

## Mathematics

### Higher level

### Paper 1

Wednesday 11 November 2015 (morning)

Candidate session number

2 hours

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#### Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- You are not permitted access to any calculator for this paper.
- Section A: answer all questions in the boxes provided.
- Section B: answer all questions in the answer booklet provided. Fill in your session number on the front of the answer booklet, and attach it to this examination paper and your cover sheet using the tag 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 HL and further mathematics HL formula booklet** is required for this paper.
- The maximum mark for this examination paper is **[120 marks]**.

























Do **not** write solutions on this page.

### Section B

Answer **all** questions in the answer booklet provided. Please start each question on a new page.

11. [Maximum mark: 17]

- (a) Solve the equation  $z^3 = 8i$ ,  $z \in \mathbb{C}$  giving your answers in the form  $z = r(\cos \theta + i \sin \theta)$  **and** in the form  $z = a + bi$  where  $a, b \in \mathbb{R}$ . [6]
- (b) Consider the complex numbers  $z_1 = 1 + i$  and  $z_2 = 2\left(\cos\left(\frac{\pi}{6}\right) + i \sin\left(\frac{\pi}{6}\right)\right)$ .
- (i) Write  $z_1$  in the form  $r(\cos \theta + i \sin \theta)$ .
- (ii) Calculate  $z_1 z_2$  and write in the form  $z = a + bi$  where  $a, b \in \mathbb{R}$ .
- (iii) Hence find the value of  $\tan \frac{5\pi}{12}$  in the form  $c + d\sqrt{3}$ , where  $c, d \in \mathbb{Z}$ .
- (iv) Find the smallest value  $p > 0$  such that  $(z_2)^p$  is a positive real number. [11]

12. [Maximum mark: 20]

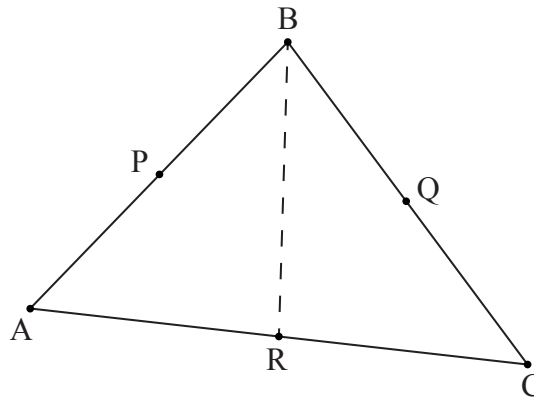
Consider the function defined by  $f(x) = x\sqrt{1-x^2}$  on the domain  $-1 \leq x \leq 1$ .

- (a) Show that  $f$  is an odd function. [2]
- (b) Find  $f'(x)$ . [3]
- (c) Hence find the  $x$ -coordinates of any local maximum or minimum points. [3]
- (d) Find the range of  $f$ . [3]
- (e) Sketch the graph of  $y = f(x)$  indicating clearly the coordinates of the  $x$ -intercepts and any local maximum or minimum points. [3]
- (f) Find the area of the region enclosed by the graph of  $y = f(x)$  and the  $x$ -axis for  $x \geq 0$ . [4]
- (g) Show that  $\int_{-1}^1 |x\sqrt{1-x^2}| dx > \left| \int_{-1}^1 x\sqrt{1-x^2} dx \right|$ . [2]



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13. [Maximum mark: 23]



Consider the triangle  $ABC$ . The points  $P$ ,  $Q$  and  $R$  are the midpoints of the line segments  $[AB]$ ,  $[BC]$  and  $[AC]$  respectively.

Let  $\vec{OA} = \mathbf{a}$ ,  $\vec{OB} = \mathbf{b}$  and  $\vec{OC} = \mathbf{c}$ .

- (a) Find  $\vec{BR}$  in terms of  $\mathbf{a}$ ,  $\mathbf{b}$  and  $\mathbf{c}$ . [2]
- (b) (i) Find a vector equation of the line that passes through  $B$  and  $R$  in terms of  $\mathbf{a}$ ,  $\mathbf{b}$  and  $\mathbf{c}$  and a parameter  $\lambda$ .
- (ii) Find a vector equation of the line that passes through  $A$  and  $Q$  in terms of  $\mathbf{a}$ ,  $\mathbf{b}$  and  $\mathbf{c}$  and a parameter  $\mu$ .
- (iii) Hence show that  $\vec{OG} = \frac{1}{3}(\mathbf{a} + \mathbf{b} + \mathbf{c})$  given that  $G$  is the point where  $[BR]$  and  $[AQ]$  intersect. [9]
- (c) Show that the line segment  $[CP]$  also includes the point  $G$ . [3]

The coordinates of the points  $A$ ,  $B$  and  $C$  are  $(1, 3, 1)$ ,  $(3, 7, -5)$  and  $(2, 2, 1)$  respectively.

A point  $X$  is such that  $[GX]$  is perpendicular to the plane  $ABC$ .

- (d) Given that the tetrahedron  $ABCX$  has volume  $12 \text{ units}^3$ , find possible coordinates of  $X$ . [9]



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