



Oxford Cambridge and RSA

## Monday 6 June 2016 – Afternoon

### FSMQ ADVANCED LEVEL

6993/01 Additional Mathematics

### QUESTION PAPER



Candidates answer on the Printed Answer Book.

**OCR supplied materials:**

- Printed Answer Book 6993/01

**Other materials required:**

- Scientific or graphical calculator

**Duration:** 2 hours

### INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.

- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- Write your answer to each question in the space provided in the Printed Answer Book.** If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given correct to three significant figures where appropriate.

### INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.

- The number of marks is given in brackets [ ] at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **100**.
- The Printed Answer Book consists of **20** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

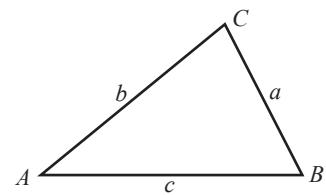
### INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

## Formulae Sheet: 6993 Additional Mathematics

In any triangle  $ABC$

**Cosine rule**  $a^2 = b^2 + c^2 - 2bc \cos A$



**Binomial expansion**

When  $n$  is a positive integer

$$(a + b)^n = a^n + \binom{n}{1} a^{n-1}b + \binom{n}{2} a^{n-2}b^2 + \dots + \binom{n}{r} a^{n-r}b^r + \dots + b^n$$

where

$$\binom{n}{r} = {}^nC_r = \frac{n!}{r!(n-r)!}$$

## Section A

Answer **all** the questions.

1 Solve the inequality  $1 - 2(x - 3) > 4x$ . [3]

2 The gradient function of a curve is given by  $\frac{dy}{dx} = 3x^2 - 4x + 2$ .

Find the equation of the curve, given that it passes through the point (1, 3).

[4]

3 Find all the values of  $x$  in the range  $0^\circ < x < 360^\circ$  that satisfy  $3\sin x = 4\cos x$ . [4]

4 You are given that  $f(x) = x^3 - x^2 + x - 6$ .

Show that

(i)  $(x - 2)$  is a factor of  $f(x)$ , [1]

(ii) the equation  $f(x) = 0$  has only one real root. [4]

5 John draws a triangle ABC with sides  $AB = 12\text{ cm}$ ,  $BC = 16\text{ cm}$  and  $AC = 20\text{ cm}$ . However, he can only measure the sides to the nearest centimetre.

(i) State the smallest possible length of AB in John's drawing. [1]

(ii) Hence calculate the largest possible value of the angle B in John's drawing. [3]

6 Two cars are initially at rest facing in the same direction on a straight road. Car A is 100 m ahead of car B. The two cars start from rest at the same moment.

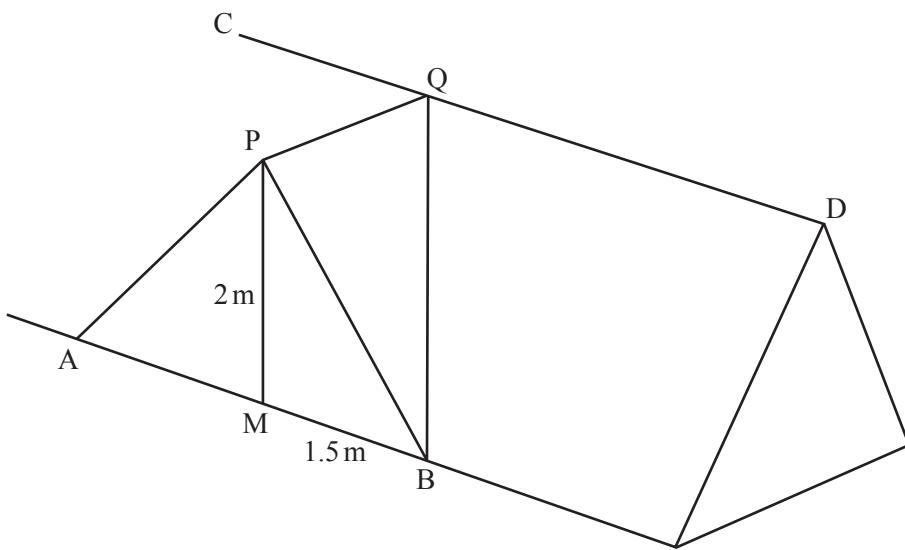
Car A moves with constant acceleration of  $1.5\text{ m s}^{-2}$  and car B moves with constant acceleration of  $2\text{ m s}^{-2}$ .

