

1. Question | 9709 Feb-March 2016 P1 V2 Q6

- 6** A vacuum flask (for keeping drinks hot) is modelled as a closed cylinder in which the internal radius is r cm and the internal height is h cm. The volume of the flask is 1000 cm^3 . A flask is most efficient when the total internal surface area, $A \text{ cm}^2$, is a minimum.

(i) Show that $A = 2\pi r^2 + \frac{2000}{r}$. [3]

- (ii) Given that r can vary, find the value of r , correct to 1 decimal place, for which A has a stationary value and verify that the flask is most efficient when r takes this value. [5]

2. Question | 9709 May-June 2016 P1 V1 Q4

- 4** A curve is such that $\frac{dy}{dx} = 2 - 8(3x + 4)^{-\frac{1}{2}}$.

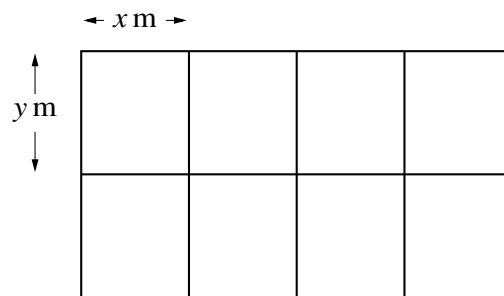
- (i) A point P moves along the curve in such a way that the x -coordinate is increasing at a constant rate of 0.3 units per second. Find the rate of change of the y -coordinate as P crosses the y -axis. [2]

The curve intersects the y -axis where $y = \frac{4}{3}$.

- (ii) Find the equation of the curve. [4]

3. Question | 9709 May-June 2016 P1 V1 Q5

5



A farmer divides a rectangular piece of land into 8 equal-sized rectangular sheep pens as shown in the diagram. Each sheep pen measures $x\text{ m}$ by $y\text{ m}$ and is fully enclosed by metal fencing. The farmer uses 480 m of fencing.

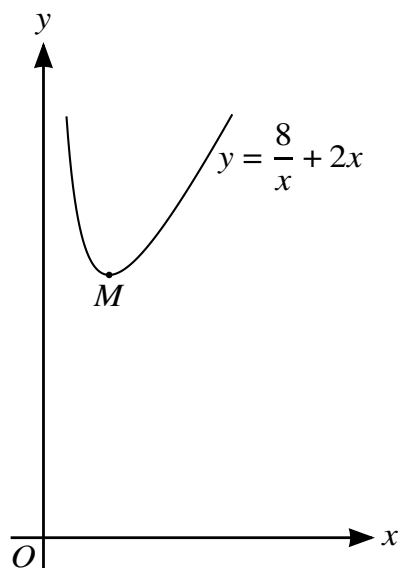
- (i) Show that the total area of land used for the sheep pens, $A\text{ m}^2$, is given by

$$A = 384x - 9.6x^2. \quad [3]$$

- (ii) Given that x and y can vary, find the dimensions of each sheep pen for which the value of A is a maximum. (There is no need to verify that the value of A is a maximum.) [3]

4. Question | 9709 May-June 2016 P1 V2 Q10

10



The diagram shows the part of the curve $y = \frac{8}{x} + 2x$ for $x > 0$, and the minimum point M .

- (i) Find expressions for $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$ and $\int y^2 dx$. [5]
- (ii) Find the coordinates of M and determine the coordinates and nature of the stationary point on the part of the curve for which $x < 0$. [5]
- (iii) Find the volume obtained when the region bounded by the curve, the x -axis and the lines $x = 1$ and $x = 2$ is rotated through 360° about the x -axis. [2]

5. Question | 9709 May-June 2016 P1 V3 Q5

- 5** A curve has equation $y = 8x + (2x - 1)^{-1}$. Find the values of x at which the curve has a stationary point and determine the nature of each stationary point, justifying your answers. [7]

6. Question | 9709 May-June 2016 P1 V3 Q7

- 7** The point $P(x, y)$ is moving along the curve $y = x^2 - \frac{10}{3}x^{\frac{3}{2}} + 5x$ in such a way that the rate of change of y is constant. Find the values of x at the points at which the rate of change of x is equal to half the rate of change of y . [7]

7. Question | 9709 Oct-Nov 2016 P1 V1 Q11

- 11** The point $P(3, 5)$ lies on the curve $y = \frac{1}{x-1} - \frac{9}{x-5}$.
- (i) Find the x -coordinate of the point where the normal to the curve at P intersects the x -axis. [5]
- (ii) Find the x -coordinate of each of the stationary points on the curve and determine the nature of each stationary point, justifying your answers. [6]

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8. Question | 9709 Oct-Nov 2016 P1 V2 Q7

7 The equation of a curve is $y = 2 + \frac{3}{2x-1}$.

(i) Obtain an expression for $\frac{dy}{dx}$. [2]

(ii) Explain why the curve has no stationary points. [1]

At the point P on the curve, $x = 2$.

(iii) Show that the normal to the curve at P passes through the origin. [4]

(iv) A point moves along the curve in such a way that its x -coordinate is decreasing at a constant rate of 0.06 units per second. Find the rate of change of the y -coordinate as the point passes through P . [2]

9. Question | 9709 Oct-Nov 2016 P1 V3 Q10

10 A curve is such that $\frac{dy}{dx} = \frac{2}{a}x^{-\frac{1}{2}} + ax^{-\frac{3}{2}}$, where a is a positive constant. The point $A(a^2, 3)$ lies on the curve. Find, in terms of a ,

(i) the equation of the tangent to the curve at A , simplifying your answer, [3]

(ii) the equation of the curve. [4]

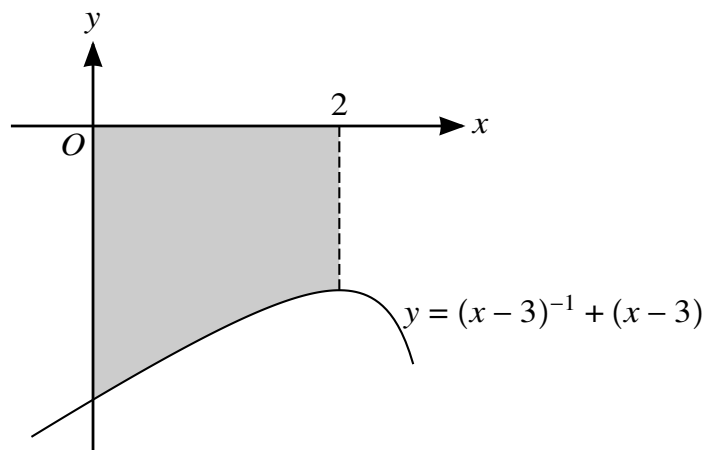
It is now given that $B(16, 8)$ also lies on the curve.

