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	
TOTAL	

AQA

Free-Standing Mathematics Qualification
Advanced Level
June 2014

Working with Algebraic and Graphical Techniques 6991/2

Unit 11

Monday 19 May 2014 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 each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- 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.

Advice
- You do not necessarily need to use all the space provided.

Section A

Answer **all** questions.

Answer each question in the space provided for that question.

Use **Bungee jumping** *on page 2 of the Data Sheet.*

1 Ellen is doing a bungee jump.

At time $t = 0$, she jumps from a point 80 metres above ground level.

After 2 seconds, she is at a height of 60 metres above ground level.

At a time t seconds after jumping, Ellen's height above ground level is y metres. For $0 \leqslant t \leqslant 2$, this height can be modelled by

$$y = m - nt^2 \qquad \text{where } m \text{ and } n \text{ are constants.}$$

(a) Find the value of m, and show that $n = 5$.

[3 marks]

(b) Use your values of m and n to complete the table.

[2 marks]

t	0	0.4	0.8	1.2	1.6	2.0
$y = m - nt^2$	80					60

(c) On the grid opposite, draw a graph of the data in the table.

[3 marks]

(d) (i) Find the gradient of the graph when $t = 1$.

[2 marks]

(ii) State the units of this gradient.

[1 mark]

(iii) Interpret the meaning of this gradient.

[1 mark]

(e) If this model continued to be valid for $t > 2$, at what time would Ellen be 5 metres above ground level?

[3 marks]

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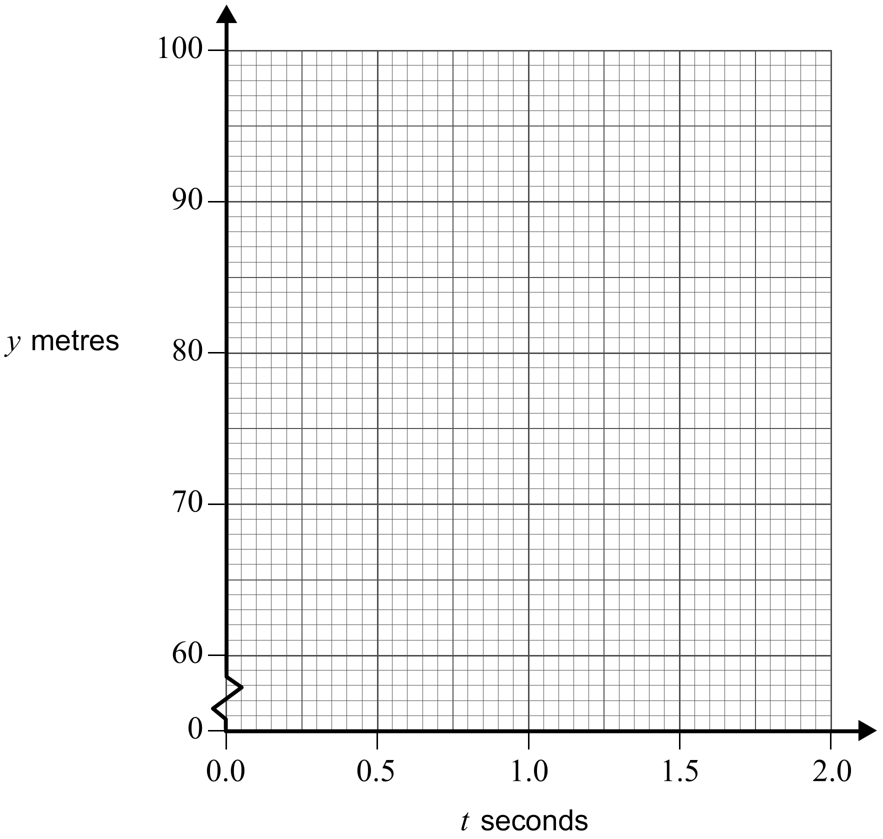

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2 Two seconds after Ellen jumps, the rope becomes taut for the first time.

At a time t seconds after jumping, Ellen's height above ground level is y metres. For $2 \leqslant t \leqslant 7.8$, this height can be modelled by

$$y = 32.1\cos\left(42.9(t - 0.693)\right)^\circ + 42.1$$

(a) Consider the function $32.1\cos\left(42.9(t - 0.693)\right)^\circ + 42.1$

(i) State the amplitude of this function.

[1 mark]

(ii) State the minimum value of this function.

[1 mark]

(iii) Find the period of this function.

[2 marks]

(b) Complete the table, giving values of y to one decimal place.

