Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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4	
5	
6	
TOTAL	

Free-Standing Mathematics Qualification
Advanced Level
June 2011

Working with Algebraic and Graphical Techniques 6991/2

Unit 11

Friday 20 May 2011 9.00 am to 10.30 am

For this paper you must have:
- a clean copy of the Data Sheet (enclosed)
- a calculator
- a ruler.

Time allowed
- 1 hour 30 minutes

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer the questions in the spaces provided. Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.
- You may **not** refer to the copy of the Data Sheet that was available prior to this examination. A clean copy is enclosed for your use.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 60.
- You may use either a scientific calculator or a graphics calculator.

Section A

Answer **all** questions in the spaces provided.

Use **Wembley stadium** *on page 2 of the Data Sheet.*

1 A mathematical model for the arch is produced. The equation is

$$y = \frac{133x}{24\,806}(315 - x)$$

where the x-coordinate of a point on the arch is the horizontal distance in metres from the left support and the y-coordinate is the vertical distance in metres above the ground at this point.

(a) Using this model, complete the table of values opposite. *(2 marks)*

(b) On the grid opposite, complete the graph of

$$y = \frac{133x}{24\,806}(315 - x) \qquad \text{for } 0 \leqslant x \leqslant 315$$ *(2 marks)*

(c) Use your graph to find:

(i) the values of x when $y = 100$; *(2 marks)*

(ii) the gradient of the graph when $x = 60$. *(2 marks)*

(d) The centre of the arch is 140 metres above the football pitch.

How far below ground level is the football pitch? *(1 mark)*

(e) The equation $y = \frac{133x}{24\,806}(315 - x)$ can be rearranged into the form

$$y = A - 0.00536(B - x)^2$$

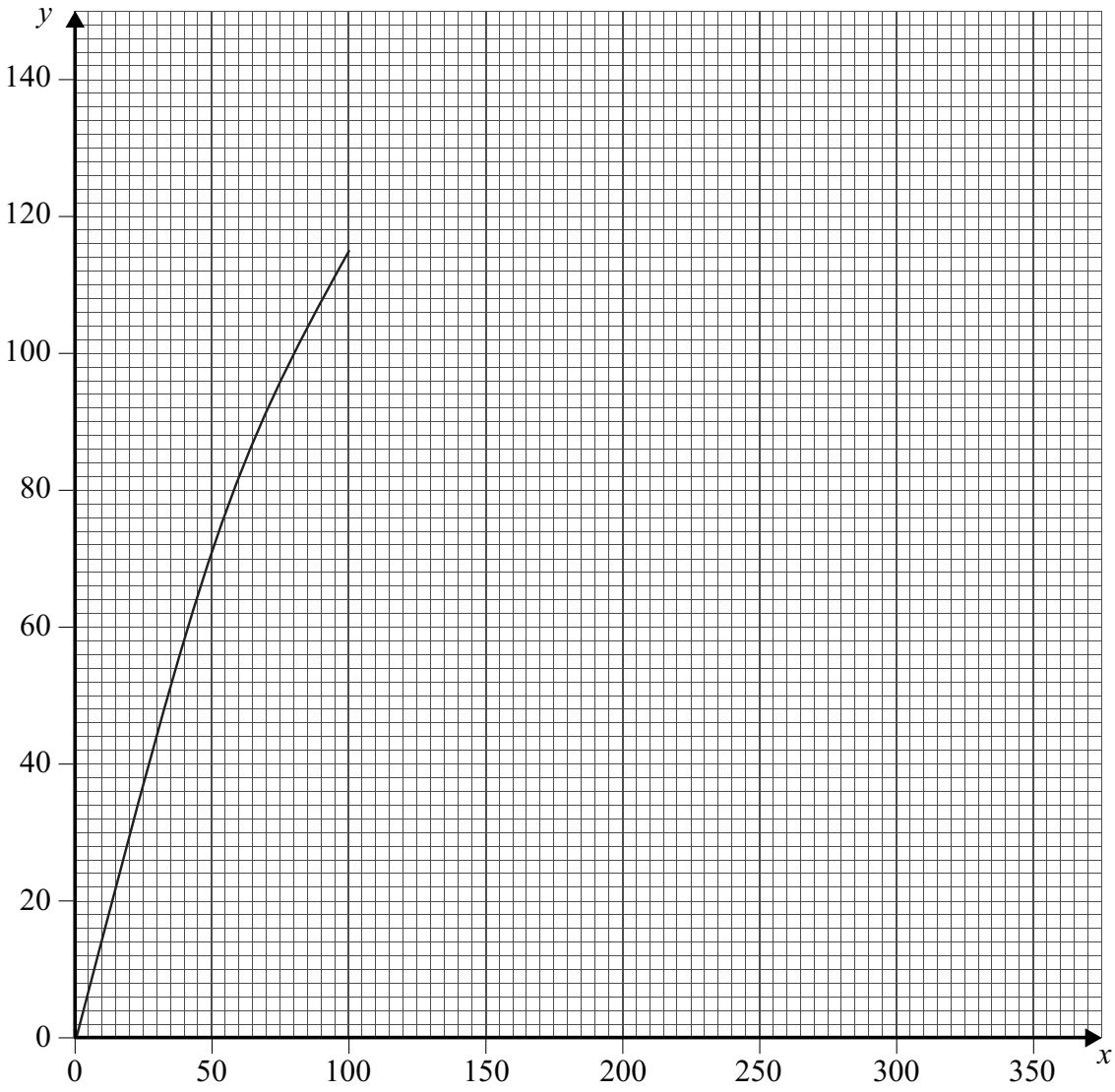
where A and B are constants.

