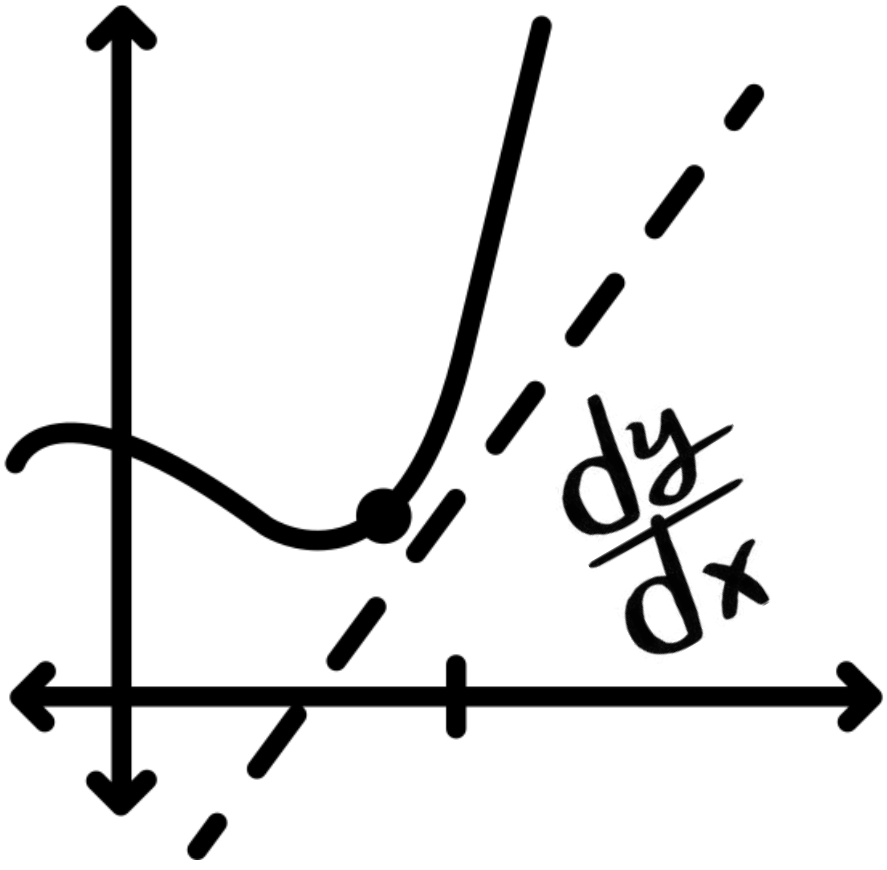
EDEXCEL IGCSE MATHEMATICS

PAPER 1H & 1HR (LINEAR)

DIFFERENTIATION

QP & MS (2018 – 2025)



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EDEXCEL IGCSE MATHEMATICS LINEAR FOR MAY 2026

by Sir Muhammad Abdullah Shah

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1. Nov 2024 1H/Q20

The curve with equation $y = 2x^4 - 64x$ has a minimum point.

Find an equation of the tangent to the curve at the minimum point.
Show clear algebraic working.

.....

(Total for Question 20 is 4 marks)

2. June 2024 1H/Q18

A curve C has equation $y = x^3 - 40x + 1$

Find the coordinates of both the points on C at which the gradient is 8

(.....,.....)

(.....,.....)

(Total for Question 18 is 5 marks)

3. June 2024 1HR/Q19

A curve C has equation $y = x^3 - 8x^2 - 12x + 5$

Curve C has exactly two stationary points, one at point A and one at point B such that

x coordinate of point $A > x$ coordinate of point B

Find the coordinates of point A
Show clear algebraic working.

(..... , ...)

(Total for Question 19 is 5 marks)

4. Nov 2023 1H/Q16

A curve has equation $y = 4x^3 - 8x + 5$

Find the x coordinates of the two points on the curve where the gradient is $\frac{1}{3}$

.....

(Total for Question 16 is 4 marks)

5. June 2023 1H/Q11

The curve **C** has equation $y = 4x^3 + x^2 - 20x$

(a) Find $\frac{dy}{dx}$

$\frac{dy}{dx} =$ .....

(2)

(b) Find the x coordinates of the points on **C** where the gradient is 4
Show clear algebraic working.

.....

(4)

(Total for Question 11 is 6 marks)

6. June 2023 1HR/Q21

The curve **T** has equation $y = x^3 - 2x^2 - 9x + 15$

(a) Find $\frac{dy}{dx}$

$\frac{dy}{dx} =$ .....

(2)

(b) Find the range of values of x for which **T** has a positive gradient.
Give your values correct to 3 significant figures.
Show your working clearly.

.....

(4)

(Total for Question 21 is 6 marks)

7. Jan 2023 1H/Q20

The radius of a right circular cylinder is x cm.

The height of the cylinder is $\left(\frac{800}{\pi x} - x\right)$ cm.

The volume of the cylinder is $V\text{cm}^3$

Find the maximum value of V
Give your answer correct to the nearest whole number.

.....

(Total for Question 20 is 5 marks)

8. Jan 2023 1HR/Q23

G is the point on the curve with equation $y = 8x^2 - 14x - 6$ where the gradient is 10
The straight line **Q** passes through the point G and is perpendicular to the tangent at G

Find an equation for **Q**
Give your answer in the form $ax + by + c = 0$ where a, b and c are integers.

.....

(Total for Question 23 is 5 marks)

9. June 2022 1H/Q17

A particle P moves along a straight line.
The fixed point O lies on this line.

