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**Mathematical studies**  
**Standard level**  
**Paper 1**

Thursday 10 November 2016 (afternoon)

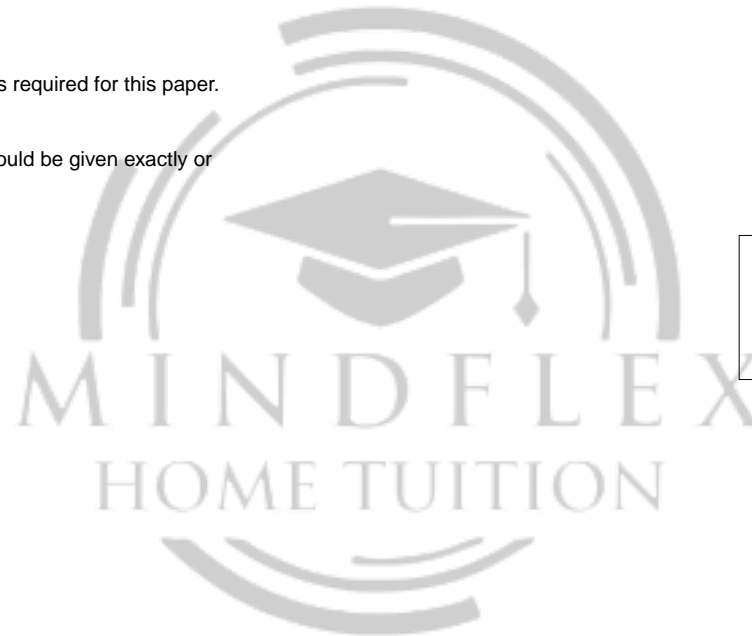
Candidate session number

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1 hour 30 minutes

**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.
- A clean copy of the **mathematical studies SL formula booklet** is required for this paper.
- Answer all questions.
- Write your answers in the boxes 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]**.



Please **do not** write on this page.  
Answers written on this page will not be marked.



Maximum marks will be given for correct answers. Where an answer is incorrect, some marks may be given for a correct method, provided this is shown by written working. Write your answers in the answer boxes provided. 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. Let  $p = \frac{\cos x + \sin y}{\sqrt{w^2 - z}}$ ,

where  $x = 36^\circ$ ,  $y = 18^\circ$ ,  $w = 29$  and  $z = 21.8$ .

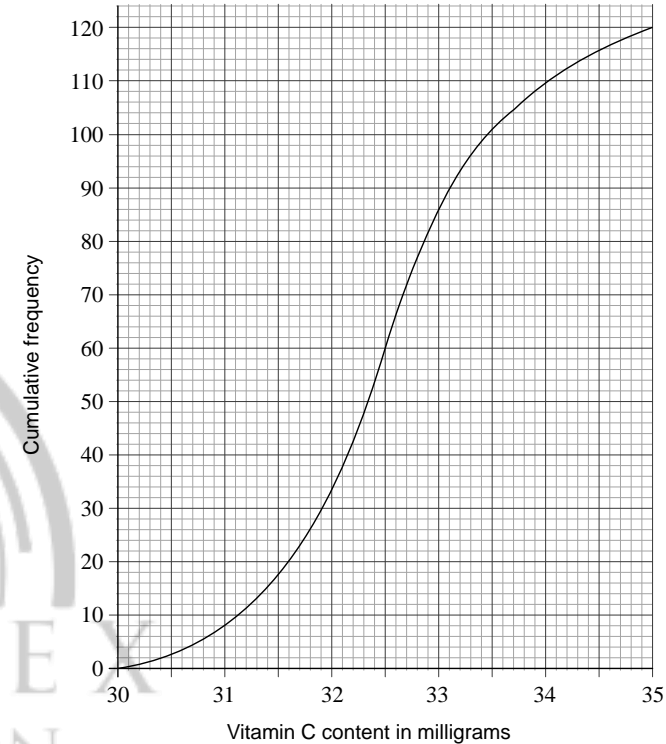
- (a) Calculate the value of  $p$ . Write down your full calculator display. [2]
- (b) Write your answer to part (a)
  - (i) correct to two decimal places; [2]
  - (ii) correct to three significant figures. [2]
- (c) Write your answer to **part (b)(ii)** in the form  $a \times 10^k$ , where  $1 \leq a < 10$ ,  $k \in \mathbb{Z}$ . [2]

Working:

Answers:

- (a) .....
- (b) (i) .....
- (ii) .....
- (c) .....

