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Mathematical studies
Standard level
Paper 2

Tuesday 14 May 2019 (morning)

1 hour 30 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- A graphic display calculator is required for this paper.
- A clean copy of the **mathematical studies SL formula booklet** is required for this paper.
- Answer all the questions in the answer booklet provided.
- Unless otherwise stated in the question, all numerical answers should be given exactly or correct to three significant figures.
- The maximum mark for this examination paper is **[90 marks]**.

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Answer **all** questions in the answer booklet provided. Please start each question on a new page. You are advised to show all working, where possible. Where an answer is incorrect, some marks may be given for a correct method, provided this is shown by written working. Solutions found from a graphic display calculator should be supported by suitable working, for example, if graphs are used to find a solution, you should sketch these as part of your answer.

1. [Maximum mark: 16]

A healthy human body temperature is 37.0°C . Eight people were medically examined and the difference in their body temperature ($^{\circ}\text{C}$), from 37.0°C , was recorded. Their heartbeat (beats per minute) was also recorded.

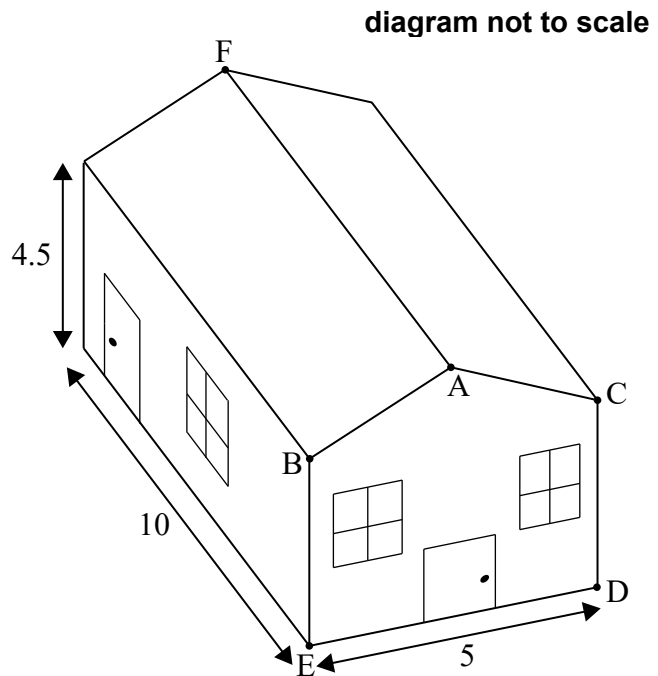
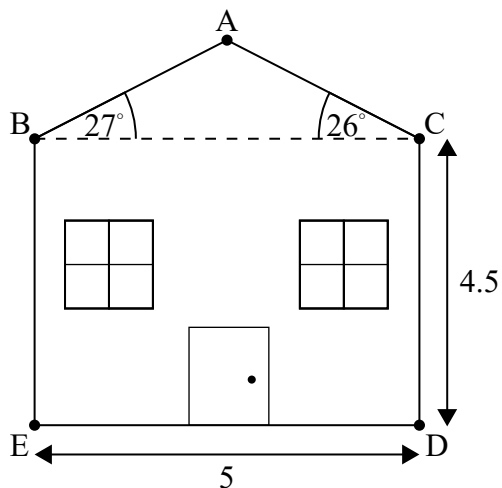
| | | | | | | | | |
|---|------|-----|------|------|------|----|-----|-----|
| Temperature difference from 37°C (x) | -0.2 | 0.3 | -0.3 | -0.2 | -0.1 | 0 | 0.2 | 0.5 |
| Heartbeat (y) | 63 | 77 | 70 | 74 | 65 | 78 | 79 | 86 |

- (a) Draw a scatter diagram for temperature difference from 37°C (x) against heartbeat (y). Use a scale of 2 cm for 0.1°C on the horizontal axis, starting with -0.3°C . Use a scale of 1 cm for 2 heartbeats per minute on the vertical axis, starting with 60 beats per minute. [4]
- (b) Write down, for this set of data
- (i) the mean temperature difference from 37°C , \bar{x} ;
- (ii) the mean number of heartbeats per minute, \bar{y} . [2]
- (c) Plot and label the point $M(\bar{x}, \bar{y})$ on the scatter diagram. [2]
- (d) (i) Use your graphic display calculator to find the Pearson's product-moment correlation coefficient, r .
- (ii) Hence describe the correlation between temperature difference from 37°C and heartbeat. [4]
- (e) Use your graphic display calculator to find the equation of the regression line y on x . [2]
- (f) Draw the regression line y on x on the scatter diagram. [2]

2. [Maximum mark: 16]

Olivia's house consists of four vertical walls and a sloping roof made from two rectangles. The height, CD , from the ground to the base of the roof is 4.5 m.

The base angles of the roof are $\hat{A}BC = 27^\circ$ and $\hat{A}CB = 26^\circ$.



The house is 10 m long and 5 m wide.

(a) Find the length AB , giving your answer to **four significant figures**. [5]

The length AC is approximately 2.84 m.