The displacement of P from O at time t seconds, $t \geqslant 1$, is s metres where

$$s = 4t^2 + \frac{125}{t}$$

The velocity of P at time t seconds, $t \geqslant 1$, is v m/s

Work out the distance of P from O at the instant when $v = 0$

..... m

(Total for Question 17 is 5 marks)

10. June 2022 1HR/Q22

The diagram shows a sketch of part of the curve with equation $y = x^2 - \frac{p}{x}$ where p is a positive constant.

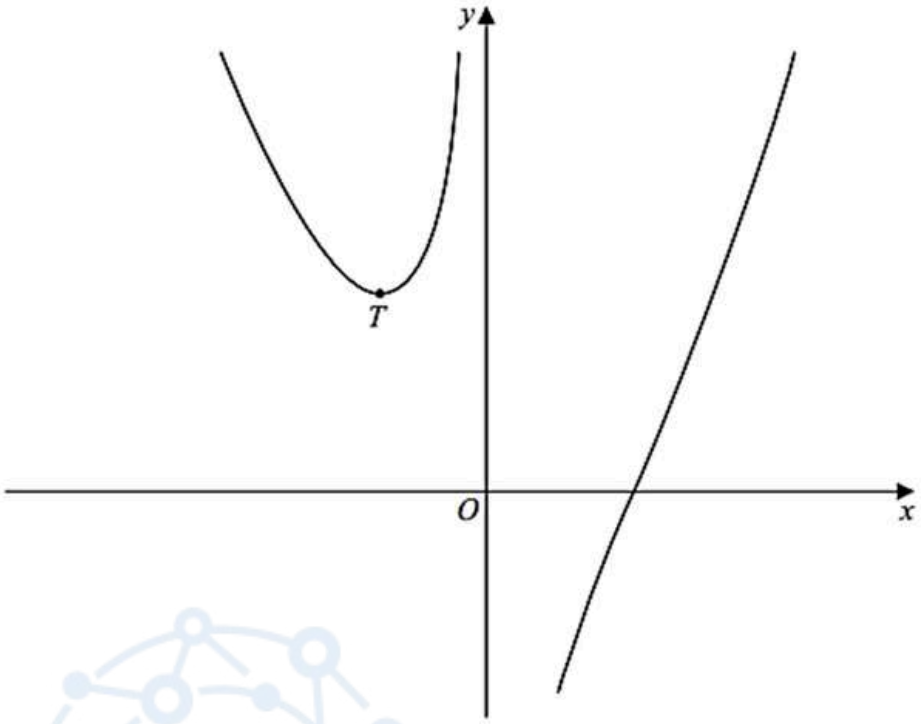


Diagram **NOT** accurately drawn

For all values of p, the curve has exactly one turning point and this turning point is a minimum shown as the point T in the sketch.

For the curve where the x coordinate of T is -3

(a) find the value of p

$p =$ .....

(4)

The line with equation $y = k$ is a tangent to the curve with equation $y = x^2 - \frac{16}{x}$

(b) Find the value of k

$k =$ .....

(3)

(Total for Question 22 is 7 marks)

11. Jan 2022 1H/Q24

The curve **C** has equation $y = ax^3 + bx^2 - 12x + 6$ where a and b are constants.

The point A with coordinates $(2, -6)$ lies on **C**
The gradient of the curve at A is 16

Find the y coordinate of the point on the curve whose x coordinate is 3
Show clear algebraic working.

$y =$ .....

(Total for Question 24 is 6 marks)

12. Jan 2022 1HR/Q23

Two particles, P and Q, move along a straight line.
The fixed point O lies on this line.

The displacement of P from O at time t seconds is s metres, where

$$s = t^3 - 4t^2 + 5t \quad \text{for } t > 1$$

The displacement of Q from O at time t seconds is x metres, where

$$x = t^2 - 4t + 4 \quad \text{for } t > 1$$

Find the range of values of t where $t > 1$ for which both particles are moving in the same direction along the straight line.

.....

(Total for Question 23 is 6 marks)

13. Nov 2021 1H/Q19

ABCED is a five-sided shape.

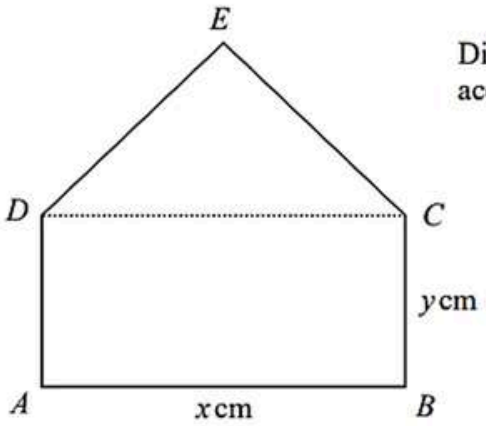


Diagram **NOT** accurately drawn

ABCD is a rectangle.
CED is an equilateral triangle.

$AB = x$ cm $BC = y$ cm

The perimeter of *ABCED* is 100 cm.
The area of *ABCED* is R cm^2

(a) Show that $R = \frac{x}{4}\left(200 - \left[6 - \sqrt{3}\right]x\right)$

(3)

(b) (i) Find the value of x for which R has its maximum value.

Give your answer in the form $\frac{p}{q-\sqrt{3}}$ where p and q are integers.

$x =$ .....

(2)

(ii) Explain why the maximum value of R is given by this value of x.

.....

.....

.....