2. A sample of 120 oranges was tested for Vitamin C content. The cumulative frequency curve below represents the Vitamin C content, in milligrams, of these oranges.



- (a) Giving your answer to one decimal place, write down the value of
  - (i) the median level of Vitamin C content of the oranges in the sample;
  - (ii) the lower quartile;
  - (iii) the upper quartile.

[3]

(This question continues on the following page)



20EP03

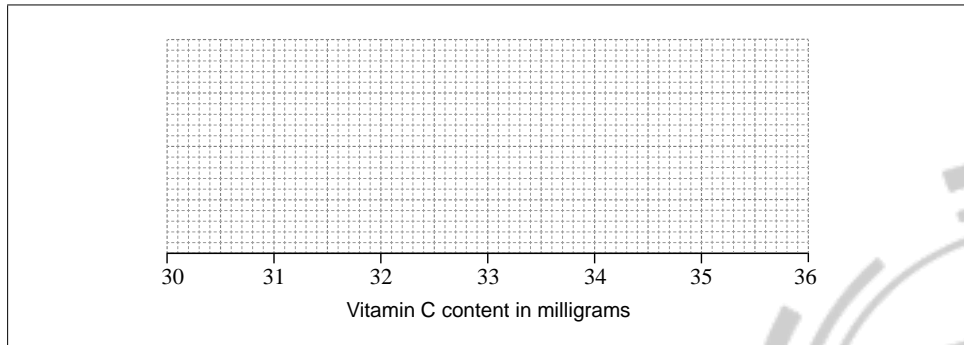


20EP04

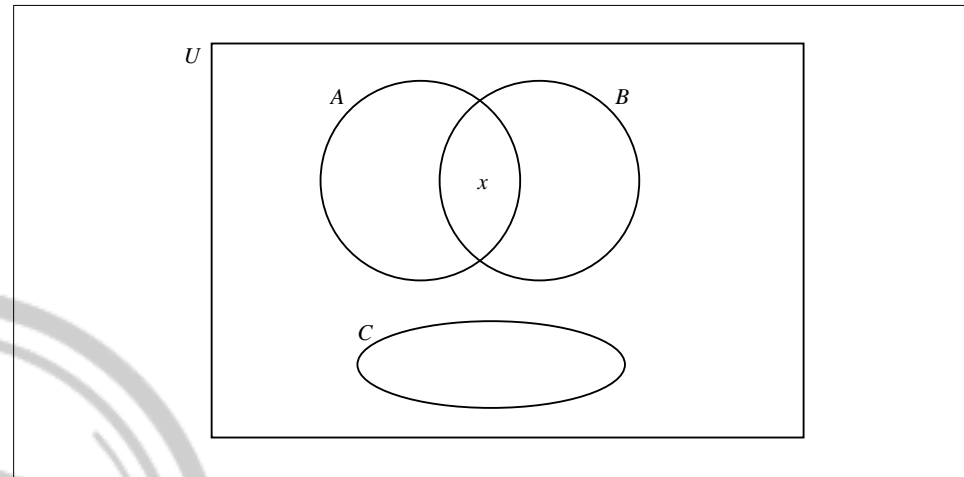
**(Question 2 continued)**

The minimum level of Vitamin C content of an orange in the sample was 30.1 milligrams.  
The maximum level of Vitamin C content of an orange in the sample was 35.0 milligrams.

