Diploma Programme
Programme du diplôme
Programa del Diploma

Mathematics: applications and interpretation
Standard level
Paper 1

24 October 2024

Zone A afternoon │ **Zone B** afternoon │ **Zone C** afternoon

1 hour 30 minutes

Candidate session number

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- A graphic display calculator is required for this paper.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- Unless otherwise stated in the question, all numerical answers should be given exactly or correct to three significant figures.
- A clean copy of the **mathematics: applications and interpretation SL formula booklet** is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

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Answers must be written within the answer boxes provided. Full marks are not necessarily awarded for a correct answer with no working. Answers must be supported by working and/or explanations. 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. Where an answer is incorrect, some marks may be given for a correct method, provided this is shown by written working. You are therefore advised to show all working.

1. [Maximum mark: 4]

One of the steepest train tracks in the world is in Tennessee, USA.

This track is $1.52\,\text{km}$ long, and the angle of elevation from the bottom of the track to the top is $36.1°$.

diagram not to scale

top
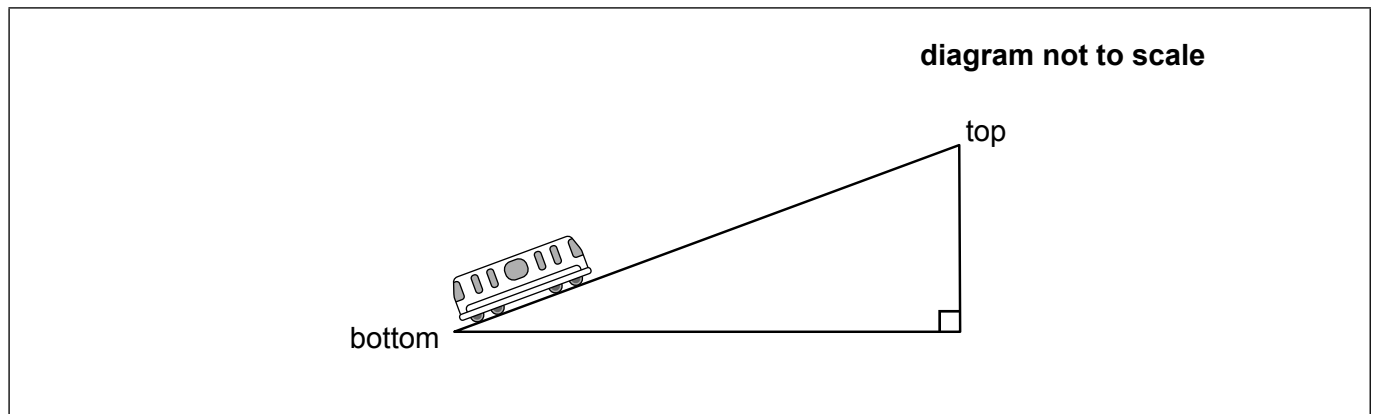
bottom

(a) Label the diagram with the given values for the track length and the angle of elevation. [2]

(b) Find the vertical change in height from the bottom of the track to the top. [2]

2. [Maximum mark: 7]

The scores on a test, out of 7 points, for 240 students are shown in the following table.

Score	1	2	3	4	5	6	7
Frequency	11	29	31	34	65	47	23

(a) Find the mean **and** standard deviation of these test scores. Give your answers correct to four significant figures. [3]

(b) The scores are multiplied by ten. Write down the new mean and standard deviation. [2]

(c) After the scores have been multiplied by ten, 30 points are added to each of them. Write down the new mean and standard deviation. [2]

Turn over

3. [Maximum mark: 5]

Tickets to enter a museum are priced at a dollars for adults and c dollars for children.

A school group of 7 adults and 60 children paid a total of $\$832$.

A family of 3 adults and 5 children paid a total of $\$108$.

(a) Write down **two** equations that represent this information. [2]

(b) Hence, find the price of

    (i) an adult ticket

    (ii) a child ticket. [2]

Rounded to the **nearest thousand**, there were $203\,000$ visitors at the museum last year.

(c) Write down the lower bound for the number of visitors last year. [1]

4. [Maximum mark: 5]

Consider the following triangle, RST, such that $RS = 39\,cm$, $ST = 40\,cm$, and $TR = 46\,cm$.

diagram not to scale
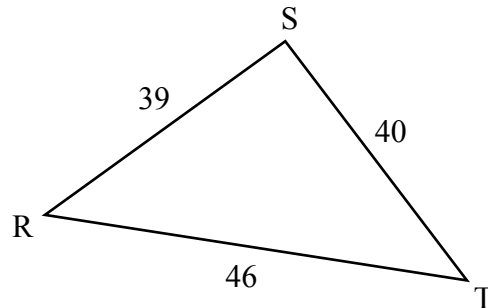
(a) Find the value of $T\hat{R}S$. [3]

(b) Find the area of the triangle RST. [2]

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5. [Maximum mark: 7]

The total cost, $C(d)$, in Canadian dollars (CAD), to hire a bicycle for d days from *Pedal Paradise* is given by the function

$$C(d) = 60d + 10, \, d \geq 3, \, d \in \mathbb{Z}.$$

The total cost includes a fixed charge to hire both a helmet and a repair kit.

(a) State, in context, what the values 60 and 10 represent. [2]

(b) Calculate the cost of hiring a bicycle for 5 days. [2]

Hema hires a bicycle from *Pedal Paradise*.

(c) Write down the minimum number of days she can hire the bicycle. [1]

(d) Given that $C^{-1}(1270) = k$, find the value of k. [2]

6. [Maximum mark: 6]

Radioactive carbon is a material that decays over time.

