Name | Reg. No | Class

3 Exp

ADDITIONAL MATHEMATICS	4047
[80 marks]	
	SEMESTER ONE EXAMINATION
	Thursday 07 May 2015
	2 hours
Candidates answer on the writing paper provided Additional material: Electronic calculator	

INSTRUCTIONS TO CANDIDATES

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Write your name, register number and class on all the work you hand in.

Write in dark blue or black pen.

You may use a pencil for any diagrams or graphs.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **ALL** questions.

Write your answers on the writing paper provided.

Show all working clearly.

Omission of essential working will result in loss of marks.

Write the brand and model of your calculator in the space provided below.

INFORMATION FOR CANDIDATES

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For π , use either your calculator value or 3.142, unless the question requires the answer in terms of π .

The number of marks is given in brackets [ ] at the end of each question or part question.

The total of the marks for this paper is **80**.

Brand / Model of Calculator

For Examiner's Use

31

This question paper consists of 5 printed pages.

Setter: Mr Chio Kah Leong

Vetter: Mrs Quek Ai Jee

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial expansion

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

where n is a positive integer and $\binom{n}{r} = \frac{n!}{(n-r)!r!} = \frac{n(n-1)\ldots(n-r+1)}{r!}$.

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$
$$\sec^2 A = 1 + \tan^2 A$$
$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$
$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$
$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$
$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$
$$\sin 2A = 2 \sin A \cos A$$
$$\cos 2A = \cos^2 A - \sin^2 A = 2\cos^2 A - 1 = 1 - 2\sin^2 A$$
$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$
$$\sin A + \sin B = 2 \sin \frac{1}{2}(A+B) \cos \frac{1}{2}(A-B)$$
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Formulae for Δ ABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$
$$a^2 = b^2 + c^2 - 2bc \cos A$$
$$\Delta = \tfrac{1}{2} ab \sin c$$

1 Find the coordinates of the points of intersection of the line $2x+y=3$ and the curve $3x^2-y^2+4xy-6=0$. [4]

2 Express $\dfrac{3x^2+4x-15}{(x-4)(1-2x)^2}$ in partial fractions. [5]

3 **(a)** The roots of the quadratic equation $2x^2-6x-5=0$ are α and β.

Find a quadratic equation whose roots are $\dfrac{\alpha}{2\beta}$ and $\dfrac{\beta}{2\alpha}$. [4]

(b) Given that α is a root of the equation $x^2=1-2x$, show that $\alpha^4+12\alpha-5=0$. [3]

4 **(a)** Solve $(x+7)(2-x)\geq -10$. [3]

(b) Find the smallest value of the integer m for which mx^2-5x+2 is positive for all real values of x. [3]

(c) Find the range of values of k for which the line $y=3x+k$ will meet the curve $2x^2-xy=9$ at two real and distinct points. [4]

5 **(a)** Given that $x^3+ax^2-5x+23\equiv(x-b)(x^2-4x+7)+c$ for all real values of x, find the values of a, b and c. [3]

(b) Given that $(x-2)$ is a factor of the polynomial $2x^3+px^2-18x+q$, where p and q are constants. It leaves a remainder of 27 when the polynomial is divided by $(x+1)$.

(i) Find the value of p and q. [4]

(ii) Factorise the polynomial completely. [3]

(iii) Hence solve the equation $2(x-1)^3+3(x-1)^2-18(x-1)+8=0$. [2]

[Turn over

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6 (i) Express $y = 4x^2 - 16x + 9$ in the form $y = a(x-h)^2 + k$ where a, h and k are constants. [2]

(ii) Hence, state the coordinates of the minimum point. [1]

(iii) Sketch the graph of $y = 4x^2 - 16x + 9$. [3]

7 A triangle has an area of $\left(12 + 7\sqrt{3}\right)$ cm^2 and a base of length $\left(\sqrt{3} + 2\right)$ cm. Without using a calculator, find the perpendicular height of the triangle in the form $\left(a + b\sqrt{3}\right)$ cm, where a and b are integers. [4]

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(a) $\log_{16} a$, [2]

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10 (a) Without using a calculator, find the value of x such that $16\left(2^x\right)^3 = \dfrac{1}{8^x}$. [3]

