toy vehicle strike wooden dowels of different sizes and diameters at different speeds and at different positions on the vehicle. We then note the position of the dowel after impact in terms of the distance from the impact site and the angle that the pedestrian was thrown. For each dowel we do this at different speeds for the vehicle and different points of impact. We then ask the students to plot the distance vs speed. In general, this illustrates that the investigation is far more complicated than the student might assume at first.

In order to vary the speed of the vehicle an inclined plane is set in place. The students calculate the speed of the vehicle at the bottom of the plane from various distances up the plane. They mark these positions on the plane. The victim is then placed at the bottom of the plane in a fixed position for all experiments.

## GPS

This can be fun if you are out of doors and have a large enough area to work with. Of course, you will also need a GPS . Take an object and conceal it some distance from where the team will start. Record the geographic coordinates of the object using the GPS. Then ask the students to navigate from their starting position to the object. This will serve as a starting point for a unit on using a CAS to assist in solving non-linear equations. We highly recommend that you start with a simple 2 -dimensional system that can be solved by hand before jumping into the full blown 4-dimensional system (x,y,z,t) needed for GPS navigation requiring the assistance of the CAS, such as Derive ${ }^{\circledR}$.

## SCENARIO \#1

## BURGLARY HOMICIDE

> Scene:
> Residential area in a single family dwelling at 2300 hours. Obvious forced break-in-glass on floor of rear kitchen door. All doors/windows were locked. Call came from spouse at residence at 2250 hours. She stated that she had just come home and found her husband on the hall floor. Apparently he had interrupted a burglary in progress and the perpetrator had shot him and had left through the same door by which he had entered. She then called 911. You see muddy footprints on the deck leading to the kitchen door and also on the kitchen floor. There are also bloody footprints on the kitchen floor exiting the scene. Several items the perpetrator was going to take had been dropped on the hall floor. The victims hands were clenched and had blood on them. In the clenched right hand was a piece of fabric. The victim's temperature (via liver probe) at 2315 is 97 degrees.

Activities to be determined:

1. Stride length-determine height of perpetrator (also determine size \& type of shoe)
2. Dusting house and items for fingerprints (also taking prints of victim \& spouse to rule out)

## Other considerations in this investigation

1. Neighborhood witnesses-did anyone see or hear anything-cars or persons in area, noise like glass breaking or gunshots and description
2. Retrieve rounds $\&$ shells from weapon
3. Analyze material in victim's hand
4. Check blood on hands-does it match victim or perpetrator
5. Check for possible DNA under victim's nails as perpetrator may have injuries
6. If possible injuries check with hospitals for any persons treated
7. Any history of breakins in the area?
8. Samples from floor, victim's clothing looking for fibers, hairs, etc

Chapters in Forensic Mathematics for the Investigation to reference

1. Finding Holmes Formula
2. Weather or Not
3. Spitter Spatter

10 When Will They Ever Change?

## SCENARIO \#2

## HOMICIDE-GUNSHOT-SERIAL KILLER

Scene:
You are called to a scene in a metropolitan area at a single family residence. The residence is unlocked and there is no sign of a break-in. (Did the victim possibly know the perpetrator and let him in?) The victim was found at 0900 by a co-worker. The victim had not shown up for work at 0700 and had not called in. This was highly unusual for the victim. The co-worker came to the house and found the door open and entered to find the victim bound with duct tape sitting on a chair in the kitchen. He immediately used his own cell phone and called police. The victim had last been seen at a nearby market at 1700 hrs the evening before. When viewing the victim you see a single gunshot wound to the head and blood spatter on the wall behind the victim. You also see a note taped to the victim which is in code. *Within the area in the last six months there have been four carbon copy homicides and you feel that this is the fifth victim. You notice at the scene that there is evidence that the victim had prepared and eaten dinner and had not cleaned up. The victim is fully dressed and the bed does not appear to have been slept in. It is summer at 0900 and the temperature in the residence is 72 degrees (home is airconditioned and turned on). There are no lights on and the TV in the living room is off. Using a temperature probe in the liver you determine over the next hour the body temperature starting now is 88degrees and will be checked every 15 minutes for change.

Activities to be determined:

1. Time since death
2. Blood spatter-possible height \& position of perpetrator and distance from victim when shot
3. Drawing of eye fluid to determine potassium level *of most use within 12 hours of death
4. Encoding of the message. *See below. For the exercise you must choose a method appropriate for your students and encode it.