Find the values of A and B. *(3 marks)*

(f) How are the values of A and B connected to the dimensions of the arch? *(2 marks)*

QUESTION PART REFERENCE

x	0	50	100	150	200	250	300	315
y	0	71	115					



QUESTION PART REFERENCE

QUESTION PART REFERENCE

Section B

Answer **all** questions in the spaces provided.

Use **Waste recycling** *on page 2 of the Data Sheet.*

2 The equation $y = ct^3 + d$, where c and d are constants, can be used to model the amount of recycled household waste, y tonnes, in terms of t, the number of years since 1997.

(a) Complete the table of values opposite. *(2 marks)*

(b) On the grid opposite, plot y against t^3.

Draw a line of best fit on your graph. *(3 marks)*

(c) Use your graph to find the values of c and d. *(3 marks)*

(d) Use your values of c and d in the equation $y = ct^3 + d$ to find:

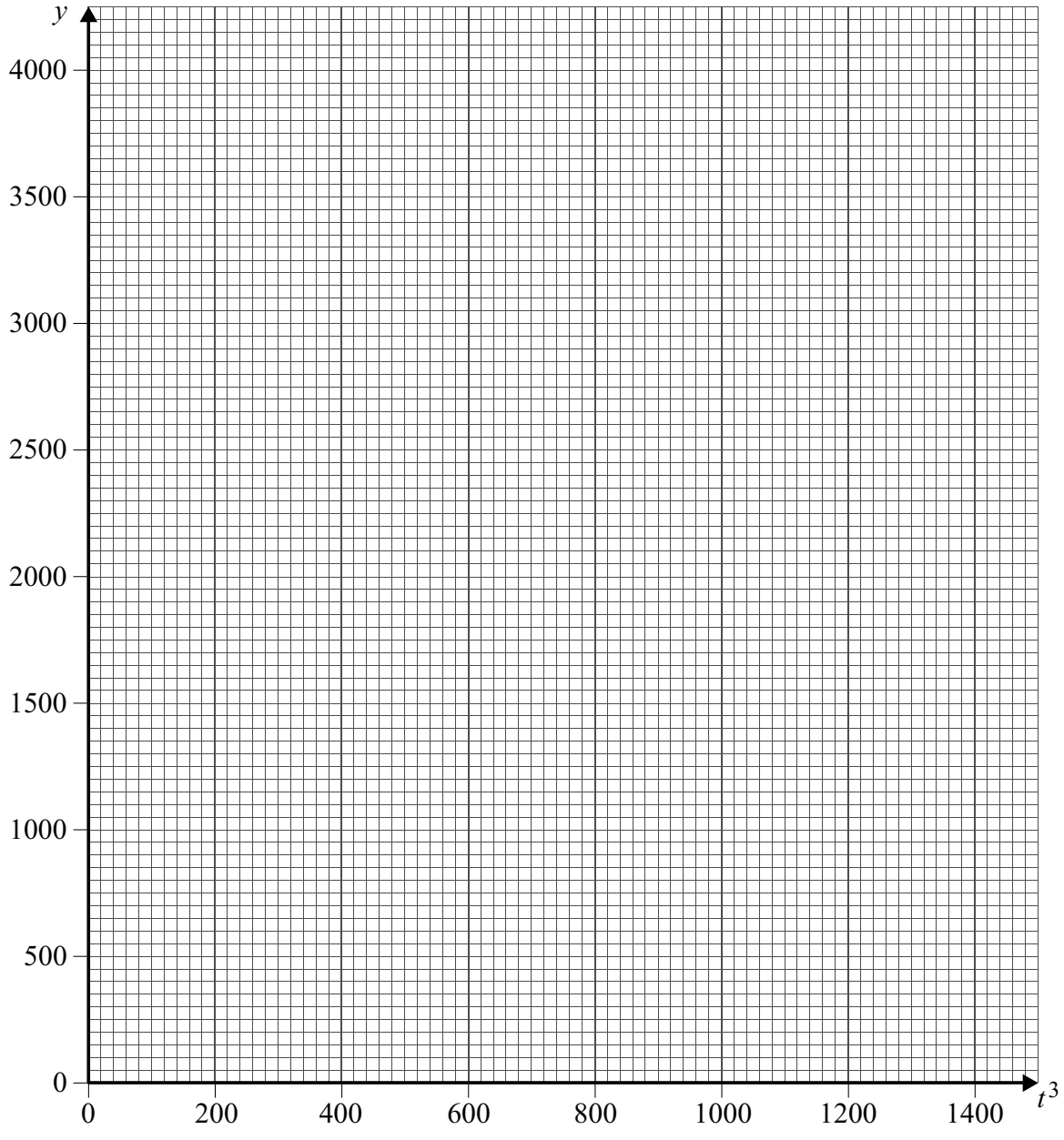
(i) the amount of recycled waste in 2005; *(2 marks)*

