Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Wednesday 19 June 2024

Morning (Time: 2 hours)

Paper reference **9ST0/03**

Statistics

Advanced

PAPER 3: Statistics in Practice

You must have:
Statistical formulae and tables booklet
Calculator

Total Marks

Candidates may use any calculator allowed by Pearson regulations.
Calculators must not have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Unless otherwise stated, inexact answers should be given to three significant figures.
- Unless otherwise stated, statistical tests should be carried out at the 5% significance level.

Information

- A booklet 'Statistical formulae and tables' is provided.
- There are 6 questions in this question paper. The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

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Answer ALL questions. Write your answers in the spaces provided.

1 The stem and leaf diagram below shows the results of a test sat by 15 students.

4	5
5	1 8 8
6	1 3 7
7	1 1 3 5 5 9
8	3
9	1

Key

4 | 5 represents 45

A lower outlier is defined as a value $<$ LQ – 1.5 IQR.

An upper outlier is defined as a value $>$ UQ + 1.5 IQR.

Show that there are no outliers for the given data set.

(6)

(Total for Question 1 is 6 marks)

2 Cats that have diabetes are treated with insulin. It is believed that insulin might cause a growth disease in cats.

Cats, that are being treated with insulin, routinely have their level of IGF-I, a growth hormone, measured to see if the insulin is causing any side effects.

A random sample of 23 cats with diabetes was obtained and these cats were put into three categories

- short-term, those who have received insulin for 31 days or less
- medium-term, those who have received insulin for 32 days to 14 months
- long-term, those who have received insulin for more than 14 months

Routine measurements of the levels of IGF-I (nanomoles per litre) in these cats are given in **Figure 1**

IGF-I measurements		
Short-term	**Medium-term**	**Long-term**
51	74	189
49	52	163
30	49	158
28	48	144
26	45	142
25	40	109
24	38	88
23		88

[Source: https://journals.sagepub.com/doi/pdf/10.1016/j.jfms.2004.01.002]

Figure 1

The data produced the following summary statistic

$$\sum x_i^2 = 182\,569$$

Viraj decides to carry out one-factor ANOVA to investigate whether there is any difference between the mean IGF-I measurement for the different lengths of time the cats received insulin.

(a) Complete Viraj's hypothesis test.

You should make any necessary assumptions.

(10)

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Question 2 continued

Question 2 continued

(b) Suggest **two** blocking factors that could be used to improve the test in (a)

(2)

(c) State **two** assumptions required for the test in (a) to be valid.

(2)

(d) With reference to your answer in (c), give **one** reason why you would recommend that Viraj does **not** use one-factor ANOVA to investigate the data in Figure 1.

(1)

(Total for Question 2 is 15 marks)

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3 Ewa was interested in the risk of Lyme disease in Poland. Ewa carried out an experiment to investigate the risk of Lyme disease in various locations. Lyme disease in humans is caused by a parasite called a 'tick'.

[Source: https://www.aaem.pl/pdf-71804-9030?filename=Risk%20of%20Lyme%20disease%20at.pdf]

Ewa compared two types of location.

- Timber acquisition, where wood was actively harvested
- Growing of forest, where forests were being grown for future harvesting

To compare the two different locations, the number of ticks in an area of $1\,m^2$ was recorded for a number of randomly selected areas in each location.

The number of ticks found in each of the randomly selected locations is shown in **Figure 2**

Number of ticks in $1\,m^2$	
Timber acquisition	**Growing of forest**
15	16
11	12
8	7
3	5
	4
	1

Figure 2

(a) Explain why it would **not** be valid to analyse this data using a Wilcoxon signed-rank test.

(1)

Ewa says that a Wilcoxon rank-sum test should be used to investigate if there is a difference in average numbers of ticks between these two locations, rather than a *t*-test.

(b) Explain why Ewa might choose to use a Wilcoxon rank-sum test.

(1)

Question 3 continued

(c) Conduct a Wilcoxon rank-sum test to investigate if there is a difference in average numbers of ticks per 1 m^2 between these two types of location.

(8)

(Total for Question 3 is 10 marks)

4 Steven uses a delivery company for his business. The company classifies packages as 'small' if they weigh up to a maximum of 2 kg

Steven sells pumpkins online.

