1(a)	$h = \frac{60}{x^2}$ seen $xh = \frac{60}{x}$ seen	**M1**	
	$[A =]2x^2 + 4x \times \frac{60}{x^2} \rightarrow 2x^2 + \frac{240}{x}$ $[A =]2x^2 + 4 \times \frac{60}{x} \rightarrow 2x^2 + \frac{240}{x}$	**A1**	**A0** if any errors **A0** if any errors
1(b)	98 112	**2**	**B1** for each
1(c)	Correct smooth curve	**3**	**B2FT** for 7 or 8 points correctly plotted or **B1FT** for 5 or 6 points correctly plotted
1(d)	90 to 92	**1**	**FT** *their* minimum point provided $\leqslant 92$
1(e)	x, x, h where $2.1 \leqslant x \leqslant 2.3$ with corresponding h	**3**	**M1** for a correct reading of *their* graph at $A = 120$ **M1** for $\frac{60}{(their 2.2)^2}$ or $\frac{120 - 2 \times (their 2.2)^2}{4 \times their 2.2}$
2(a)	Ruled line through (0, 3.5) and (7, 0)	**2**	**B1** for short or unruled line or for two correct coordinates soi
2(b)	$x = 1$ $y = 3$	**1**	**FT** where their line crosses $y = x + 2$ provided it crosses on given grid
3(a)	Tangent drawn at $x = -1$	**B1**	
	–3 to –2	**B1**	Dep on close attempt at tangent at $x = -1$
3(b)	–3.9 to –3.8 0 3.8 to 3.9	**3**	**B1** for each If 0 scored, **M1** for line $y = 2$ drawn at least from (–1, 2) to (1, 2) If 0 scored, **SC1** for answers (–3.9 to –3.8, 2) and (0, 2) and (3.8 to 3.9, 2)
4(a)	4.5 oe	**1**	

5(a)	-5.5 or $-5\frac{1}{2}$ or $-\frac{11}{2}$	**1**	
5(b)	Correct smooth curve	**3**	**B2FT** for 6 or 7 points correctly plotted or **B1FT** for 4 or 5 points correctly plotted
5(c)	Line $y = 3$ only intersects the graph once oe	**2**	**M1** for $\frac{x^3}{2} - 3x - 1 = 3$ soi or $y = 3$ soi
5(d)(i)	Ruled line through (1, 1) and (–2, –1)	**1**	
5(d)(ii)	$\frac{2}{3}$ nfww	**2**	**M1** for gradient = $\frac{1+1}{1+2}$ oe
5(d)(iii)	FT reading three x-values where *their L* intersects *their* curve	**2**	**B1FT** for two correct
6....	$[y =] x^2 - 3x$ $[y =] 2 - x^2$ $[y =] x^3 - 2$ cao	**3**	**B1** for each
7(a)	2.04 or 2.035 to 2.036	**1**	
7(b)	Correct smooth curve	**3**	**B2FT** for 8 or 9 points correctly plotted or **B1FT** for 6 or 7 points correctly plotted
7(c)	Tangent drawn at (1, 2.25)	**B1**	
	–2 to –1.1	**B1**	Dependent on close attempt at tangent
7(d)(i)	Ruled line through (0, 3) and (6, 0)	**2**	**B1** for short or unruled line or for two correct points soi or line with negative gradient passing through (0, 3)
7(d)(ii)	Reading at intersections of line with curve	**2**	**Strict FT** intersections of *their* line with *their* curve **B1FT** for each
7(d)(iii)	$A = -12$ $B = 8$	**3**	**B2** for $6x^2 - 24x + 16$ [= 0] or $3x^2 - 12x + k$ [= 0] or $3x^2 - kx + 8$ [= 0], $k \neq 0$ or **M1** for using given equations to form an equation in x $3 - \frac{x}{2} = \frac{x}{4} + \frac{2}{x}$ oe or $2\left(\frac{x}{4} + \frac{2}{x}\right) + x = 6$ oe

