MAISON DES EXAMENS
Service Interacadémique des Examens & Concours

BANQUE DE SUJETS

ANGLAIS / MATHÉMATIQUES

SECTION EUROPÉENNE

SESSION 2022

L'usage de la calculatrice avec mode examen actif est autorisé.
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BACCALAUREAT GÉNÉRAL ET TECHNOLOGIQUE
SESSION 2022

ÉPREUVE SPÉCIFIQUE MENTION « SECTION EUROPÉENNE OU DE LANGUE ORIENTALE »
Académies de Paris – Créteil – Versailles

Binôme : Anglais / Mathématiques

Sujet n°1
Differentiation

The first part of this page is a summary that can be helpful to do the exercise.

Let f be a function defined and differentiable over an interval I
If $f'(x) > 0$ over *I*, then f is an increasing function over *I*.
If $f'(x) < 0$ in over *I*, then f is a decreasing function over *I.*

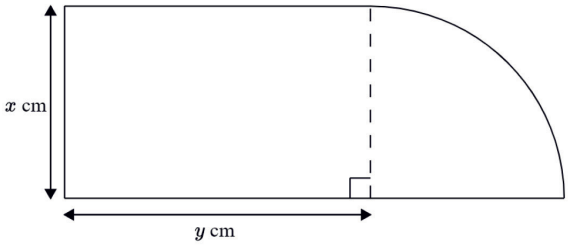
A stationary point $a \in I$ of the graph of f is a point where the gradient *f'(a)* is equal to 0.

It is a maximum if *f''(a)<0* and a minimum if *f''(a)>0.*

Let *C* be a circle of radius r.

- The perimeter of the circle is given by the formula $2\pi r$.
- The area of the circle is given by the formula πr^2

EXERCISE



The diagram above shows a metal plate consisting of an x cm by y cm rectangle and a quarter-circle. The perimeter of the plate is 60 cm.

1) What is the radius of the circle?

2) Express y in terms of x.

3) Let $f(x) = 30x - x^2$.

a) Give the range where *f(x) >0*
b) find the stationary values of $f(x)$.
c) Is it a maximum or a minimum value?
d) What are the dimensions of the plate in this case?

Adapted from Cambridge AS&A Level Mathematics

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Sujet n°2

D3 / Sequences

The first part of this page is a summary that can be helpful to do the exercise.

Arithmetic sequence

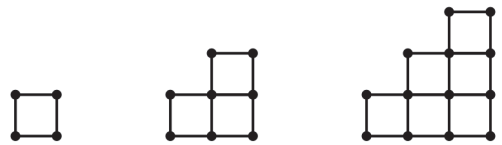
A sequence (a_n) is an arithmetic progression (AP) with common difference d if it can be written $a_{n+1} = a_n + d$, where $n \geq 1$.

The n-th term of an arithmetic sequence whose first term is a_1 and common difference d can be written $a_n = a_1 + (n-1)d$.

For any integer n, $1 + 2 + \cdots + n = \frac{n(n+1)}{2}$ and $1^2 + 2^2 + 3^2 + \cdots + n^2 = \frac{n(n+1)(2n+1)}{6}$

EXERCISE

Max uses matches to make the following diagrams, always following the same pattern.



step 1 step 2 step 3

1) Draw the diagram corresponding to the next step (step 4), following the same pattern.
Let u_n be the number of matches used for step n.

2) Could u_n be an AP or a GP? Explain your answer.

3) Complete the following table:

Step n	1	2	3	4
u_n = number of matches	4	10		
n^2				
$v_n = u_n - n^2$				

4) Assume that (v_n) follows the same pattern

a) What sort of sequence is it exactly?

b) Express v_n in terms of n.

5) a) Express u_n in terms of n.

b) How many matches will Max need at step 10?

c) There are 240 matches in a box of matches. How many boxes will Max need to complete the first 10 steps? Could he make more steps with these boxes?

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Sujet n°5

<u>Thème</u> : D3 – Suites – Sequences

Document 1 : *Victoria Amazonica*

Victoria Amazonica is the largest of all water lilies(1) with huge circular leaves that, incredibly, are strong enough to support the weight of a child. (…) The seeds are the size of peas.(…) They germinate well when placed in warmer water and develop over the next few weeks. (…) By this time, the *Victoria* has leaves about the size of a CD (…) The leaves are at their biggest in June. At this time of the year, the *Victoria Amazonica* will produce a fully grown leaf in about a week, from a small bud to a leaf potentially over 2 m wide in just seven days.

Source: S.Taylor, 11/05/2020, https://www.kew.org/read-and-watch/growing-propagation-giant-waterliles

Questions

Considering a water lily at the beginning of its growth, let u_n be the diameter (in centimetres) of the water lily after n days.

1. Given that $u_0 = 12$ and that the diameter of the water lily increases by 50 % every day, work out u_1 and u_2.
2. Write u_{n+1} in terms ofu_n.
3. Is (u_n) an arithmetic progression? A geometric progression?
4. Express u_n in terms of n.
5. a) What is the diameter of the water lily after 1 week? (to 3 s.f.)

   b) At this time, what is the area(2) of the water lily? (to 2 s.f.)
6. If the growth continued, how long would it theoretically take for the water lily to cover a 10 meter wide pond(3)?

(1) Water lily: a plant whose large, flat leaves and petals float on the surface of lakes and pools.

(2) area of a disc: πR^2

(3) pond: an area of water smaller than a lake, often artificially made.

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Sujet n°6
Thème: D1-Mapping

The first part of this page is a summary that can help you do the exercise.

Any quadratic function can be written as: $f(x) = ax^2 + bx + c$ with a, b and c constants, $a \neq 0$. The graph of f is called a parabola.

The abscissa of the vertex of the parabola is $-\frac{b}{2a}$.

To solve a quadratic equation $ax^2 + bx + c = 0$ with $a \neq 0$, calculate the discriminant $\Delta = b^2 - 4ac$.

- If $\Delta > 0$, the quadratic has two real solutions that are:
  $x_1 = \frac{-b-\sqrt{\Delta}}{2a}$ and $x_2 = \frac{-b+\sqrt{\Delta}}{2a}$
- If $\Delta = 0$, the equation has one and only solution which is:
  $$x_0 = -\frac{b}{2a}$$
- If $\Delta < 0$, the equation has no real solution.

EXERCISE

During a game, a baseball player throws a ball straight up into the air. The height of the ball is given by the function $h(t) = at^2 + bt + 6$, where t represents the time (in seconds) since the ball was thrown and h, the height (in feet) of the ball above the ground. It is given that after one second, the ball is 86 feet high and after 4 seconds, the ball is 134 feet high.