The weight of a packaged pumpkin, harvested after 20 weeks of growth, is assumed to be normally distributed with a mean of **1.8 kg** and a standard deviation of **100 g**

(a) Find the proportion of such packaged pumpkins that would be too heavy to be sent as 'small'.

(1)

(b) Find the probability that, for a sample of 10 such packaged pumpkins, selected at random, their **mean** weight is below 1.7 kg

(2)

Question 4 continued

Steven believes that if pumpkins are harvested after **19** weeks, then the mean weight of a packaged pumpkin will be lower than 1.75 kg

(c) Investigate Steven's belief, given that a sample of 10 packaged pumpkins harvested after 19 weeks is found to have a mean weight of 1.7 kg

You may assume that the standard deviation for the weights of these packaged pumpkins is also 100 g

(5)

Steven obtained the sample of 10 pumpkins in part (c) from the corner of the field nearest to his house.

(d) By considering an assumption that had to be made about the sample in order for the investigation in (c) to be valid, comment on the validity of your conclusion in (c)

You should state the assumption made.

(2)

Question 4 continued

(e) Define a parameter and a statistic.

Give an example of each in the context of this question.

(4)

Steven also sells melons, whose weights may be assumed to be normally distributed, with a mean weight of 1880 g

(f) Given that 3% of the melons weigh more than 2 kg, determine the standard deviation of the weight of a melon.

(3)