Find

(i) the distance that car B travels before it overtakes car A, [4]

(ii) the speed of car B at the moment when it overtakes car A. [2]

7 An extension to the roof of a house is shown in the diagram below.



The ridge, CD, and the lines AB and PQ are horizontal. PQ is perpendicular to CD. M is the midpoint of AB. The line PM is vertical.

APB is an isosceles triangle with height 2 metres and base length 3 metres.  
Angle PQM is  $45^\circ$ .

Find

(i) the length of PQ. [1]

(ii) the angle PBQ. [4]

8 (i) Write down the binomial expansion of  $(1 + \delta)^3$ . [2]

(ii) Hence explain why, if  $\delta$  is small,  $(1 + \delta)^3 \approx 1 + 3\delta$ .  
[ $\approx$  means 'is approximately equal to'] [1]

You are given that the equation  $x^3 - 0.9x - 0.206 = 0$  has a root very close to  $x = 1$ .

(iii) Substitute  $x = 1 + \delta$  into the equation and use the approximation in part (ii) to find an estimate of this root, correct to 3 significant figures. Show all your working. [4]

9 A curve has equation  $y = x^3 - 3x^2 - 3x + 4$ .  
Points P and Q lie on the curve. The coordinates of P are  $(3, -5)$ .

(i) Find the equation of the tangent to the curve at P. [4]

The tangent to the curve at Q is parallel to the tangent to the curve at P.

(ii) Find the coordinates of Q. [3]

10 (i) On the axes given in the Printed Answer Book, indicate the region for which the following inequalities hold. You should shade the region that is **not** satisfied by the inequalities.

$$\begin{aligned}4x + 3y &\leq 30 \\y &\geq 2x \\x &\geq 1\end{aligned}$$

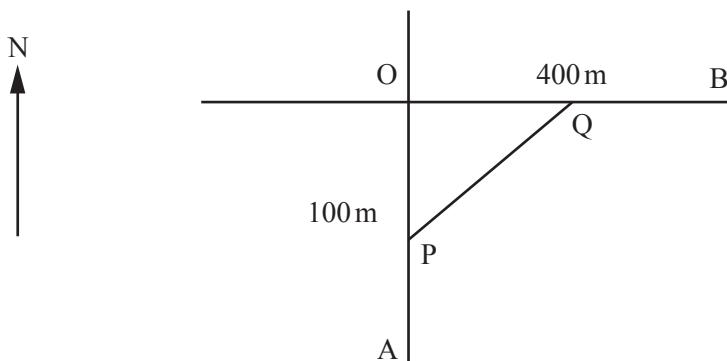
[5]

(ii) Find the maximum value of  $7x + 4y$  subject to these conditions.

[2]

## Section B

11 A railway track runs due east-west and is crossed at O by a road running due south-north, as shown below. The crossing has no barriers.



Initially a train is at point B, 400 m from O, and a car is at point A, 100 m from O. The train is travelling at a constant speed of  $25 \text{ m s}^{-1}$  towards O and the car is travelling at a constant speed of  $20 \text{ m s}^{-1}$  towards O.

At time  $t$  seconds the train is at point Q and the car is at point P.

(i) Find expressions for the distances OP and OQ as functions of  $t$ . [2]

(ii) The distance between the car and the train at time  $ts$  is  $x \text{ m}$ . Find a formula for  $x^2$  in terms of  $t$ . Give your formula in the form  $x^2 = a + bt + ct^2$  where  $a$ ,  $b$  and  $c$  are to be determined. [3]

(iii) Differentiate this formula with respect to  $t$  and find the time at which  $x^2$  is a minimum. Hence find the shortest distance between the car and the train. [6]

(iv) Show that the car passes point O before the train. [1]

12 The line  $L_1$  has equation  $3x - y = 1$  and the point P has coordinates  $(8, 3)$ .

(i) Find the equation of the line  $L_2$  which passes through P and is perpendicular to line  $L_1$ . [3]

(ii) Find the coordinates of the point Q where  $L_1$  and  $L_2$  intersect. [3]

(iii) Find the length PQ. [2]

(iv) Write down the equation of the circle that has centre P and line  $L_1$  as a tangent. [1]

(v) Find the equation of the other line that is a tangent to the circle and is parallel to line  $L_1$ . [3]

13 The cost of a packet of buns in a local supermarket is  $x$  pence and the cost of a loaf of bread is  $x + 75$  pence.