- (b) Draw a box-and-whisker diagram on the grid below to represent the Vitamin C content, in milligrams, for this sample. [3]



3. The following Venn diagram shows the sets  $A$ ,  $B$ ,  $C$  and  $U$ .  $x$  is an element of  $U$ .



- (a) In the table indicate whether the given statements are True or False. [5]

Statement	True or False
$x \in C$	
$x \subset B$	
$A \cup B \neq \emptyset$	
$A \cap B \subset C$	
$A \cap C = \emptyset$	

- (b) On the Venn diagram, shade the region  $A \cap (B \cup C)'$ . [1]

**Working:**

Working area for question 2(b).

**Answers:**

- (a) (i) .....  
(ii) .....  
(iii) .....



4. In this question give all answers correct to two decimal places.

Javier takes 5000 US dollars (USD) on a business trip to Venezuela. He exchanges 3000 USD into Venezuelan bolivars (VEF).

The exchange rate is 1 USD = 6.3021 VEF.

- (a) Calculate the amount of VEF that Javier receives. [2]

During his time in Venezuela, Javier spends 1250 USD and 12000 VEF. On his return home, Javier exchanges his remaining VEF into USD.

The exchange rate is 1 USD = 8.7268 VEF.

- (b) Calculate the total amount, in USD, that Javier has remaining from his 5000 USD after his trip to Venezuela. [4]

Working:

Answers:

- (a) .....  
(b) .....

5. Consider the following logic propositions.

$p$ : Sandi gets up before eight o'clock  
 $q$ : Sandi goes for a run  
 $r$ : Sandi goes for a swim

- (a) Write down in words the compound proposition

$p \Rightarrow (q \vee r)$ . [3]

- (b) Complete the following truth table. [2]

$p$	$q$	$r$	$q \vee r$	$p \Rightarrow (q \vee r)$
T	T	T		
T	T	F		
T	F	T		
T	F	F		
F	T	T		
F	T	F		
F	F	T		
F	F	F		

- (c) On a morning when Sandi does **not** get up before eight o'clock, use your truth table to determine whether  $p \Rightarrow (q \vee r)$  is a tautology, contradiction or neither. [1]

Working:

Answers:

- (a) .....  
.....  
.....  
(c) .....



20EP07



20EP08

6. A hospital collected data from 1000 patients in four hospital wards to review the quality of its healthcare. The data, showing the number of patients who became infected during their stay in hospital, was recorded in the following table.

	Ward				Total
	Pasteur	Nightingale	Jenner	Fleming	
Patients infected	44	27	13	16	100
Patients not infected	281	303	182	134	900
<b>Total</b>	325	330	195	150	1000

A  $\chi^2$ -test was performed at the 5% significance level.  
The critical value for this test is 7.815.

The null hypothesis for the test is

$H_0$ : Becoming infected during a stay in the hospital is independent of the ward.

- (a) Find the expected frequency of the patients who became infected whilst in Nightingale ward. [2]
- (b) For this test, write down the  $\chi^2$  statistic. [2]
- (c) State, giving a reason, whether the null hypothesis should be rejected. [2]

Working:

Answers:

- (a) .....
- (b) .....
- (c) .....

7. A balloon in the shape of a sphere is filled with helium until the radius is 6 cm.

- (a) Calculate the volume of the balloon. [2]

The volume of the balloon is increased by 40%.

- (b) Calculate the radius of the balloon following this increase. [4]

Working:

Answers:

- (a) .....
- (b) .....



20EP09



20EP10

8. Passengers of Flyaway Airlines can purchase tickets for either Business Class or Economy Class.

On one particular flight there were 154 passengers.

Let  $x$  be the number of Business Class passengers and  $y$  be the number of Economy Class passengers on this flight.

- (a) Use the above information to write down an equation in  $x$  and  $y$ . [1]

On this flight, the cost of a ticket for each Business Class passenger was 320 euros and the cost of a ticket for each Economy Class passenger was 85 euros. The total amount that Flyaway Airlines received for these tickets was 14 970 euros.

