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Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

ENGINEERING

Cambridge TECHNICALS

Combined feedback on the January 2017 exam paper (including selected exemplar candidate answers and commentary)

Unit 1 - Mathematics for engineering

Version 1

ocr.org.uk/engineering

CONTENTS

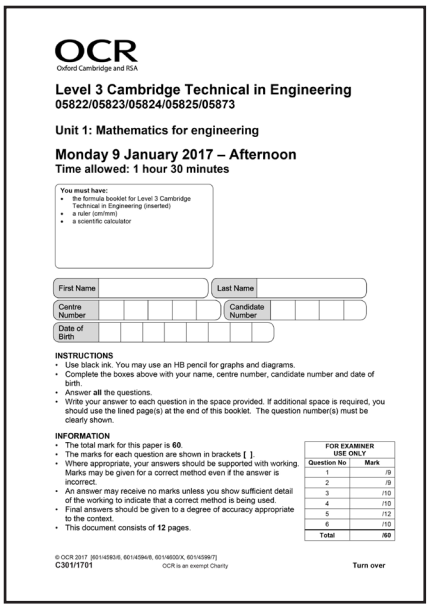
INTRODUCTION

This resource brings together the questions from the January 2017 examined unit (Unit 1), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We've also included candidate exemplar answers with commentaries for Question 2.

The marking guidance and the examiner's comments are taken straight from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from: https://interchange.ocr.org.uk/



OCR
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Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 1: Mathematics for engineering

Monday 9 January 2017 – Afternoon
Time allowed: 1 hour 30 minutes

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a scientific calculator

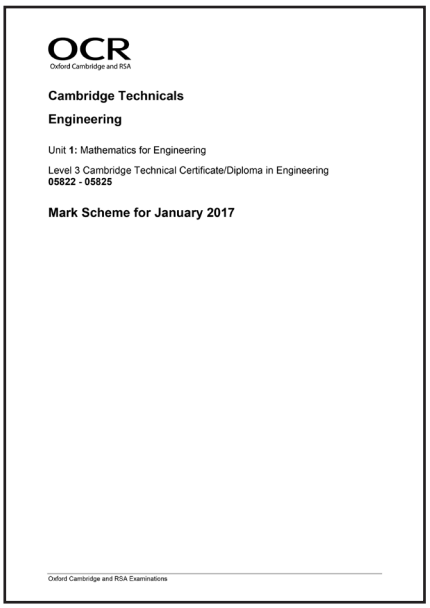
First Name | Last Name
Centre Number | Candidate Number
Date of Birth

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided. 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.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **12** pages.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/9
2	/9
3	/10
4	/10
5	/12
6	/10
Total	/60

C301/1701 OCR is an exempt Charity Turn over



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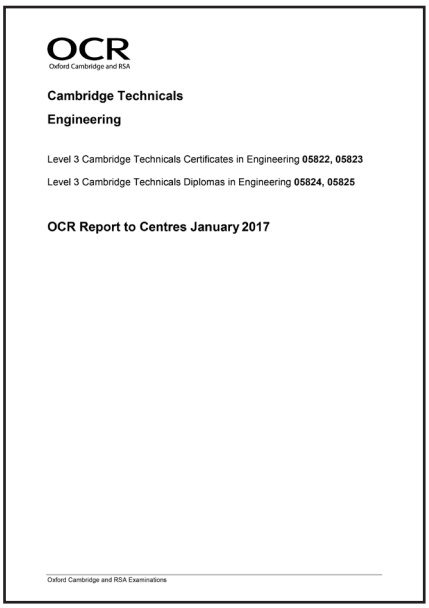
Cambridge Technicals
Engineering

Unit **1**: Mathematics for Engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for January 2017

Oxford Cambridge and RSA Examinations



OCR
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Cambridge Technicals
Engineering

Level 3 Cambridge Technicals Certificates in Engineering **05822, 05823**

Level 3 Cambridge Technicals Diplomas in Engineering **05824, 05825**

OCR Report to Centres January 2017

Oxford Cambridge and RSA Examinations

GENERAL EXAMINER COMMENTS ON THE PAPER

This is a mandatory unit across all qualifications in the Cambridge Technicals in Engineering suite.

While candidates generally performed to expectation, there appeared to be a number of gaps in their knowledge and other weaknesses. Although question 1 produced the best answers in the paper the algebraic manipulation elsewhere in the paper was usually quite poor.

It is hoped that the following points may help centres to prepare future cohorts of candidates for this unit.

Question 1

1 **(a)** Solve the equation $2x+3=7$.

$2x + 3 = 7 \Rightarrow 2x = 4$

$\Rightarrow x = 2$

[2]

(b) **(i)** Multiply out and simplify $(x+2)(x-3)$.

$x^2 - 3x + 2x - 6$

$= x^2 - x - 6$

[2]

(ii) Factorise $x^2+2x-15$.

$(x + 5)(x - 3)$ or $(x + 5)$ and $(x - 3)$

[2]

(c) You are given $f(x)=x^3-3x^2+4x-1$.

(i) Find the value of f(1).

f(1) = 1 **[1]**

(ii) Explain whether your result of part **(i)** shows that $x = 1$ is a root of the equation $f(x) = 0$.

No.

For $x = 1$ to be a root, f(1) = 0, but it isn't.

Accept "it is not = 0" **[2]**

Mark scheme guidance

1 (a) Soi subtraction of 3 or division by 2.

1 (b) (i) 4 terms SOI | $(x2 \pm px \pm qx \pm r)$

1 (b) (ii) $(x \pm 5)\ (x \pm 3)$ or $(x \pm 5)$ and $(x \pm 3)$

1 (c) (ii) Do not award without an explanation.

Or $f(1) = 1$ means that division by $(x - 1)$ gives a remainder.