1. Write two equations in terms of a or/and b to prove that $h(t) = -16t^2 + 96t + 6$.
2. When will the ball be at its highest position? How high will the ball be at that time?
3. When will the ball hit the ground? Round to the nearest tenth.
4. Describe the graph of function h in a coordinate plane (vertex, x-intercept, y-intercept…).
5. When will the ball be higher than 8 feet? Round to the nearest hundredth.
6. Can you give another example of real-life application of parabola?

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PROBABILITY

Sujet D7 – n°7

The first part of this page is a summary that can help you do the exercise.

For any events A and B of the sample space:

$$P(A) = P(A \cap B) + P(A \cap \bar{B})$$
$$P(\bar{B}) = 1 - P(B)$$

Conditional probability:

Let A and B be two events. The probability of A given B is $P(A|B) = \frac{P(A \cap B)}{P(B)}$ provided that $P(B) \neq 0$.

Binomial distribution:

If the random variable X gives the number of successes in *n* trials, then X follows the binomial distribution with parameters n and p.
The expectation of a random variable X following a binomial distribution of parameters n and p is equal to np.

EXERCISE

Elsa plans to plant two types of flowers in her garden: 30% are tulips and the rest are roses. Both types will yield either white or yellow flowers.
If the flower is a tulip, the probability that it is white is 0.4. If not, the probability that the flower is yellow is 0.2.

Let T be the event “the flower is a tulip”, R the event “the flower is a rose”, W the event “the flower is white” and Y the event “the flower is yellow”.

1. Draw a tree diagram.
2. Calculate the probability that a flower, chosen at random, will be white.
3. Suppose a white flower is randomly picked from Elsa’s garden, what is the probability of the flower being a tulip?
4. Anna, Elsa’s sister, randomly picked 10 flowers from her garden. Suppose that Elsa has planted a large amount of flowers, we can consider that Anna picked 10 flowers with replacement. Let X be the random variable counting the number of white flowers picked by Anna.
   a) Explain why X follows a binomial distribution and give its parameters.
   b) Find the probability that Anna picked at least five white flowers (round to the 3rd d.p.).
   c) Calculate the expectation of X . Interpret in the context of the exercise.

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Sujet n°8

Thème : D1 - MAPPING

The first part of this page is a summary that can be helpful to do the exercise.

The standard form equation of a quadratic function is: $f(x) = ax^2 + bx + c$ with a, b and c constants, $a \neq 0$. The graph of f is called a parabola.

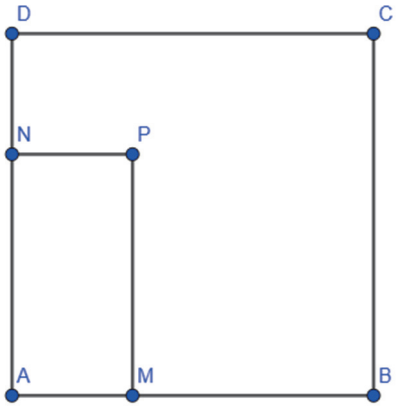
The abscissa of the vertex of the parabola is $-\frac{b}{2a}$.

DO NOT WRITE ON THE SUBJECT!!

EXERCISE

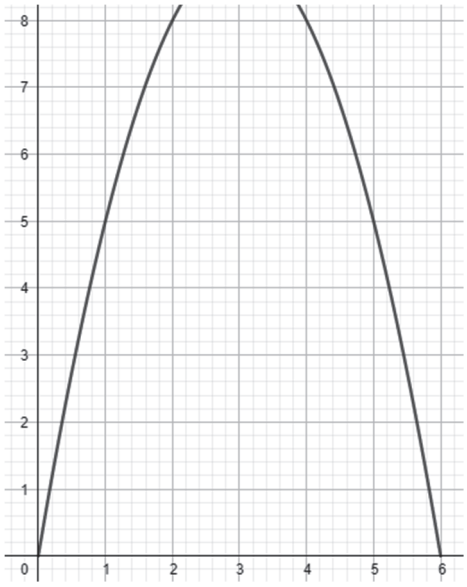
Consider a square ABCD. Let M be a point of [AB] and N a point of [AD] such as:

- AB = 6 cm
- AM = DN = x
- AMPN is a rectangle.



1) What are the possible values of x?

2) Determine the area of the rectangle AMPN in terms of x.



Here is an incomplete graph of the function f representing the area of AMPN against x.

3) Describe the graph of the function f (name, shape, x-intercept, y-intercept, vertex…).

4) Find the value of the area of AMPN when AM is equal to 5 cm.

5) For what distances AM will the area be greater than 6 cm²?

6) Where should M be so that the area is as large as possible?

7) Can you give another example of real-life application of parabola?

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Sujet n°9
Thème: D0 – Core knowledge

The first part of this page is a summary that can help you do the exercise.

Three numbers a, b, c are in the ratio p:q:r where p, q and r are different from 0 if $\frac{a}{p} = \frac{b}{q} = \frac{c}{r}$

1) **a)** Here are simultaneous equations. Solve them, using the method you prefer.

$$\begin{cases} 3x + 2y = 13 \\ 2x + y = 8 \end{cases}$$

b) Yesterday morning, Joe bought three scones and two muffins at his favourite bakery. He paid £13. His sister, Emma, decided to buy at the same bakery two scones and a muffin to taste them all. She paid £8.
Using the previous question, prove that a scone costs £3 and that the price of a muffin is £2.

2) Joe loved the muffins so much that he decided to bake some himself. He found a recipe which uses flour, sugar and butter in the ratio 3:1:1.

a) As Joe wants to use 600g of flour, what are the amounts of sugar and butter he needs?

b) Given that a muffin weighs 200g, how many muffins can he bake with the previous quantities?

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Binôme : Anglais / Mathématiques

PROBABILITY

Sujet D7 – n°10

For any events A and B of the sample space:

$$P(A) = P(A \cap B) + P(A \cap \bar{B})$$
$$P(\bar{B}) = 1 - P(B)$$

Conditional probability:

Let A and B be two events. The probability of A given B is $P(A|B) = \frac{P(A \cap B)}{P(B)}$ provided that $P(B) \neq 0$.

Binomial distribution:

If the random variable X gives the number of successes in *n* trials, then X follows the binomial distribution with parameters n and p.
The expectation of a random variable X following a binomial distribution of parameters n and p is equal to np.

EXERCISE

John likes playing tennis, and today he has a match to play in Cambridge.