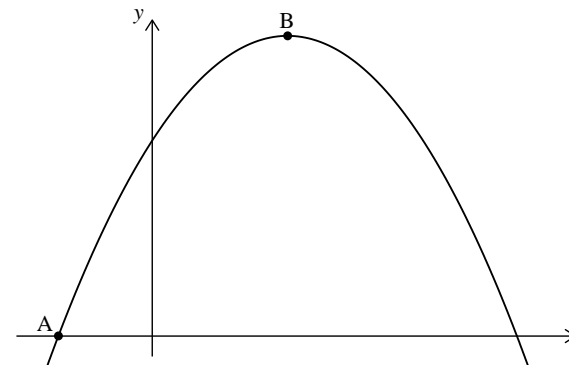
- (b) Use the information about the cost of tickets to write down a second equation in  $x$  and  $y$ . [1]

- (c) Find the value of  $x$  and the value of  $y$ . [2]

The airline's finance officer wrote down the total amount received by the airline for these tickets as 14 270 euros.

- (d) Find the percentage error. [2]

9. The graph of the quadratic function  $f(x) = c + bx - x^2$  intersects the  $x$ -axis at the point  $A(-1, 0)$  and has its vertex at the point  $B(3, 16)$ .



- (a) Write down the equation of the axis of symmetry for this graph. [2]

- (b) Find the value of  $b$ . [2]

- (c) Write down the range of  $f(x)$ . [2]

Working:

**Answers:**

(a) .....

(b) .....

(c) .....

(d) .....

Working:

**Answers:**

(a) .....

(b) .....

(c) .....



20EP11



20EP12



10. A hydraulic hammer drives a metal post vertically into the ground by striking the top of the post. The distance that the post is driven into the ground, by the  $n$ th strike of the hammer, is  $d_n$ .

The distances  $d_1, d_2, d_3, \dots, d_n$  form a geometric sequence.

The distance that the post is driven into the ground by the first strike of the hammer,  $d_1$ , is 64 cm.

The distance that the post is driven into the ground by the second strike of the hammer,  $d_2$ , is 48 cm.

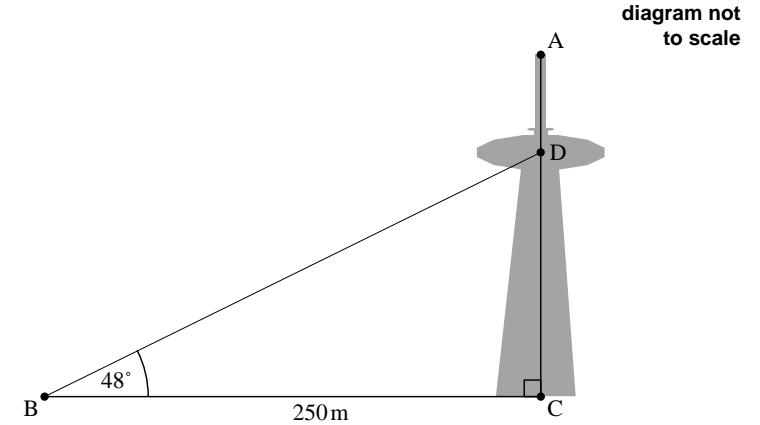
- (a) Find the value of the common ratio for this sequence. [2]
- (b) Find the distance that the post is driven into the ground by the eighth strike of the hammer. [2]
- (c) Find the **total depth** that the post has been driven into the ground after 10 strikes of the hammer. [2]

Working:

Answers:

- (a) .....
- (b) .....
- (c) .....

11. AC is a vertical communications tower with its base at C. The tower has an observation deck, D, three quarters of the way to the top of the tower, A.



From a point B, on horizontal ground 250m from C, the angle of elevation of D is  $48^\circ$ .

- (a) Calculate CD, the height of the observation deck above the ground. [2]
- (b) Calculate the angle of depression from A to B. [4]

Working:

Answers:

- (a) .....
- (b) .....



