



Oxford Cambridge and RSA

Wednesday 14 October 2020 – Afternoon

AS Level Mathematics A

H230/02 Pure Mathematics and Mechanics

Time allowed: 1 hour 30 minutes



You must have:

- the Printed Answer Booklet
- a scientific or graphical calculator

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided in the **Printed Answer Booklet**. If you need extra space use the lined pages at the end of the Printed Answer Booklet. The question numbers must be clearly shown.
- Fill in the boxes on the front of the Printed Answer Booklet.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question.
- The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. When a numerical value is needed use $g = 9.8$ unless a different value is specified in the question.
- Do **not** send this Question Paper for marking. Keep it in the centre or recycle it.

INFORMATION

- The total number of marks for this paper is **75**.
- The marks for each question are shown in brackets [].
- This document has **8** pages.

ADVICE

- Read each question carefully before you start your answer.

Formulae
AS Level Mathematics A (H230)

Binomial series

$$(a+b)^n = a^n + {}^n C_1 a^{n-1} b + {}^n C_2 a^{n-2} b^2 + \dots + {}^n C_r a^{n-r} b^r + \dots + b^n \quad (n \in \mathbb{N}),$$

$$\text{where } {}^n C_r = {}_n C_r = \binom{n}{r} = \frac{n!}{r!(n-r)!}$$

Differentiation from first principles

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

Standard deviation

$$\sqrt{\frac{\sum(x-\bar{x})^2}{n}} = \sqrt{\frac{\sum x^2}{n} - \bar{x}^2} \quad \text{or} \quad \sqrt{\frac{\sum f(x-\bar{x})^2}{\sum f}} = \sqrt{\frac{\sum fx^2}{\sum f} - \bar{x}^2}$$

The binomial distribution

If $X \sim B(n, p)$ then $P(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$, mean of X is np , variance of X is $np(1-p)$

Kinematics

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$s = \frac{1}{2}(u+v)t$$

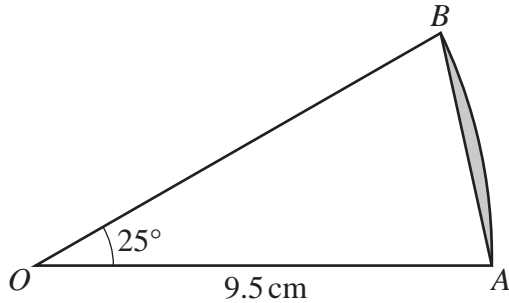
$$v^2 = u^2 + 2as$$

$$s = vt - \frac{1}{2}at^2$$

Section A: Pure Mathematics

Answer **all** the questions.

1



The diagram shows a sector AOB of a circle with centre O and radius 9.5 cm. The angle AOB is 25° .

- (a) Calculate the length of the straight line AB . [2]
- (b) Find the area of the segment shaded in the diagram. [3]

2 Two curves have equations $y = \ln x$ and $y = \frac{k}{x}$, where k is a positive constant.

- (a) Sketch the curves on a **single** diagram. [3]
- (b) Explain how your diagram shows that the equation $x \ln x - k = 0$ has exactly one real root. [2]

3 **In this question you must show detailed reasoning.**

Find the equation of the normal to the curve $y = 4\sqrt{x} - 3x + 1$ at the point on the curve where $x = 4$. Give your answer in the form $ax + by + c = 0$, where a , b and c are integers. [7]

4 In this question you must show detailed reasoning.

The cubic polynomial $6x^3 + kx^2 + 57x - 20$ is denoted by $f(x)$. It is given that $(2x - 1)$ is a factor of $f(x)$.

(a) Use the factor theorem to show that $k = -37$. [2]

(b) Using this value of k , factorise $f(x)$ completely. [3]

(c) (i) Hence find the three values of t satisfying the equation $6e^{-3t} - 37e^{-2t} + 57e^{-t} - 20 = 0$. [2]

(ii) Express the sum of the three values found in part (c)(i) as a single logarithm. [2]

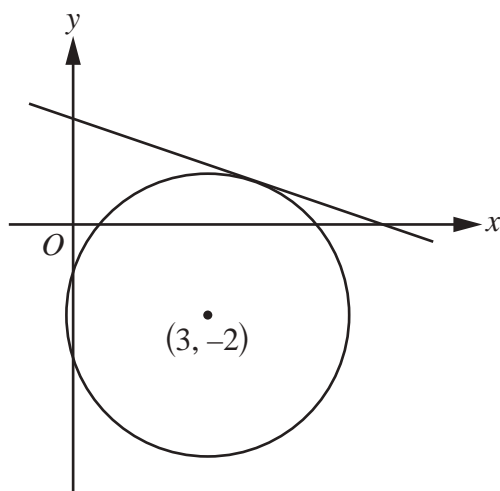
5 A curve has equation $y = a(x+b)^2 + c$, where a , b and c are constants. The curve has a stationary point at $(-3, 2)$.