1) When John has to serve, he is allowed two serves.
   The probability that his first serve is in is 0.8.
   He has probability 0.7 of winning the point when his first serve is in. Otherwise, his probability of winning the point is only 0.4.

   a) Draw the tree diagram to represent this information.
   b) Find the probability that he wins the point when he is serving.
   c) Given that he does win the point, find the probability that his first serve was out.

2) Let assume that usually, John's probability of winning a point (serving or receiving) is 0.57.
   Today, during the first set, we can assume that all the points are independent since John is not tired yet. During this first set, 60 points are played.
   Let X be the random variable counting the number of points won by John.
   a) Explain why X follows a binomial distribution and give its parameters.
   b) What is the probability that John wins 40 of them?
   c) Calculate the expectation of X . Interpret in the context of the exercise.

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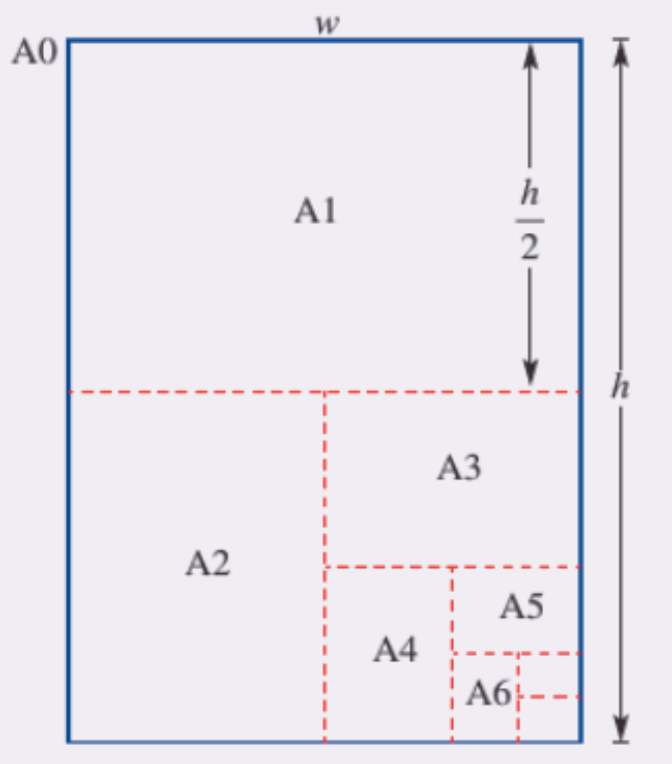
Sujet n°12

<u>Thème</u> SEQUENCE

The A series of paper sizes, e.g. A4, are based on international standards. If we split an A0 paper into two equal parts we get two A1 papers ; and if we split an A1 paper into two equal parts we get two A2 papers ; and so on. See the picture below.



The paper sizes are such that the ratio between the height and width of each paper size is the same.

The height is taken to be the longer side length of each rectangle.

Let an A0 piece of paper have width w mm and height h mm.

For every integer $n \geq 0$, let w_n and h_n be the width and height (in mm) of a An piece of paper. In particular, we have $w_0 = w$ and $h_0 = h$.

1. Complete the table below for the corresponding height and width of the A paper series in terms of w and h .

An	Width w_n	Height h_n
A0	w	h
A1	$\frac{h}{2}$	w
A2		
A3		
A4		
A5		
A6		

2. Remember that, if we split an An paper into two equal parts along the long side, we get an A$n+1$ paper: write w_{n+1} in terms of h_n and h_{n+1} in terms of w_n .
3. The ratio $\frac{h_n}{w_n}$ has to be the same for all paper sizes, in particular for A0 and A1 paper sizes. Determine the value of the ratio $\frac{h}{w}$.
4. From your results in question 3, write a relation for the height h_n in terms of the width w_n, for all integer $n \geq 0$.
5. From your results in questions 2 and 4, write a recursive formula for the sequences (w_n) and (h_n) .
6. A0 paper has an area of 1 square meter. Determine the dimensions, w and h, of A0 paper in exact form in mm.
7. Use your results to determine the length and width in mm for A4 paper. Do those values look familiar to you?

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Sujet n°13

Thème D0 - **Core Knowledge**

"Many thousands of riders are now using electric scooters* daily on US streets shared with millions of pedestrians and drivers," the authors—a group of researchers at University of California, Los Angeles—write.

To catch some of the first injury-related data, the researchers monitored medical records at two emergency departments for a year, skimming for scooter injuries. They nabbed 249 reports of injuries involving electric scooters between September 1, 2017 and August 31, 2018. For comparison, they identified 195 bicycle injuries and 181 pedestrian injuries at the emergency departments during the same time frame.

Of those injured in scooter-related accidents, 58 percent were male and the mean age was 33.7 years old. Around 91 percent of the injured were people riding a scooter at the time of their injury. The remaining were non-riding pedestrians.

The most common type of injuries recorded were head injuries, accounting for 40 percent of scooter injuries overall, the researchers found. Other common injuries included bone fractures (32 percent) and the grouping of contusions, sprains, and lacerations (28 percent).

Researchers noted that only 10 of the injured riders were documented as wearing a helmet despite local laws requiring helmet use.

Adapted from Beth Mole - 1/26/2019 – Ars Technica

* electric scooter = *trottinette électrique*

Part A Using the data provided in this article, answer the following questions, rounding all the results to the nearest unit.

1. What is the ratio between electric scooter injuries and bicycle injuries? Give it in its simplest form.
2. Out of the 249 people that were recorded as being injured due to electric scooters, how many were women?
3. Among the 249 people injured by electric scooters, how many were riding an electric scooter? And how many were non-riding pedestrians?
4. Are there other types of injuries than head injuries, bone fractures and contusions, sprains and lacerations? Explain.
5. With the data given in this article, find the percentage of injured riders who wore no helmet among injured riders.

Part B

6. Have you ever used an electric scooter? If yes, describe your feelings while riding the scooter. If no, would you like to ride one? Explain why.
7. According to your experience, how is the cohabitation of electric scooters and pedestrians in your home town?

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Sujet n°14

Thème DIFFERENTIATION

The first part of this page is a summary that can be helpful to do the exercise.

Applications of derivatives

Let f be a function defined and differentiable over an interval I
If $f'(x) > 0$ over *I*, then f is an increasing function over *I*.
If $f'(x) < 0$ in over *I*, then f is a decreasing function over *I.*

A stationary point $a \in I$ of the graph of f is a point where the gradient *f'(a)* is equal to 0.