Full marks can be earned even if $f(1) \neq 1$

Give B2 for Yes if their $f(1) = 0$

Examiner comments

1 Algebra

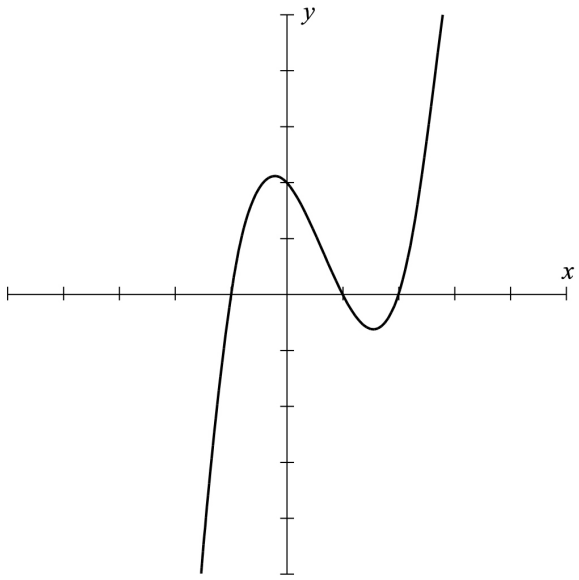
Most of the basic topics assessed in this question were understood by candidates who usually performed well. A few candidates had not got a good enough grasp of Algebra and made some quite elementary errors.

The part that was least well answered was part (d), changing the subject of a formula. When there are three terms, multiplying one term by, for instance, 2, requires every term to be treated similarly, for otherwise the equality ceases to hold. Typical errors were for instance, changing

$s = ut + \frac{1}{2}at^2$ to $2s = ut + at^2$

Question 2

2 **(a)** The graph of $y = f(x)$ is sketched on the axes below.



On the same axes sketch the following graphs. Each graph should be labelled clearly.

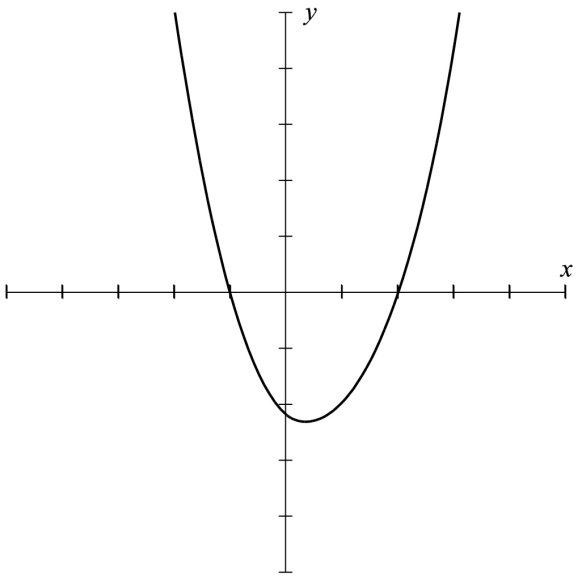
(i) $y = f(x) + 2$, [2]

Whole graph shifted up (or down)
Up by 2 and labelled correctly

(ii) $y = f(x + 2)$. [2]

Whole graph shifted left (or right)
Left by 2 and labelled correctly

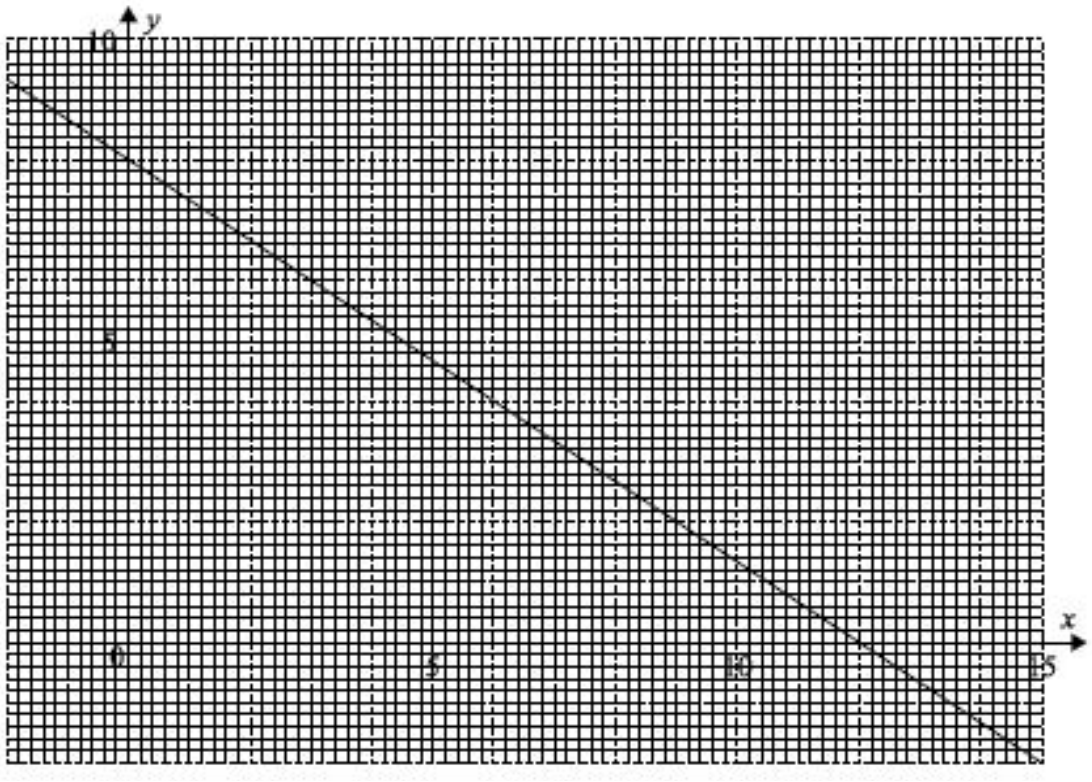
(b) The graph of $y = g(x)$ is sketched on the axes below.



