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Candidate surname					Other names									
Pearson Edexcel					Centre Number					Candidate Number				
Level 3 GCE					<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>					<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>				
Linear Combinations														
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Statistics Advanced Topic Test														
You must have: Statistical formulae and tables booklet Calculator												Total Marks <input type="text"/>		

**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 5 questions in this question paper. The total mark for this paper is 50.
- 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.

1. Polyurethane foam is made up of a resin and an activator. When mixed together, the foam can be used for insulation and filling in holes.

The weight of a barrel of resin, X kg, arriving at a builders' merchant is assumed to be normally distributed with a mean of 65 and a standard deviation of 1.5.

The weight of a barrel of activator, Y kg, arriving at a builders' merchant is assumed to be normally distributed with a mean of 70 and a standard deviation of 2.

A builder purchases a barrel of resin and a barrel of activator.

- (a) Find the mean and the variance of the **total** weight of the two barrels. (3)

- (b) Find the probability that the total weight of the two barrels is over 138 kg. (1)

- (c) State one further assumption required for your answers to be valid. (1)

Resin sold at a cost of £1.59 per kg and activator is sold at a cost of £1.28 per kg.

- (d) Write down a suitable linear combination, in terms of X and Y , for the cost of buying these two barrels. (1)

(Total 6 marks)

2. In an article about the natural selection of British birds, **Figure 1** shows summary statistics about five traits from a large number of living cliff swallows. The traits relate to lengths of different body parts of the birds.

	Mean	Standard Deviation
Wing Length	106.87	2.31
Tail Length	46.13	1.83
Tarsus Length	11.52	0.59
Culmen Length	6.94	0.31
Culmen Width	6.27	0.37

Figure 1

[Source: www.jstor.org/stable/2640681]

All measurements are in millimetres.

You may assume that the measurements for each of the five traits may be modelled by independent normal distributions.

- (a) For a randomly selected living cliff swallow, find the probability that

(i) the tarsus length is more than 12 mm,

(1)

(ii) the wing length is more than 2.5 times the tail length.

(5)

A “selection index” for living cliff swallows is a linear combination formed by the sum of the five traits.

- (b) Find the probability that the selection index for a randomly selected cliff swallow is between 160 and 170.

(4)

(Total 10 marks)

3. Justyna runs a start-up confectionery company and is mass producing Justyna's Jaffa Cakes as her launch product.

Each Justyna's Jaffa Cake is made up of a sponge base, a disc of orange jelly and a covering of chocolate.

The production machine used creates the three components under the following specifications:

- The weight of the sponge base is normally distributed with a mean of 6.5 g and a standard deviation of 0.25 g,
- The weight of the jelly disc is normally distributed with a mean of 3.0 g and a standard deviation of 0.15 g,
- The weight of the chocolate is normally distributed with a mean of 2.7 g and a standard deviation of 0.20 g.

The random variable J , in g, represents the total weight of a Justyna's Jaffa Cake.

You may assume the weights of the sponge base, the jelly disc and the chocolate are all independent of each other.

- (a) Find the mean and variance of J .

(3)

The packaging claims that an individual Justyna's Jaffa Cake has an estimated weight of 12 g.

- (b) Find the probability a randomly selected Justyna's Jaffa Cake is under the estimated weight.

(1)

Justyna plans to package Justyna's Jaffa Cakes in a paper tray containing 8 Justyna's Jaffa Cakes and within a cardboard box.

The packaging is manufactured under the following specifications:

- The weight of the paper tray is normally distributed with a mean of 6 g and a standard deviation of 0.5 g
- The weight of the cardboard box is normally distributed with a mean of 7 g and a standard deviation of 0.6 g

Justyna decides to state the weight of the box of Justyna's Jaffa Cakes on the packaging as 110 g.

- (c) Show that T , the total weight of a box of Justyna's Jaffa Cakes, may be modelled by the distribution $N(110.6, 1.61)$

(3)

- (d) Find the probability that a fully packaged box of 8 Justyna's Jaffa Cakes weighs under 110 g.

(1)

- (e) Use your answer to (d) to comment on Justyna's decision to state the weight on the packaging as 110 g.

(1)

(Total 9 marks)

4. Oscar Piastri and Max Verstappen are two Formula 1 racing drivers who competed at the Abu Dhabi grand prix in 2024.

Oscar Piastri's lap times have a mean of 90.04 seconds and a standard deviation of 4.98 seconds.

Max Verstappen's lap times have a mean of 89.85 seconds and a standard deviation of 3.97 seconds.

[Source: https://en.mclarenf1.com/2024/gp/s9313/lap_times/-821/]

The race consisted of 58 laps of the same track and the lap times are assumed to be independent of each other.

- (a) If both drivers were to race on the same track again, explain why the average lap time for each driver may be modelled by normal distributions.

(1)

- (b) Hence show that P and V , the total race times of Oscar Piastri and Max Verstappen respectively, may be modelled by $N(5222.32, 1438.42)$ and $N(5211.30, 914.13)$ respectively.

(4)

Using these models and making any necessary assumptions,

- (c) find the probability that Oscar Piastri will beat Max Verstappen in a race of 58 laps on this track.

(5)

- (d) Explain why your answer to part (c) may not be valid.

(1)

(Total 11 marks)

5. The annual cost of utility bills (in £) for three major utilities (Gas, Electricity and Water) are recorded for three different household sizes.

The means and standard deviations of the annual costs of utility bills is shown in **Figure 2** below.

	Gas		Electricity		Water	
Household size	Mean	SD	Mean	SD	Mean	SD
Small (e.g. 1 bed flat/house)	583.59	150.18	640.59	175.53	507	98.46
Medium (e.g. 2-3 bed house)	836.79	250.61	882.16	215.71	850.50	135.49
Large (e.g. 4+ bed house)	1184.94	326.48	1241.45	375.15	1390.67	267.41

Figure 2

Iris is a financial advisor who is advising a housing developer on energy costs. She decides to model the annual cost of utility bills under each factor combination as independent normal distributions.

- (a) Find the probability that a randomly selected small sized household has an annual electricity bill of more than £700

(1)

Three medium sized households are randomly selected.

- (b) Find the probability that the average annual gas bill for these three households is less than £900

(2)

- (c) Find the probability that a randomly selected large sized household has an annual gas bill of more than 20% higher than the average annual gas bill of three randomly selected medium sized households.

(5)

- (d) Find the probability that the annual water bill of a small sized household contributes to more than a third of its total annual utility bill.

(6)

(Total 14 marks)

TOTAL FOR PAPER: 50 MARKS