[2 marks]

t	2	3	4	5	6	7	7.8
y	60.0	37.1	16.8				60.5

(c) The graph opposite shows how Ellen's actual height above the ground varies for $2 \leqslant t \leqslant 7.8$.

On the same axes, draw the graph of

$$y = 32.1\cos\left(42.9(t - 0.693)\right)^\circ + 42.1 \quad \text{for} \quad 2 \leqslant t \leqslant 7.8$$

[3 marks]

(d) At the point where $t = 3$, find the percentage error in the height obtained by using the model.

[3 marks]

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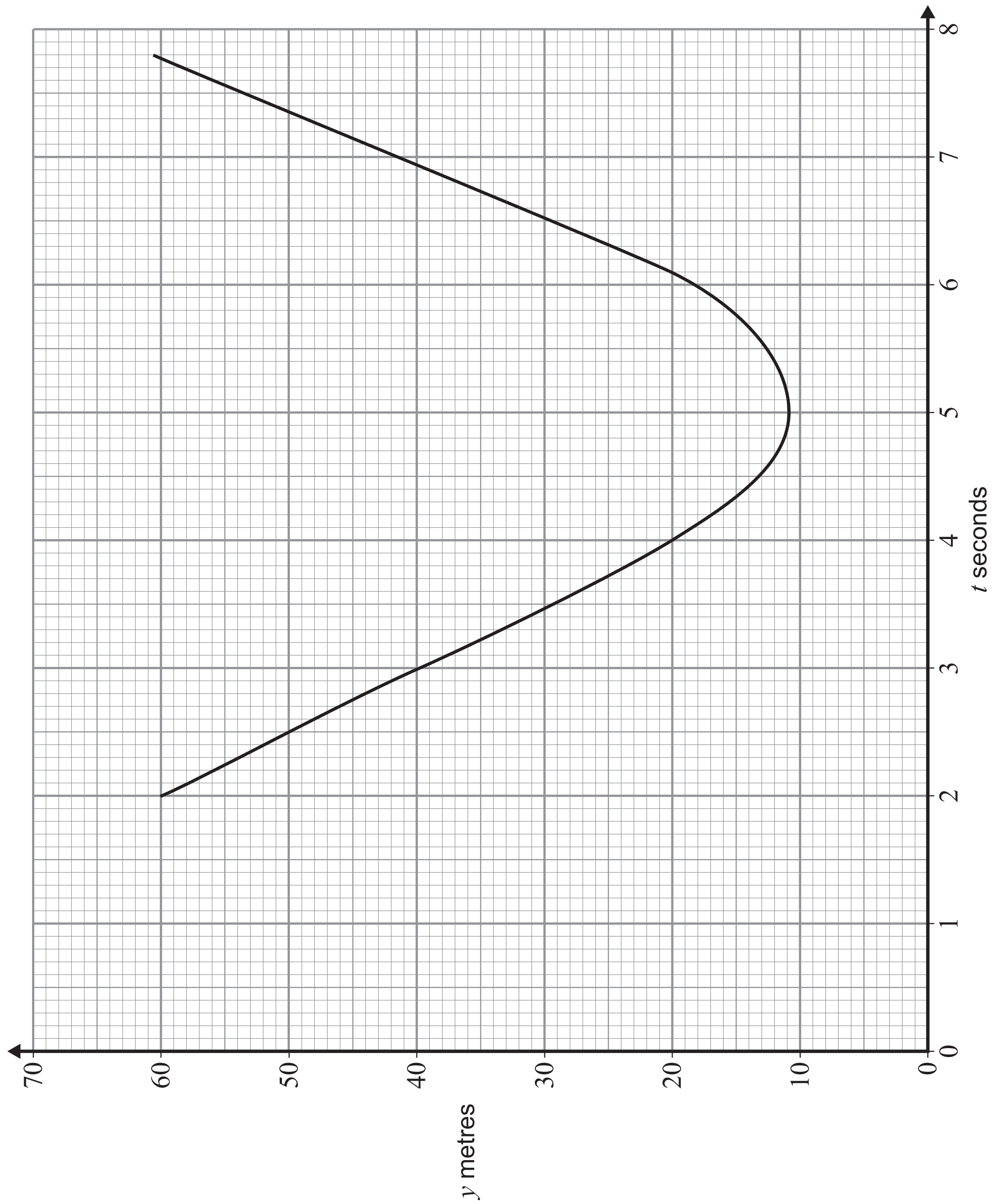

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3 The rope becomes slack again 7.8 seconds after Ellen jumps.

At a time t seconds after jumping, Ellen's height above ground level is y metres. For $7.8 \leqslant t \leqslant 9.6$, this height can be modelled by

$$y = 64.1 - 5(t - 8.7)^2$$

Use this model to answer the following questions.