(b) Given that $3^{2x+1} \times 5^{x-1} = 9^{2x} \times 25^x$, find the value of 45^x. [3]

(c) By using an appropriate substitution, solve the following equation $9^{x+1} - 28\left(3^x\right) + 3 = 0$. [4]

[Turn over

11 Solve the following equations

(a) $e^{2+x} = 3$, [2]

(b) $\lg(x+4) - \lg(x-3) = 3\lg 2$, [3]

(c) $\log_2 x + 8\log_x 2 = 9$. [4]

END OF PAPER

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3 Exp

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END OF PAPER

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Marking Scheme
Sec 3E_AM_SA1_2015

Qn.	Solutions	Marks	Remarks
1	$2x+y=3 \quad \to \quad (1)$ $3x^2-y^2+4xy-6=0 \quad \to \quad (2)$ $From\ (1):\ \ y=3-2x \quad \to \quad (3)$ $Sub\ (3)\ into\ \ (2),$ $3x^2-(3-2x)^2+4x(3-2x)-6=0$ $3x^2-(9-12x+4x^2)+12x-8x^2-6=0$ $-9x^2+24x-15=0$ $3x^2-8x+5=0$ $(3x-5)(x-1)=0$ $x=\frac{5}{3} \quad or \quad x=1$ $y=3-2\left(\frac{5}{3}\right) \quad , \quad y=1$ $=-\frac{1}{3}$ The coordinates are $\left(\frac{5}{3},-\frac{1}{3}\right)$ and $(1,1)$.	M1 M1 M1 **A1 for both correct answers**	91.3 % of the candidates know how to solve this question whereas quite many of them made careless mistakes in the process of solving. Weak in Algebraic Manipulation skills Many candidates did not show the factorisation form of the quadratic equation. Some candidates did not give the solutions in point form

2	$\dfrac{3x^2+4x-15}{(x-4)(1-2x)^2} = \dfrac{A}{x-4}+\dfrac{B}{1-2x}+\dfrac{C}{(1-2x)^2}$ $= \dfrac{A(1-2x)^2+B(x-4)(1-2x)+C(x-}{(x-4)(1-2x)^2}$ Comparing numerators, $3x^2+4x-15 = A(1-2x)^2+B(x-4)(1-2x)+C(x-4)$ *When* $x=4$, $3(4)^2+4(4)-15 = A(-7)^2$ $49 = 49A$ $A = 1$ *When* $x=\frac{1}{2}$, $3\left(\frac{1}{2}\right)^2+4\left(\frac{1}{2}\right)-15 = C\left(-\frac{7}{2}\right)$ $-\frac{49}{4} = -\frac{7}{2}C$ $C = \frac{7}{2}$ *When* $x=0$, $-15 = A-4B-4C$ $-15 = 1-4B-4\left(\frac{7}{2}\right)$ $4B = 2$ $B = \frac{1}{2}$ $\therefore \dfrac{3x^2+4x-15}{(x-4)(1-2x)^2} = \dfrac{1}{x-4}+\dfrac{1}{2(1-2x)}+\dfrac{7}{2(1-2x)^2}$	**M1** **M1** **M1** **M1** **A1**	77.8% of the candidates are able to form the right partial fractions. Mistake: $\dfrac{3x^2+4x-15}{(x-4)(1-2x)^2} = \dfrac{A}{x-4}+\dfrac{Bx+C}{(1-2x)^2}$ Some candidates were not aware that the best method is "Sub the right x values"