On the same axes sketch the graph of $y = 2g(x)$. [2]

Whole graph stretched, through same points on x axis.
Above graph when x positive and below graph when x is negative.

(c) The graph of the equation $2x + 3y = 24$ is shown on the grid below.



(i) On the same grid plot the line $y = 2x$. **[2]**

Straight line through origin with positive gradient
Correct line

(ii) Hence write down the solution to the following simultaneous equations.

$$2x + 3y = 24$$
$$y = 2x$$

(3, 6) ..... **[1]**

Mark scheme guidance

2 (a) (i) Ignore (incorrect) labels

2 (a) (ii) Ignore (incorrect) labels

2 (b) Must have correct orientation

2 (c) (ii) ft their intersection
Allow even if line in (c)(i) is wrong.

Examiner comments

2 Transformation of graphs

This question was the one that was answered least well. A significant number of candidates did not understand what was required of them. Those that did have some understanding often lost marks because of poor drawing. For instance, the graph of $y = \mathrm{f}(x) + k$ is, for all values of x, k units above the curve $y = \mathrm{f}(x)$; they do not intersect. The curve $y = \mathrm{f}(x + k)$ is a transformation to the left of $y = \mathrm{f}(x)$. The curve $y = k\mathrm{g}(x)$ cuts the x-axis at the same points as the curve $y = \mathrm{g}(x)$.

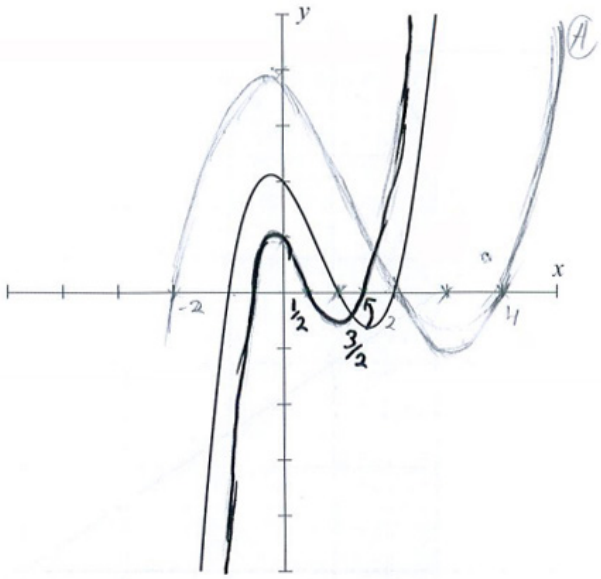
Very few candidates understood these points and of those who seemed to, many produced such poor graphs that it was not clear enough that the properties required were satisfied and so no credit could be given.

In part (c) most gave a straight line through the origin but not all got a correct gradient. Several solutions for part (ii) did not related to part (i) and attempted elimination or substitution. Several also gave an x value only.

Exemplar candidate work

Question 2 - Low level answer

2 **(a)** The graph of $y = f(x)$ is sketched on the axes below.

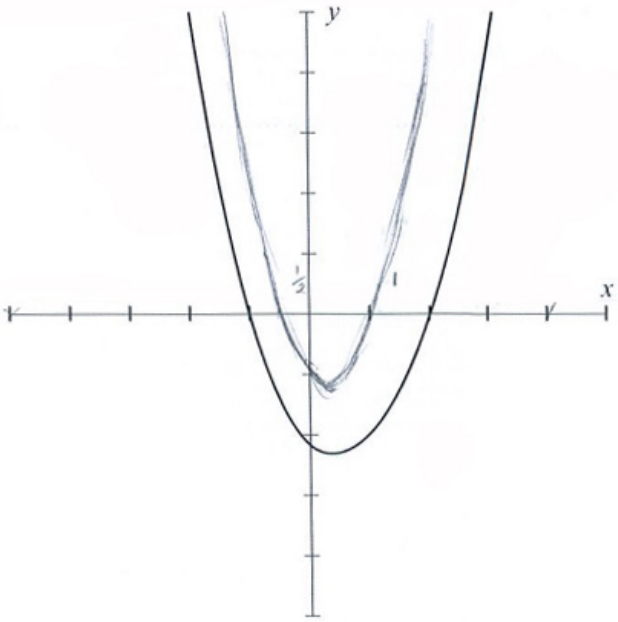


On the same axes sketch the following graphs. Each graph should be labelled clearly.

(i) $y = f(x) + 2$, [2]

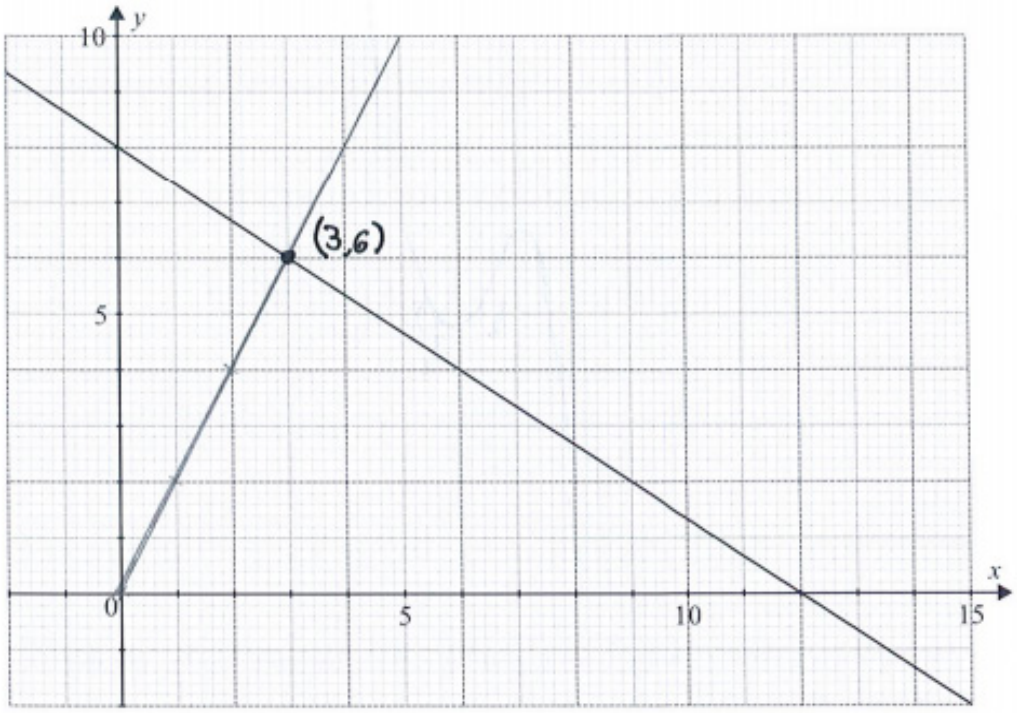
(ii) $y = f(x + 2)$. [2]