(a) (i) State the maximum value of y.

[1 mark]

(ii) State the value of t which gives this maximum.

[1 mark]

(b) Express y in the form $y = at^2 + bt + c$.

[3 marks]

(c) Find the times when $y = 62$.

[3 marks]

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Section B

Answer **all** questions.

Answer each question in the space provided for that question.

Use **Electric car** *on page 3 of the Data Sheet.*

4 The graph on the Data Sheet shows how the number of revolutions per minute (RPM) of the electric car engine is related to the torque of the engine in foot pounds.

If $y = \text{(RPM)} - 2000$
and T foot pounds is the torque,
it is thought that y can be modelled by an equation of the form

$$y = Ak^T$$

where A and k are constants.

(a) Show that for this model $\log_{10} y = \log_{10} A + T \log_{10} k$.

[1 mark]

(b) Complete the table.

[2 marks]

T	6	10	20	30	40	50	60	70
y	3000	2500	1400	850	600	380	200	120
$\log_{10} y$	3.48	3.40	3.15	2.93				

(c) On the grid opposite, draw the graph of $\log_{10} y$ against T.
Draw a line of best fit.

[3 marks]

(d) Find the constants A and k, and hence express y in terms of T.

[4 marks]

(e) Use your equation to estimate T when $y = 1000$.

[3 marks]

(f) Use your equation to estimate the **RPM** when $T = 80$.

[2 marks]

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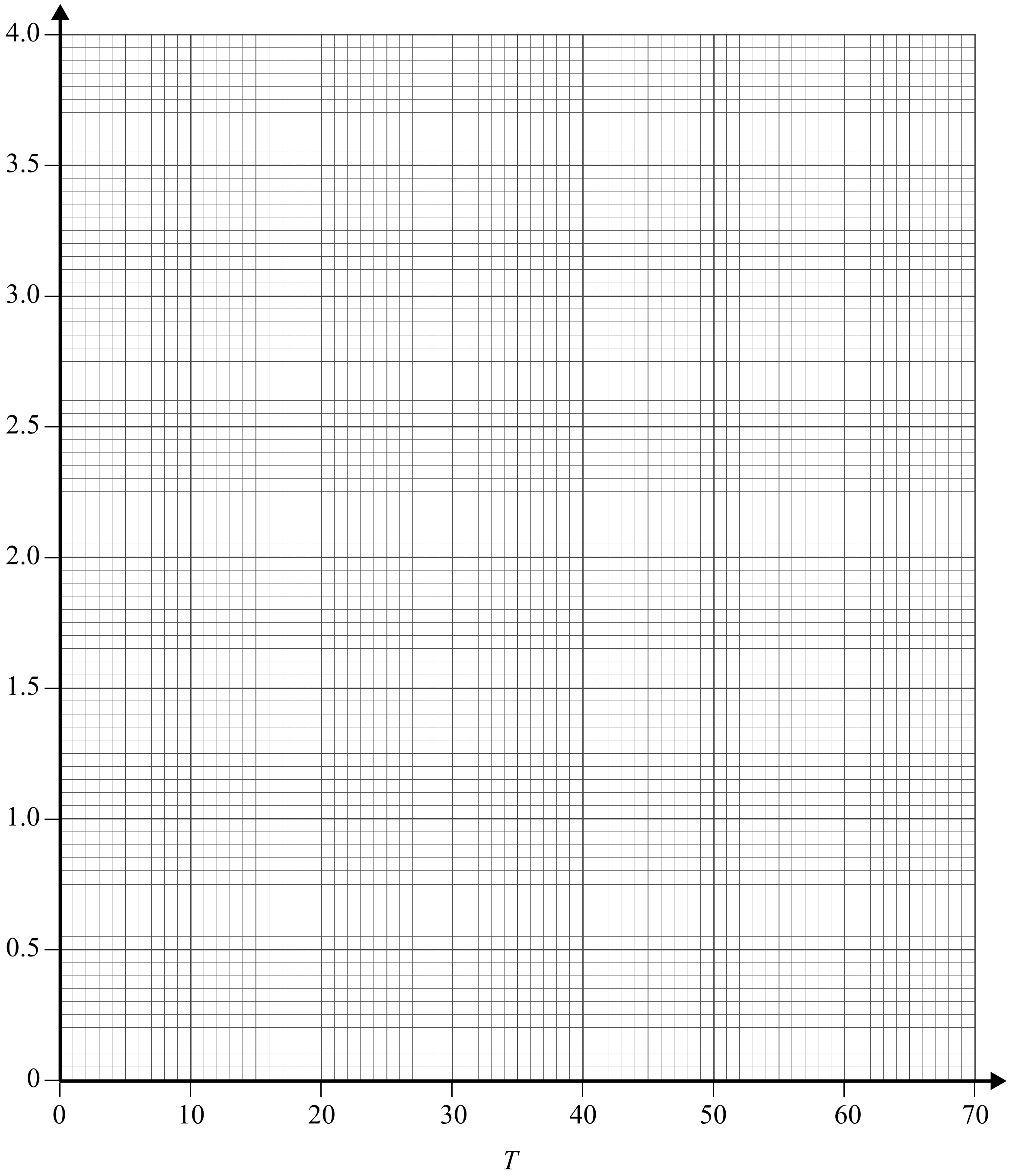

