



Oxford Cambridge and RSA

Monday 20 May 2019 – Afternoon

AS Level Further Mathematics A

Y535/01 Additional Pure Mathematics

Time allowed: 1 hour 15 minutes



You must have:

- Printed Answer Booklet
- Formulae AS Level Further Mathematics A

You may use:

- a scientific or graphical calculator

INSTRUCTIONS

- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** If additional space is required, use the lined page(s) at the end of the Printed Answer Booklet. The question number(s) must be clearly shown.
- You are permitted to use a scientific or graphical calculator in this paper.
- 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 $g\text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION

- The total mark for this paper is **60**.
- The marks for each question are shown in brackets [].
- **You are reminded of the need for clear presentation in your answers.**
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **4** pages.

Answer **all** the questions.

- 1 In decimal (base 10) form, the number N is 15 260.
- (a) Express N in binary (base 2) form. [1]
- (b) Using the binary form of N , show that N is divisible by 7. [2]
- 2 (a) The convergent sequence $\{a_n\}$ is defined by $a_0 = 1$ and $a_{n+1} = \sqrt{a_n} + \frac{4}{\sqrt{a_n}}$ for $n \geq 0$.
Calculate the limit of the sequence. [1]
- (b) The convergent sequence $\{b_n\}$ is defined by $b_0 = 1$ and $b_{n+1} = \sqrt{b_n} + \frac{k}{\sqrt{b_n}}$ for $n \geq 0$, where k is a constant.
Determine the value of k for which the limit of the sequence is 9. [3]
- 3 The non-zero vectors \mathbf{x} and \mathbf{y} are such that $\mathbf{x} \times \mathbf{y} = \mathbf{0}$.
- (a) Explain the geometrical significance of this statement. [2]
- (b) Use your answer to part (a) to explain how the line equation $\mathbf{r} = \mathbf{a} + t\mathbf{d}$ can be written in the form $(\mathbf{r} - \mathbf{a}) \times \mathbf{d} = \mathbf{0}$. [2]
- 4 The sequence $\{u_n\}$ is defined by $u_1 = 1$ and $u_{n+1} = 2u_n + n^2$ for $n \geq 1$.
Determine u_n as a function of n . [8]

- 5 The tetrahedron T , shown below, has vertices at $O(0, 0, 0)$, $A(1, 2, 2)$, $B(2, 1, 2)$ and $C(2, 2, 1)$.

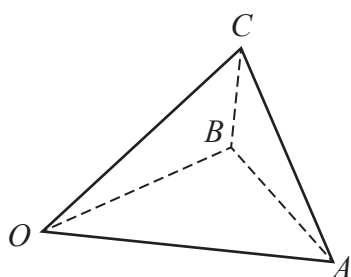


Diagram not drawn to scale

Show that the surface area of T is $\frac{1}{2}\sqrt{3}(1 + \sqrt{51})$. [8]

- 6 (a) Determine all values of x for which $16x \equiv 5 \pmod{101}$. [4]

(b) Solve

(i) $95x \equiv 6 \pmod{101}$, [2]

(ii) $95x \equiv 5 \pmod{101}$. [2]

- 7 You are given the set $S = \{1, 5, 7, 11, 13, 17\}$ together with \times_{18} , the operation of multiplication modulo 18.

(a) Complete the Cayley table for (S, \times_{18}) given in the Printed Answer Booklet. [4]

(b) Prove that (S, \times_{18}) is a group. (You may assume that \times_{18} is associative.) [3]

(c) Write down the order of each element of the group. [2]

(d) Show that (S, \times_{18}) is a cyclic group. [1]

(e) (i) Give an example of a non-cyclic group of order 6. [1]

(ii) Give one reason why your example is structurally different to (S, \times_{18}) . [1]

Turn over for question 8

- 8 The motion of two remote controlled helicopters P and Q is modelled as two points moving along straight lines.

Helicopter P moves on the line $\mathbf{r} = \begin{pmatrix} 2 + 4p \\ -3 + p \\ 1 + 3p \end{pmatrix}$ and helicopter Q moves on the line $\mathbf{r} = \begin{pmatrix} 5 + 8q \\ 2 + q \\ 5 + 4q \end{pmatrix}$.

The function z denotes $(PQ)^2$, the square of the distance between P and Q .

- (a) Show that $z = 26p^2 + 81q^2 - 90pq - 58p + 90q + 50$. [3]
- (b) Use partial differentiation to find the values of p and q for which z has a stationary point. [4]
- (c) With the aid of a diagram, explain why this stationary point must be a minimum point, rather than a maximum point or a saddle point. [2]
- (d) Hence find the shortest possible distance between the two helicopters. [2]

The model is now refined by modelling each helicopter as a sphere of radius 0.5 units.

- (e) Explain how this will change your answer to part (d). [2]

END OF QUESTION PAPER

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