20EP13



20EP14

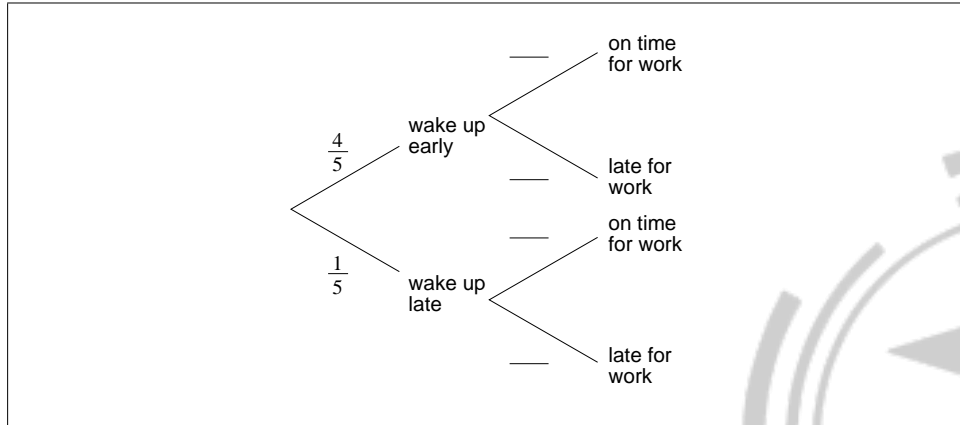
12. On a work day, the probability that Mr Van Winkel wakes up early is  $\frac{4}{5}$ .

If he wakes up early, the probability that he is on time for work is  $p$ .

If he wakes up late, the probability that he is on time for work is  $\frac{1}{4}$ .

(a) Complete the tree diagram below.

[2]



The probability that Mr Van Winkel arrives on time for work is  $\frac{3}{5}$ .

(b) Find the value of  $p$ .

[4]

Working:

Answers:

(b) .....

13. A comet orbits the Sun and is seen from Earth every 37 years. The comet was first seen from Earth in the year 1064.

(a) Find the year in which the comet was seen from Earth for the fifth time.

[3]

(b) Determine how many times the comet has been seen from Earth up to the year 2014.

[3]

Working:

Answers:

(a) .....

(b) .....



20EP15



20EP16

14. The equation of a curve is  $y = \frac{1}{2}x^4 - \frac{3}{2}x^2 + 7$ .

(a) Find  $\frac{dy}{dx}$ . [2]

The gradient of the tangent to the curve at a point P is -10.

(b) Find the coordinates of P. [4]

**Working:**

**Answers:**

- (a) .....
- (b) .....

15. Gabriella purchases a new car.

The car's value in dollars,  $V$ , is modelled by the function

$$V(t) = 12870 - k(1.1)^t, t \geq 0$$

where  $t$  is the number of years since the car was purchased and  $k$  is a constant.

(a) Write down, and simplify, an expression for the car's value when Gabriella purchased it. [2]

After two years, the car's value is \$9143.20.

(b) Find the value of  $k$ . [2]

This model is defined for  $0 \leq t \leq n$ . At  $n$  years the car's value will be zero dollars.

(c) Find the value of  $n$ . [2]

**Working:**

**Answers:**

- (a) .....
- (b) .....
- (c) .....



20EP17



20EP18

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be marked.

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**Mathematical studies**  
**Standard level**  
**Paper 2**

Friday 11 November 2016 (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]**.

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: 17]

In the month before their IB Diploma examinations, eight male students recorded the number of hours they spent on social media.

For each student, the number of hours spent on social media ( $x$ ) and the number of IB Diploma points obtained ( $y$ ) are shown in the following table.

Hours on social media ( $x$ )	6	15	26	12	13	40	33	23
IB Diploma points ( $y$ )	43	33	27	36	39	17	20	33

- (a) On graph paper, draw a scatter diagram for these data. Use a scale of 2 cm to represent 5 hours on the  $x$ -axis and 2 cm to represent 10 points on the  $y$ -axis. [4]
- (b) Use your graphic display calculator to find
- (i)  $\bar{x}$ , the mean number of hours spent on social media;
- (ii)  $\bar{y}$ , the mean number of IB Diploma points. [2]
- (c) Plot the point  $(\bar{x}, \bar{y})$  on your scatter diagram and label this point M. [2]
- (d) Write down the value of  $r$ , the Pearson's product-moment correlation coefficient, for these data. [2]
- (e) Write down the equation of the regression line  $y$  on  $x$  for these eight male students. [2]
- (f) Draw the regression line, from part (e), on your scatter diagram. [2]

Ten female students also recorded the number of hours they spent on social media in the month before their IB Diploma examinations. Each of these female students spent between 3 and 30 hours on social media.