(1)

(Total for Question 19 is 6 marks)

14. Jan 2021 1H/Q21

A curve has equation $y = f(x)$

The coordinates of the minimum point on this curve are $(-9, 15)$

(a) Write down the coordinates of the minimum point on the curve with equation

(i) $y = f(x + 3)$

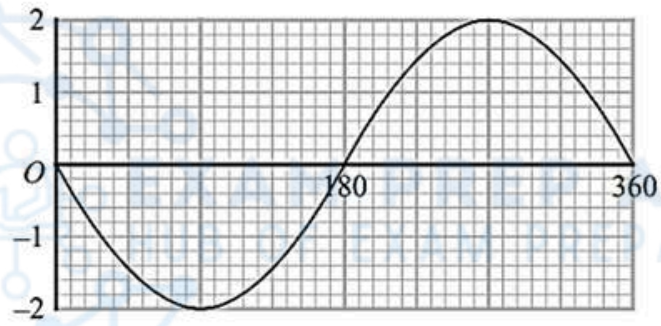
(.....)

(ii) $y = \frac{1}{3} f(x)$

(.....)

(2)

The graph of $y = a\cos(x + b)°$ for $0 \leqslant x \leqslant 360$ is drawn on the grid below.



Given that $a > 0$ and that $0 < b < 360$

(b) find the value of a and the value of b.

$a =$ .....

$b =$ .....

(2)

(Total for Question 21 is 4 marks)

15. Jan 2021 1HR/Q20

A particle P is moving along a straight line.
The fixed point O lies on the line.

At time t seconds ($t \geqslant 0$), the displacement of P from O is s metres where

$$s = t^3 - 9t^2 + 33t - 6$$

Find the minimum speed of P.

..... m/s

(Total for Question 20 is 5 marks)

16. Nov 2020 1H/Q23

Curve **C** has equation $y = px^3 - mx$ where p and m are positive integers.

Find the range of values of x, in terms of p and m, for which the gradient of **C** is negative.

.....

(Total for Question 23 is 4 marks)

17. Nov 2020 1HR/Q13

The curve **C** has equation $y = 5x^3 - x^2 - 6x + 4$

(a) Find $\frac{dy}{dx}$

$\frac{dy}{dx} =$ .....

(2)

There are two points on the curve **C** at which the gradient of the curve is 2

(b) Find the x coordinate of each of these two points.
Show clear algebraic working.

.....

(4)

(Total for Question 13 is 6 marks)

18. Jan 2020 1H/Q15

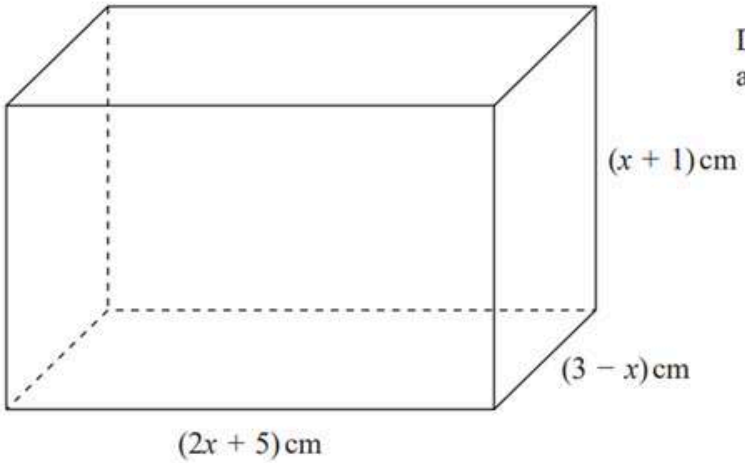


Diagram **NOT** accurately drawn

The diagram shows a cuboid of volume V cm^3

(a) Show that $V = 15 + 16x - x^2 - 2x^3$

(3)

There is a value of x for which the volume of the cuboid is a maximum.

(b) Find this value of x.
Show your working clearly.
Give your answer correct to 3 significant figures.

$x =$ .....

(5)

(Total for Question 15 is 8 marks)

19. Jan 2020 1HR/Q23

A particle moves along a straight line.
The fixed point O lies on this line.
The displacement of the particle from O at time t seconds, $t \geqslant 0$, is s metres where

$$s = t^3 + 4t^2 - 5t + 7$$

At time T seconds the velocity of P is V m/s where $V \geqslant -5$

Find an expression for T in terms of V.

Give your expression in the form $\dfrac{-4 + \sqrt{k + mV}}{3}$ where k and m are integers to be found.

$T =$ .....

(Total for Question 23 is 6 marks)

20. June 2019 1H/Q24

A particle P is moving along a straight line that passes through the fixed point O.
The displacement, s metres, of P from O at time t seconds is given by

$$s = t^3 - 6t^2 + 5t - 4$$

Find the value of t for which the acceleration of P is $3\,\text{m/s}^2$

$t =$ .....

(Total for Question 24 is 4 marks)

21. June 2019 1HR/Q16

A particle P is moving along a straight line.
The fixed point O lies on this line.

At time t seconds, the displacement, s metres, of P from O is given by

$$s = 4t^3 - 6t^2 + 5t$$

At time t seconds, the velocity of P is v m/s.

(a) Find an expression for v in terms of t.

$v =$ .....

(2)

(b) Find the time at which the acceleration of the particle is $6\,\text{m/s}^2$

..... seconds

(3)

(Total for Question 16 is 5 marks)

22. Jan 2019 1H/Q12

The curve C has equation $y = \frac{1}{3}x^3 - 9x + 1$

(a) Find $\frac{dy}{dx}$

$\frac{dy}{dx} =$

(2)

(b) Find the range of values of x for which C has a negative gradient.

(3)

(Total for Question 12 is 5 marks)

23. Jan 2019 1HR/Q13

A curve **C** has equation $y = x^3 - x^2 - 8x + 12$

(a) Find $\frac{dy}{dx}$

$\frac{dy}{dx} =$ .....