(iii) Find the value of a and, using this value, find the distance AB . [5]

11 A curve has equation $y = (kx - 3)^{-1} + (kx - 3)$, where k is a non-zero constant.

(i) Find the x -coordinates of the stationary points in terms of k , and determine the nature of each stationary point, justifying your answers. [7]

(ii)

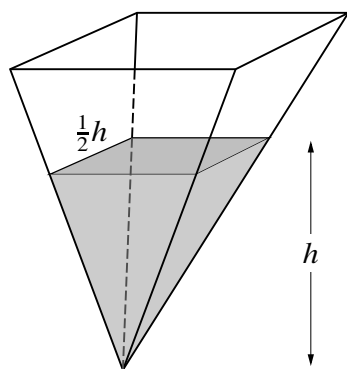


The diagram shows part of the curve for the case when $k = 1$. Showing all necessary working, find the volume obtained when the region between the curve, the x -axis, the y -axis and the line $x = 2$, shown shaded in the diagram, is rotated through 360° about the x -axis. [5]

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(i) Express the volume of water in the container in terms of h . [1]

[The volume of a pyramid having a base area A and vertical height h is $\frac{1}{3}Ah$.]

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Topical questions | 121 questions

Water is steadily dripping into the container at a constant rate of 20 cm^3 per minute.

- (ii) Find the rate, in cm per minute, at which the water level is rising when the height of the water level is 10 cm. [4]

[illegible]

12. Question part 1/2 | 9709 Feb-March 2017 P1 V2 Q7

7 The function f is defined for $x \geq 0$ by $f(x) = (4x + 1)^{\frac{3}{2}}$.

(i) Find $f'(x)$ and $f''(x)$. [3]

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The first, second and third terms of a geometric progression are respectively $f(2)$, $f'(2)$ and $kf''(2)$.

(ii) Find the value of the constant k . [5]

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12. Question part 2/2 | 9709 Feb-March 2017 P1 V2 Q7

[illegible]

13. Question part 1/2 | 9709 Feb-March 2017 P1 V2 Q9

9 The point $A(2, 2)$ lies on the curve $y = x^2 - 2x + 2$.

(i) Find the equation of the tangent to the curve at A . [3]

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The normal to the curve at A intersects the curve again at B .

(ii) Find the coordinates of B . [4]

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13. Question part 2/2 | 9709 Feb-March 2017 P1 V2 Q9

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The tangents at A and B intersect each other at C .

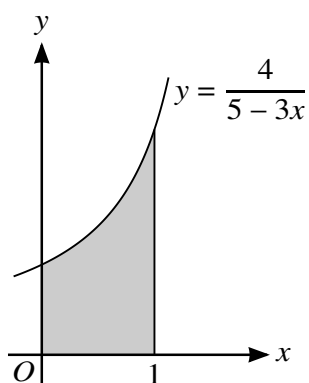
(iii) Find the coordinates of C .

[4]

[illegible]

$$A = \frac{\sqrt{3}}{2}x^2 + \frac{24\,000}{\sqrt{3}}x^{-1}. \quad [3]$$
[illegible]

[illegible][illegible]



(i) Find the equation of the normal to the curve at the point where $x = 1$ in the form $y = mx + c$, where m and c are constants. [5]

[illegible]

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15. Question part 2/2 | 9709 May-June 2017 P1 V1 Q10

The shaded region is bounded by the curve, the coordinate axes and the line $x = 1$.

- (ii) Find, showing all necessary working, the volume obtained when this shaded region is rotated through 360° about the x -axis. [5]

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5 A curve has equation $y = 3 + \frac{12}{2-x}$.

[illegible]

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Topical questions | 121 questions

16. Question part 2/2 | 9709 May-June 2017 P1 V2 Q5

- (ii) A point moves along the curve in such a way that the x -coordinate is increasing at a constant rate of 0.04 units per second. Find the rate of change of the y -coordinate when $x = 4$. [2]

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17. Question part 1/2 | 9709 May-June 2017 P1 V2 Q9

9 The equation of a curve is $y = 8\sqrt{x} - 2x$.

(i) Find the coordinates of the stationary point of the curve. [3]

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(ii) Find an expression for $\frac{d^2y}{dx^2}$ and hence, or otherwise, determine the nature of the stationary point. [2]

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17. Question part 2/2 | 9709 May-June 2017 P1 V2 Q9

(iii) Find the values of x at which the line $y = 6$ meets the curve.

[3]

[illegible]

(iv) State the set of values of k for which the line $y = k$ does not meet the curve.

[1]

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18. Question part 1/2 | 9709 May-June 2017 P1 V3 Q6

6 The line $3y + x = 25$ is a normal to the curve $y = x^2 - 5x + k$. Find the value of the constant k . [6]

[illegible]

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18. Question part 2/2 | 9709 May-June 2017 P1 V3 Q6

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19. Question | 9709 Oct-Nov 2017 P1 V1 Q1

- 1** A curve has equation $y = 2x^{\frac{3}{2}} - 3x - 4x^{\frac{1}{2}} + 4$. Find the equation of the tangent to the curve at the point $(4, 0)$. [4]

[illegible]

[illegible][illegible]

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20. Question part 2/2 | 9709 Oct-Nov 2017 P1 V1 Q4

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(iii) Find the maximum volume of a cone that can be made by these machines. [1]

[illegible]

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[illegible]

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21. Question part 2/2 | 9709 Oct-Nov 2017 P1 V2 Q8

(iii) Given that the curve passes through the point $(6, 2)$, find the equation of the curve.

[4]

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22. Question | 9709 Oct-Nov 2017 P1 V3 Q4

- 4** The function f is such that $f(x) = (2x - 1)^{\frac{3}{2}} - 6x$ for $\frac{1}{2} < x < k$, where k is a constant. Find the largest value of k for which f is a decreasing function. [5]

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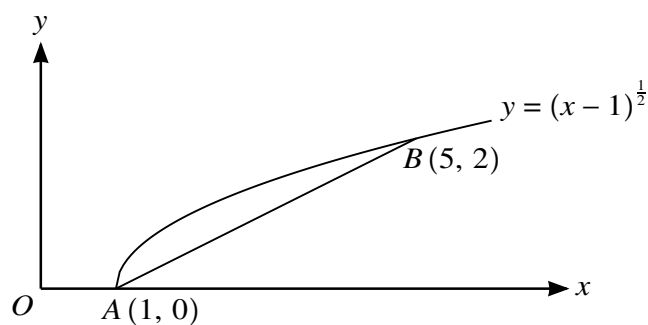
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23. Question part 2/2 | 9709 Oct-Nov 2017 P1 V3 Q10

- (ii)** It is now given that the curve has a stationary point at $(-2, -3)$ and that the gradient of the curve at $x = 1$ is 9. Find $f(x)$. [6]

This image shows a full page of a document template. It consists of approximately 28 evenly spaced horizontal dotted lines across the entire width of the page, providing a guide for handwriting practice or structured note-taking. There are no margins, text, or other markings present.