(ii) the first year when the amount of recycled waste was expected to exceed 5000 tonnes. *(3 marks)*

QUESTION PART REFERENCE

QUESTION PART REFERENCE

t	1	3	5	7	9	11
t^3						
y	820	890	1090	1520	2300	3520



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QUESTION PART REFERENCE

QUESTION PART REFERENCE

Section C

Answer **all** questions in the spaces provided.

Use **Computer speeds** *on page 2 of the Data Sheet.*

3 The computing speed, S operations per second, can be modelled by the equation

$$S = ka^t$$

where t is the number of years since 1972 and a and k are constants.

(a) Complete the table of values opposite. *(2 marks)*

(b) On the grid opposite, plot $\ln S$ against t.

Draw a line of best fit on your graph. *(3 marks)*

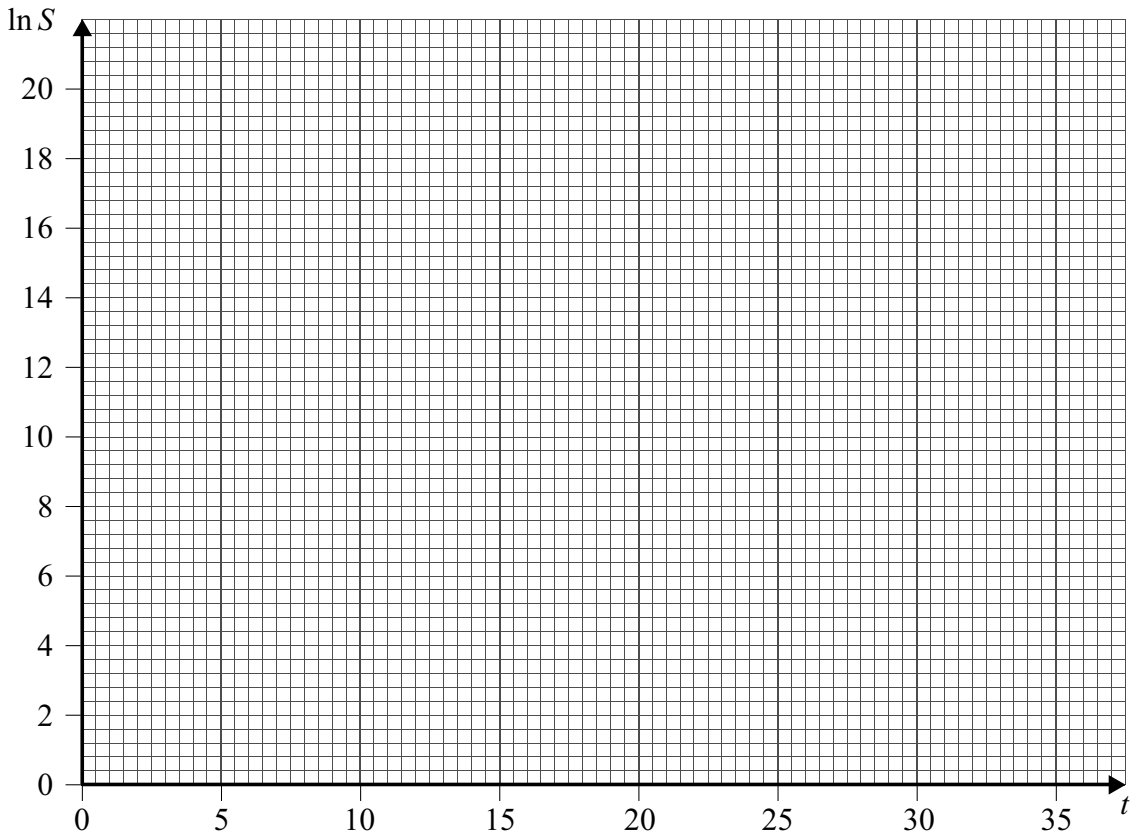
(c) Find the equation for the line of best fit in terms of $\ln S$ and t. *(3 marks)*