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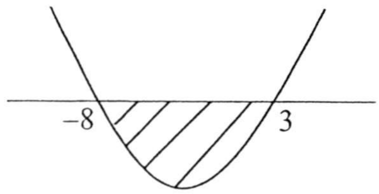
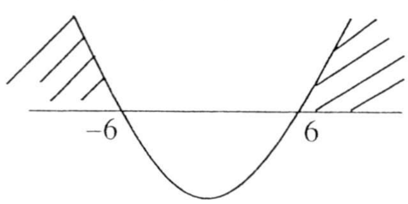
3(a)	$2x^2-6x-5=0$ $\alpha+\beta=3,$ $\alpha\beta=-\frac{5}{2}$	**M1**	77.8% of the candidates are able to apply $\alpha^2+\beta^2=(\alpha+\beta)^2-2\alpha\beta$ to find the sum of the new roots. But many made the following mistake: $=\frac{\alpha}{2\beta}+\frac{\beta}{2\alpha}$ $=\frac{2\alpha^2+2\beta^2}{2\alpha\times2\beta}$ $=\frac{2(\alpha+\beta)^2-2\alpha\beta}{2\alpha\beta}$
	Sum of new roots $=\frac{\alpha}{2\beta}+\frac{\beta}{2\alpha}$ $=\frac{\alpha^2+\beta^2}{2\alpha\beta}$ $=\frac{(\alpha+\beta)^2-2\alpha\beta}{2\alpha\beta}$ $=\frac{3^2-2\left(-\frac{5}{2}\right)}{2\left(-\frac{5}{2}\right)}$ $=-\frac{14}{5}$	**M1**	
	Product of new roots $=\frac{\alpha}{2\beta}\times\frac{\beta}{2\alpha}=\frac{1}{4}$	**M1**	
	The new equation is $x^2+\frac{14}{5}x+\frac{1}{4}=0 \quad or \quad 20x^2+56x+5=0$	**A1**	
3(b)	$x^2=1-2x$ Since α is a root, $\alpha^2=1-2\alpha$ $\alpha^4=(1-2\alpha)^2$	**M1**	This seems to be one of the most difficult questions. Only 34.9% of the candidates are able to solve it.
	$\alpha^4=1-4\alpha+4\alpha^2$ $\alpha^4=1-4\alpha+4(1-2\alpha)$	**M1**	
	$\alpha^4=1-4\alpha+4-8\alpha$ $\alpha^4+12\alpha-5=0 \qquad (shown)$	**A1**	

4(a)	$(x+7)(2-x)\geq -10$ $2x-x^2+14-7x\geq -10$ $-x^2-5x+24\geq 0$ $x^2+5x-24\leq 0$ $(x+8)(x-3)\leq 0$  $\therefore \quad -8\leq x\leq 3$	**M1** **M1** **A1**	57.1% of the candidates are able to solve the quadratic inequality with the correct presentation. Common Mistake: $(x+8)(x-3)\leq 0$ $(x+8)\leq 0 \quad or \quad (x-3)\leq 0$
4(b)	For $mx^2-5x+2>0$ for all real values of x, $\Rightarrow \quad b^2-4ac<0$ $\Rightarrow \quad 25-4(m)(2)<0$ $\Rightarrow \quad 25-8m<0$ $\Rightarrow \quad 8m>25$ $\Rightarrow \quad m>\frac{25}{8} \quad or \quad m>3\frac{1}{8}$	**M1** **M1** **A1**	50% of the candidates are able to solve it correctly. Common Mistake: $b^2-4ac>0$
4(c)	$y=3x+k \quad \rightarrow (1)$ $2x^2-xy=9 \quad \rightarrow (2)$ $Sub. (1)\, into\, (2): \quad 2x^2-x(3x+k)=9$ $-x^2-kx-9=0$ $x^2+kx+9=0$ For the line to meet the curve at two real & distinct points, $b^2-4ac>0$ $k^2-4(1)(9)>0$ $k^2-36>0$ $(k-6)(k+6)>0$  $\therefore \quad k<-6 \quad or \quad k>6$	**M1** **M1** **M1** **A1**	80.2% of the candidates are able to link the question to $b^2-4ac>0$ Common Mistake: $k^2>36$ $\Rightarrow k>\pm 6$

