

## Mathematics

### Higher level

### Paper 2

Thursday 12 November 2015 (afternoon)

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.
- A graphic display calculator is required 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]**.























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Answers written on this page will not  
be marked.



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### Section B

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

11. [Maximum mark: 18]

A survey is conducted in a large office building. It is found that 30% of the office workers weigh less than 62 kg and that 25% of the office workers weigh more than 98 kg. The weights of the office workers may be modelled by a normal distribution with mean  $\mu$  and standard deviation  $\sigma$ .

- (a) (i) Determine two simultaneous linear equations satisfied by  $\mu$  and  $\sigma$ . [6]
- (ii) Find the values of  $\mu$  and  $\sigma$ . [6]
- (b) Find the probability that an office worker weighs more than 100 kg. [1]

There are elevators in the office building that take the office workers to their offices. Given that there are 10 workers in a particular elevator,

- (c) find the probability that at least four of the workers weigh more than 100 kg. [2]

Given that there are 10 workers in an elevator and at least one weighs more than 100 kg,

- (d) find the probability that there are fewer than four workers exceeding 100 kg. [3]

The arrival of the elevators at the ground floor between 08:00 and 09:00 can be modelled by a Poisson distribution. Elevators arrive on average every 36 seconds.

- (e) Find the probability that in any half hour period between 08:00 and 09:00 more than 60 elevators arrive at the ground floor. [3]

An elevator can take a maximum of 10 workers. Given that 400 workers arrive in a half hour period independently of each other,

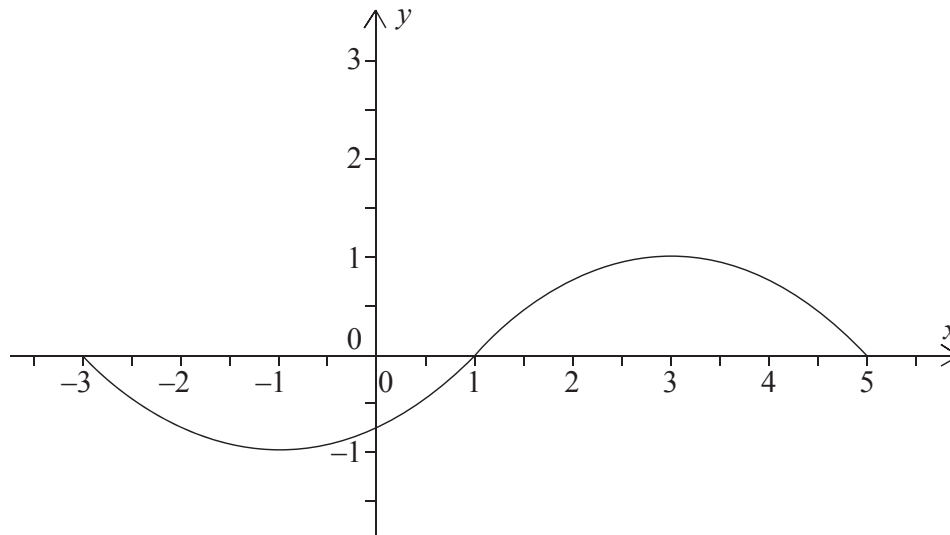
- (f) find the probability that there are sufficient elevators to take them to their offices. [3]



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12. [Maximum mark: 21]

The following graph represents a function  $y = f(x)$ , where  $-3 \leq x \leq 5$ .  
The function has a maximum at  $(3, 1)$  and a minimum at  $(-1, -1)$ .



(a) The functions  $u$  and  $v$  are defined as  $u(x) = x - 3$ ,  $v(x) = 2x$  where  $x \in \mathbb{R}$ .

(i) State the range of the function  $u \circ f$ .

(ii) State the range of the function  $u \circ v \circ f$ .

(iii) Find the largest possible domain of the function  $f \circ v \circ u$ .

[7]

(b) (i) Explain why  $f$  does not have an inverse.

(ii) The domain of  $f$  is restricted to define a function  $g$  so that it has an inverse  $g^{-1}$ .  
State the largest possible domain of  $g$ .

(iii) Sketch a graph of  $y = g^{-1}(x)$ , showing clearly the  $y$ -intercept and stating the coordinates of the endpoints.

[6]

Consider the function defined by  $h(x) = \frac{2x-5}{x+d}$ ,  $x \neq -d$  and  $d \in \mathbb{R}$ .

(c) (i) Find an expression for the inverse function  $h^{-1}(x)$ .

(ii) Find the value of  $d$  such that  $h$  is a self-inverse function.

For this value of  $d$ , there is a function  $k$  such that  $h \circ k(x) = \frac{2x}{x+1}$ ,  $x \neq -1$ .

(iii) Find  $k(x)$ .

[8]

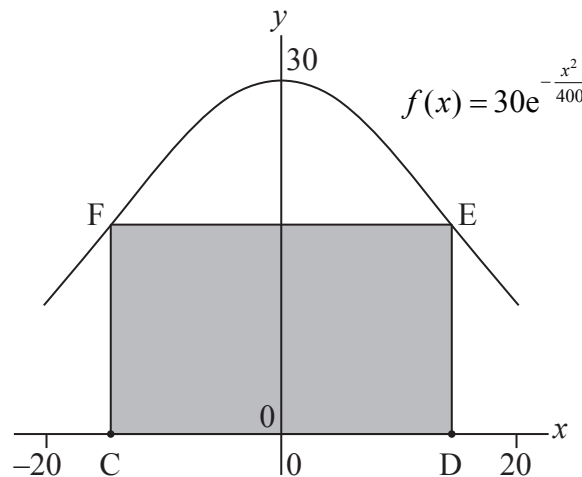


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13. [Maximum mark: 21]

The following diagram shows a vertical cross section of a building. The cross section of the roof of the building can be modelled by the curve  $f(x) = 30e^{-\frac{x^2}{400}}$ , where  $-20 \leq x \leq 20$ .

Ground level is represented by the  $x$ -axis.



- (a) Find  $f''(x)$ . [4]
- (b) Show that the gradient of the roof function is greatest when  $x = -\sqrt{200}$ . [3]

The cross section of the living space under the roof can be modelled by a rectangle CDEF with points  $C(-a, 0)$  and  $D(a, 0)$ , where  $0 < a \leq 20$ .

- (c) Show that the maximum area  $A$  of the rectangle CDEF is  $600\sqrt{2}e^{-\frac{1}{2}}$ . [5]
- (d) A function  $I$  is known as the Insulation Factor of CDEF. The function is defined as  $I(a) = \frac{P(a)}{A(a)}$  where  $P$  = Perimeter and  $A$  = Area of the rectangle.
- (i) Find an expression for  $P$  in terms of  $a$ .
- (ii) Find the value of  $a$  which minimizes  $I$ .
- (iii) Using the value of  $a$  found in part (ii) calculate the percentage of the cross sectional area under the whole roof that is not included in the cross section of the living space. [9]