(2)

The curve **C** has two turning points.

(b) Work out the x coordinates of the two turning points.
Show your working clearly.

.....

(3)

(c) Show that the x-axis is a tangent to the curve **C**.

(2)

(Total for Question 13 is 7 marks)

24. June 2018 1HR/Q19

The curve shown in the diagram has equation

$$y = x^3 - 27x + k \text{ where } k \text{ is a positive constant with } k < 54$$

The curve has a maximum point at $A\ (a, b)$
The curve has a minimum point at $B\ (c, d)$

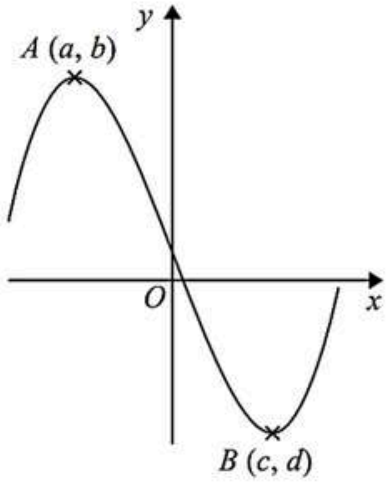


Diagram **NOT** accurately drawn

Using differentiation, find the value of $b - d$
Show your working clearly.

.....

(Total for Question 19 is 6 marks)

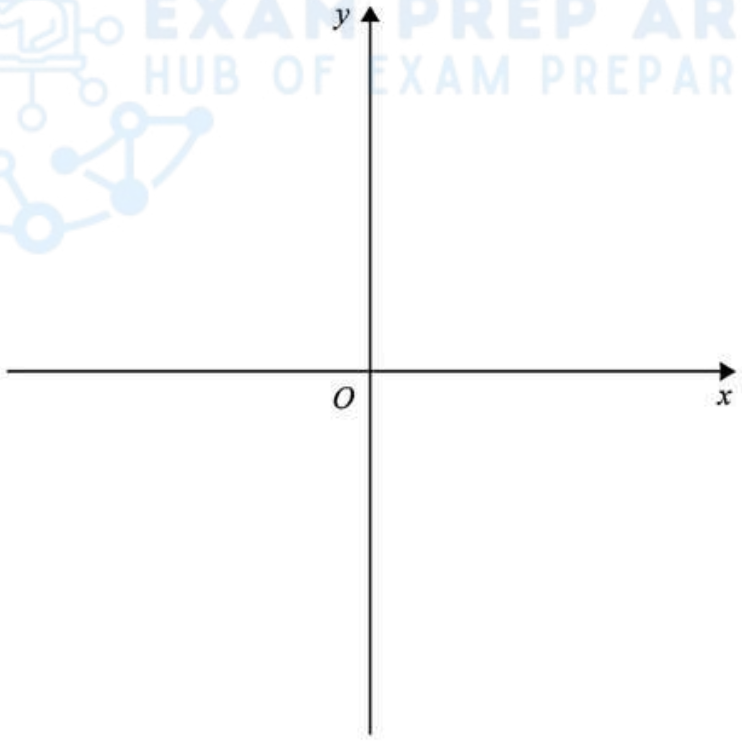
25. Sample 2018 1H/Q21

The curve C has equation $y = x^2 - 6x + 4$

Using the axes below, sketch the curve C.
On your sketch show clearly

(i) the exact coordinates of any points of intersection of C with the coordinate axes,

(ii) the coordinates of the turning point.



(Total for Question 21 is 6 marks)

MARKING SCHEME

1. Nov 2024 1H/Q20

20	$4\times 2x^3$ or $8x^3$ or ± 64		4	M1 for differentiating one term correctly
	$8x^3-64=0$ oe			M1 dep on M1 The equation must be in the form $ax^3-64=0$ oe where $a\neq 0$ or $8x^3+b=0$ oe where $b\neq 0$ where a and b are constants
	$x=\sqrt[3]{\frac{64}{8}}\ (=2)$			M1 dep on previous M1 for solving for x. The equation must be in the form $ax^3-64=0$ oe where $a\neq 0$ or $8x^3+b=0$ oe where $b\neq 0$ where a and b are constants
	Working required	$y=-96$		A1 oe eg $y+96=0$ or $y=0x-96$ or $-y=96$ dep on M3 must be an equation in terms of y Do not accept -96 or $(2,-96)$
				Total 4 marks

2. June 2024 1H/Q18

18	$3x^2$ **or** -40		5	M1 for differentiating one of the first two terms correctly
	$3x^2-40$			A1 for both terms correct and no additions
	"$3x^2-40$" $=8$			M1ft dep on M1 for equating their quadratic derivative with 8 (Derivative must be in the form ax^2-40 or $3x^2-b$ where $a\neq 0$ and $b\neq 0$)
	$(y=)"4"^3-40\times"4"+1\ (=-95)$ or $y=("-4")^3-40\times"-4"+1\ (=97)$			M1ft dep on previous M1 for substituting at least one x value into y NB Following through from $ax^2-40=8$ or $3x^2-b=8$, their x values must be correct
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	$(4,-95)$, $(-4,97)$		A1 both coordinates must be paired correctly
				Total 5 marks

3. June 2024 1HR/Q19

18	$3x^2$ **or** -40		5	M1 for differentiating one of the first two terms correctly
	$3x^2-40$			A1 for both terms correct and no additions
	"$3x^2-40$" $=8$			M1ft dep on M1 for equating their quadratic derivative with 8 (Derivative must be in the form ax^2-40 or $3x^2-b$ where $a\neq 0$ and $b\neq 0$)
	$(y=)"4"^3-40\times"4"+1\ (=-95)$ or $y=("-4")^3-40\times"-4"+1\ (=97)$			M1ft dep on previous M1 for substituting at least one x value into y NB Following through from $ax^2-40=8$ or $3x^2-b=8$, their x values must be correct
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	$(4,-95)$, $(-4,97)$		A1 both coordinates must be paired correctly
				Total 5 marks