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Section C

Answer **all** questions.

Answer each question in the space provided for that question.

Use **Pendulum** *on page 4 of the Data Sheet.*

5 A simple pendulum of length l metres has period T seconds.

T can be modelled by the equation

$$T = 2l^{\frac{1}{2}} \quad \text{for} \quad l > 0$$

(a) Find the period of a simple pendulum of length 0.4 metres.

[1 mark]

(b) Find an expression for l in terms of T.

[2 marks]

(c) Find the length of a simple pendulum with period 2 seconds.

[1 mark]

(d) On the grid opposite, sketch the graph of $T = 2l^{\frac{1}{2}}$.

[2 marks]

(e) On the Moon, a simple pendulum of a given length has a period that is different from the value it would have on Earth.

On the Moon, T can be modelled by an equation of the form

$$T = kl^{\frac{1}{2}}$$

where k is a constant.

(i) A simple pendulum of length 0.8 metres has a period of 4.4 seconds on the Moon. Find the value of k, giving your answer to three significant figures. Hence express T in terms of l.

[2 marks]

(ii) Use your equation to find the length of a simple pendulum which has a period of 2 seconds on the Moon.

[2 marks]

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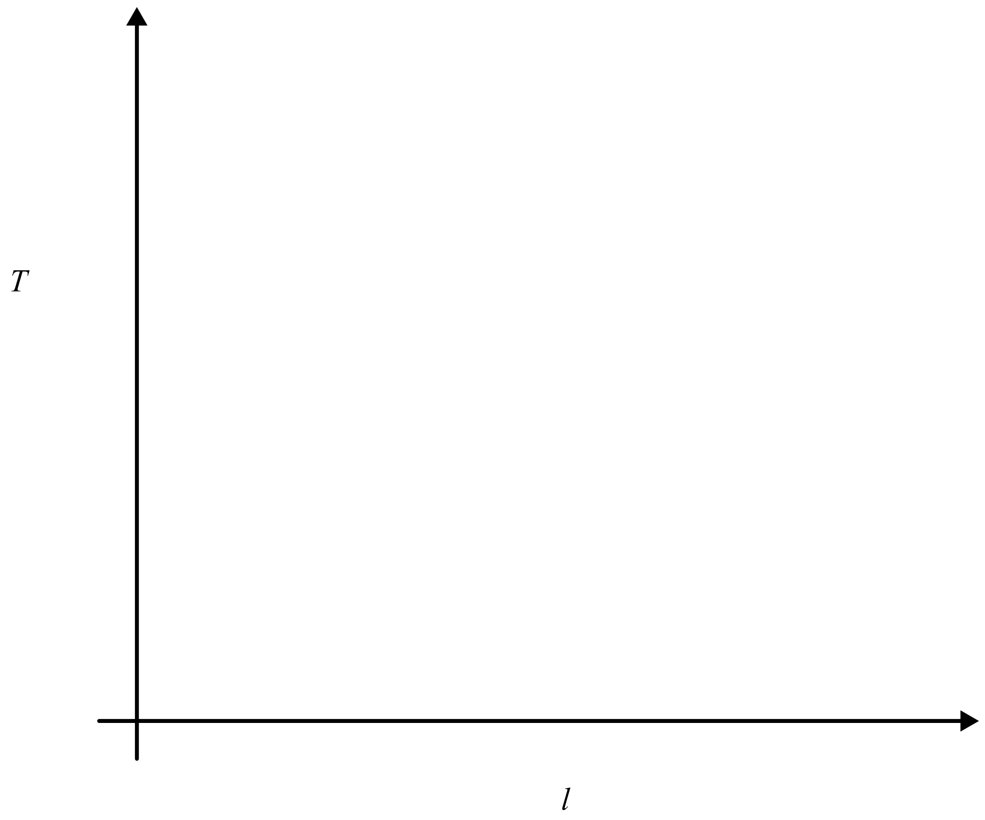

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