The mass, $m(t)$ (in nanograms), of radioactive carbon in a fossil of a plant, after t years, can be modelled by the function

$$m(t) = 120e^{-0.000121t}$$

where t is the time since the plant died.

(a)   Write down the initial mass of the radioactive carbon.   [1]

(b)   Find the mass of the radioactive carbon after $20\,000$ years.   [2]

(c)   Calculate the smallest number of complete years it takes for more than half the sample to decay.   [3]

Turn over

7. [Maximum mark: 7]

The mass, W, of Scottish Terriers (a breed of dog) is normally distributed with a mean of $8.9\,\text{kg}$ and a standard deviation of $1.2\,\text{kg}$.

(a) A Scottish Terrier is selected at random. Calculate the probability this dog's mass is more than $7.2\,\text{kg}$. [2]

The following curve represents this distribution. It is known that $P(W < a) = 0.1$ and $P(W > b) = 0.1$.
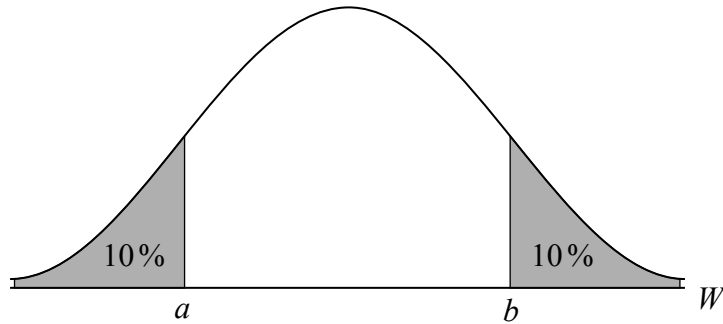
(b) Find the value of

(i) a

(ii) b. [3]

(c) Two Scottish Terriers are selected at random from a large population. Find the probability that both dogs have a mass less than $7.2\,\text{kg}$. [2]

8. [Maximum mark: 5]

On 1 January in a particular year, Anton invests $18000 in a new bank account. The account earns 4% simple interest, on the original $18000, at the start of each subsequent year.

The amounts in the account at the start of each year form an arithmetic sequence.

(a) Find the common difference of this sequence. [2]

After k complete years, the amount in Anton's account will be greater than $32000 for the first time.

(b) Find the value of k. [3]

9.   [Maximum mark: 7]

The records at a driving school show that 60% of students pass their driving test on the first attempt.

A group of 30 students take their driving test for the first time.

As part of its quality control, the driving school uses the model $X \sim \text{B}\,(30,\,0.60)$, where X is the number of students who pass the driving test.

(a)   Calculate the

(i)   mean of X

(ii)   variance of X.   [2]

(b)   Find the probability that

(i)   exactly 21 students pass the test

(ii)   fewer than 12 students pass the test.   [4]

(c)   State one assumption that the driving school makes in using this model.   [1]

10. [Maximum mark: 6]

When Humberto retires, he invests $300\,000$ in an annuity fund that earns interest at a nominal rate of 3.8% per year, compounded monthly.

Humberto then withdraws 2800 at the end of every month to pay for his living expenses.

(a) Find how much is in the annuity fund after 8 years. [3]

(b) Calculate how many times Humberto is able to make these withdrawals. [3]

11. [Maximum mark: 7]

A fair game is played where points are scored as follows:

- A win scores w points.

- A draw scores 0 points.

- A loss scores -7 points.

Let X be the number of points scored during a game. The probability distribution is shown.

x	w	0	-7
P $(X = x)$	0.35	0.4	p

(a) Find the value of p. [2]

The game is played 60 times.

(b) Find the expected number of losses. [2]

(c) Calculate the value of w, given that the game is fair. [3]

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12. [Maximum mark: 7]

Consider the curve $y = 5x^2 - \dfrac{3}{x^3}$.

(a)   Find $\dfrac{dy}{dx}$. [3]

(b)   Write down the gradient of the curve at $x = 1$. [1]

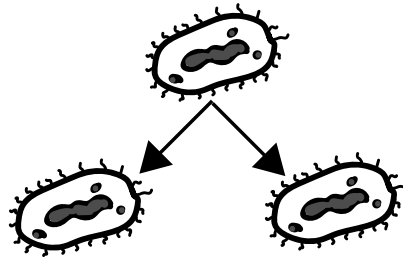(c)   Hence, find the equation of the normal to the curve at $x = 1$. [3]

Turn over

13. [Maximum mark: 7]

A type of bacteria reproduces by **dividing in two** every 10 minutes.

There were 1250 bacteria in a colony 10 minutes after the start of an experiment.

The following table is used to estimate the number of bacteria, u_n, for this colony.

The values of u_n form the terms of a sequence.

n	1	2	3		9		k
Time in minutes	10	20	30		90		$10k$
Number of bacteria, u_n	1250	2500	5000		…		…

(a)   Complete the table by adding the two missing values.   [3]

As the number of bacteria increases from 1250 to 2500, the total number of **bacterial divisions** is 1250.

(b)   (i)   Find the value of n when the number of bacteria is 1.28×10^6.

        (ii)   Hence or otherwise, find the total number of bacterial divisions as the number of bacteria increases from 1250 to 1.28×10^6. Give your answer correct to the nearest thousand bacterial divisions.   [4]

(This question continues on the following page)

(Question 13 continued)

Please **do not** write on this page.

Answers written on this page
will not be marked.