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(i) Find the equation of the line AB , giving your answer in the form $y = mx + c$. [2]

[illegible]

(ii) Find, showing all necessary working, the equation of the tangent to the curve which is parallel to AB . [5]

[illegible]

Topical questions | 121 questions

(iii) Find the perpendicular distance between the line AB and the tangent parallel to AB . Give your answer correct to 2 decimal places. [3]

Topical questions | 121 questions

8 A curve has equation $y = \frac{1}{2}x^2 - 4x^{\frac{3}{2}} + 8x$.

(i) Find the x -coordinates of the stationary points. [5]

[illegible]

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Topical questions | 121 questions

25. Question part 2/2 | 9709 Feb-March 2018 P1 V2 Q8

(ii) Find $\frac{d^2y}{dx^2}$. [1]

[illegible]

(iii) Find, showing all necessary working, the nature of each stationary point. [2]

[illegible]

Topical questions | 121 questions

2 A point is moving along the curve $y = 2x + \frac{5}{x}$ in such a way that the x -coordinate is increasing at a constant rate of 0.02 units per second. Find the rate of change of the y -coordinate when $x = 1$. [4]

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(i) Show that the curve has no stationary points. [3]

[illegible]

(ii) Denoting the gradient of the curve by m , find the stationary value of m and determine its nature. [5]

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Topical questions | 121 questions

27. Question part 2/3 | 9709 May-June 2018 P1 V1 Q10

[illegible]

- (iii) Showing all necessary working, find the area of the region enclosed by the curve, the x -axis and the line $x = 6$. [4]

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Additional Page

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8 (i) The tangent to the curve $y = x^3 - 9x^2 + 24x - 12$ at a point A is parallel to the line $y = 2 - 3x$. Find the equation of the tangent at A . [6]

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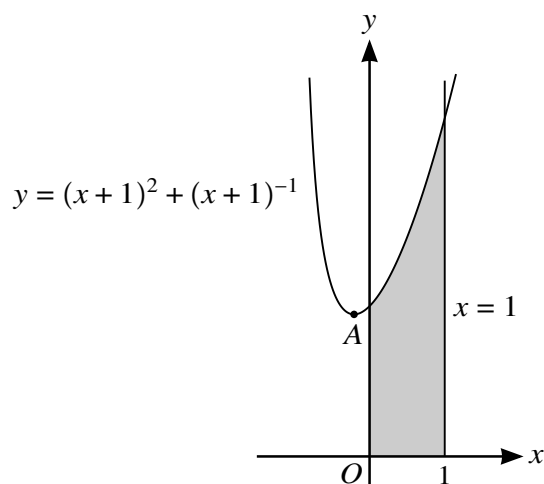
Topical questions | 121 questions

28. Question part 2/2 | 9709 May-June 2018 P1 V3 Q8

[illegible]

- (ii)** The function f is defined by $f(x) = x^3 - 9x^2 + 24x - 12$ for $x > k$, where k is a constant. Find the smallest value of k for f to be an increasing function. [2]

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(i) Show that the x -coordinate of A satisfies the equation $2(x + 1)^3 = 1$ and find the exact value of $\frac{d^2y}{dx^2}$ at A . [5]

[illegible]

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Topical questions | 121 questions

29. Question part 2/3 | 9709 May-June 2018 P1 V3 Q11

- (ii) Find, showing all necessary working, the volume obtained when the shaded region is rotated through 360° about the x -axis. [6]

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6 A curve has a stationary point at $(3, 9\frac{1}{2})$ and has an equation for which $\frac{dy}{dx} = ax^2 + a^2x$, where a is a non-zero constant.

[illegible][illegible]

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Topical questions | 121 questions

30. Question part 2/2 | 9709 Oct-Nov 2018 P1 V1 Q6

[illegible]

(iii) Determine, showing all necessary working, the nature of the stationary point. [2]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

31. Question part 1/2 | 9709 Oct-Nov 2018 P1 V1 Q10

10 A curve has equation $y = \frac{1}{2}(4x - 3)^{-1}$. The point A on the curve has coordinates $(1, \frac{1}{2})$.

(i) (a) Find and simplify the equation of the normal through A .

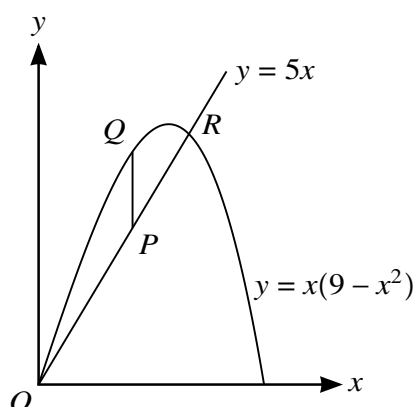
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- [2]

[illegible]



(i) Express the length of PQ in terms of t , simplifying your answer. [2]

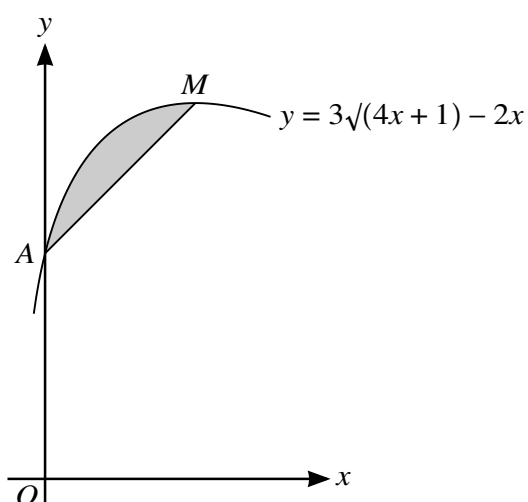
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[illegible]



The diagram shows part of the curve $y = 3\sqrt{4x + 1} - 2x$. The curve crosses the y -axis at A and the stationary point on the curve is M .

- (i) Obtain expressions for $\frac{dy}{dx}$ and $\int y dx$. [5]

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(ii) Find the coordinates of M .

[3]

[illegible]

(iii) Find, showing all necessary working, the area of the shaded region.

[4]

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33. Question part 3/3 | 9709 Oct-Nov 2018 P1 V2 Q11

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34. Question | 9709 Oct-Nov 2018 P1 V3 Q2

- 2** The function f is defined by $f(x) = x^3 + 2x^2 - 4x + 7$ for $x \geq -2$. Determine, showing all necessary working, whether f is an increasing function, a decreasing function or neither. [4]

[illegible]

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Topical questions | 121 questions

35. Question part 1/2 | 9709 Feb-March 2019 P1 V2 Q4

4 A curve has equation $y = (2x - 1)^{-1} + 2x$.

(i) Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$.