(a) State the values of b and c . [2]

When the curve is translated by $\begin{pmatrix} 4 \\ 0 \end{pmatrix}$ the transformed curve passes through the point $(3, -18)$.

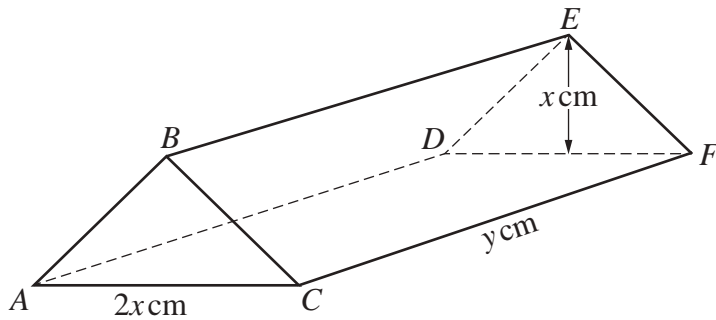
(b) Determine the value of a . [3]

6 In this question you must show detailed reasoning.



The diagram shows the line $3y + x = 7$ which is a tangent to a circle with centre $(3, -2)$.

Find an equation for the circle. [6]



The diagram shows a model for the roof of a toy building. The roof is in the form of a solid triangular prism $ABCDEF$. The base $ACFD$ of the roof is a horizontal rectangle, and the cross-section ABC of the roof is an isosceles triangle with $AB = BC$.

The lengths of AC and CF are $2x$ cm and y cm respectively, and the height of BE above the base of the roof is x cm.

The total surface area of the **five** faces of the roof is 600 cm^2 and the volume of the roof is $V \text{ cm}^3$.

- (a) Show that $V = kx(300 - x^2)$, where $k = \sqrt{a} + b$ and a and b are integers to be determined. [6]
- (b) Use differentiation to determine the value of x for which the volume of the roof is a maximum. [4]
- (c) Find the maximum volume of the roof. Give your answer in cm^3 , correct to the nearest integer. [1]
- (d) Explain why, for this roof, x must be less than a certain value, which you should state. [2]

Section B: Mechanics

Answer **all** the questions.

- 8** A particle is in equilibrium under the action of the following three forces:
 $(2p\mathbf{i} - 4\mathbf{j})$ N, $(-3q\mathbf{i} + 5p\mathbf{j})$ N and $(-13\mathbf{i} - 6\mathbf{j})$ N.
Find the values of p and q . [3]
- 9** A crane lifts a car vertically. The car is inside a crate which is raised by the crane by means of a strong cable. The cable can withstand a maximum tension of 9500 N without breaking. The crate has a mass of 55 kg and the car has a mass of 830 kg.
- (a) Find the maximum acceleration with which the crate and car can be raised. [2]
- (b) Show on a clearly labelled diagram the forces acting on the **crate** while it is in motion. [1]
- (c) Determine the magnitude of the reaction force between the crate and the car when they are ascending with maximum acceleration. [3]
- 10** A particle P is moving in a straight line. At time t seconds P has velocity v m s⁻¹ where $v = (2t + 1)(3 - t)$.
- (a) Find the deceleration of P when $t = 4$. [2]
- (b) State the positive value of t for which P is instantaneously at rest. [1]
- (c) Find the total distance that P travels between times $t = 0$ and $t = 4$. [3]

11 A car starts from rest at a set of traffic lights and moves along a straight road with constant acceleration 4 m s^{-2} . A motorcycle, travelling parallel to the car with constant speed 16 m s^{-1} , passes the same traffic lights exactly 1.5 seconds after the car starts to move. The time after the car starts to move is denoted by t seconds.

(a) Determine the two values of t at which the car and motorcycle are the same distance from the traffic lights. [6]

These two values of t are denoted by t_1 and t_2 , where $t_1 < t_2$.

(b) Describe the relative positions of the car and the motorcycle when $t_1 < t < t_2$. [1]

(c) Determine the maximum distance between the car and the motorcycle when $t_1 < t < t_2$. [3]

END OF QUESTION PAPER

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