8(a)(i)	1, 2	**1**	
8(a)(ii)	Correct curve	**3**	**B2FT** for 6 or 7 points correctly plotted or **B1FT** for 4 or 5 points correctly plotted
8(a)(iii)	Tangent drawn at (2, 16)	**B1**	
	18 to 27	**B1**	Dependent on correct tangent or close attempt
8(a)(iv)(a)	$a = -60$, $b = 36$	**2**	**B1** for either correct or $3(4^x) - 60x + 36$ [= 0]
8(a)(iv)(b)	$y = 20x - 12$ ruled line	**M2**	**M1** for one correct coordinate soi
	0.7 to 0.8, 2.65 to 2.75	**B1**	
8(b)	$p = 1$	**B1**	
	$q = 9$	**B2**	**M1** for [$y =$] $(4 - x)(x + 2)$ oe or [$y =$] $q - (x - 1)^2$ oe or two correct equations in x and y using (–2, 0), (4, 0) or (0, 8) or **SC1** for $q = -9$
9(a)	–1.8	**1**	
9(b)	Correct smooth curve	**3**	**B2FT** for 8 or 9 points correctly plotted or **B1FT** for 6 or 7 points correctly plotted
9(c)	Tangent drawn at (1, 4.8)	**B1**	Dep on <u>curve</u> drawn between (0, 3) and (2, 5.4)
	1.2 to 1.6	**B1**	Dep on close attempt at tangent
9(d)(i)	Ruled line through (–2, 5) to (2, 3) crossing curve three times	**2**	**B1** for short or unruled line or for two correct coordinates soi
9(d)(ii)	–3.8 to –3.7 0.4 to 0.5 3.3 to 3.4	**2**	**FT** intersection of *their* line with *their* 'curve' **B1FT** for two correct
9(d)(iii)	$A = -25$ $B = 10$	**3**	**B2** for one correct or **M1** for $\frac{8-x}{2} = 3 + 2x - \frac{x^3}{5}$ oe
10(a)	1.25 oe	**1**	
10(b)	Correct smooth curve	**2**	**B1FT** for at least 6 points correctly plotted
10(c)	$y = -\frac{1}{5}x + 2.4$ oe final answer	**3**	**M1** for $\frac{d-b}{c-a}$ from correct (a, b) and (c, d) **M1** for correct method to find y intercept

10(d)	line drawn through (1, 3) with negative gradient, crossing the curve twice	**B1**	
	5.8 to 6.2	**B1**	
11(a)	Acceptable justification eg Length = $\frac{18}{x}$ leading to answer **or** $y = x + x + \frac{18}{x}$	**1**	
11(b)(i)	20, 13, 20	**2**	**B1** for two correct
11(b)(ii)	Correct smooth curve	**3**	**B2FT** for 8 or 9 points correctly plotted or **B1FT** for 6 or 7 points correctly plotted
11(c)	1.6 to 1.8 and 5.2 to 5.4	**2**	**FT** reading their graph at $y = 14$ Tolerance ± 1 mm **B1FT** for one correct
11(d)(i)	240	**2**	**B1** for $y = 12$ soi
11(d)(ii)	7.4 to 7.7	**2**	**B1** for 17.5 soi
12(a)	5.5, 5.5 oe	**1**	Both correct
12(b)	Correct smooth curve	**3**	**B2FT** for 8 or 9 points correctly plotted or **B1FT** for 6 or 7 points correctly plotted
12(c)	tangent drawn at $x = 1.5$	**B1**	Dependent on a curve drawn between $x = 1$ and $x = 2$
	–1.7 to –1.3	**B1**	
12(d)	$x \leqslant$ 0.6 to 0.9 $x \geqslant$ 5.1 to 5.4	**2**	**B1** for one correct or **SC1** for answers reversed
12(e)(i)	Ruled line passing through (0, 3) and (4, 0) crossing curve twice	**2**	**B1** for short or unruled line or for two correct points plotted
12(e)(ii)	$A = -9$, $B = -4$	**2**	**B1** for either correct or $2x^2 - 9x - 4$ [=0] or **M1** for $\left(\frac{x^2}{2} - 3x + 2\right) = \frac{12 - 3x}{4}$ oe After 0, **SC1** for $A = -9.2$ to -8.8 and $B = -4.2$ to -3.8
13(a)(i)	–4.5 –4.5	**1**	Both correct
13(a)(ii)	Correct smooth curve	**3FT**	**B2FT** for 8 or 9 points correctly plotted Or **B1FT** for 6 or 7 points correctly plotted Or **B1** for the correct scales drawn

13(a)(iii)	–2.4 to –1.6 dependent on tangent drawn	**2**	Accept a correctly formed $\Delta y \div \Delta x$ isw **B1** for tangent drawn at (3, 1.5)
13(a)(iv)(a)	**–2 cao**		
13(a)(iv)(b)	–2.4 to –2.3 and 4.3 to 4.4		**FT** reading their graph at $y =$ *their* –2 Tolerance ± 1 small square **B1 FT** for one correct
13(b)(i)	4	**1**	
13(b)(ii)	3	**1**	
13(b)(iii)	324	**1**	

14(a)	$x(x + 2)(10 – x)$ $= 10x + 20 – x^2 – 2x$ $y = 20 + 8x – x^2$ **AG**	**B1** for $(x + 2)$ and $(10 – x)$ seen
14(b)	Smooth curve through 11 correct integer points	**B3** for 6 or 7 correct integer points plotted or **B2** for 4 or 5 correct integer points plotted or **B1** for 2 or 3 correct integer points plotted
14(c)	9.1 to 9.4 with $y = x$ drawn	**B1** for $y = x$ drawn or 9.1 to 9.4 with no line drawn/wrong line drawn
14(d)	–3, 6	**B1** for $5x + 2$ soi **M1** for *their*$(5x + 2) = 20 + 8x – x^2$ leading to $x^2 – 3x – k$ [=0] or $x^2 – kx – 18$[= 0] or equivalent 3 term quadratic **A1** for $(x + 3)(x – 6)$ [= 0] or $\frac{3 \pm \sqrt{3^2 – 4 \times 1 \times –18}}{2 \times 1}$ oe or $\frac{3}{2} \pm \sqrt{\frac{81}{4}}$ oe After A0, **SC1** for answer 6 or –3