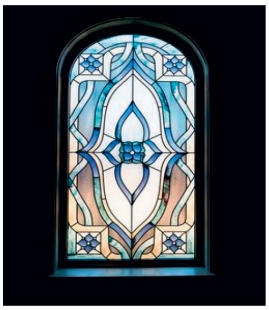
It is a maximum if *f''(a)<0* and a minimum if *f''(a)>0.*

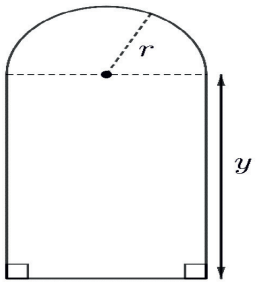
Let *C* be a circle of radius r.

- The perimeter of the circle is given by the formula $2\pi r$.
- The area of the circle is given by the formula πr^2

EXERCICE

Many objects, such as windows, are composite shapes. The stained-glass window represented is made up of a rectangle and a semi-circle.

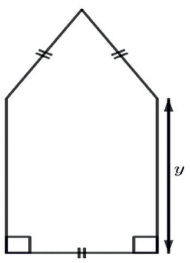




A window company is interested in exploring the relationship between the perimeter of the window and its area. It also wants to look at maximizing the area for a fixed perimeter.

1. The perimeter of the window is fixed at *P* metre.
   a. Find an expression for the height y of the rectangular section in terms of the radius r .
   b. Compute the area, A m² , of the window in the form $A = ar^2 + br$ where a and b are constants.
   c. the dimensions of the window that maximize its area and the maximum area for *P=6m*

2. Investigate a second stained-glass window, as represented, with an equilateral triangle top section. Compare its maximum area with question 1, for the same perimeter of 6 m.



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PROBABILITY

Sujet D7 – n°15

Julia is an independent consultant who has to travel from Paris to London on the Eurostar for a special work assignment. She will earn £800 as a basis salary plus a bonus of £100 if she manages to catch the 8 a.m. train or a bonus of £200 if she manages to catch the 7 a.m. train.

Julia is waiting for a train at the Gare du Nord in Paris and is placed on standby: she is not guaranteed a definite seat. If there is no seat on a given train, then she waits to see if there is a seat on the next train.

This information is provided for Julia at the station.

Train	Probability of a seat	Cost
7 a.m.	$\frac{1}{2}$	£ 290
8 a.m.	$\frac{2}{3}$	£ 200
9 a.m.	$\frac{3}{4}$	£ 150
No further train	-	£ 0

Part A

1. Using a tree diagram, show all Julia's options and the probabilities for the three trains (*all branch paths might not have the same length*).
2. a) Prove that the probability of catching the 9 a.m. train is $\frac{1}{8}$.
   b) Find the probability that Julia will catch
   - the 7 a.m. train
   - the 8 a.m. train.
3. What is the probability that Julia will miss all available trains?

Part B

4. Tabulate the cost of travel, the total salary (including the potential bonus) and the profit (salary minus cost) of each outcome and its corresponding probability.

Train	7 a.m.	8 a.m.	9 a.m.	No further train
Cost (£)				£ 0
Total Salary (£)				£ 0
Profit (£)				£ 0
Probability				

5. Find Julia's expected (average) profit for that day.

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Sujet n°16

DIFFERENTIATION

The first part of this page is a summary which may help you solve the following exercise.

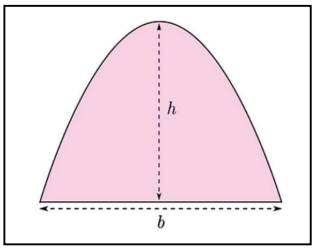
Applications of derivatives

Let f be a function defined and differentiable over an interval I

- If $f'(x) > 0$ over *I*, then f is an increasing function over *I*.
- If $f'(x) < 0$ in over *I*, then f is a decreasing function over *I.*

A stationary point $a \in I$ of the graph of f is a point where the gradient *f'(a)* is equal to 0. It is a maximum if *f''(a)<0* and a minimum if *f''(a)>0.*

The area of a parabolic segment is found by the formula $\frac{2}{3} b \times h$ where b is the segment's base length and h, the height of the parabola.



Exercise :

During an epidemic, the number of patients in thousands , t days after the occurrence of the first cases, is modelled by a quadratic function $f(t) = at^2 + bt + c$

We know that after 10 days after the occurrence of the first cases, there are 120,000 patients, and 20 days after the occurrence of the first cases, there are 210,000 patients. After 90 days the epidemic has been eradicated.

Part A: We want to determine a, b and c

1. Write a linear system of 3 equations in a, b and c using the information given above
2. Solve the linear system

Part B: Let $f(t) = -0.15t^2 + 13.5t$

1. Give the number of patients after 30 days.
2. Give the maximum number of patients during this epidemic.
3. The hospital is under pressure if the number of patients is at least 270,000.
   For how many days is the hospital going to be under pressure?
4. To evaluate the average number of patients during this epidemic, we have to compute the area under the parabola and divide the result by the length of the epidemic.
   Give the average number of patients during this epidemic per day.

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PROBABILITY

Sujet D7 – n°17

The first part of this page is a summary which may help you solve the following exercise.

Let A and B be two events:

- $A \cap B$ is the event "both A and B occur"
- the probability that A occurs, given that B has occurred, is denoted by $P_B\ (A)$and, provided that $P(B) \neq 0$, $P_B\ (A) = \frac{P(A \cap B)}{P(B)}$

Exercise:

For screening tests, the aim is to detect as many people as possible who could be infected with the SARS-CoV-2 coronavirus in order to isolate them and prevent them from infecting others. We want to ensure that infected people are identified. What we want to maximize, in this case, is the sensitivity, i.e., the proportion of true positives among all infected individuals. This is the probability that a test is positive for an infected person: the higher the probability, the more sensitive the test is.

For diagnostic tests, the aim is to establish a diagnosis, i.e., to find out whether a person is infected with the SARS-CoV-2 coronavirus. It is then important to make sure that the disease is detected. We want to make sure that people who are not infected are correctly identified. What you want to maximize in this case is the specificity, i.e., the proportion of true negatives among all uninfected individuals. This is the probability that a test will be negative for a person who is not infected: the higher the probability, the more specific the test is.

To evaluate a test, both its specificity and sensitivity must be considered. The ideal is to choose a test that optimizes both sensitivity and specificity.

From the website "adios Corona"

In France, the "Haute Autorité de la Santé" considers that diagnostic tests for COVID-19 must have a minimum specificity of 99% and a minimum sensitivity of 80%.

We want to evaluate if a test meets the "Haute Autorité de la Santé" criteria

For this test, 58% of a sample of patients are diagnosed positive. 98% of the patients diagnosed positive are infected, and 89% of the patients diagnosed negative are not infected.

Let T be the event: "the test is positive" and I be the event "the patient is infected".