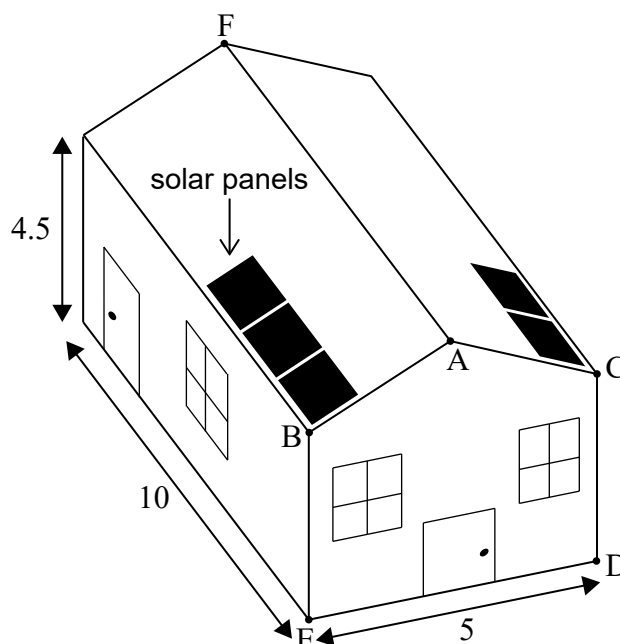
(b) Find the total area of the two rectangles that make up the roof. [3]

(This question continues on the following page)

(Question 2 continued)

Olivia decides to put solar panels on the roof. The solar panels are fitted to both sides of the roof.

diagram not to scale



Each panel is 1.6 m long and 0.95 m wide. All the panels must be arranged in uniform rows, with **the shorter edge** of each panel parallel to AB or AC. Each panel must be at least 0.3 m from the edge of the roof and the top of the roof, AF.

- (c) Find the maximum number of complete panels that can be fitted to the whole roof. [3]

Olivia estimates that the solar panels will cover an area of 29 m^2 .

- (d) Find the percentage error in her estimate. [3]

Olivia investigates arranging the panels, such that **the longer edge** of each panel is parallel to AB or AC.

- (e) State whether this new arrangement will allow Olivia to fit more solar panels to the roof. Justify your answer. [2]

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3. [Maximum mark: 15]

A survey was conducted on a group of people. The first question asked how many pets they each own. The results are summarized in the following table.

| | | | | | | |
|-----------------------------|----|----|----|----|----|---|
| Number of pets owned | 0 | 1 | 2 | 3 | 4 | 5 |
| Number of people | 20 | 45 | 40 | 30 | 20 | 5 |

- (a) Write down the total number of people, from this group, who are **pet owners**. [1]
- (b) Write down the modal number of pets. [1]
- (c) For these data, write down
- (i) the median number of pets;
- (ii) the lower quartile;
- (iii) the upper quartile. [3]

The second question asked each member of the group to state their age and preferred pet. The data obtained is organized in the following table.

| Preferred pet | Age | |
|----------------------|-----------------|---------------------|
| | Teenager | Non-teenager |
| cat | 23 | 32 |
| dog | 35 | 23 |
| bird | 16 | 13 |
| other | 11 | 7 |

- (d) Write down the ratio of teenagers to non-teenagers in its simplest form. [1]

A χ^2 test is carried out at the 10% significance level.

- (e) State
- (i) the null hypothesis;
- (ii) the alternative hypothesis. [2]
- (f) Write down the number of degrees of freedom for this test. [1]
- (g) Calculate the expected number of teenagers that prefer cats. [2]
- (h) Use your graphic display calculator to find the p -value for this test. [2]
- (i) State the conclusion for this test. Give a reason for your answer. [2]