(b) The graph of $y = g(x)$ is sketched on the axes below.



On the same axes sketch the graph of $y = 2g(x)$. [2]

(c) The graph of the equation $2x + 3y = 24$ is shown on the grid below.



(i) On the same grid plot the line $y = 2x$. **[2]**

(ii) Hence write down the solution to the following simultaneous equations.

$2x + 3y = 24$

$y = 2x$

$2x + 3(2x) = 24$ $y = 2 \times 3$ $(3, 6)$ **[1]**

$2x + 6x = 24$ $y = 6$

$8x = 24$

$x = 3$

2

1

3

Commentary

The transformation of the graph of a function is a specific part of the specification (2.1).

This includes the transformation of $y = f(x)$ parallel to the y axis, $y = f(x)+a$ or parallel to the x axis, $y = f(x + a)$, a stretch parallel to the y axis, $y = af(x)$ or parallel to the x axis $y = f(ax)$ where a is a positive or negative number.

(Learners should be encouraged to experiment for themselves the effect of changing the value of a in these cases using a graph drawing software package to gain understanding.)

In this question, the two transformations in part(a) do not change the shape of the curve but move it. This learner has not understood this and has changed the shape in both responses.

In part (b), if $f(k) = 0$ for one or more values of k then $af(k) = 0$ also so the transformed graph cuts the x axis in the same place as the original curve. This learner has not understood this either and has translated the curve upwards by 1 unit, thus demonstrating a confusion between the two types of transformations.

Part (c) is about an understanding of the relationship between intersections of lines on a coordinate graph and an algebraic solution.

This learner has correctly drawn the line $y = 2x$ and it intersects the given line in the correct place. The learner has, however, not understood that the solution of the simultaneous equations is the coordinates of the point of intersection of the two lines.(1.5 in the specification).

The learner has also not understood the meaning of the instruction "write down" which means that no further work needs to be done. In solving the simultaneous equations algebraically to give the correct answer, candidates were awarded the mark but they penalised themselves in terms of the time spent doing the extra work.

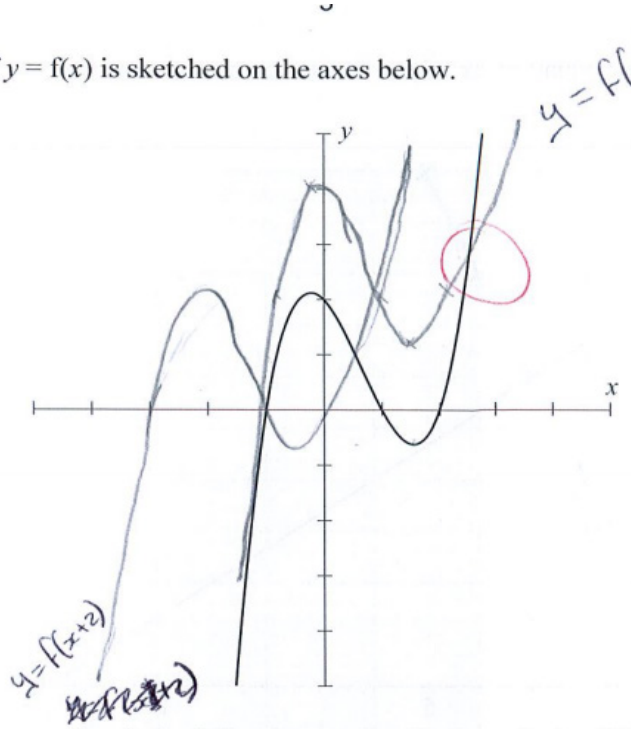
This is what has been done here. Full marks for this part were therefore awarded even though the method was not as expected.

This learner has demonstrated some understanding of one part of the specification (1.5) but not the other (1.2).

Exemplar candidate work

Question 2 - Medium level answer

(a) The graph of $y = f(x)$ is sketched on the axes below.

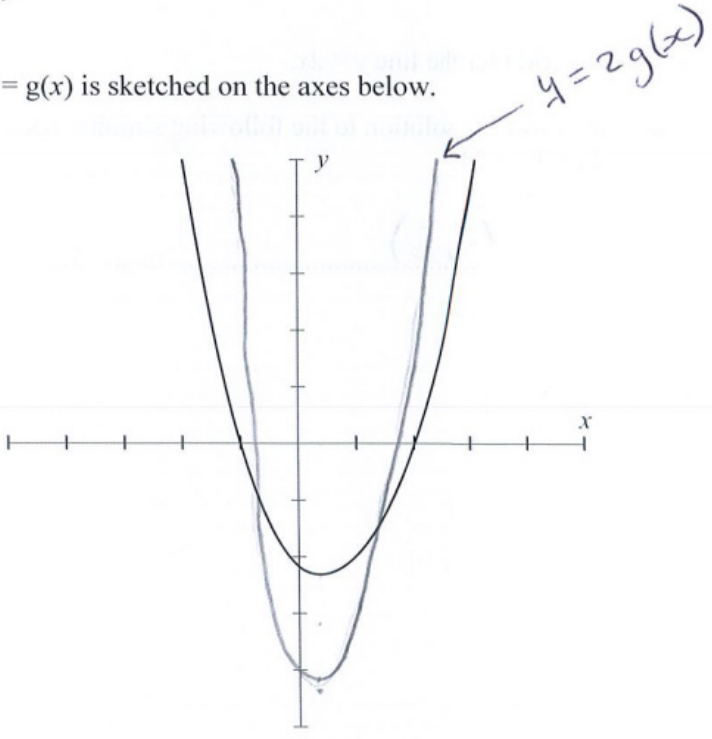


On the same axes sketch the following graphs. Each graph should be labelled clearly.