15 (a)	3.75	**1**	
(b)	Correct curve ft	**2ft**	B1 for 4 correct plots ft
(c)	(0.3 to 0.5) ft	**2ft**	M1 for a reasonable tangent at $x = 2.5$
(d)	0 cao (3.05 to 3.25) ft	**2ft**	B1 for either
(e) (i)	$y = 4 – x$	**2**	M1 for $x^3 + 10x – 80 = 0 \equiv \frac{x}{20}(x^2 – 10) =$ $ax + b$ oe
(ii)	*L* drawn on the grid ft	**1ft**	Dependent on at least 1 mark in (e)(i).
(iii)	(3.55) ft	**1ft**	Dependent on at least 1 mark in (e)(i).

16 (a)	0.5	**1**	
(b)	Correct graph with smooth curve	**2**	**B1** for at least 4 correct points
(c)	Tangent drawn and gradient = 2.3 to 3.0	**2**	**B1** for tangent drawn at $x = 4$ or **B1** for gradient 2.3 to 3.0
(d) (i)	Correct method to eliminate y and reaching the given equation without error including at least one intermediate line	**1**	
(ii)	2.3 to 2.4 dep on line drawn	**2**	**B1** for $2x + y = 6$ drawn
(e) (i)	$\frac{1}{3}$ or 0.33..	**1**	
(ii)	Tangent gradient roughly $\frac{1}{3}$	**1**	
(iii)	$y = \frac{1}{3}x + k$ oe where $0 < k < 0.25$	**2ft**	Ft from their e(i) **B1** for $\frac{1}{3}x + k$ oe where $0 < k < 0.25$ or $y = \frac{1}{3}x + k$ oe (any k outside range)

17 (a)	36	**1**	
(b)	Correct plots ft and curve	**2**	**P1** for 6 correct plots **ft**
(c) (i)	4 < gradient < 6	**2ft**	**B1** for tangent at $t = 4$
(ii)	Speed oe	**1**	
(d)	Their 2.5	**2ft**	**B1** for their 1.8 and their 4.3
(e) (i)	Their 1.65 towards Their 4.7 away from	**2ft**	**B1** for one correct **ft**
(ii)	$t^2 + \frac{48}{t} - 20 = 12$ oe isw	**1**	
(iii)	–32 cao	**1**	

18 (i)	4, 4 and smooth correct graph drawn	3	**B1** for 4 and 4 **B1** for 7 correct plots
(ii)	(y =) 6.2 to 6.4	1	
(iii)	line drawn and $x = -0.7$ to -0.8 $x = 2.7$ to 2.8	2	**M1** for correct line drawn
(iv)	line drawn and $x = -2.3$ to -2.7	2	**M1** for horizontal line crossing curve at intersection of $x = 3.5$ and their curve or for the line $y = -2.75$

19	**(a)**	11 11	**1**	
	(b)	correct scales, plots (ft) and curve	**3**	**P2** correct scales and at least 7 plots (ft) or All plots correct ft or **P1** for aleast 7 plots (ft) or Correct scales drawn
	(c)	2 (±0.5)	**2ft**	Dependent on tangent drawn at $x = 3$ **M1** for tangent at $x = 3$
	(d) **(i)**	–5 cao	**1**	
	(ii)	**(a)** –1 **(b)** 5	**2**	**B1** for either
	(e)	(0.6) (3.4)	**3ft**	**B1** for $x^2 - 4x - 1 = -3$ soi and **B1** for the line $y = -3$ or **M1** for $x^2 - 4x - 1 = k$ and **A1** for the line $y = k$ **SC3** for 0 for new curve drawn
20	**(a)**	$[L =]\quad 2(x + \frac{50}{x})$ or $2x + 2\frac{50}{x}$ or $x + x + \frac{50}{x} + \frac{50}{x}$	2	**B1** for $\frac{50}{x}$ seen
	(b)	41.5 to 41.6, 45	2	**B1** for one correct
	(c)	Correct smooth curve through the eight given points correctly plotted on correctly scaled axes	3	± half a small square **B2** for seven or eight of the given points correctly plotted on *their* axes or **B1** for six of the given points correctly plotted on *their* axes
	(d)	2.8 to 3.2 < x < 16.8 to 17.2	B1 B1	**M1** for attempt to read off two x values at $y = 40$
	(e) **(i)**	27.5 < answer < 28.5	1	
	(ii)	7, 7 cao	1	
	(f)	10, 10 cao	1	