The equation of the regression line  $y$  on  $x$  for these ten female students is

$$y = -\frac{2}{3}x + \frac{125}{3}.$$

An eleventh girl spent 34 hours on social media in the month before her IB Diploma examinations.

- (g) Use the given equation of the regression line to estimate the number of IB Diploma points that this girl obtained. [2]
- (h) Write down a reason why this estimate is not reliable. [1]

2. [Maximum mark: 12]

A group of 66 people went on holiday to Hawaii. During their stay, three trips were arranged: a boat trip ( $B$ ), a coach trip ( $C$ ) and a helicopter trip ( $H$ ).

From this group of people:

- 3 went on all three trips;
- 16 went on the coach trip **only**;
- 13 went on the boat trip **only**;
- 5 went on the helicopter trip **only**;
- $x$  went on the coach trip and the helicopter trip **but not** the boat trip;
- $2x$  went on the boat trip and the helicopter trip **but not** the coach trip;
- $4x$  went on the boat trip and the coach trip **but not** the helicopter trip;
- 8 did not go on any of the trips.

(a) Draw a Venn diagram to represent the given information, using sets labelled  $B$ ,  $C$  and  $H$ . [5]

(b) Show that  $x = 3$ . [2]

(c) Write down the value of  $n(B \cap C)$ . [1]

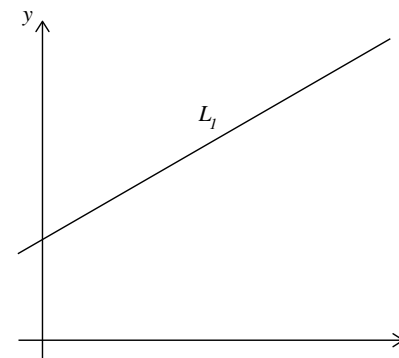
One person in the group is selected at random.

(d) Find the probability that this person

- (i) went on at most one trip;
- (ii) went on the coach trip, given that this person also went on both the helicopter trip and the boat trip. [4]

3. [Maximum mark: 17]

The line  $L_1$  has equation  $2y - x - 7 = 0$  and is shown on the diagram.



The point A has coordinates  $(1, 4)$ .

(a) Show that A lies on  $L_1$ . [2]

The point C has coordinates  $(5, 12)$ . M is the midpoint of AC.

(b) Find the coordinates of M. [2]

(c) Find the length of AC. [2]

The straight line,  $L_2$ , is perpendicular to AC and passes through M.

(d) Show that the equation of  $L_2$  is  $2y + x - 19 = 0$ . [5]

The point D is the intersection of  $L_1$  and  $L_2$ .

(e) Find the coordinates of D. [2]

The length of MD is  $\frac{\sqrt{45}}{2}$ .

(f) Write down the length of MD correct to five significant figures. [1]

The point B is such that ABCD is a rhombus.

(g) Find the area of ABCD. [3]

4. [Maximum mark: 11]

A manufacturer produces 1500 boxes of breakfast cereal every day.

The weights of these boxes are normally distributed with a mean of 502 grams and a standard deviation of 2 grams.

(a) Draw a diagram that shows this information. [2]

All boxes of cereal with a weight between 497.5 grams and 505 grams are sold. The manufacturer's income from the sale of each box of cereal is \$2.00.

(b) (i) Find the probability that a box of cereal, chosen at random, is sold.

(ii) Calculate the manufacturer's expected daily income from these sales. [4]

The manufacturer recycles any box of cereal with a weight **not** between 497.5 grams and 505 grams. The manufacturer's recycling cost is \$0.16 per box.

(c) Calculate the manufacturer's expected daily recycling cost. [2]

A **different** manufacturer produces boxes of cereal with weights that are normally distributed with a mean of 350 grams and a standard deviation of 1.8 grams.

This manufacturer sells all boxes of cereal that are above a minimum weight,  $w$ .