(i) $y = f(x) + 2$, **[2]** 0

(ii) $y = f(x + 2)$. **[2]** 2

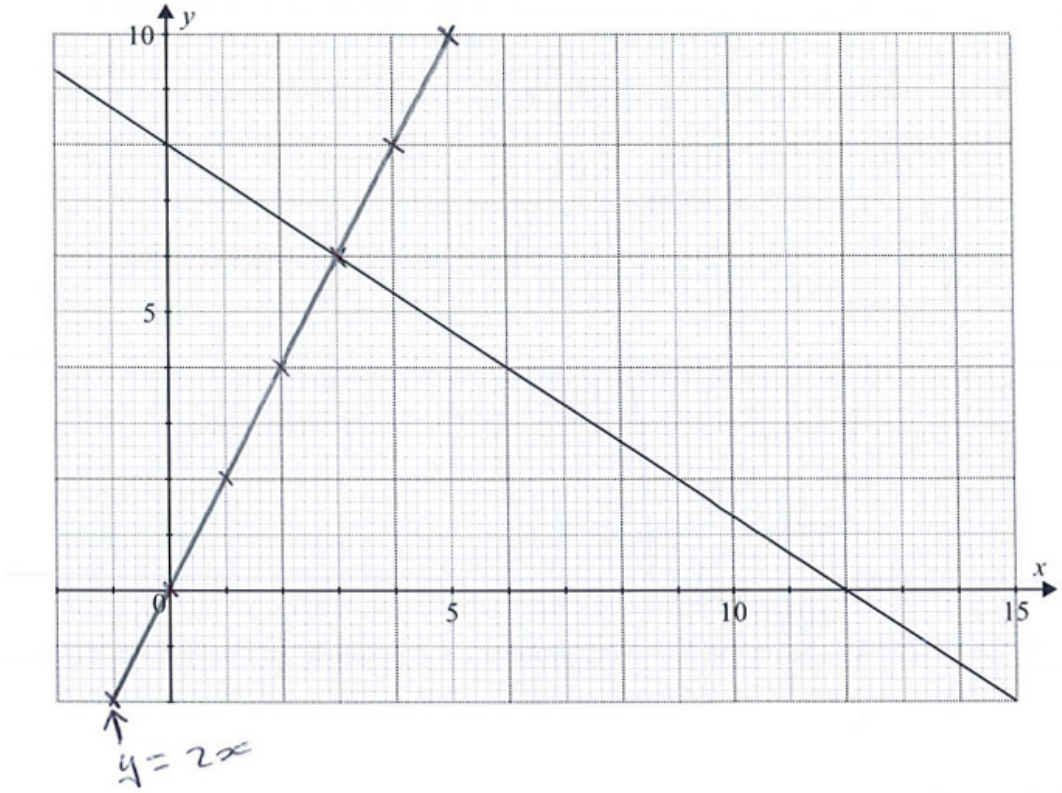
(b) The graph of $y = g(x)$ is sketched on the axes below.



0

On the same axes sketch the graph of $y = 2g(x)$. **[2]**

c) The graph of the equation $2x + 3y = 24$ is shown on the grid below.



(i) On the same grid plot the line $y = 2x$. **[2]** 2

(ii) Hence write down the solution to the following simultaneous equations.

$2x + 3y = 24$

$y = 2x$

(3, 6) ..... **[1]** 1

Commentary

This question deals with the topics 1.2 and 1.5 of the specification.

In part (a) the learner has demonstrated an understanding of the transformations required and in part (ii) has translated the curve in the right direction. (It is not necessarily intuitively obvious that in the transformation y = f(x + a) where a is positive means a shift to the left.)

In part (ii) also the learner has clearly understood that the curve needs to be shifted upwards. (Learners should be encouraged to experiment for themselves the effect of changing the value of a in these cases using a graph drawing software package to gain understanding.)

However, in the case of translating upwards the translated curve will at all points be above the original and by the same amount. It is not clear in this case that the learner understands this fully. What is clear is that the learner has not been careful enough with the sketching; a moment's thought may have enabled this learner to get part (i) correct.

Again, in part (b) the learner seems to have an understanding of what the transformation is and the problem may well lie in not being careful enough with the drawing. If f(k) = 0 for one or more values of k then af(k) = 0 also so the transformed graph cuts the x axis in the same place as the original curve. So in this case, while the general shape may seem to be correct, the sketch is fundamentally incorrect in that it does not cut the x axis in the same places as the original curve.