[3]

[illegible]

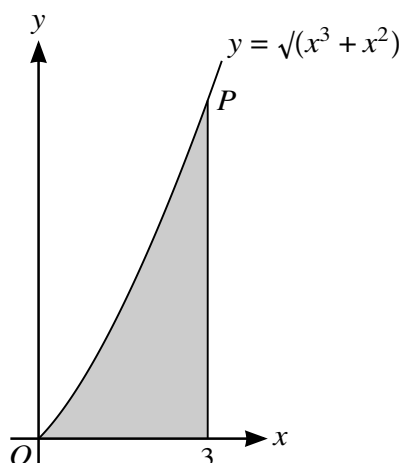
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Topical questions | 121 questions

35. Question part 2/2 | 9709 Feb-March 2019 P1 V2 Q4

- (ii) Find the x -coordinates of the stationary points and, showing all necessary working, determine the nature of each stationary point. [4]

[illegible]



(i) Find, showing all necessary working, the volume obtained when the shaded region is rotated through 360° about the x -axis. [4]

[illegible]

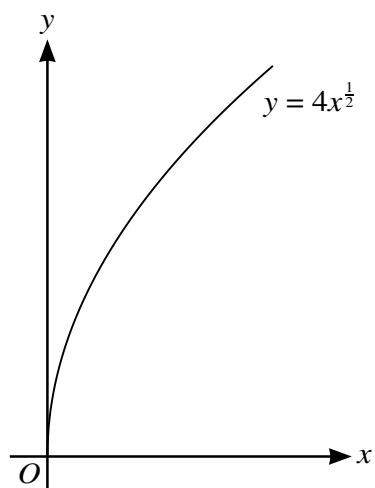
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Topical questions | 121 questions

36. Question part 2/2 | 9709 Feb-March 2019 P1 V2 Q9

- (ii) P is the point on the curve with x -coordinate 3. Find the y -coordinate of the point where the normal to the curve at P crosses the y -axis. [6]

[illegible]



(i) The straight line with equation $y = x + 3$ intersects the curve at points A and B . Find the length of AB . [6]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

37. Question part 2/3 | 9709 Feb-March 2019 P1 V2 Q10

- (ii) The tangent to the curve at a point T is parallel to AB . Find the coordinates of T . [3]

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- (iii) Find the coordinates of the point of intersection of the normal to the curve at T with the line AB . [3]

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37. Question part 3/3 | 9709 Feb-March 2019 P1 V2 Q10

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Topical questions | 121 questions

38. Question | 9709 May-June 2019 P1 V1 Q2

- 2** The line $4y = x + c$, where c is a constant, is a tangent to the curve $y^2 = x + 3$ at the point P on the curve.

(i) Find the value of c .

[3]

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(ii) Find the coordinates of P .

[2]

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39. Question | 9709 May-June 2019 P1 V2 Q3

3 A curve is such that $\frac{dy}{dx} = x^3 - \frac{4}{x^2}$. The point $P(2, 9)$ lies on the curve.

(i) A point moves on the curve in such a way that the x -coordinate is decreasing at a constant rate of 0.05 units per second. Find the rate of change of the y -coordinate when the point is at P . [2]

[illegible]

(ii) Find the equation of the curve. [3]

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Topical questions | 121 questions

9 The curve C_1 has equation $y = x^2 - 4x + 7$. The curve C_2 has equation $y^2 = 4x + k$, where k is a constant. The tangent to C_1 at the point where $x = 3$ is also the tangent to C_2 at the point P . Find the value of k and the coordinates of P . [8]

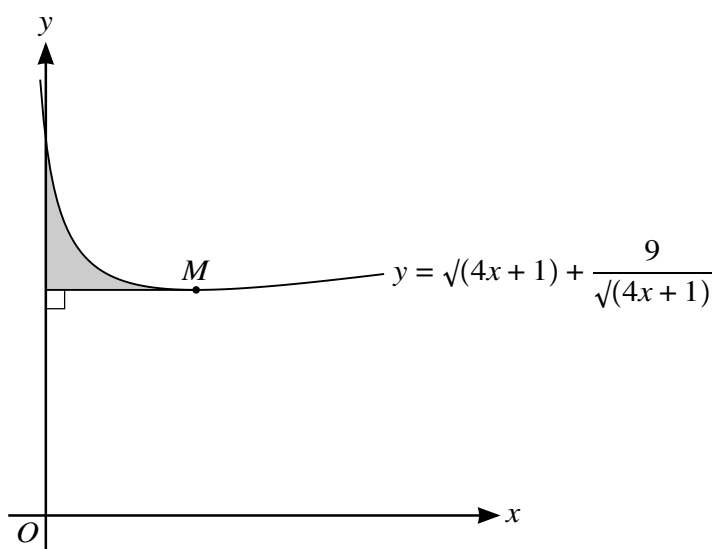
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Topical questions | 121 questions

40. Question part 2/2 | 9709 May-June 2019 P1 V2 Q9

[illegible]



The diagram shows part of the curve $y = \sqrt{4x + 1} + \frac{9}{\sqrt{4x + 1}}$ and the minimum point M .

- (i) Find expressions for $\frac{dy}{dx}$ and $\int y \, dx$. [6]

[illegible]

[illegible]

(iii) Find, showing all necessary working, the area of the shaded region. [3]

[illegible]

Topical questions | 121 questions

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Topical questions | 121 questions

42. Question part 1/2 | 9709 May-June 2019 P1 V3 Q8

- 8** A curve is such that $\frac{dy}{dx} = 3x^2 + ax + b$. The curve has stationary points at $(-1, 2)$ and $(3, k)$. Find the values of the constants a, b and k . [8]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

42. Question part 2/2 | 9709 May-June 2019 P1 V3 Q8

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

43. Question | 9709 Oct-Nov 2019 P1 V1 Q2

- 2 An increasing function, f , is defined for $x > n$, where n is an integer. It is given that $f'(x) = x^2 - 6x + 8$. Find the least possible value of n . [3]

[illegible]

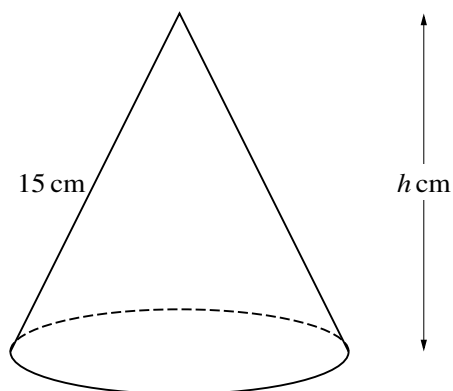
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Topical questions | 121 questions

44. Question | 9709 Oct-Nov 2019 P1 V1 Q3

- 3** The line $y = ax + b$ is a tangent to the curve $y = 2x^3 - 5x^2 - 3x + c$ at the point $(2, 6)$. Find the values of the constants a , b and c . [5]

[illegible]



(ii) Show that the volume, $V \text{ cm}^3$, of the cone is given by $V = \frac{1}{3}\pi(225h - h^3)$. [2]

[The volume of a cone of radius r and vertical height h is $\frac{1}{3}\pi r^2 h$.]