Question 4 continued

A histogram of weights of melons is produced and is shown in **Figure 3**

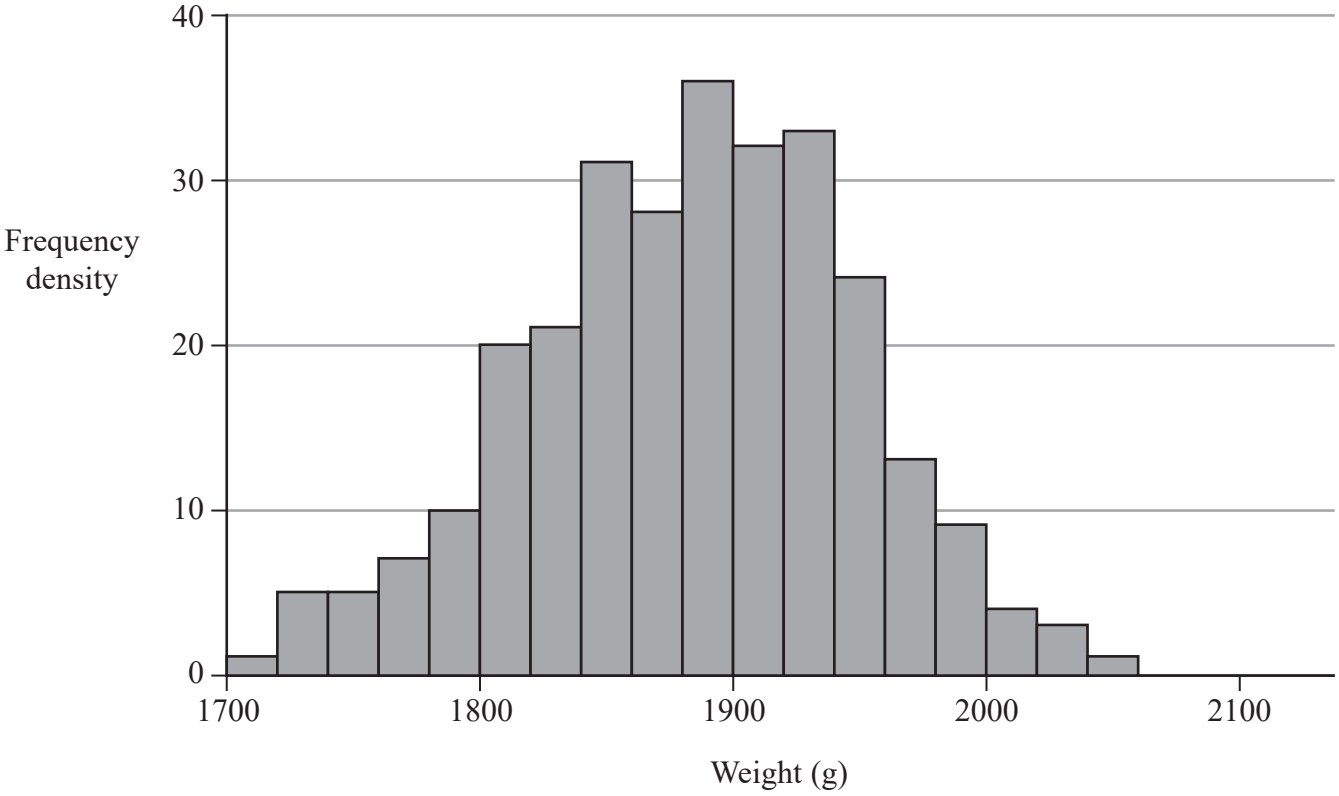

Figure 3

(g) Give **two** reasons why **Figure 3** suggests the normal distribution used in (f) is appropriate for modelling the weights of melons.

(2)

(Total for Question 4 is 19 marks)

5 Linus is interested in the US stock market, where it is possible to buy shares in companies.

Linus models the **change**, increase or decrease, in price of a share, on a randomly chosen day in 2023, as a normal distribution.

Using past data, Linus decides to use $X \sim N(0.65, 4.78)$ to model the change in price of a share in an electronics company, in dollars, on a randomly selected day.

[Source: www.nasdaq.com]

(a) Explain, in context, the property represented by the random variable $2X$

(1)

X_1 and X_2 are independent random variables which follow the same distribution as X

(b) Explain, in context, the property represented by the random property $X_1 + X_2$

(1)

One working week for the stock market, consisting of Monday to Friday, is chosen at random from those in 2023

(c) Find the probability that, at the end of the chosen working week, the price of a share in the electronics company is at least five dollars more than it was at the start of that working week.

You may assume that changes in price are independent of day.

(3)

Question 5 continued

Linus says the probability in part (c) is the probability that, during a randomly selected working week, the price of a share has changed by at least five dollars.

(d) Give **two** reasons why Linus is wrong.

(2)

The change in price of a share one day may impact the change in price of that share on the following day.

(e) Explain how this information impacts the assumption and the validity of the calculation in (c)

(2)

Linus's estimates of the parameters were based on **only** data from January 2023

(f) Explain, with a reason, how Linus could improve the validity of his model.

(2)

(Total for Question 5 is 11 marks)

6 Josceline has a music player with 145 songs stored on it.

The shuffle function on Josceline's music player selects the next song to play by **randomly selecting** a song from all the songs stored on the music player.

Josceline's friend, Suji, has a different music player with 80 songs stored on it.

The shuffle function of Suji's music player creates a **list**, in **random order**, of all the songs stored on the music player, and then plays through this list. When it has played through all the songs, it repeats the process, creating a new random list.

(a) Identify the type of sampling that

(i) Josceline's shuffle function performs,

(1)

(ii) Suji's shuffle function performs.

(1)

(b) Explain the difference between the two types of sampling identified in (a)(i) and (a)(ii)

(1)

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Question 6 continued

(c) Explain how Josceline could use a random number generator to select a sample of 30 songs, from those on her music player.

(4)

(d) Find the probability that, when Josceline uses the shuffle function of her music player,

(i) the first and second songs played are the same,

(1)

(ii) the first four songs played are all different,

(2)

(iii) the first 146 songs played are all different.

(1)

Question 6 continued

Suji claims that the shuffle function of her music player will never play the same song twice in a row.

(e) Explain why Suji is wrong.

(1)

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Question 6 continued

Of the 145 songs on Josceline's music player, 35 are by the same singer.

Josceline believes that, when using her shuffle function, songs by this singer come up more often than she would expect.

To investigate her belief, she counts the number of songs by this singer that appeared in the first 30 songs played with her shuffle function. She found that 11 of these songs were by the singer.

(f) Carry out a hypothesis test to investigate Josceline's belief.

(5)

Question 6 continued

Suji wants to carry out the same hypothesis test used in (f), using the first 30 songs played with her shuffle function.

(g) Explain why Suji's test would not be valid.

(2)

(Total for Question 6 is 19 marks)

TOTAL FOR PAPER IS 80 MARKS

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