(i) Write an expression for the number of packets of buns that can be bought for £5.40 and an expression for the number of loaves that can be bought for £5.40. [2]

The number of packets of buns that can be bought for £5.40 is 5 more than the number of loaves that can be bought for £5.40.

(ii) Using this information and your answer to part (i), derive an equation in  $x$  and show that it simplifies to  $x^2 + 75x - 8100 = 0$ . [5]

(iii) Solve this equation to find the cost of a packet of buns and the cost of a loaf of bread. [5]

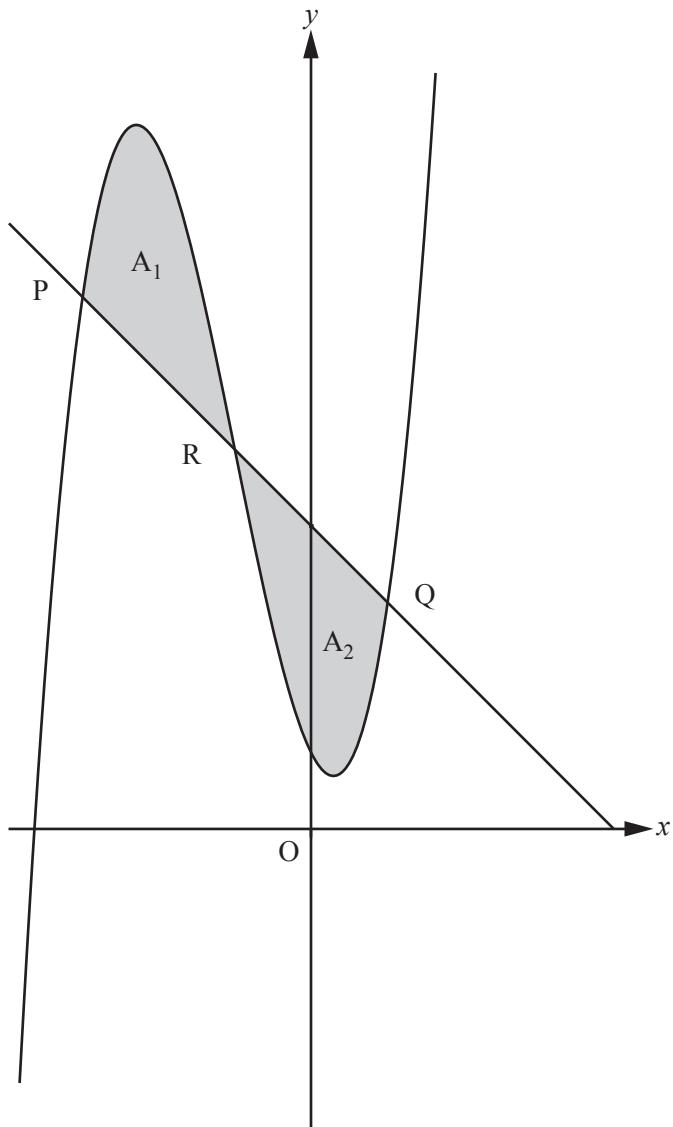
**Question 14 is printed overleaf**

14 The equation of a curve is given by  $y = x^3 + ax^2 + bx + 1$ . The points P (−3, 7) and Q (1, 3) lie on the curve.

(i) Form two equations in  $a$  and  $b$ . Solve these equations to show that  $a = 3$  and  $b = -2$ . [4]

(ii) Find the midpoint, R, of the line PQ and show that R lies on the curve. [2]

The diagram below shows the curve and the line PRQ.



The area between the curve and the line segment PR is  $A_1$  and the area between the curve and the line segment RQ is  $A_2$ .

(iii) Show that  $A_1 = A_2$ . [6]

**END OF QUESTION PAPER**

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