4. Nov 2023 1H/Q16

16	$\left(\frac{dy}{dx}=\right)3\times4x^2-8\ (=12x^2-8)$		4	B2 for $3\times4x^2-8$ or $12x^2-8$ (with no other terms) (B1 for one term, ie $3\times4x^2$ or $12x^2$ or -8)
	"$12x^2-8$" $=\frac{1}{3}$			M1 for equating their initial derivative with the given gradient. Derivative must be a **quadratic** (dep on B1)
	Working not required, so correct answer scores full marks (unless from obvious incorrect working)	$\pm\frac{5}{6}$		A1oe Ignore y values Allow $\pm0.83(333\ldots)$ or $\pm\sqrt{\frac{25}{36}}$ oe
				Total 4 marks

5. June 2023 1H/Q11

11 (a)			2	M1 for at least 2 of $12x^2$, $2x$, -20
		$12x^2+2x-20$		A1
(b)	$12x^2+2x-20=4$ oe		4	M1 ft, for equating their dy/dx to 4
	$12x^2+2x-24\ (=0)$ **or** $6x^2+x-12\ (=0)$			M1 (dep on M1) ft their dy/dx in the form $ax^2+bx\ (+c)$
	eg $(6x-8)(2x+3)\ (=0)$ **or** $(3x-4)(2x+3)\ (=0)$ **or** $x=\frac{-2\pm\sqrt{(2)^2-(4\times12\times-24)}}{2\times12}$			M1 for solving their three-term quadratic equation using any correct method - if factorising, allow brackets which expanded give 2 out of 3 terms correct (if using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{-2\pm\sqrt{4+1152}}{24}$ oe)
	Working required	$\frac{4}{3}, -\frac{3}{2}$		A1 (dep on M2) oe, allow 1.33(3...) for $\frac{4}{3}$, both values – isw any attempt to find y coordinates
				Total 6 marks

6. June 2023 1HR/Q21

21 (a)	$3x^2$ or $-2\times2x$ or $-4x$ or -9 oe		2	M1 for differentiating one term correctly
		$3x^2-4x-9$		A1 for a correct expression Allow $3x^2-2\times2x-9$
(b)	$(x=)\frac{4\pm\sqrt{(-4)^2-(4\times3\times-9)}}{2\times3}$ **or** $3\left[\left(x-\frac{2}{3}\right)^2-\left(\frac{2}{3}\right)^2\right]-9(=0)$		4	M1 for finding the critical values for a 3-term quadratic using any correct method - if using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{4\pm\sqrt{16+108}}{6}$ oe **or** eg $3\left(x-\frac{2}{3}\right)^2-10\frac{1}{3}$ oe)
		-1.19 and 2.52		A1 for critical values of -1.19 **and** 2.52 or better (for this A1 mark allow -1.2 or -1.18 **and** 2.5 **or** $\frac{2\pm\sqrt{31}}{3}$ oe)
		$x<-1.19$		A1 awrt -1.19
		$x>2.52$		A1 awrt 2.52
				Total 6 marks

7. Jan 2023 1H/Q20

20	$(V=)\pi x^2\left(\frac{800}{\pi x}-x\right)$ or $800x-\pi x^3$ oe		5	M1 for volume of cylinder (in terms of one variable, e.g. x or r)
	$\left(\frac{dV}{dx}=\right)800-3\pi x^2$			M1ft for differentiating an expression in one variable to find 800 **or** $\pm 3\pi x^2$ (must come from a cubic in the form $800x\pm\pi x^3$ or $800x\pm ax^3$ or $bx\pm\pi x^3$ where $a\neq 0$ and $b\neq 0$)
	"$800-3\pi x^2$"$=0$			M1ft dep on previous M1 for equating their $\frac{dV}{dx}$ to zero (must be a quadratic in the form $800\pm ax^2$ or $b\pm 3\pi x^2$ where $a\neq 0$ and $b\neq 0$)
	$(x=)\sqrt{\frac{800}{3\pi}}\left(=\sqrt{84.8(8263...)}\right)$ or $\frac{\sqrt{9600\pi}}{6\pi}$ or 9.2(13177…)			A1 for a correct value of x Allow use of quadratic formula
	Award marks within the range from correct working	4914		A1 accept 4910 – 4914
				Total 5 marks

8. Jan 2023 1HR/Q23

23	$\left(\frac{dy}{dx}=\right)16x-14$		5	M1 Differentiation to obtain 2 terms with at least 1 correct
	$16x-14=10$			M1 their dy/dx = 10 dep on M1
	$(1.5,-9)$ or $x=1.5, y=-9$			A1 coordinates of point on curve at which gradient is 10 – allow given as coordinates or as x worked out and y worked out if meaning is clear
	eg $y--9=-\frac{1}{10}(x-\frac{3}{2})$ oe or eg $-9=-\frac{1}{10}\times 1.5+c$ oe			M1 A correct method to find the equation for line **Q** using (1.5, –9)
	Correct answer scores full marks (unless from obvious incorrect working)	$2x+20y+177=0$		A1 oe where a, b, c are integers eg $10x+100y+885=0$
				Total 5 marks