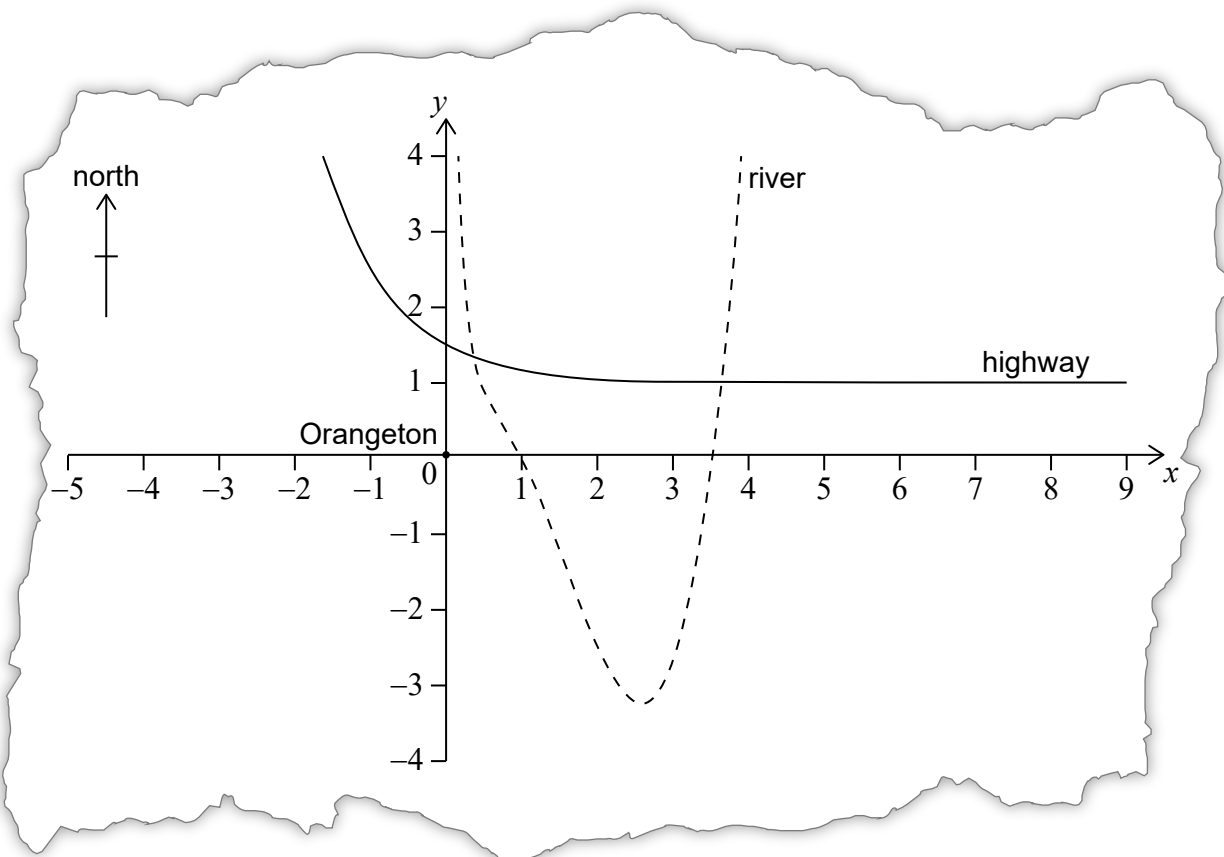
4. [Maximum mark: 15]

Consider the function $f(x) = x^3 - 5x^2 + 6x - 3 + \frac{1}{x}$, $x > 0$.

(a) Find the value of $f(x)$ when $x = \frac{1}{2}$.

[2]

The function $f(x) = x^3 - 5x^2 + 6x - 3 + \frac{1}{x}$, $x > 0$, models the path of a river, as shown on the following map, where both axes represent distance and are measured in kilometres. On the same map, the location of a highway is defined by the function $g(x) = 0.5(3)^{-x} + 1$.



The origin, $O(0, 0)$, is the location of the centre of a town called Orangeton.

A straight footpath, P , is built to connect the centre of Orangeton to the river at the point where $x = \frac{1}{2}$.

- (b) (i) Find the function, $P(x)$, that would define this footpath on the map.
 (ii) State the domain of P .

[5]

(This question continues on the following page)

(Question 4 continued)

Bridges are located where the highway crosses the river.

- (c) Find the coordinates of the bridges relative to the centre of Orangeton. [4]

A straight road is built from the centre of Orangeton, due north, to connect the town to the highway.

- (d) Find the distance from the centre of Orangeton to the point at which the road meets the highway. [2]

This straight road crosses the highway and then carries on due north.

- (e) State whether the straight road will ever cross the river. Justify your answer. [2]

5. [Maximum mark: 14]

John purchases a new bicycle for 880 US dollars (USD) and pays for it with a Canadian credit card. There is a transaction fee of 4.2% charged to John by the credit card company to convert this purchase into Canadian dollars (CAD).

The exchange rate is 1 USD = 1.25 CAD.

- (a) Calculate, in CAD, the total amount John pays for the bicycle. [3]

John insures his bicycle with a US company. The insurance company produces the following table for the bicycle's value during each year.

| Year | Value of the bicycle (USD) |
|------|----------------------------|
| 1st | 880 |
| 2nd | 704 |
| 3rd | 563.20 |
| ... | ... |

The values of the bicycle form a geometric sequence.

- (b) Find the value of the bicycle during the 5th year. **Give your answer to two decimal places.** [3]
- (c) Calculate, in years, when the bicycle value will be less than 50 USD. [2]

During the 1st year John pays 120 USD to insure his bicycle. Each year the amount he pays to insure his bicycle is reduced by 3.50 USD.

- (d) Find the total amount John has paid to insure his bicycle for the first 5 years. [3]

John purchased the bicycle in 2008.

- (e) Justify why John should not insure his bicycle in 2019. [3]

6. [Maximum mark: 14]

The function $f(x) = \frac{1}{3}x^3 + \frac{1}{2}x^2 + kx + 5$ has a local maximum and a local minimum. The local maximum is at $x = -3$.

- (a) Show that $k = -6$. [5]
- (b) Find the coordinates of the local **minimum**. [2]
- (c) Write down the interval where the gradient of the graph of $f(x)$ is negative. [2]
- (d) Determine the equation of the normal at $x = -2$ in the form of $y = mx + c$. [5]
-