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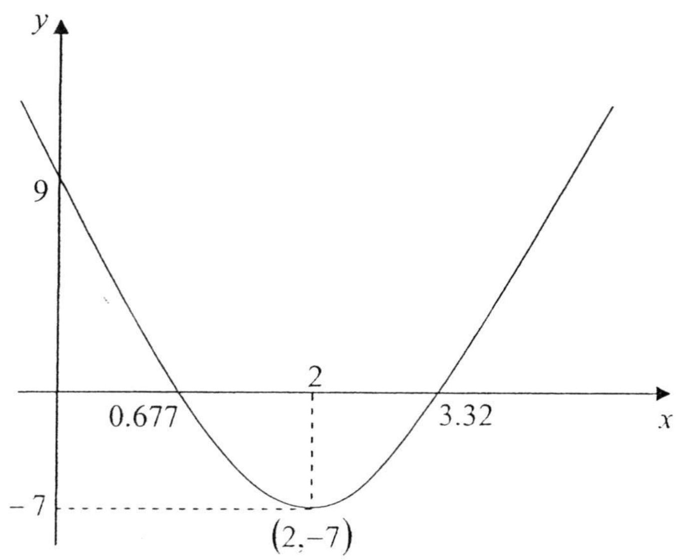
5(a)	$x^3+ax^2-5x+23\equiv(x-b)(x^2-4x+7)+c$ Comparing coeff. of, $x:\quad -5=7+4b$ $4b=-12$ $b=-3$ $x^2:\quad a=-4-b$ $a=-4+3$ $a=-1$ $x^0:\quad 23=-7b+c$ $23=21+c$ $c=2$	B1 B1 B1	73.0% of the candidates are able to use the best method "Comparing Coefficients" to solve the problem.
5(b) (i)	Let $f(x)=2x^3+px^2-18x+q$ Given that $f(2)=0$ *and* $f(-1)=27$ $\Rightarrow 2(2)^3+p(2)^2-18(2)+q=0$ *and* $-2+p+18+q$ $\Rightarrow\ 4p+q=20\ \rightarrow(1)$ *and* $p+q=11\ \rightarrow(2$ $(1)-(2):\quad 3p=9$ $p=3$ $\therefore\ q=11-3=8$	M1+M1 M1 A1 for both correct answers	84.1% of the candidates are able to apply the Remainder & Factor Theorems to form the 2 equations correctly.
(ii)	$f(x)=(x-2)(2x^2+Bx-4)$ Comparing coeff. of, $x:\quad -18=-4-2B$ $2B=14$ $B=7$	M1 M1 A1	77.8% of the candidates are able to factorise a cubic equations
(iii)	*Now,* $f(x)=(x-2)(2x^2+7x-4)$ $=(x-2)(2x-1)(x+4)$		

	If $f(x-1)=0,$ $\Rightarrow\ 2(x-1)^3+3(x-1)^2-18(x-1)+8=0$ $\Rightarrow\ x-1=2 \quad or \quad x-1=\frac{1}{2} \quad or \quad x-1=-4$ $\Rightarrow\ x=3 \quad or \quad x=1\frac{1}{2} \quad or \quad x=-3$	**M1** **A1 for all 3 correct answers**	This seems to be another difficult question. Only 31.7% of them are able to solve it correctly.
6(i) **(ii)** **(iii)**	$y=4x^2-16x+9$ $=4\left(x^2-4x+\frac{9}{4}\right)$ $=4\left[(x-2)^2-4+\frac{9}{4}\right]$ $=4\left[(x-2)^2-\frac{7}{4}\right]$ $=4(x-2)^2-7$ $(2,-7)$ $x-intercepts:$ $Let\ y=0,\quad 4(x-2)^2-7=0$ $x=0.677 \quad or \quad 3.32$ $y-intercept:$ $Let\ x=0,\quad y=9$  B1 – Correct shape B1 – Correct *x*/*y*-intercepts B1 – Correct turning point	 **M1** **A1** **B1** **B3**	42.9% of the candidates are able to convert ax^2-bx+c into $a(x-h)^2+k$ Careless mistakes made in algebraic Manipulation Majority of the candidates are weak in sketching.