[illegible]

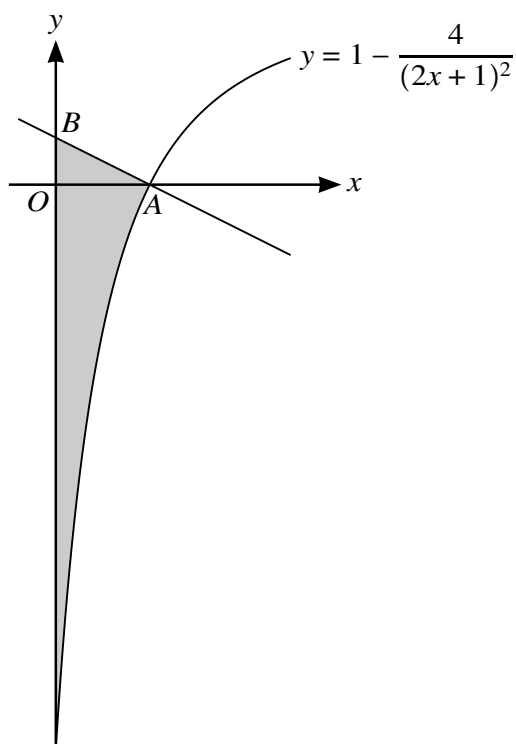
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Topical questions | 121 questions

45. Question part 2/2 | 9709 Oct-Nov 2019 P1 V2 Q5

- (ii) Given that h can vary, find the value of h for which V has a stationary value. Determine, showing all necessary working, the nature of this stationary value. [5]

[illegible]



(i) Obtain expressions for $\frac{dy}{dx}$ and $\int y dx$. [4]

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[4]

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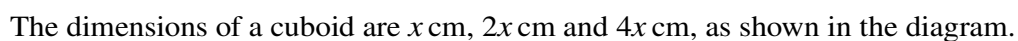
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Topical questions | 121 questions

3 The equation of a curve is $y = x^3 + x^2 - 8x + 7$. The curve has no stationary points in the interval $a < x < b$. Find the least possible value of a and the greatest possible value of b . [4]

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- $$S = 7V^{\frac{2}{3}}. \quad [3]$$

[illegible]

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Topical questions | 121 questions

48. Question part 2/2 | 9709 Oct-Nov 2019 P1 V3 Q5

- (ii) When the volume of the cuboid is 1000 cm^3 the surface area is increasing at $2 \text{ cm}^2 \text{ s}^{-1}$. Find the rate of increase of the volume at this instant. [4]

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Topical questions | 121 questions

8 A function f is defined for $x > \frac{1}{2}$ and is such that $f'(x) = 3(2x - 1)^{\frac{1}{2}} - 6$.

(i) Find the set of values of x for which f is decreasing. [4]

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Topical questions | 121 questions

49. Question part 2/2 | 9709 Oct-Nov 2019 P1 V3 Q8

(ii) It is now given that $f(1) = -3$. Find $f(x)$.

[4]

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Topical questions | 121 questions

50. Question | 9709 Feb-March 2020 P1 V2 Q1

- 1** The function f is defined by $f(x) = \frac{1}{3x+2} + x^2$ for $x < -1$.

Determine whether f is an increasing function, a decreasing function or neither. [3]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

51. Question | 9709 Feb-March 2020 P1 V2 Q4

- 4** A curve has equation $y = x^2 - 2x - 3$. A point is moving along the curve in such a way that at P the y -coordinate is increasing at 4 units per second and the x -coordinate is increasing at 6 units per second.

Find the x -coordinate of P .

[4]

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[illegible][illegible]

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Topical questions | 121 questions

52. Question part 2/2 | 9709 Feb-March 2020 P1 V2 Q10

(c) Find the equation of the curve.

[4]

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Topical questions | 121 questions

9 The equation of a curve is $y = (3 - 2x)^3 + 24x$.

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Topical questions | 121 questions

53. Question part 2/2 | 9709 May-June 2020 P1 V1 Q9

(b) Find the coordinates of each of the stationary points on the curve.

[3]

[illegible]

(c) Determine the nature of each stationary point.

[2]

[illegible]

[illegible]

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55. Question | 9709 May-June 2020 P1 V2 Q10

10 The equation of a curve is $y = 54x - (2x - 7)^3$.

(a) Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$. [4]

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(b) Find the coordinates of each of the stationary points on the curve. [3]

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(c) Determine the nature of each of the stationary points. [2]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

56. Question part 1/2 | 9709 May-June 2020 P1 V3 Q6

- 6** A point P is moving along a curve in such a way that the x -coordinate of P is increasing at a constant rate of 2 units per minute. The equation of the curve is $y = (5x - 1)^{\frac{1}{2}}$.
- (a)** Find the rate at which the y -coordinate is increasing when $x = 1$. [4]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

56. Question part 2/2 | 9709 May-June 2020 P1 V3 Q6

- (b)** Find the value of x when the y -coordinate is increasing at $\frac{5}{8}$ units per minute. [3]

[illegible]

Topical questions | 121 questions

3 Air is being pumped into a balloon in the shape of a sphere so that its volume is increasing at a constant rate of $50 \text{ cm}^3 \text{ s}^{-1}$.

Find the rate at which the radius of the balloon is increasing when the radius is 10 cm. [3]

[illegible]

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Topical questions | 121 questions

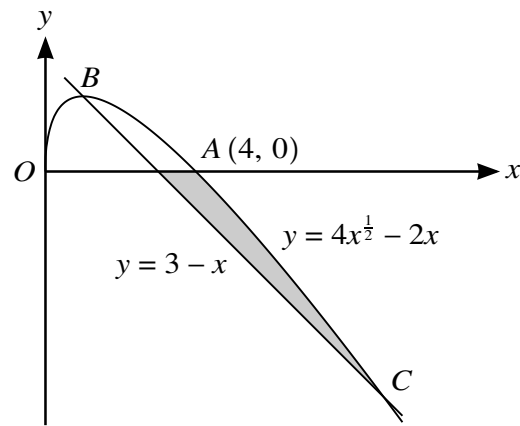
58. Question | 9709 Oct-Nov 2020 P1 V1 Q6

6 The equation of a curve is $y = 2 + \sqrt{25 - x^2}$.

Find the coordinates of the point on the curve at which the gradient is $\frac{4}{3}$. [5]

[illegible]

12



The diagram shows a curve with equation $y = 4x^{\frac{1}{2}} - 2x$ for $x \geq 0$, and a straight line with equation $y = 3 - x$. The curve crosses the x -axis at $A (4, 0)$ and crosses the straight line at B and C .