(d) Hence express S in terms of t. *(2 marks)*

QUESTION PART REFERENCE

QUESTION PART REFERENCE

t	0	10	21	31	35
S	3.5×10^3	1.34×10^5	5.5×10^6	8.4×10^7	4×10^8
$\ln S$					



QUESTION PART REFERENCE

QUESTION PART REFERENCE

4 Another model for S states that S doubles every two years.

(a) (i) Using 1972 as the starting year, calculate what this model predicts for computer speeds for the year 1982. *(2 marks)*

(ii) Calculate the percentage error in using this model to predict the value of S in 1982. *(2 marks)*

(b) Use the axes opposite to sketch the graph of S against time, t, for this model. *(2 marks)*

QUESTION PART REFERENCE

QUESTION PART REFERENCE

Section D

Answer **all** questions in the spaces provided.

Use **Circadian rhythms** *on page 2 of the Data Sheet.*

5 The temperature, T °C, of an average human being can be modelled by the equation

$$T = 36.8 - 0.65\sin(15h + 30)^\circ$$

where h is the number of hours since midnight.

(a) What is the minimum temperature predicted by this model? *(1 mark)*

(b) At what time did this minimum temperature occur? *(2 marks)*

(c) What is the maximum temperature predicted by this model? *(1 mark)*

(d) At what time did this maximum temperature occur? *(2 marks)*

(e) At what times does this model predict the temperature will be 36.8 °C? *(3 marks)*

(f) For the function $36.8 - 0.65\sin(15h + 30)^\circ$, state:

(i) the amplitude; *(1 mark)*

(ii) the period. *(1 mark)*

(g) Describe fully the transformation that maps the graph of $T = \sin h^\circ$ onto the graph of $T = \sin(h + 30)^\circ$. *(1 mark)*

(h) Describe fully the transformations that map the graph of $T = \sin h^\circ$ onto the graph of $T = 36.8 + 0.65\sin h^\circ$. *(2 marks)*

QUESTION PART REFERENCE

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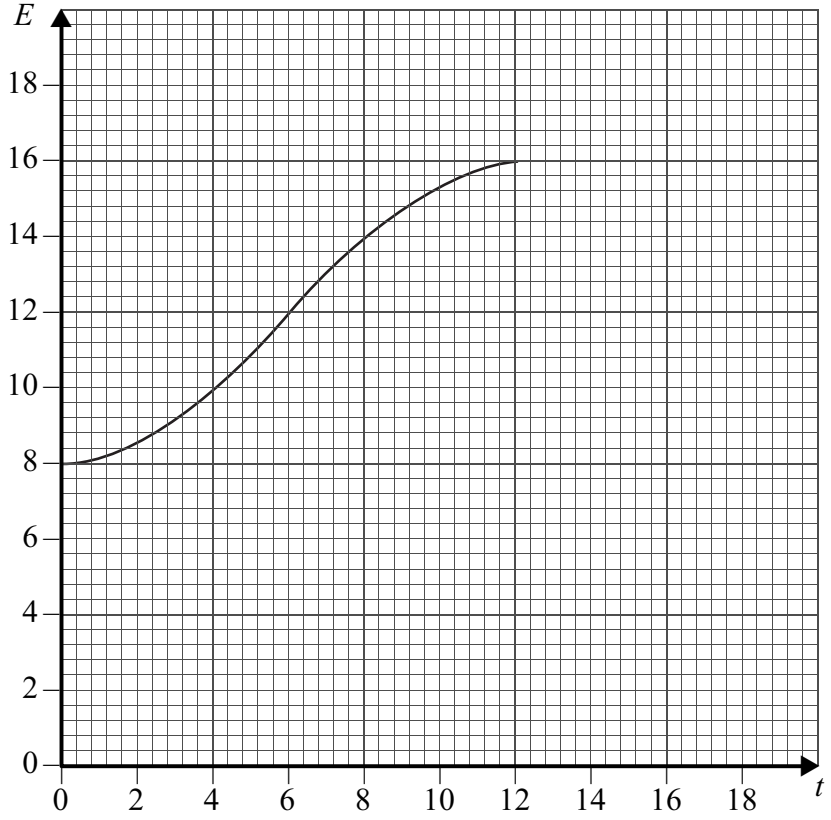
QUESTION PART REFERENCE

6 The graph below shows the enzyme levels, E, in a plant over a 12-hour period.

On the same set of axes, draw the graph of the inverse function. *(3 marks)*

QUESTION PART REFERENCE



END OF QUESTIONS

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