## Other considerations in this investigation

1. Fingerprints
2. Duct tap-brought into scene? Same as used at other crime scenes?
3. Footprints-outside or within blood spatter on floors
4. Talking to co-workers/friends/acquaintances where victim was known. Had victim mentioned to anyone that he felt stalked or followed. Any personal problems?
5. Look for witnesses-neighbors re: vehicles or people noticed in neighborhood
6. Analyze stomach contents for time frame since victim had eaten
7. Check victim and scene for hairs, fibers that may have come from perpetrator \& documentation of anyone that had come into the scene
8. Analyze paper, ink on note-where purchased or manufactured \& did it match with other scene notes. Same or different coding as other scenes. Handwriting or printer comparisons
9. Type and caliber of projectile-any shell casings at scene
10. Speak with person who found victim-why had they come to scene, what time \& had they touched anything
*The translation of the message is: "You detectives are too stupid to catch me. I will kill again."

Chapters in Forensic Mathematics for the Investigation:
2. Weather or Not
3. Alphabet Soup
6. Spitter Spatter

## SCENARIO \#3

## PEDESTRIAN STRUCK

## Scene:

Police patrol vehicle came upon victim who was lying alongside the roadway with obvious multiple trauma at 0400 . The road was an unlit paved rural two lane road which had a posted speed of 40 mph . The weather was cool ( 50 degrees F ) and dry and it was a moonless night. The victim had dark hair and was wearing dark hooded sweatshirt and dark pants and shoes. He was found lying facedown three feet from the paved road on the grassy berm. No identification was found or about the victim. When the coroner arrived the victim's core temp was 97.2 (F) and the major impact to the body was to the left hip/pelvis area. *Height of the impact point suggests a higher vehicle such as a pickup, delivery or large truck. Small chips of green metallic paint are found on the victim. Further back on the road is found a small pile of dirt and debris which possibly correlates to the passenger side fender of the vehicle. This may be 'fender drop' which can occur at the impact location and may contain soil, sand, stone, tar chips, etc., which might help in determining where the impacting vehicle may have come from.

Activities to be determined:

1. Time of death
2. Identification using fingerprints
3. Determining distance and angle thrown and attempt at finding the velocity of the vehicle.

## Other considerations in this investigation

1. Canvas area to find anyone who had seen the victim last and at what time.
2. When had police last come through the area
3. Check for tattoos, scars, dental \& skeletal xrays, DNA for help with identification
4. Toxicology results
5. Missing persons flyers
6. Notify local auto/truck repair facilities for notification of any green/metallic vehicle that was brought in for repair with right front/fender damage
7. Paint can be analyzed for possible make/model of vehicle
8. Analyze fender drop and canvas possible matching geographic areas
9. Check delivery services for any traffic in the area

Chapters in book to reference:
2. Weather or Not
4. Speed Kills
10. When Will They Ever Change?

## SCENARIO \#4

## SINGLE VEHICLE MOTOR VEHICLE ACCIDENT

## Scene:

Single vehicle into pole. Location is just outside of town on a state road. The two lane paved roadway is dry and the posted speed limit by the vehicle is 40 mph . The accident had been called in by a passerby at 0230 hours who had not witnessed the accident and had been traveling in the opposite direction. The temperature when you arrive on the scene is 62 degrees ( F ). Just back the road , from where the vehicle came to rest, is a very sharp curve with a clear set of braking \& skid marks leading out from the center of the curve, followed by loose gravel at the edge of the roadway where the vehicle left the road. The posted speed just prior to the curve is 25 mph . The vehicle is an older model and the victim is seat-belted but was not equipped with an air bag.

Activities to be determined:

1. Using GPS determine location of accident \& distance from a fixed point such a town line
2. Determine the time of death
3. Determine speed of the vehicle using the length of the skid marks Other considerations in this investigation
4. ID of victim-documentation/verification on victim \& in vehicle. If still unkown use tattoos, scars, teeth, healed fractures, fingerprints
5. Blood toxicology
6. When and where last seen
7. Traveling alone?
8. Possible time expected at final destination
9. Utility pole number
10. Signs on roadway that driver attempted to correct skid
11. Extent of intrusion of tree into vehicle

Chapters in book to reference:
2. Weather or Not
5. Investigating Motor Vehicle Accidents
11. Where In The World Is It?