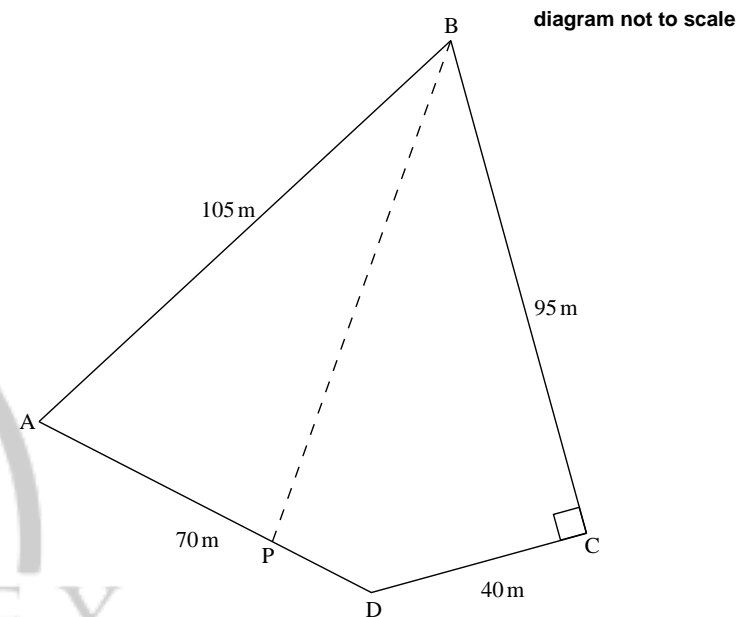
They sell 97% of the cereal boxes produced.

(d) Calculate the value of  $w$ . [3]

5. [Maximum mark: 16]

A farmer owns a plot of land in the shape of a quadrilateral ABCD.

$AB = 105\text{ m}$ ,  $BC = 95\text{ m}$ ,  $CD = 40\text{ m}$ ,  $DA = 70\text{ m}$  and angle  $DCB = 90^\circ$ .



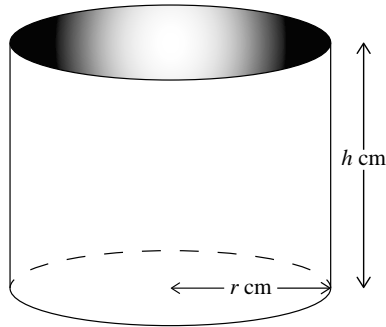
The farmer wants to divide the land into two equal areas. He builds a fence in a straight line from point B to point P on AD, so that the area of PAB is equal to the area of PBCD.

Calculate

- (a) the length of BD; [2]
- (b) the size of angle DAB; [3]
- (c) the area of triangle ABD; [3]
- (d) the area of quadrilateral ABCD; [2]
- (e) the length of AP; [3]
- (f) the length of the fence, BP. [3]

6. [Maximum mark: 17]

A water container is made in the shape of a cylinder with internal height  $h$  cm and internal base radius  $r$  cm.



The water container has no top. The inner surfaces of the container are to be coated with a water-resistant material.

(a) Write down a formula for  $A$ , the surface area to be coated. [2]

The volume of the water container is  $0.5 \text{ m}^3$ .

(b) Express this volume in  $\text{cm}^3$ . [1]

(c) Write down, in terms of  $r$  and  $h$ , an equation for the volume of this water container. [1]

(d) Show that  $A = \pi r^2 + \frac{1000000}{r}$ . [2]

The water container is designed so that the area to be coated is minimized.

(e) Find  $\frac{dA}{dr}$ . [3]

(f) Using your answer to part (e), find the value of  $r$  which minimizes  $A$ . [3]

(g) Find the value of this minimum area. [2]

One can of water-resistant material coats a surface area of  $2000 \text{ cm}^2$ .

(h) Find the least number of cans of water-resistant material that will coat the area in part (g). [3]

Mathematical studies Standard level Paper 1

Monday 13 November 2017 (afternoon)

1 hour 30 minutes

Candidate session number

Grid for candidate session number

Instructions to candidates

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