1. Draw a tree diagram representing the situation.
2. a. Calculate the probability that a patient is diagnosed positive and is infected.
   b. Calculate the probability that a patient is diagnosed negative and is infected.
   c. Calculate the probability that a patient is infected.
3. Evaluate the specificity and the sensitivity.
4. Conclude.

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Sujet n°21
Thème : Core knowledge

1) For each statement, say if it is true or false:

a) No radii have the same length.

b) The diameter of a circle is the longest chord.

c) A circle is all points in the same plane that lie at an equal distance from a given point.

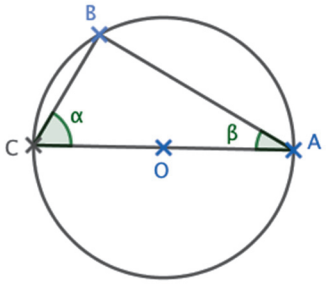
d) The circumference of a circle is given by the formula $C = \pi \times D$, where D is the diameter.

2) In English speaking countries, Thales' theorem states that:

"If three points A, B, and C lie on the circumference of a circle, whereby the line AC is the diameter of the circle, then angle ∠ABC is a right angle."

Let consider the following figure:

Let O be the centre of the circle.



a) Let consider triangles ABO and BCO: what type of triangles are they? Justify your answer.

b) What can you say about angles in each triangle?

c) Without calculating any value of α nor β, explain how you can prove that the value of α+β is 90°, using the angle sum in triangle ABC.

d) What type of triangle is triangle ABC?

3) Applications:

a) If ∠BCA = 62°, what is the measure of ∠BAC? And the measure of ∠BOC ? What can you notice?

b) If AB = 6 cm and BC = 8 cm, work out the length of the diameter of its circumscribed circle.

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Sujet n°22

Thème: D1 – Mapping

The first part of this page is a summary that can help you do the exercise.

Any quadratic function can be written as: $f(x) = ax^2 + bx + c$ with a, b and c constants, $a \neq 0$. The graph of f is called a parabola.
The abscissa of the vertex of the parabola is $-\frac{b}{2a}$.
To solve a quadratic equation $ax^2 + bx + c = 0$ with $a \neq 0$, calculate the discriminant $\Delta = b^2 - 4ac$.

- If $\Delta > 0$, the quadratic has two real solutions that are:
  $x_1 = \frac{-b-\sqrt{\Delta}}{2a}$ and $x_2 = \frac{-b+\sqrt{\Delta}}{2a}$
- If $\Delta = 0$, the equation has one and only solution which is:
  $$x_0 = -\frac{b}{2a}$$
- If $\Delta < 0$, the equation has no real solution.

A magic square is a square in which the sum of numbers of each row, each column and both main diagonals are the same.

The aim is to complete the following magic square by replacing each letter by the corresponding number.

$\boldsymbol{a}$		$\boldsymbol{e}$
	$\boldsymbol{c}$	$\boldsymbol{f}$
$\boldsymbol{b}$	$\boldsymbol{d}$	

Here are some clues to find the values of the letters $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, $\boldsymbol{d}$, $\boldsymbol{e}$, $\boldsymbol{f}$.

1) $\boldsymbol{a}$ is the number which satisfies the equality:
$$x^2 - 2x - 2 = (x - \boldsymbol{a})^2 - 3.$$

2) $\boldsymbol{b}$ is the product of the two roots of the quadratic function $2x^2 + 11x - 6$.

3) $\boldsymbol{c}$ is the number of solutions of the equation $x^2 + 2x + 3 = 0$.

4) $\boldsymbol{d}$ is the minimum of the quadratic function $x^2 + 18x + 85$.

5) $\boldsymbol{e}$ is the y-coordinate of the intersection point of the linear functions $y = x - 3$ and $y = -3x + 21$.

6) $\boldsymbol{f}$ is the greatest preimage of 2 for the function $f(x) = x^2 + 6x + 10$.

7) Now, you can complete the magic square. Be ready to explain all your results!

8) Do you know other Maths games? Can you explain the benefits of those games?

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Sujet n°23

Thème : D0 – Core knowledge

The first part of this page is a summary that can help you do the exercise.

- 1000 cm^3 = 1L
- If ABE is a right-angled triangle at B: $\sin \angle ABE = \frac{EB}{AE}$; $\tan \angle ABE = \frac{EB}{AB}$; $\cos \angle ABE = \frac{AB}{AE}$

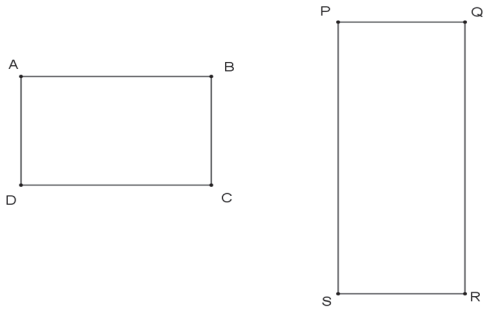
The following problems are independent and can be solved in any desired order.

1. Here are two rectangles.

It is known that : QR = 10 cm, BC = PQ,

AC = 9.6 cm, and the area of PQRS is 45 cm^2.

Find the perimeter of ABCD, correct to 1 d.p.

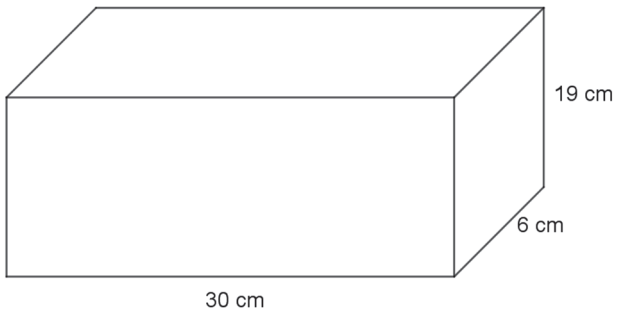


2. A container is in the shape of a cuboid.

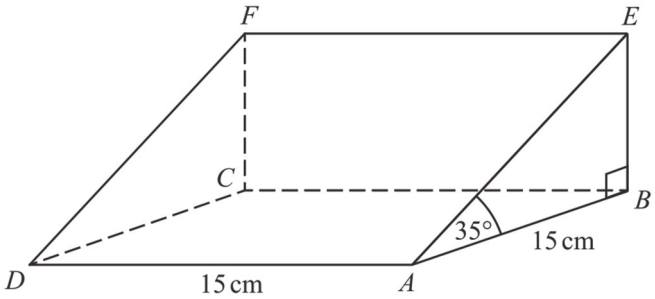
The container is $\frac{2}{3}$ full of water.

A cup holds 275 ml of water.

