Assignment Brief 6.2

Unit Name: Forensic Science	**Unit Number:** Unit 6
Assignment Title: Calculations	**Assignment Number:** 6.2
Date Set:	**Due Date:**

Assessment Objective(s): AO2b

Brief:

Forensic scientists use mathematical calculations

- to help in analysing evidence
- to calculate where additional evidence might be looked for.
- to assess the probability of the evidence being attributable to more than one person.

Task:

Read through the scenarios and answer the questions.

The scenarios are entitled:

- The position from which a gun was fired.
- Poisoning by lead?
- Reliability in matching DNA fingerprints.

Max marks possible for this task: 4

Resources:

The position from which a gun was fired

(Answers are given in italics)

A body was discovered in the middle of a wood. A bullet was removed from the body. A search of the area immediate area around the body found footprints at the base of a tree roughly 50 metres from the body. These footprints were subsequently analysed and used to find a suspect.

Use calculations to show that the firer of the gun could have been standing 50 metres away and so the owner of the shoes that made the footprints could have fired the gun and could have been the murderer.

The trajectory of the bullet after firing the gun will be an arc.

(a) Sketch the trajectory, assuming that:

- the bullet was fired at a shoulder height of 1.50m
- the direction of the bullet at firing was horizontal
- the victim was hit in his stomach 1.48m above the ground.

(Note: The vertical scale will need to be exaggerated with respect to the horizontal scale)

(b) Calculate the vertical distance that the bullet travelled.

0.02 m

(c) The vertical component of the bullet's motion can be analysed by assuming that the bullet was in free fall.

Use the answer from part (b) to obtain the time of travel for the bullet, assuming that the vertical distance travelled = $ut + \frac{1}{2} at^2$
where u = initial velocity in ms^{-1}
t = time of travel in s
a = acceleration due to gravity
= 9.8 ms^{-2}

$0.02 = \frac{1}{2} \times 9.8 \times t^2$
$t^2 = 0.04/9.8 = 0.00408$
$t = 0.064$

(d) Use the answer from part (c) to calculate the horizontal distance travelled assuming that

- the velocity of the bullet on firing was 840 ms^{-1}
- the horizontal distance travelled = $ut + \frac{1}{2} at^2$
  where u = initial velocity in m s^{-1}
  t = time of travel in s
  a = acceleration in ms^{-2}

Horizontal distance = 840 x 0.064 =53.67m

(e) Discuss the validity of this evidence in court.

Poisoning by lead?

An elderly man who has been living by himself was found dead at his house by a neighbour. The neighbour had not seen him for several days so had called to see if he was alright.

The house in which the elderly man lived was built in the nineteenth century and had not been modernised so still had lead pipes in which the water flowed.

The forensic science team need to find out if the cause of death was lead poisoning from the lead pipes or whether there is another cause of death.

The concentration of lead ions Pb^{2+} in a solution can be found using the colour produced by the chelating agent dithizone ($C_6H_5 – N = N – CS –NH – NH – H_5C_6$).

A buffer solution of pH 9 is added to the solution under investigation. A drop of tetren (teraethylene pentamine) is added to prevent the interference of other metal ions. Dithizone is added to the mixture, which is then shaken. The colour of the lower layer containing dithizone is compared to the colour produced by the same test using known solutions of known concentrations of the lead ion.

Solutions of known concentrations of lead nitrate must be prepared.

1 dm^3 of a solution of containing 0.64g lead nitrate $Pb(NO_3)_2$ is made.

This is the stock solution.

(a) Calculate the concentration of lead nitrate in the stock solution.

5 cm^3 of the stock solution were pipetted into a volumetric flask and made up to 1dm^3.

(b) Calculate the concentration of this solution.

10 cm^3 of the stock solution were pipetted into a volumetric flask and made up to 1dm^3.

(c) Calculate the concentration of this solution.

50 cm^3 of the stock solution were pipetted into a volumetric flask and made up to 1dm^3.

(d) Calculate the concentration of this solution.

When the dithizone is added under the conditions of the test, an orange colour is seen if the concentration of the lead compound is greater than 30.0×10^{-6} mols dm^{-3}. A colour between green and red is seen if the concentration of the lead compound is less than 30.0×10^{-6} mols dm^{-3}.

(e) Which of the solutions of lead nitrate would produce an orange colour?

(f) Is this analysis sufficient to decide whether the elderly man died of lead poisoning due to the lead in the water in the pipes of his house?

(g) Write about what evidence and facts are needed in order to be sure of the cause of death.

Reliability in Matching DNA fingerprints.

Obtaining and comparing DNA found at a crime scene with the DNA taken from a suspect is one of the techniques used as evidence in a conviction.

DNA is processed and treated in such a way as to obtain visible evidence known as a DNA fingerprint. Such a fingerprint is a series of lines.

DNA fingerprints from samples found at the crime scene and taken from the suspects are compared to find out if the lines are in exactly the same place in each fingerprint.

The lines represent the position of an allele at a genetic locus. The genetic locus is the position at which the gene is present in a cell.

Different versions of a gene are called alleles. It is genes that determine the characteristics of organisms.

As every cell formed by fertilisation inherits genes from both male and female the alleles at any particular genetic locus can be the same (homozygous) or different (heterozygous.)

In the analysis of a DNA fingerprint the genetic locus and the allele is identified.

The DNA of 324 people (i.e. 648 alleles) was analysed.

The frequency at which two DNA fingerprints could match was calculated.

At locus CSF1PO the allele 10 was observed 162 times out of a total of 648.

(a) Calculate the frequency at which the allele occurred.

At the same genetic locus, the allele 11 was noted 216 times out of a total of 648.

(b) Calculate the frequency at which this allele occurred.

These alleles come from either the male or the female so the chance of having both these alleles is two times the frequency of allele 10 (p), multiplied by the chance of having allele 11(q), i.e. 2pq.

(c) Calculate the chance of having both allele 10 and allele 11.

(d) Complete the table below using the methods used in (a), (b) and (c).

DNA Profile		Allele frequency from data base				Genotype frequency for locus	
Locus	**Alleles**	**times allele observed**	**size of data base**	**Frequency**		**formula**	**number**
CSF1PO	10	162	648	p		2pq	
	11	216		q			
TPOX	8	343	648	p		p^2	
	8						
THO1	6	155	648	p		2pq	
	7	97		q			
vWA	16	136	648	p		p^2	
	16						

The probability of having a match at several loci is obtained by multiplication.

The genotype frequency for each locus is multiplied together.

(e) Use the values from the table to calculate the probability of having a match at:

(i) locus CSF1PO and locus TPOX

(ii) locus CSF1PO and locus TPOX and locus THO1

(i) locus CSF1PO and locus TPOX and locus THO1 and locus vWA

The answer to (e) (iii) gives the chance of two fingerprints matching at four different lines i.e. at four different loci.

(f) Is this chance value enough to assume that the matching of two DNA fingerprints from the crime scene and from the suspect proves the suspect guility of the crime? Explain the reasoning behind your answer.

(g) How could the chance of matching DNA fingerprints be reduced?

(h) Are there any other errors that could be introduced during the process of DNA analysis?

(i) If you were the defence lawyer trying to prove that the fact that your clients' DNA matches that of DNA found at the crime scene does not prove your client guilty, what other facts would you bring produce in your evidence?