9. June 2022 1H/Q17

17	$8t$ or $\pm 125t^{-2}$ oe		5	M1 for differentiating one term correctly
	$8t-125t^{-2}$ oe or $8t-\frac{125}{t^2}$ oe			A1 for both terms correct
	$8t-125t^{-2}=0$ **and** $(t=)\sqrt[3]{\frac{125}{8}}(=2.5)$			M1 for equating their $8t\pm at^{-2}$ oe or $bt\pm 125t^{-2}$ oe to zero **and** solving for t ie must have correct powers of t and at least one correct coefficient and correct isolation of t
	$4("2.5")^2+\frac{125}{"2.5"}$			M1 dep on previous M mark for substituting into s
		75		A1
				Total 5 marks

10. June 2022 1HR/Q22

22 (a)	$\left(\frac{dy}{dx}=\right)2x+px^{-2}$ oe		4	M2 Both terms correct (M1 for one term correct)
	$2(-3)+p(-3)^{-2}(=0)$			M1 (dep on M1) substitute -3 into a derivative of the form $ax+bx^{-2}$
		54		A1
(b)	$\left(\frac{dy}{dx}=\right)2x+16x^{-2}=0$		3	M1 set $\frac{dy}{dx}=0$, at least one term correct
	eg $2x^3+16=0$ **or** $2x^3=-16$ **or** $x^3=-8$ **or** $x=\sqrt[3]{-8}$ **or** $x=-2$			M1 rearrangement of the correct equation to remove the negative power of x
		12		A1
				Total 7 marks

11. Jan 2022 1H/Q24

24	eg $-6 = 8a + 4b - 24 + 6$ **or** $8a + 4b = 12$ oe		6	M1	for substituting $x = 2$ and $y = -6$ into the equation for **C**
	$\left(\frac{dy}{dx} =\right) 3ax^2 + 2bx - 12$ oe			M1	at least 2 terms correct
	eg $16 = 12a + 4b - 12$ **or** $12a + 4b = 28$ oe			M1ft	(dep on previous M1) follow through their $\frac{dy}{dx}$
	$a = 4$ **and** $b = -5$			M1	for $a = 4$ **and** $b = -5$
	eg "4"$\times 3^3 +$ "-5"$\times 3^2 - 12 \times 3 + 6$			M1ft	correctly substituting their a, their b and $x = 3$ into the equation for **C**
		33		A1	(dep on M3) allow (3, 33)
					Total 6 marks

12. Jan 2022 1HR/Q23

23	$3t^2 - 2\times 4t + 5$ or $3t^2 - 8t + 5$		6	M1 for differentiation of s with 2 out of 3 terms correct (can be implied by subsequent working)
	$3t^2 - 2\times 4t + 5 = 0$ or $3t^2 - 8t + 5 = 0$			M1 (dep on previous M1) for equating at least a 2TQ to zero (allow inequality signs), E.g. $3t^2 - 8t = 0$ or $3t^2 + 5 = 0$ (can be implied by subsequent working)
	$(t =)\frac{5}{3}$ oe (and $t = 1$)			A1 for $\frac{5}{3}$ (and $t = 1$ may be crossed out or absent) (allow $\frac{5}{3} = 1.6(66666)$ to 2 sf truncated or rounded)
	$2t - 4 = 0$			M1 for differentiation of x to find $at + b = 0$ (allow inequality signs) where $a = 2$ and $b = -4$
	$(t =)2$			A1 for a correct value of t
		$(1 <)t < \frac{5}{3}$ **and** $t > 2$		A1 oe $(t > 1)$ $t < \frac{5}{3}$ and $t > 2$
				Total 6 marks

13. Nov 2021 1H/Q19

19 (a)	E.g. $x + y + x + y + x = 100$ oe or $3x + 2y = 100$ oe $\left(y = \frac{100 - 3x}{2}\right)$		3	M1 for a correct equation for the perimeter of the shape **or** for a correct expression for the area of triangle *CED*
	E.g. $\frac{1}{2} \times x \times x \times \sin 60$ $\left(= \frac{1}{2} \times x \times x \times \frac{\sqrt{3}}{2}\right)$ $\left(= \frac{x^2\sqrt{3}}{4}\right)$ **and** E.g. $x^2 = \left(\frac{x}{2}\right)^2 + h^2$ **and** $= \frac{1}{2} \times x \times \frac{x\sqrt{3}}{2}$ $\left(= \frac{x^2\sqrt{3}}{4}\right)$			
	x"$\left(\frac{100 - 3x}{2}\right)$"+"$\frac{x^2\sqrt{3}}{4}$"oe			M1 for the area of the shape in terms of x only
	E.g. $x\left(\frac{200 - 6x}{4}\right) + \frac{x^2\sqrt{3}}{4}$ or $\frac{x}{4}(200 - 6x + x\sqrt{3})$ or $\frac{200x - 6x^2}{4} + \frac{x^2\sqrt{3}}{4}$ or $\frac{x}{4}(200x - 6x^2 + x^2\sqrt{3})$	Shown		A1 for the area given in correct form with full working shown (at least one intermediate step before the answer)

(b) (i)	$\left(\frac{dR}{dx}=\right)50-\frac{3}{2}\times2\times x+2\times\frac{x\sqrt{3}}{4}=0$ oe		2	M1 for differentiation of correct expression with 2 out of 3 terms correct and equated to 0 (can be implied by subsequent working)
	Correct answer scores full marks (unless from obvious incorrect working)	$\frac{100}{6-\sqrt{3}}$		A1 for a correct expression
(ii)		Correct reason	1	B1 for correct reason R is a quadratic with negative coefficient of x^2 E.g. the graph of R is ∩ shaped or (allow $\frac{d^2R}{dx^2}<0$ oe)
				Total 6 marks