What is the greatest number of cups that can be completely filled with water from the container? How much water will be left?



3. The diagram shows a triangular prism. The base, ABCD, of the prism is a square of side length 15 cm. Angles ABE and CBE are right angles. Angle EAB = $35°$. M is the point on DA such that DM : MA = $2 : 3$.



a) Check that line-segment MA is 9 cm long.

b) Use a trigonometric ratio to find the length of AE in triangle ABE. Give the result to 1 d.p.

c) Assuming the fact that triangle AME is right-angled at A, find the value of EM.

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Sujet n°24

Thème : D1-Mapping

The first part of this page is a summary that can help you do the exercise.

Any quadratic function can be written as: $f(x) = ax^2 + bx + c$ with a, b and c constants, $a \neq 0$. The graph of f is called a parabola.

The abscissa of the vertex of the parabola is $-\frac{b}{2a}$.

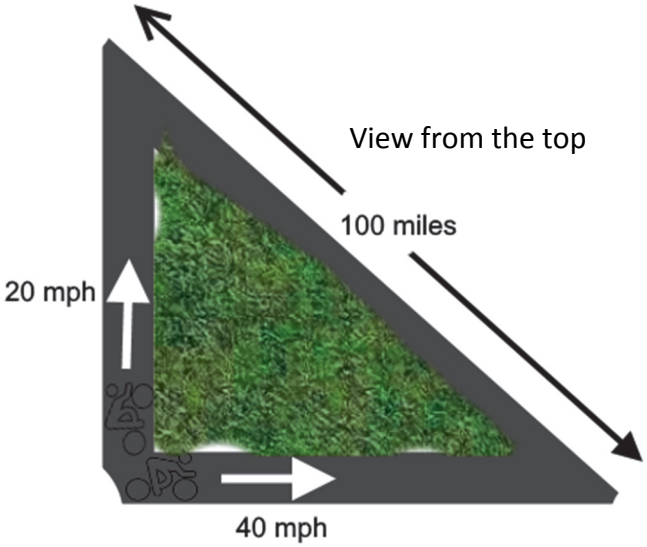
To solve a quadratic equation $ax^2 + bx + c = 0$ with $a \neq 0$, calculate the discriminant $\Delta = b^2 - 4ac$.

- If $\Delta > 0$, the quadratic has two real solutions that are:
  $x_1 = \frac{-b-\sqrt{\Delta}}{2a}$ and $x_2 = \frac{-b+\sqrt{\Delta}}{2a}$
- If $\Delta = 0$, the equation has one and only solution which is:
  $$x_0 = -\frac{b}{2a}$$
- If $\Delta < 0$, the equation has no real solution.

Two cyclists, Alice and Bob, move away from a town along two perpendicular paths at 20 m/h and 40 m/h respectively. Bob starts the journey an hour later than Alice.

The objective of this problem is to find how long it would take them to be 100 miles apart.

Let t be the time passed since Alice left, in hours.



1. Express the distance, in meters, travelled by Alice in terms of t.
2. Explain why the distance, in meters travelled by Bob is $40(t-1)$.
3. Hence deduce that the total time taken for the journey satisfies the equation
   $$5t^2 - 8t - 21 = 0$$
4. Finally find the time taken for them to be 100 miles apart.

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Sujet n°25
Thème : Domaine 4 – Statistiques

The first part of this page is a summary that can be helpful to do the exercise.

Given a statistical ordered distribution:

- The Median is a value that split the ordered distribution in two halves
- The lower quartile (LQ) is a value one-quarter on the way into the distribution
- The upper quartile (UQ) is a value three-quarter on the way into the distribution.

EXERCISE. Women in politics

The following table gives the percentage of women in parliaments from 23 of the most populated countries in the world.

Country	Percentage
China	25
India	12
USA	19
Indonesia	20
Brazil	11
Pakistan	22
Nigeria	6
Bangladesh	20

Russia	16
Japan	10
Mexico	42
Philippines	29
Ethiopia	39
Vietnam	27
Egypt	15
Congo	11
Iran	6

Germany	31
Turkey	15
France	39
UK	32
Thailand	5
Italy	35

Source: http://archive.ipu.org/wmn-f/classif.htm

1) Find the median of this sample. Comment the value you found.

2) Give the lower and upper quartile. What do these values show?

3) Compute the interquartile range. Comment your result.

4) Represent these data in a boxplot.

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Sujet n°30

Statistics

The first part of this page is a summary that can be helpful to do the exercise.
Given a statistical ordered distribution:

- The Median is a value that split the ordered distribution in two halves
- The lower quartile (LQ) is a value one-quarter on the way into the distribution
- The upper quartile (UQ) is a value three-quarter on the way into the distribution.

EXERCISE

A survey has been conducted on a group (group A) of people who caught COVID-19 even though they were vaccinated. They were asked how many days they had symptoms. The results are registered in the following table:

Number of days with symptoms	0	1	2	3	4	5	6	7	8
Frequency	17	8	11	6	8	10	4	5	1

Group A

1) How many people took part in this survey?

2) Give the percentage of people who had no symptoms. Round the percentage to 1 d.p.

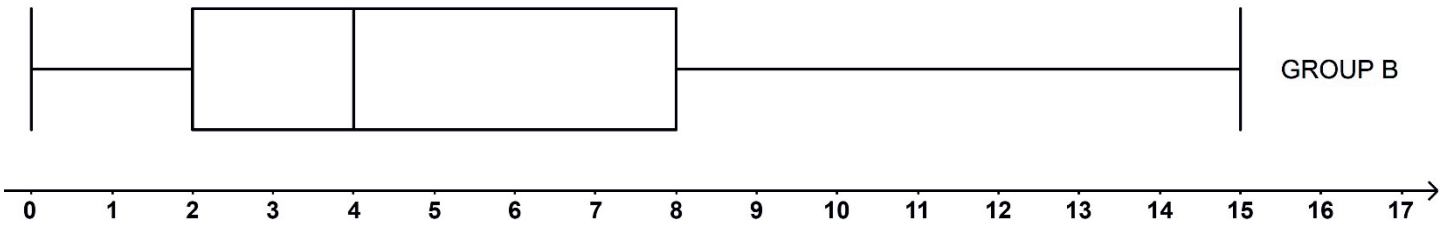
3) a. Explain how you can find the median of this data (no calculation is asked here).

   b. The median is 2. Explain what it means in context.

4) Prove that the interquartile range is 4.

5) a. Sketch the box-plot for group A below (above the boxplot of group B)

GROUP A



b. The other box-plot (group B) drawn above corresponds to another group of people who caught COVID-19 but who were not vaccinated.
By comparing both groups, discuss the vaccine's efficacy.