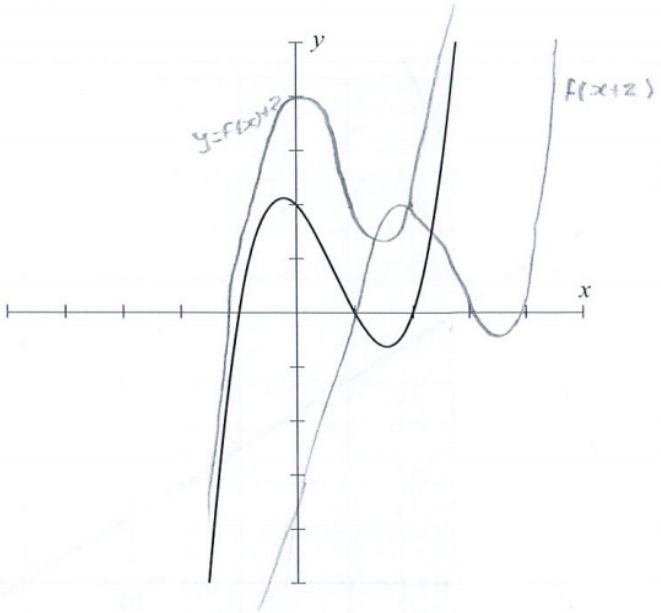
Part (c) is fully correct. The learner has drawn the line correctly and has correctly interpreted that the solution to the simultaneous equations is simply the coordinates of the intersection of the lines in the graph.

This learner seems to have a good grasp of these topics but would have gained more marks if the graphs had been rather more carefully drawn. A sketch was required rather than a plot but a sketch must show the essential features of the curve and this the learner has failed to provide.

Exemplar candidate work

Question 2 - High level answer

(a) The graph of $y = f(x)$ is sketched on the axes below.

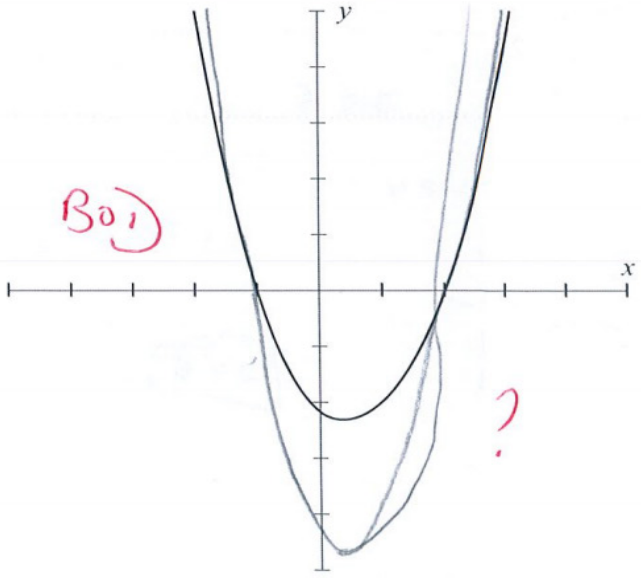


On the same axes sketch the following graphs. Each graph should be labelled clearly.

(i) $y = f(x) + 2$, **[2]** 2

(ii) $y = f(x + 2)$. **[2]** 1

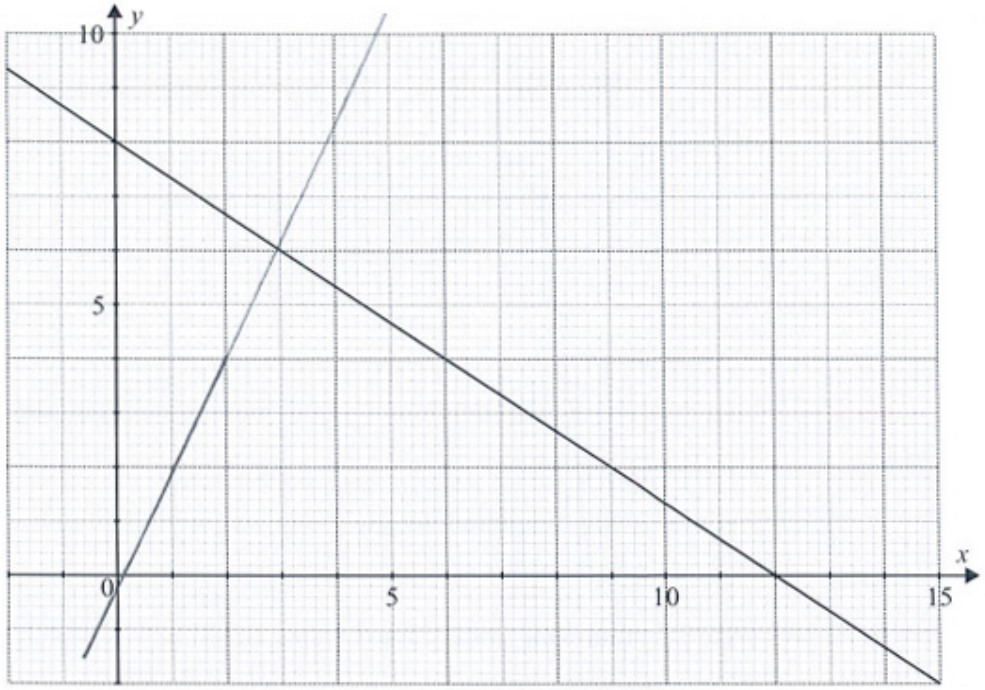
(b) The graph of $y = g(x)$ is sketched on the axes below.



2

On the same axes sketch the graph of $y = 2g(x)$. **[2]**

(c) The graph of the equation $2x + 3y = 24$ is shown on the grid below.



(i) On the same grid plot the line $y = 2x$. **[2]**

(ii) Hence write down the solution to the following simultaneous equations.

$2x + 3y = 24$

$y = 2x$

$x = 3$ $y = 6$ ..... **[1]**

2

$2x + (3 \times 2x) = 24$

$2x + 6x = 24$

$8x = 24$ ✓

$x = 3$

$y = (2 \times 3)$ ✓

$y = 6$

1

8

$2x + 3y = 24$

$6 + 18 = 24$ ✓

Commentary

In part (a)(i) both marks were awarded, but this learner was close to losing one or both marks through careless sketching. In this transformation the transformed curve lies the same distance above the original graph at all points. It might be interpreted that they actually cross but do not actually do so.