14. Jan 2021 1H/Q21

21	(a)(i)		(−12, 15)	1	B1	
	(ii)		(−9, 5)	1	B1	
	(b)		$a=2$ and $b=90$	2	B2	for both values correct (B1 for $a=2$ **or** $b=90$ **or** $a=-2$ **and** $b=-90$)
						Total 4 marks

15. Jan 2021 1HR/Q20

20	$(v=)\ 3t^2-9\times2t+33$		5	M1	for differentiating at least 2 terms correctly
	$(a=)\ 3\times2t-$ '18' or $(t=)-\frac{-18}{2\times3}\left(=\frac{18}{6}\right)$	$(v=)3\left[(t-3)^2-(3)^2\right](+33)$ **or** $(v=)3\left[(t-3)^2-(3)^2(+11)\right]$		M1	dep ft must be a two term linear equation **or** for the use of $(t=)-\frac{b}{2a}$ **or** for a **correct** first step for completing the square on at least a two term quadratic
	$6t-18=0$ **or** $t=3$	$(v=)3\left[(t-3)^2-(3)^2\right]+33$ **or** $(v=)3\left[(t-3)^2-(3)^2+11\right]$		M1	dep on at least M2 for equating their acceleration to 0 **or** for a **correct** method for completing the square on at least a two term quadratic
	$3\times$'3'$^2-18\times$'3'$+33$	$(v=)3(t-3)^2+6$ **or** $(v=)3\left[(t-3)^2+2\right]$		M1	dep on at least M2 for substituting their t into v **or** for a seeing a **correct** simplified expression after completing the square
		6		A1	
					Total 5 marks

16. Nov 2020 1H/Q23

23	$\left(\frac{dy}{dx}=\right)3px^2-m$	4	M1	for $3px^2$ **or** $-m$
	$3px^2-m<0$ oe		M1	ft dep on M1 for setting up an inequality with their '$3px^2$'−'m' must be a two-term expression in the form $apx^2\pm m$
	$\pm\sqrt{\frac{m}{3p}}$		B1	for both critical values
		$-\sqrt{\frac{m}{3p}}<x<\sqrt{\frac{m}{3p}}$	A1	may be seen as two separate inequalities
				Total 4 marks

17. Nov 2020 1HR/Q13

13	(a)		$15x^2 - 2x - 6$	2	B2 (B1	for correct differentiation for 2 of $15x^2$, $-2x$, -6 correct)
	(b)	e.g. "$15x^2 - 2x - 6$" = 2 oe		4	M1	ft, for equating their dy/dx to 2
		$15x^2 - 2x - 8 (= 0)$			M1	(dep on M1) ft their three-term quadratic
		e.g. $(3x + 2)(5x - 4) (= 0)$ $x = \frac{2 \pm \sqrt{(-2)^2 - (4 \times 15 \times -8)}}{2 \times 15}$			M1	for solving their quadratic equation using any correct method - if factorising, allow brackets which expanded give 2 out of 3 terms correct (if using formula or completing the square allow one sign error and some simplification – allow as far as e.g. $\frac{2 \pm \sqrt{4 + 480}}{30}$ oe)
			$-\frac{2}{3}, \frac{4}{5}$		A1	oe, dep on M2 (allow −0.66 or better), Both values – isw any attempt to find y coordinates
						Total 6 marks

18. Jan 2020 1H/Q15

15	(a)	$(2x + 5)(x + 1) = 2x^2 + 2x + 5x + 5$ $(= 2x^2 + 7x + 5)$ **or** $(x + 1)(3 - x) = -x^2 + 3x - x + 3$ $(= -x^2 + 2x + 3)$ **or** $(3 - x)(2x + 5) = -2x^2 + 6x - 5x + 15$ $(= -2x^2 + x + 15)$		3	M1 for multiplying out two brackets correctly at least 3 terms correct	M2 for at least 4 terms correct out of a maximum of 8 terms $6x^2 - 2x^3 + 6x - 2x^2 + 15x - 5x^2 + 15 - 5x$
		E.g. $[(2x^2 + 7x + 5)(3 - x) =]$ $-2x^3 - 7x^2 - 5x + 6x^2 + 21x + 15$ **or** $[(-x^2 + 2x + 3)(2x + 5) =]$ $-2x^3 - 5x^2 + 10x + 4x^2 + 6x + 15$ **or** $[(-2x^2 + x + 15)(x + 1) =]$ $-2x^3 - 2x^2 + 15x + x^2 + x + 15$			M1 for at least 3 terms correct out of a maximum of 6 terms **or** for at least 4 terms correct out of a maximum of 8 terms	
			Shown		A1	

15	(b)	$\left(\frac{dV}{dx} =\right) 16 - 2x + \left(3 \times -2x^2\right)$ oe		5	M1 for the correct differentiation of at least 2 correct terms from 16 **or** $-2x$ **or** $(3 \times -2x^2)$
		$\left(\frac{dV}{dx} =\right) 16 - 2x - 6x^2$ oe			A1 for a correct differentiated expression
		'$16 - 2x - 6x^2$' = 0 oe			M1 (dep on M1) for equating their differentiated expression to zero
		E.g. $(x =) \frac{-2 \pm \sqrt{2^2 - 4 \times 6 \times -16}}{2 \times 6}$ oe (accept + in place of ±) or E.g. $6\left(\left(x + \frac{1}{6}\right)^2 - \left(\frac{1}{6}\right)^2\right) - 16 (= 0)$ oe			M1 (dep on M1) for a complete method to solve their 3-term quadratic equation (allow one sign error and some simplification – allow as far as $\frac{-2 \pm \sqrt{4 + 384}}{12}$)
			1.47		A1 dep on M1 for answer in range 1.47 – 1.5 from correct working (Must reject −1.80 to −1.81 if calculated)
					Total 8 marks