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Sujet n°31
STATISTICS
Sujet D4 -

The first part of this page is a summary that will help you to do the exercise.

A **box and whisker** plot or diagram (otherwise known as a boxplot), is a graph summarizing a set of data.

The **median** is a measure of central tendency which divides a set of observed values into two equally sized groups.

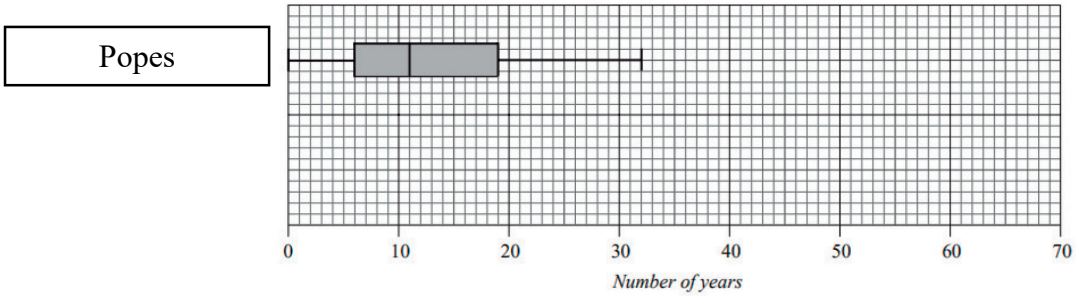
In statistics, a **quartile** is a type of quantile which divides the number of data points into four parts, or *quarters*, of more-or-less equal size.

EXERCISE

The length of reign of each of the **last 19 monarchs** is given in the table.

George VI	16 years	**George IV**	10 years	**James II**	3 years
Edward VIII	0 years	**George III**	60 years	**Charles II**	25 years
George V	26 years	**George II**	33 years	**Charles I**	24 years
EdwardVII	9 years	**George I**	13 years	**James I**	22 years
Victoria	64 years	**Anne**	12 years	**Elizabeth I**	45 years
William IV	7 years	**William III**	14 years	**Mary**	5 years
				Edward VI	6 years

1) Order the data set from the lowest to the greatest value.
   (You can represent the data in an ordered stem and leaf diagram).
2) Find the median and quartiles of the length of reign of these 19 monarchs.
   You **must** show calculations to support your answer.
3) Calculate the range and the interquartile range.
4) Write down the name of any monarch whose length of reign is an outlier.
5) The box and whisker plot shows the length of reign of the last 19 popes.



Draw a box and whisker plot for the length of reign of the last 19 monarchs on a copy of the diagram.

6)
   a. **Statement 1: 25 % of the reigns of the last 19 popes are greater than 19 years**
   b. **Statement 2: 50 % of the reigns of the last 19 popes are less than 11 years**
   c. **Statement 3: 20 % of the reigns of the last 19 monarchs are greater than 20 years**

Are the statements true or false? Explain your reasoning.

7) Compare the length of reign of the monarchs and popes.

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Sujet n°32

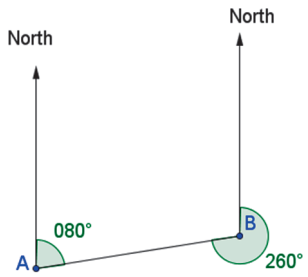
<u>Thème</u>: D5 - Advanced Geometry

The first part of this page is a summary which will help you solve the following exercise

Bearings:
A bearing is an angle measured clockwise from the north direction.

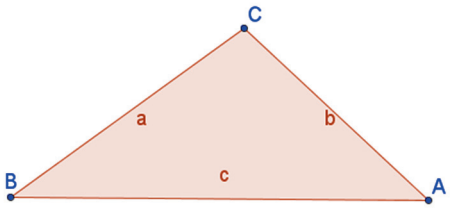
The bearing of B from A is 080 degrees (note that

three figures are always given) as shown in the diagram on the right.



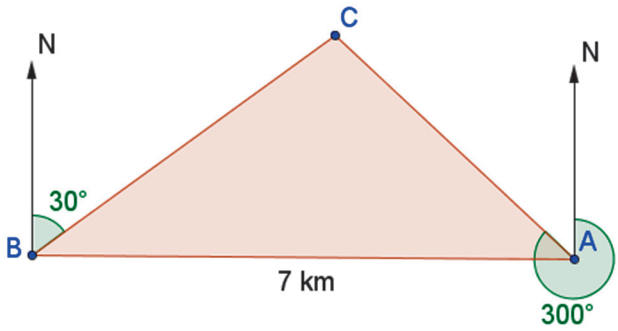
Formulae:

- $\frac{\sin\angle A}{a} = \frac{\sin\angle B}{b} = \frac{\sin\angle C}{c}$ (the *sine rule)*;
- $\sin(30°) = \frac{1}{2}$ and $\sin(60°) = \frac{\sqrt{3}}{2}$;
- The velocity : $v = \frac{d}{t}$ where d is the distance and t is the time.



<u>EXERCISE</u>:

Two fire lookout towers are located in a national park close to a lake. They are 7 kilometres away from each other.
The map on the right shows the towers viewed from the sky.
Points A and B represent the towers. The arrows point northwards.
At point C, a fire starts on a bearing of $030°$ from B and on a bearing of $300°$ from A.



1) Work out the measures of angles $\angle A$, $\angle B$ and $\angle C$ in the ABC triangle.
2) What can you say about triangle ABC ?
3) Work out the bearing of Tower B from Tower A.
4) Calculate the distance between Tower B and the fire using the sine rule.
5) Calculate the distance between A and C. Round to 2 dp.
6) A fire-fighting plane can fly from tower A to the fire at a speed of $303\ km.h^{-1}$.
   A fire truck can go from tower B to the fire at a speed of $70\ km.h^{-1}$.
   Which vehicle will reach the fire first?

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Sujet n°34

D4 Statistics: Florence Nightingale's Rose Charts

Florence Nightingale is best remembered for her work as a nurse during the Crimean War (1853-1856) and her contribution towards the reform of the sanitary conditions in military field hospitals. However, what is less well known about this amazing woman is her love of mathematics, especially statistics, and how this love played an important part in her life's work.

Although being female meant Nightingale had to fight against the military authorities at every step, she went about reforming the hospital system. Back then, injured soldiers were 7 times more likely to die from disease in hospital, than on the battlefield.