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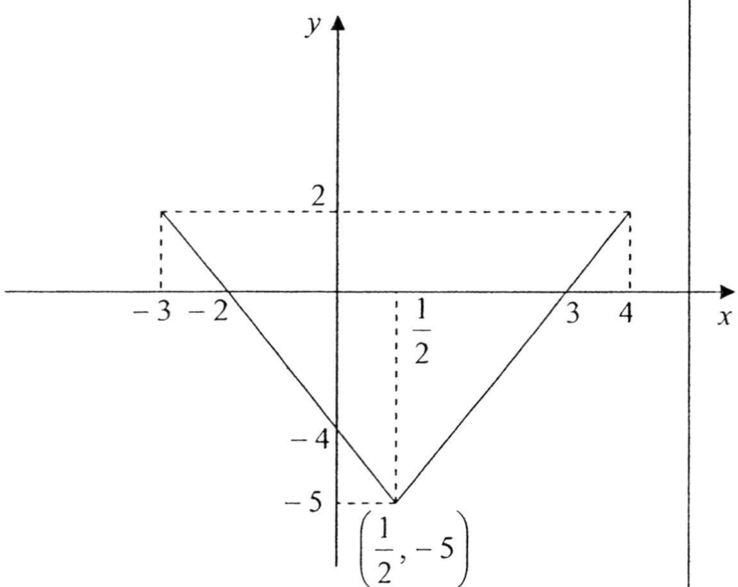
7	Area of triangle $=12+7\sqrt{3}$ $\frac{1}{2}(\sqrt{3}+2)\times h=12+7\sqrt{3}$ $\frac{1}{2}h=\frac{12+7\sqrt{3}}{\sqrt{3}+2}\times\frac{\sqrt{3}-2}{\sqrt{3}-2}$ $\frac{1}{2}h=\frac{12\sqrt{3}-24+7(3)-14\sqrt{3}}{3-4}$ $\frac{1}{2}h=\frac{-2\sqrt{3}-3}{-1}$ $\frac{1}{2}h=3+2\sqrt{3}$ $h=6+4\sqrt{3}$	M1 M1 M1 A1	70.6% of the candidates know how to rationalise the denominator in surd. Mistake: Could not form an expression for h. Did not know how to rationalise the denominator.
8(a)	$\log_a 4=x$, $\log_a 5=y$ $\log_{16} a=\frac{1}{\log_a 16}$ $=\frac{1}{2\log_a 4}$ $=\frac{1}{2x}$	M1 A1	63.5% of the candidates are able to solve it. Common Mistakes: $\frac{1}{\log_a 4^2}=\frac{1}{x^2}$ $\frac{1}{\log_a 16}=-\log_a 16$
8(b)	$\log_a(20\sqrt{a})$ $=\log_a 20+\log_a\sqrt{a}$ $=\log_a 4+\log_a 5+\frac{1}{2}\log_a a$ $=x+y+\frac{1}{2}$	M1 M1 A1	This is another difficult question. Only 35.7% of the candidates got it right. Common Mistakes: $\log_a 20a^{\frac{1}{2}}=\frac{1}{2}\log_a 20a$ $\log_a 20a^{\frac{1}{2}}=\log_a 20\times\log_a a^{\frac{1}{2}}$ $\log_a(4\times5)a^{\frac{1}{2}}=\log_a 4a^{\frac{1}{2}}+\log_a 5a^{\frac{1}{2}}$
8(c)	$\log_a\left(\frac{25}{64}\right)^x$ $=x[\log_a 25-\log_a 64]$ $=x[2\log_a 5-3\log_a 4]$ $=x(2y-3x)$ $=2xy-3x^2$	M1 M1 A1	40.5% got it right. Common Mistakes: $\log_a\left(\frac{25}{64}\right)^x=\frac{\log_a 25^x}{\log_a 64^x}$ $\log_a\left(\frac{25}{64}\right)^x=(\log_a 25-\log_a 64)^x$ $x(\log_a 5^2-\log_a 4^3)=x(y^2-x^3)$

9(i)	$\lvert 2x-1 \rvert -5=0$ $\lvert 2x-1 \rvert =5$ $2x-1=5 \quad or \quad 2x-1=-5$ $x=3 \quad or \quad x=-2$	**M1** **A1 for both correct answers**	90.5% of the candidates got it right.
9(ii)	*When* $y=0, x=3 \quad or \quad x=-2.$ *When* $x=0, y=-4.$ *When* $x=-3, y=2.$ *When* $x=4, y=2.$ *Vertex*: $x=\frac{3+(-2)}{2}=\frac{1}{2}$ $y=-5$ *Coord. of vertex* $=\left(\frac{1}{2}, 5\right)$  B1 – Correct x/y-intercepts and end points B1 – Correct vertex B1 – Correct V-shaped	**B3**	This question was badly done. Only 21.4% of the candidates are able to sketch it correctly. Common Mistakes: Cannot see the connection between (i) and (ii). Part (i) gives the x-intercepts. Cannot find the vertex point. Not aware that it is a V-shaped graph.