19. Jan 2020 1HR/Q23

18	ai				B1	tangent drawn at P ($x = 2$)
					M1	(dep on B1) for a method to find gradient e.g. $\frac{\text{difference in } y\text{-values}}{\text{difference in } x\text{-values}}$
			−0.6	3	A1	(dep on B1) accept answers in range −0.4 to −0.7 **and** from correct figures for their line
	aii	e.g. $y = -0.6x + c$ **or** $y = mx + 3.6$ **or** $2.4 = -0.6 \times 2 + c$			M1	for start of method to find the tangent equation e.g. $y = mx + c$ where m is their gradient **or** $y = mx + c$ where c is the y-intercept for their tangent **or** for substituting a point from the curve e.g. (2, 2.4) into $y = mx + c$ where m is their gradient
			$y = -0.6x + 3.6$	2	A1	ft their gradient from (i) and intercept of their tangent, so long as intercept / value of c is > 3
	b		3		B1	
			−1	2	B1	
						Total 7 marks

20. June 2019 1H/Q24

24		$(v =) 3t^2 - 6 \times 2t + 5 (+ 0)$		4	M1	for differentiating at least 2 terms correctly
		$(a =) 3 \times 2t - 12$			M1	dep ft
		$6t - 12 = 3$			M1	dep on at least M1 for equating their acceleration in terms of t to 3
			2.5 oe		A1	
						Total 4 marks

21. June 2019 1HR/Q16

16	(a)	$3\times4t^2-2\times6t+5$		2	M1	For 2 terms correct
			$12t^2-12t+5$		A1	Fully correct
	(b)	$24t-12$		3	M1	Method to differentiate their v, ft a 3 term quadratic expression from (a)
		"$24t-12$" = 6			M1	ft if previous M1 awarded
			0.75		A1	oe
						Total 5 marks

22. Jan 2019 1H/Q12

Question		Working	Answer	Mark	Notes
12	(a)	$3\times\frac{1}{3}x^2-9$			M1 for $3\times\frac{1}{3}x^2$ oe **or** -9 oe
			x^2-9 oe	2	A1 or for $1x^2-9$ oe
	(b)		$-3 < x < 3$ oe	3	B3 may be seen as two separate inequalities if not B3 then award B2 for $x < 3$ **or** $x > -3$ **or** $-3 \le x \le 3$ if not B2 then award B1 for $x^2 - 9 < 0$ **or** $x^2 < 9$ oe **or** for $(x-3)(x+3)$ **or** for $(x =) \pm 3$ (values maybe seen in incorrect inequalities) SC: If no marks awarded and M1 awarded in (a) then award B1 for "quadratic" < 0

23. Jan 2019 1HR/Q13

Question	Working	Answer	Mark	Notes
13 (a)		$3x^2-2x-8$	2	B2 (B1 for at least 1 correct non zero term)
(b)	"$3x^2-2x-8$" $=0$	$-\frac{4}{3}, 2$	3	M1 Dep on at least B1, ft on M marks only dep on $\frac{dy}{dx}$ being a 3 term quadratic
	$(3x+4)(x-2)$ $(=0)$			M1
	or			
	$x=\frac{2\pm\sqrt{100}}{2\times3}$ or $x=\frac{2\pm\sqrt{(-2)^2-4\times3\times(-8)}}{2\times3}$			
				A1 (dep 2nd M1)
(c)	At $x=2$, $y=2^3-2^2-8\times2+12$ $(=0)$ **or** at $x=-\frac{4}{3}$, $y=\left(-\frac{4}{3}\right)^3-\left(-\frac{4}{3}\right)^2-8\times\left(-\frac{4}{3}\right)+12$ $\left(=\frac{500}{27}\right)$	Shown	2	M1 Substitutes at least one of $-\frac{4}{3}$ **or** 2 **or** their answer from (b) into $(y=)x^3-x^2-8x+12$
				A1 must show that (2,0) is a turning point on the curve and give concluding statement

24. June 2018 1HR/Q19

19	$\frac{dy}{dx}=3x^2-27$	108		M1 for at least one of $3x^2$ or 27
	$3x^2-27=0$			M1 (dep) for a 2 or 3 term quadratic =0
	$x=\pm3$			A1
	When $x=-3$, $b=(-3)^3-27(-3)+k$ $(=54+k)$ When $x=3$, $d=3^3-27(3)+k$ $(=-54+k)$			M1 for either substituting $x=3$ or $x=-3$ into the y expression. Only award this mark if k or a number representing k is in the expression for b or d
	$b-d=54+k-(-54+k)$			M1 dep on all previous M marks. Expressions for b and d must have k or the same number representing k
				A1
				Total 6 marks

25. Sample 2018 1H/Q21

21	e.g. $\frac{dy}{dx}=2x-6$ **or** $(x-3)^2-3^2+4$ **or** $\frac{'3+\sqrt{5}'+'3-\sqrt{5}'}{2}$			M1
	$(x-3)^2-5$ **or** $x=3$			A1 (ft providing previous M1 scored) for (3, −5)
	eg. $x=\frac{--6\pm\sqrt{(-6)^2-4\times1\times4}}{2\times1}$ **or** $x=3\pm\sqrt{3^2-4}$ **or** $(x-3)^2=5$			M1 for correct method to find roots
	$x=3\pm\sqrt{5}$			A1 or exact equivalents
		Correct graph	6	B2 for fully correct labelled graph (see end of mark scheme) (B1 for parabola intercepting y-axis at (0, 4))
				Total 6 marks