- (a) Find, by calculation, the x -coordinates of B and C . [4]

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- (b) Show that B is a stationary point on the curve. [2]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

59. Question part 2/3 | 9709 Oct-Nov 2020 P1 V1 Q12

(c) Find the area of the shaded region.

[6]

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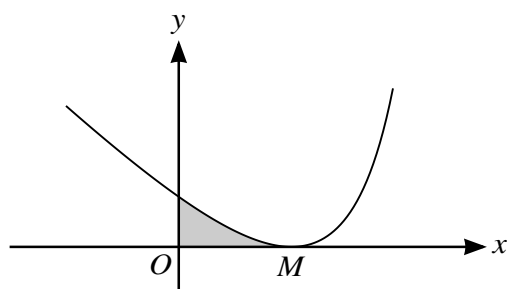
[illegible]

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- Find the rate of increase of the y -coordinate when $x = 4$. [3]

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- [illegible]



(a) Find expressions for $\frac{dy}{dx}$, $\frac{d^2y}{dx^2}$ and $\int y \, dx$. [6]

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Topical questions | 121 questions

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- [illegible]

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Topical questions | 121 questions

62. Question part 1/2 | 9709 Oct-Nov 2020 P1 V3 Q8

8 The equation of a curve is $y = 2x + 1 + \frac{1}{2x+1}$ for $x > -\frac{1}{2}$.

(a) Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$. [3]

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Topical questions | 121 questions

62. Question part 2/2 | 9709 Oct-Nov 2020 P1 V3 Q8

(b) Find the coordinates of the stationary point and determine the nature of the stationary point. [5]

[illegible]

Topical questions | 121 questions

10 A curve has equation $y = \frac{1}{k}x^{\frac{1}{2}} + x^{-\frac{1}{2}} + \frac{1}{k^2}$ where $x > 0$ and k is a positive constant.

- Find the value of k . [4]

[illegible]

Topical questions | 121 questions

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Find the value of k .

[5]

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Topical questions | 121 questions

64. Question part 1/2 | 9709 Feb-March 2021 P1 V2 Q6

- 6** A curve is such that $\frac{dy}{dx} = \frac{6}{(3x-2)^3}$ and $A(1, -3)$ lies on the curve. A point is moving along the curve and at A the y -coordinate of the point is increasing at 3 units per second.

- (a) Find the rate of increase at A of the x -coordinate of the point. [3]

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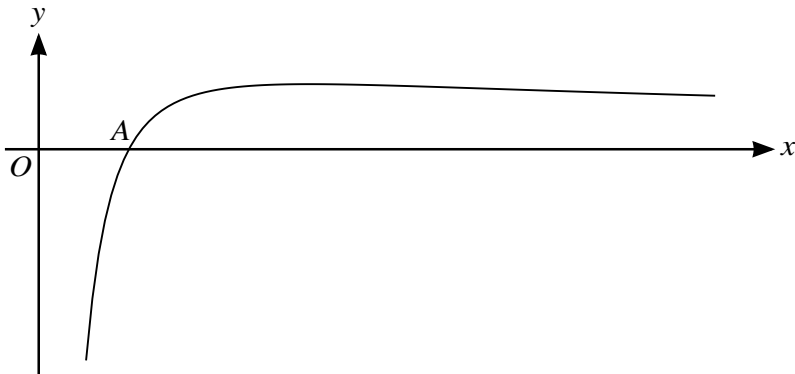
64. Question part 2/2 | 9709 Feb-March 2021 P1 V2 Q6

(b) Find the equation of the curve.

[4]

[illegible]

11



The diagram shows the curve with equation $y = 9(x^{-\frac{1}{2}} - 4x^{-\frac{3}{2}})$. The curve crosses the x -axis at the point A .

(a) Find the x -coordinate of A . [2]

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(b) Find the equation of the tangent to the curve at A . [4]

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[2]

- (d)** Find the area of the region bounded by the curve, the x -axis and the line $x = 9$.

[4]

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[2]

[illegible]

- (d) Find the exact area of the region bounded by the curve, the x -axis and the lines $x = 0$ and $x = 4$. [4]

[illegible]

Additional Page

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[illegible]

67. Question | 9709 May-June 2021 P1 V2 Q3

3 The equation of a curve is $y = (x - 3)\sqrt{x + 1} + 3$. The following points lie on the curve. Non-exact values are rounded to 4 decimal places.

$A(2, k)$ $B(2.9, 2.8025)$ $C(2.99, 2.9800)$ $D(2.999, 2.9980)$ $E(3, 3)$

(a) Find k , giving your answer correct to 4 decimal places. [1]

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(b) Find the gradient of AE , giving your answer correct to 4 decimal places. [1]

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The gradients of BE , CE and DE , rounded to 4 decimal places, are 1.9748, 1.9975 and 1.9997 respectively.

(c) State, giving a reason for your answer, what the values of the four gradients suggest about the gradient of the curve at the point E . [2]

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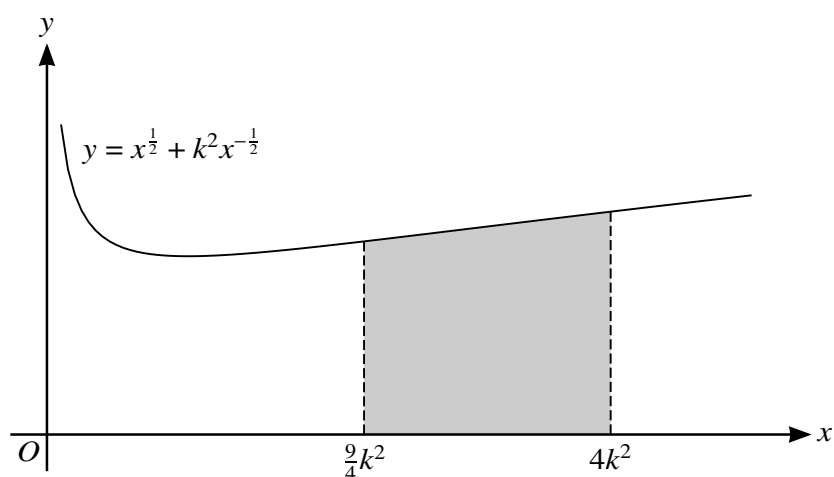
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(a) Find the coordinates of the minimum point of the curve, giving your answer in terms of k . [4]