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10(a)	$16\left(2^{x}\right)^{3}=\frac{1}{8^{x}}$ $2^{4}.2^{3x}=\left(2^{-3}\right)^{x}$ $2^{4+3x}=2^{-3x}$ $\Rightarrow\quad 4+3x=-3x$ $\Rightarrow\quad 6x=-4$ $\Rightarrow\quad x=-\frac{2}{3}$	**M1** **M1** **A1**	60.3% got it right. Common Mistakes: Cannot apply the Laws of Indices correctly-- $16(2^{x})^{3}=32^{3x}$ $2^{4}\times 2^{3x}=2^{12x}$ $2^{3x}=2^{3}\times 2^{x}$
10(b)	$3^{2x+1}\times 5^{x-1}=9^{2x}\times 25^{x}$ $\left(3^{2}\right)^{x}\times 3\times 5^{x}\times 5^{-1}=9^{2x}\times 5^{2x}$ $(9\times 5)^{x}\times\frac{3}{5}=(9\times 5)^{2x}$ $45^{x}\times\frac{3}{5}=45^{2x}$ $45^{2x-x}=\frac{3}{5}$ $45^{x}=\frac{3}{5}$	**M1** **M1** **A1**	This is the MOST difficult question. Only 14.3% got it right. **Common Mistakes:** $3^{2x+1}\times 5^{x-1}=9^{2x}\times 25^{x}$ $\Rightarrow 3^{2x+1}=9^{2x}\ and\ 5^{x-1}=25^{x}$ $\frac{3^{2x+1}}{3^{4x}}=\frac{5^{2x}}{5^{x-1}}$ $\Rightarrow 2x+1-4x=2x-(x-1)$ $3^{4x}=3^{4}\times 3^{x}$ $5^{2x}=5^{2}\times 5^{x}$
10(c)	$9^{x+1}-28\left(3^{x}\right)+3=0$ $\left(3^{2x}\right)\times 9-28\left(3^{x}\right)+3=0$ $Let\ y=2^{x}.$ $\therefore\quad 9y^{2}-28y+3=0$ $(9y-1)(y-3)=0$ $y=\frac{1}{9}\quad or\quad y=3$ $3^{x}=3^{-2}\quad or\quad 3^{x}=3$ $x=-2\quad or\quad x=1$	**M1** **M1** **A1 for both correct answers**	57.1% of the candidates are able to convert it into a quadratic equation.

11(a)	$e^{2+x}=3$ $2+x=\ln 3$ $x=\ln 3-2$ ≈ -0.901	 **M1** **A1**	72.2% got this right. Common Mistake: $2+x=\ln 3$ $\Rightarrow x=\dfrac{\ln 3}{2}$
11(b)	$\lg(x+4)-\lg(x-3)=3\lg 2$ $\lg\left(\dfrac{x+4}{x-3}\right)=\lg 2^3$ $\dfrac{x+4}{x-3}=8$ $x+4=8x-24$ $7x=28$ $x=4$	 **M1** **M1** **A1**	54.8% got it right. Common Mistakes: Apply the Quotient Law wrongly. Unable to convert from a log equation to a non-log equation.
11(c)	$\log_2 x+8\log_x 2=9$ $\log_2 x+\dfrac{8}{\log_2 x}=9$ *Let* $y=\log_2 x$. $\therefore\ y+\dfrac{8}{y}=9$ $y^2-9y+8=0$ $(y-8)(y-1)=0$ $y=8$ *or* $y=1$ $\log_2 x=8$ *or* $\log_2 x=1$ $x=2^8=256$ *or* $x=2$	 **M1** **M1** **M1** **A1 for both correct answers**	This question is difficult. Only 31.0% got it right. Common Mistakes: $(\log_2 x)^2=2\log_2 x$ $(\log_2 x)^2=\log_2 x^2$ Not aware that the log equation can be solved by forming a quadratic equation

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