In part (a)(ii) the learner has understood that the transformation is parallel to the x axis. It is not necessarily intuitively obvious that in the transformation $y = f(x + a)$ where a is positive means a shift to the left and this learner has made the error of shifting the graph the wrong way.

Likewise in part (b) it seems clear that the learner understands what the transformation does but has not been very careful with the sketching. The two graphs pass through the same points on the x axis and is at all points above between these intersections and at all points below outside. The marker has decided that the learner has demonstrated an understanding of these points even though the curve has not been sketched well.

Part (c) is fully correct. This learner has understood that the solution to the simultaneous equations is the coordinates of the points of intersection of the lines.

This response has lost one mark, in part (a)(ii) but was close to losing more because of the poor drawing.

Question 3

3 (a) Toolmart sell assorted screwdrivers and spanners in two "economy bags". Bag A contains 6 spanners and 8 screwdrivers and costs £10. Bag B contains 9 spanners and 6 screwdrivers and costs £10.20.
Let x be the cost of one spanner and y the cost of one screwdriver.

(i) Write down two simultaneous equations in x and y from the given information.

$6x + 8y = 10$
$9x + 6y = 10.2$

[2]

(ii) Solve these equations simultaneously to find the cost of a spanner and the cost of a screwdriver.

For e.g. mult 1st eqn by y 1.5 $\Rightarrow 9x + 12y = 15$
Subtract $\Rightarrow 6y = 4.8 \Rightarrow y = 0.8$
Substitute $\Rightarrow x = 0.6$
Spanner costs 60p and screwdriver 80p

[5]

(b) The speed, v m s^{-1}, of a car which moves with constant acceleration, a m s^{-2}, is given by $v^2 = u^2 + 2as$ where s m is the distance travelled and u m s^{-1} is the initial speed.
A car moves from rest with constant acceleration 2 m s^{-2}.

Find the speed of the car after it has moved 100 m.

Substitute given values correctly into $v^2 = u^2 + 2as$
$\Rightarrow v^2 \ \ 0 + 2 \times 2 \times 100 = 400$
$\Rightarrow v = 20$
(Speed of car is 20 ms^{-1})

[3]

Mark scheme guidance

3 (a) (i) oe
oe

3 (a) (ii) Method to eliminate or substitute
Correct equation(s)
Substitute to find other value
x and y
Answer stated

Examiners comments

3 The solution of equations

In (a) candidates were able to construct the equations from the information given and to follow the standard procedure for solving them simultaneously (usually by elimination). However, a significant number forgot the context and did not read the question properly and so only gave final values of x and y rather than the cost of the screwdriver and spanner.

Part (b) was usually answered well.

Question 4

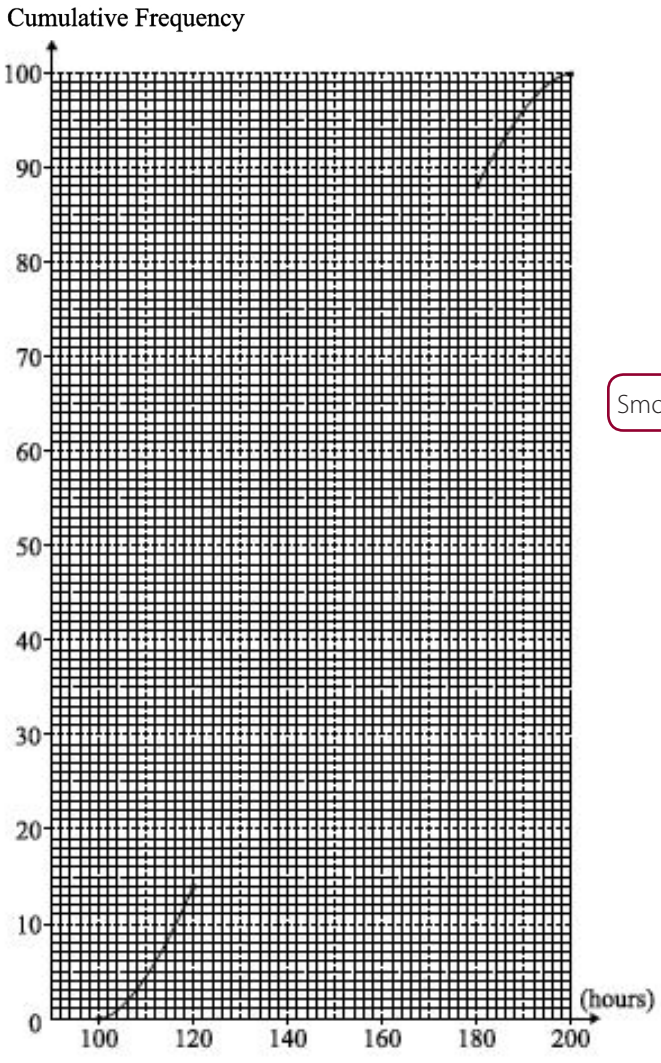
4 The life of a sample of batteries is tested. The results are given in the frequency table below.

Life of battery (h hours)	Frequency	Cumulative frequency
$h \leq 100$	0	0
$100 < h \leq 120$	14	
$120 < h \leq 140$	26	
$140 < h \leq 160$	30	
$160 < h \leq 180$	18	
$180 < h \leq 200$	12	100

(i) Fill in the cumulative frequency column in the table above. **[2]**

Values in table: 14 40 70 88

(ii) Complete the cumulative frequency graph below. **[2]**



Smooth curve through their points

Life of battery (h hours)

(iii) From your graph find

(*A*) the median value,

Attempt to find 50th percentile
Answer: 148±3 ..... **[2]**

(*B*) the interquartile range,

Attempt to find 25th, 75th percentiles
Answer: 162-128 = 34±4 .....

..... **[2]**

(*C*) the percentage of batteries that last less than 175 hours.

Attempt to find number at 175
Answer: 84±2 .....