[illegible]

[illegible]

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Topical questions | 121 questions

69. Question part 1/2 | 9709 Oct-Nov 2021 P1 V2 Q9

- 9** The volume $V \text{ m}^3$ of a large circular mound of iron ore of radius $r \text{ m}$ is modelled by the equation $V = \frac{3}{2}\left(r - \frac{1}{2}\right)^3 - 1$ for $r \geq 2$. Iron ore is added to the mound at a constant rate of 1.5 m^3 per second.
- (a)** Find the rate at which the radius of the mound is increasing at the instant when the radius is 5.5 m . [3]

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Topical questions | 121 questions

(b) Find the volume of the mound at the instant when the radius is increasing at 0.1 m per second. [3]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

70. Question part 1/2 | 9709 Oct-Nov 2021 P1 V2 Q10

10 The function f is defined by $f(x) = x^2 + \frac{k}{x} + 2$ for $x > 0$.

(a) Given that the curve with equation $y = f(x)$ has a stationary point when $x = 2$, find k . [3]

[illegible]

Topical questions | 121 questions

(b) Determine the nature of the stationary point.

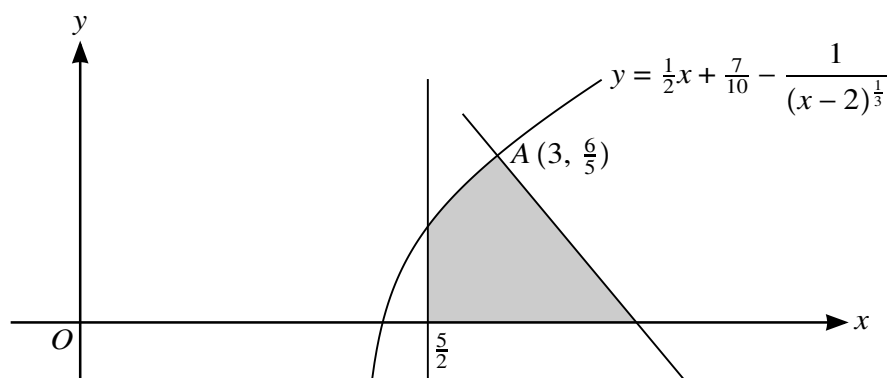
[2]

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(c) Given that this is the only stationary point of the curve, find the range of f .

[2]

[illegible]



The diagram shows the line $x = \frac{5}{2}$, part of the curve $y = \frac{1}{2}x + \frac{7}{10} - \frac{1}{(x-2)^{\frac{1}{3}}}$ and the normal to the curve at the point A $(3, \frac{6}{5})$.

- (a) Find the x -coordinate of the point where the normal to the curve meets the x -axis. [5]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

71. Question part 2/2 | 9709 Oct-Nov 2021 P1 V2 Q11

(b) Find the area of the shaded region, giving your answer correct to 2 decimal places.

[6]

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[illegible]

- Determine whether f is an increasing function, a decreasing function or neither. [3]

[illegible]

10 A curve has equation $y = f(x)$ and it is given that

$$f'(x) = \left(\frac{1}{2}x + k\right)^{-2} - (1 + k)^{-2},$$

where k is a constant. The curve has a minimum point at $x = 2$.

(a) Find $f''(x)$ in terms of k and x , and hence find the set of possible values of k . [3]

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It is now given that $k = -3$ and the minimum point is at $(2, 3\frac{1}{2})$.

(b) Find $f(x)$. [4]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

73. Question part 2/3 | 9709 Oct-Nov 2021 P1 V3 Q10

[illegible]

- (c)** Find the coordinates of the other stationary point and determine its nature. [4]

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Topical questions | 121 questions

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(a) Find, in terms of k , the values of x at which there is a stationary point. [4]

[illegible]

$$f(x) = 4(3x - 4)^{-1} + 3x \quad \text{for } x \geq \frac{3}{7}.$$

- [illegible]

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9 The equation of a curve is $y = 3x + 1 - 4(3x + 1)^{\frac{1}{2}}$ for $x > -\frac{1}{3}$.

(a) Find $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$. [3]

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9709 Mathematics Paper 1 - Differentiation

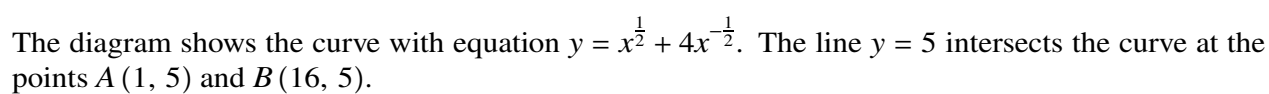
Topical questions | 121 questions

75. Question part 2/2 | 9709 May-June 2022 P1 V2 Q9

(b) Find the coordinates of the stationary point of the curve and determine its nature.

[4]

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Topical questions | 121 questions

(b) Calculate the area of the shaded region.

[4]

[illegible]

Topical questions | 121 questions

11 The point P lies on the line with equation $y = mx + c$, where m and c are positive constants. A curve has equation $y = -\frac{m}{x}$. There is a single point P on the curve such that the straight line is a tangent to the curve at P .

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

77. Question part 2/3 | 9709 May-June 2022 P1 V3 Q11

The normal to the curve at P intersects the curve again at the point Q .

(b) Find the coordinates of Q in terms of m .

[4]

[illegible]

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[illegible]

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3 A curve has equation $y = ax^{\frac{1}{2}} - 2x$, where $x > 0$ and a is a constant. The curve has a stationary point at the point P , which has x -coordinate 9.

Find the y -coordinate of P . [5]

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8 The function f is defined by $f(x) = 2 - \frac{3}{4x-p}$ for $x > \frac{p}{4}$, where p is a constant.