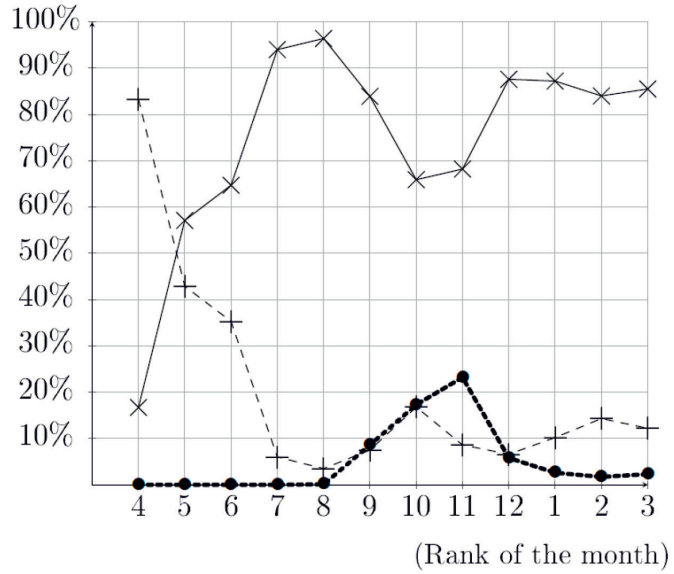
Using her statistics, she illustrated the need for sanitary reform in all military hospitals. While pressing her case, Nightingale gained the attention of Queen Victoria and Prince Albert as well as that of the Prime Minister, Lord Palmerston. Her wishes for a formal investigation were granted in May 1857 and led to the establishment of the Royal Commission on the Health of the Army. In 1858, for her contributions to army and hospital statistics Nightingale became the first woman to be elected to be a Fellow of the Royal Statistical Society.

Adapted from *MacTutor History of Mathematics Archive*

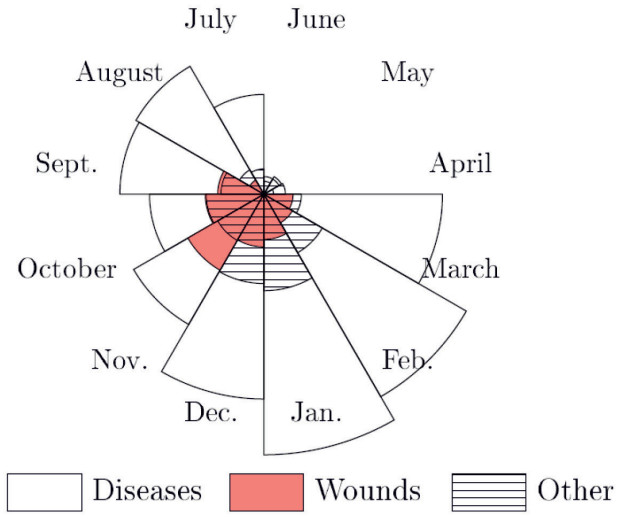
Document 1 : Death rates sorted by cause during the Crimean War

Month (1854-1855)	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Death by avoidable diseases (%)	16.7	57.1	64.7	94.0	96.4	83.9	65.9	68.2	87.6	87.2	84.0	85.5
Death by wounds (%)	0.0	0.0	0.0	0.0	0.1	8.6	17.3	23.2	5.8	2.6	1.7	2.3
Death by other causes (%)	83.3	42.9	35.3	6.0	3.5	7.5	16.8	8.6	6.6	10.2	14.3	12.2

Document 2 : Line charts from the table



Document 3 : Florence Nightingale's Rose Chart from the same period



1. Match each line (plain line, dashed line, dotted line) in Document 2 with its corresponding death cause from Document 1. Explain how you proceed.

2. In Document 3, each represented area is made to be proportional to the number of dead soldiers.

According to the rose chart, what is the main cause of death? Is that surprising given the context?

3. On which document can you see what the deadliest month is?

4. If you had to convince people that sanitary changes are needed, which chart would you choose and why?

5. Let's consider, in Document 1, the percentage of death by avoidable diseases during the Crimean War.

a) Calculate the mean and the median.
b) Interpret in the context of the exercise.

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Sujet n°D2-n°35

DIFFERENTIATION

The first part of this page is a summary that can be helpful to do the exercise.

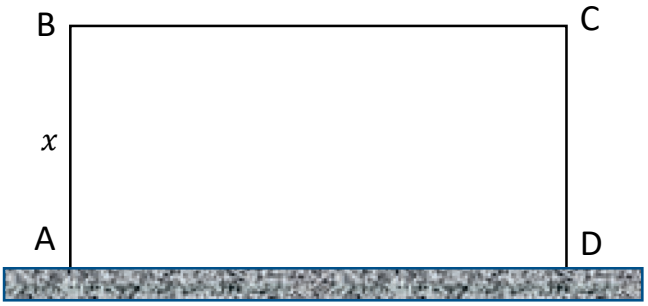
Let f be a function defined and differentiable over an interval I
If $f'(x) > 0$ over *I*, then f is an increasing function over *I*.
If $f'(x) < 0$ in over *I*, then f is a decreasing function over *I.*

A stationary point $a \in I$ of the graph of f is a point where the gradient *f'(a)* is equal to 0.

It is a maximum if *f''(a)<0* and a minimum if *f''(a)>0.*

Exercise

Emmy wants to build a rectangle enclosure for her animal (a goat) with a surface of 800 square feet. In order to minimize the costs, she plans to build it against her house and wonders which minimum length of barrier she has to buy to surround the enclosure. She draws the figure below.



1. Let *x* be the length *AB* and *y* be the length *BC*. Express *y* in terms of *x*.
2. Express the perimeter in term of *x*
3. Let f be the function defined by $f(x) = 2x + \frac{800}{x}$.
    a. What is the range of *f*?
    b. Give the variations of f.
    c. Find the stationary point of the function *f,* and solve Emmy's problem.

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Sujet n°36

D3: SEQUENCES

Aunt Lucy's Legacy

The first part of this page can be useful to do the exercise.

The sum of the first n terms of an arithmetic progression with first term a and common ratio r is:

$$n \times \frac{2a + (n-1)r}{2}$$

The sum of the first n terms of a geometric progression with first term a and common ratio r is:

$$a \times \frac{1 - r^n}{1 - r}$$

This morning, Lindsay received that letter of her Aunt Lucy.

Dear Lindsay,

Now that I am getting old (I turn 70 today) I want to give you some of my money. I shall give you a sum each year, starting now. You can choose which of the following options you would like to use.

1. £50 now, £60 next year, £70 the year after and so on.
2. £10 now, one and a half as much next year, one and a half as much again the year after and so on.

Of course, the option can only operate while I am alive. I look forward to hearing which option you choose and why.

Love,

Aunt Lucy

From Website Maths Map, https://www.transum.org/Software/Investigations/Aunt_Lucy.asp

Help her make the best choice.