..... **[2]**

Mark scheme guidance

4 (i) B1 one error (but ft remaining entries)

4 (ii) B1 one error

4 (iii) (A) Horizontal line drawn across at 50 on the y-axis soi
Ft an incorrect graph

4 (iii) (B) Ft an incorrect graph

4 (iii) (C) Ft an incorrect graph
Sc "16% last longer" 2 marks

N.B. Care in (iii) (A), (B) and (C) that lines drawn to find values are "across and down" rather than "up and back".

N.B. In 4(ii) do not accept a series of straight lines through the points. It must be a smooth curve.

In 4(iii) accept calculations based on ratios. B2 in each case, providing the answers are within the ranges given above.

Examiner comments

4 Cumulative frequency graph

Almost all candidates were able to complete the table correctly and to produce a good cumulative frequency curve.

Most then were able to extract from the graph the values required. A few candidates did not realise that the interquartile range is a number and not a range.

Calculating values using similar triangles was accepted providing the answers fell within the acceptable range. The drawing of straight lines between the points to give the "curve" was not, however, acceptable.

Question 5

5 **(a)** Find the integral $\int \cos 3x \, dx$.

Anything involving $\sin 3x$

$\frac{1}{3} \sin 3x + c$

..... **[2]**

(b) A ball is thrown vertically upwards from ground level. Its height, h m, is given by the formula

$$h = 20t - 5t^2$$

where time t is in seconds.

(i) Find, by differentiation, a formula for the velocity of the ball.

$\left(v = \frac{dh}{dt} \right) = 20 - 10t$

..... **[2]**

(ii) Find the time when the ball reaches its maximum height.

$v = 0 \rightarrow 20 - 10t = 0$

$\Rightarrow t = 2$

..... **[2]**

(iii) Find this maximum height.

$t = 2 \Rightarrow h = 20 \times 2 - 5 \times 2^2 = 20$

..... **[2]**

(c) A 1000 μF capacitor is connected in series with a 2 kΩ resistor across a 12 V d.c. supply. At time t seconds, the potential difference, V_c, is given by the formula

$V_c = V_s \left(1 - e^{-t/RC}\right)$

where V_s is the voltage supply, R is the resistance of the resistor in ohms and C is the capacitance of the capacitor in Farads.

Find the time taken for the potential difference to reach 10 V.

$RC = 2000 \times 0.001 = 2$

$10 = 12\left(1 - e^{-t/2}\right)$

$\Rightarrow e^{-t/2} = 1$

$\Rightarrow \frac{t}{2} = \ln 6 = 1.79$ oe

$\Rightarrow t = 3.58$

..... **[4]**

Mark scheme guidance

5 (a) Condone lack of c

5 (b) (i) Evidence of differentiation eg a + bt
If t0 seen then only give M mark if t0 = 1 also seen

5 (b) (ii) Their function set = 0
Cao

5 (b) (iii) Substitute their value for t
Cao

5 (c) Attempt to solve equation
Take logs
Ft from incorrect RC. Accept t = 3.6

Examiners comments

5 Calculus

In part (a) there were some mixed responses and some were unaware how to carry out the integration. In part (b) the formula for v was often found correctly but then candidates were unable to use it to find the required results.

Part (c) was not done well and very few candidates got full marks. Obtaining the incorrect value for RC usually resulted in the final answer being incorrect by factors of 10 and some credit was given. However, the errors were usually compounded by poor algebra in the attempt to solve the equation.

Question 6

6 (a) A triangular lamina ABC has angles A = 30°, B = 60° and C = 90°.
BC = 10 cm.

Find the length of AB.

$\frac{10}{AB} = \cos 60 \quad (= \sin 30)$

$\Rightarrow AB = \frac{10}{\cos 60}$

$= 20$ cm

..... **[3]**

(b) The triangular cross section of a prism has sides 8 cm, 9 cm and 11 cm.

Find the largest angle of the cross section.

$\cos\theta = \frac{8^2 + 9^2 - 11^2}{2 \times 8 \times 9}$

$= 0.1666$

$\Rightarrow \theta = 80.4$

Accept 80° or 81° if all working correct.

..... **[4]**

(c) A sector of a circle has an arc length of 5 cm. The radius of the circle is 10 cm.

Find the angle of the sector in degrees.

Use of $s = 2\pi r \frac{\theta}{360} \Rightarrow 5 = 20\pi \frac{\theta}{360} = \frac{\theta\pi}{18}$

$\Rightarrow \theta = \frac{90}{\pi} = 28.6...$

Alternatively:

Use of $s = \theta r \rightarrow 5 = 10 \Rightarrow \theta = \frac{1}{2}$ radians

$\Rightarrow \theta = \frac{1}{2} \times \frac{180}{\pi} = 28.6...$

..... **[3]**

Mark scheme guidance

6 (a) Accept $\frac{AB}{\sin 90} = \frac{10}{\sin 30}$ oe

6 (b) Any correct application of cosine rule.
Correct angle.
(Or 0.6969... or 0.5909...)
(Or 45.8 or 53.8)
i.e. a correct "wrong angle" gets 3.
SC. Finding all 3 angles correctly B4

6 (c) Correct formula in degrees or radians with correct substitutions

Evidence of making θ the subject

Examiner comments

6 Trigonometry

Part (a) was intended as a test of right-angled triangles, but many candidates did not realise this and used the sine rule with the angle 900. Correct answers by this process were credited but the extra manipulation required often introduced errors.

In (b) few candidates knew that in a triangle the largest angle was opposite the longest side. Consequently, many candidates who demonstrated a clear understanding of the cosine rule undertook a great deal of work to find all three angles before deciding which one was the largest. Others found another angle by the cosine rule and then used the sin rule to obtain the correct angle

The required formula in part (c) is in the formula book but a number used the wrong formula or wrote it down incorrectly. The most common incorrect formula was that for the area of the sector.

Some candidates gave the answer in radians, ignoring the instruction of the question.

The small print

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