- [illegible]

(b) Express $f^{-1}(x)$ in the form $\frac{p}{a} - \frac{b}{cx-d}$, where a, b, c and d are integers. [4]

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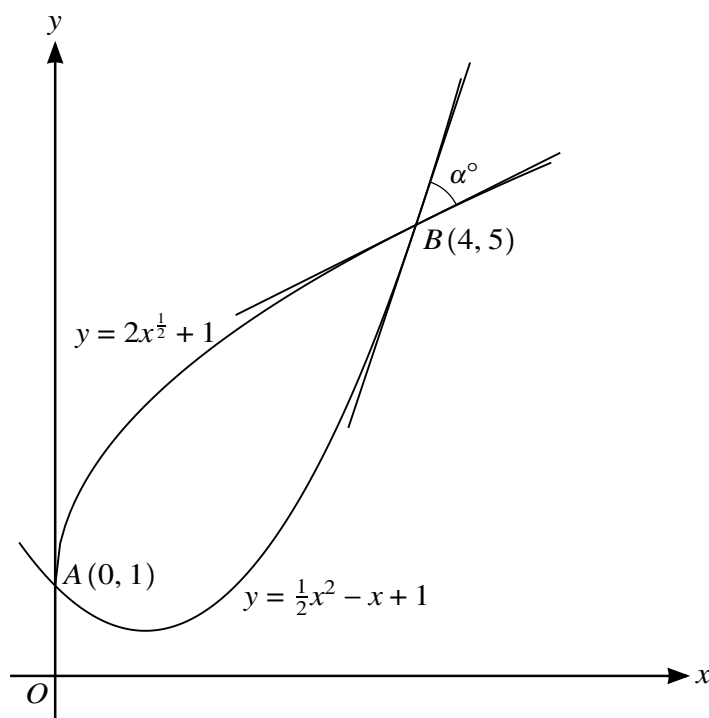
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(c) Hence state the value of p for which $f^{-1}(x) \equiv f(x)$. [1]

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(a) Find the area of the region between the two curves. [5]

[illegible]

Topical questions | 121 questions

(b) Find α . [5]

[illegible]

Topical questions | 121 questions

4 A large industrial water tank is such that, when the depth of the water in the tank is x metres, the volume $V \text{ m}^3$ of water in the tank is given by $V = 243 - \frac{1}{3}(9 - x)^3$. Water is being pumped into the tank at a constant rate of 3.6 m^3 per hour.

Find the rate of increase of the depth of the water when the depth is 4m, giving your answer in cm per minute. [5]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

82. Question part 1/2 | 9709 Oct-Nov 2022 P1 V3 Q7

7 The curve $y = f(x)$ is such that $f'(x) = \frac{-3}{(x+2)^4}$.

(a) The tangent at a point on the curve where $x = a$ has gradient $-\frac{16}{27}$.

Find the possible values of a .

[4]

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82. Question part 2/2 | 9709 Oct-Nov 2022 P1 V3 Q7

(b) Find $f(x)$ given that the curve passes through the point $(-1, 5)$.

[3]

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3 A curve has equation $y = \frac{1}{60}(3x + 1)^2$ and a point is moving along the curve.

Find the x -coordinate of the point on the curve at which the x - and y -coordinates are increasing at the same rate. [4]

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5 The line with equation $y = kx - k$, where k is a positive constant, is a tangent to the curve with equation $y = -\frac{1}{2x}$.

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85. Question part 1/2 | 9709 May-June 2023 P1 V1 Q9

- 9 Water is poured into a tank at a constant rate of 500 cm^3 per second. The depth of water in the tank, t seconds after filling starts, is h cm. When the depth of water in the tank is h cm, the volume, $V\text{ cm}^3$, of water in the tank is given by the formula $V = \frac{4}{3}(25 + h)^3 - \frac{62500}{3}$.

- (a) Find the rate at which h is increasing at the instant when $h = 10$ cm. [3]

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85. Question part 2/2 | 9709 May-June 2023 P1 V1 Q9

(b) At another instant, the rate at which h is increasing is 0.075 cm per second.

Find the value of V at this instant.

[3]

[illegible]

Topical questions | 121 questions

11 The equation of a curve is such that $\frac{dy}{dx} = 6x^2 - 30x + 6a$, where a is a positive constant. The curve has a stationary point at $(a, -15)$.

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[illegible]

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Topical questions | 121 questions

86. Question part 2/2 | 9709 May-June 2023 P1 V1 Q11

(c) Find the equation of the curve.

[3]

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(d) Find the coordinates of any other stationary points on the curve.

[2]

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$$y = k\sqrt{4x + 1} - x + 5,$$

where k is a positive constant.

(a) Find $\frac{dy}{dx}$. [2]

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(b) Find the x -coordinate of the stationary point in terms of k . [2]

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87. Question part 2/3 | 9709 May-June 2023 P1 V2 Q11

- (c) Given that $k = 10.5$, find the equation of the normal to the curve at the point where the tangent to the curve makes an angle of $\tan^{-1}(2)$ with the positive x -axis. [4]

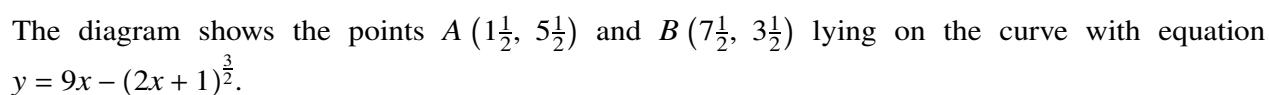
[illegible]

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- [illegible]

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- [illegible]

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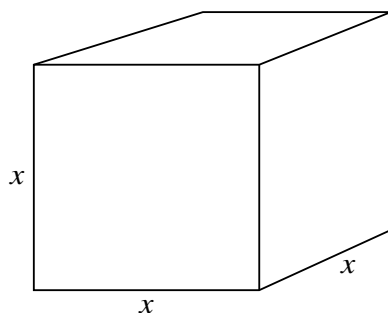
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[illegible]

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Find the rate of increase of V when $x = 20$. [3]

[illegible]

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Topical questions | 121 questions

90. Question part 1/2 | 9709 Oct-Nov 2023 P1 V1 Q10

10 A curve has a stationary point at $(2, -10)$ and is such that $\frac{d^2y}{dx^2} = 6x$.

(a) Find $\frac{dy}{dx}$. [3]

[illegible]

(b) Find the equation of the curve. [3]

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- (d) Find the equation of the tangent to the curve at the point where the curve crosses the y-axis. [2]

[illegible]

Topical questions | 121 questions

10 The equation of a curve is $y = f(x)$, where $f(x) = (4x - 3)^{\frac{5}{3}} - \frac{20}{3}x$.

- (a)** Find the x -coordinates of the stationary points of the curve and determine their nature. [6]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

91. Question part 2/2 | 9709 Oct-Nov 2023 P1 V2 Q10

[illegible]

(b) State the set of values for which the function f is increasing.

[1]

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9 A curve has equation $y = 2x^{\frac{1}{2}} - 1$.

- (a)** Find the equation of the normal to the curve at the point $A(4, 3)$, giving your answer in the form $y = mx + c$. [3]

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A point is moving along the curve $y = 2x^{\frac{1}{2}} - 1$ in such a way that at A the rate of increase of the x -coordinate is 3 cm s^{-1} .

- (b)** Find the rate of increase of the y -coordinate at A . [2]

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At A the moving point suddenly changes direction and speed, and moves down the normal in such a way that the rate of decrease of the y -coordinate is constant at 5 cm s^{-1} .

- (c)** As the point moves down the normal, find the rate of change of its x -coordinate. [3]

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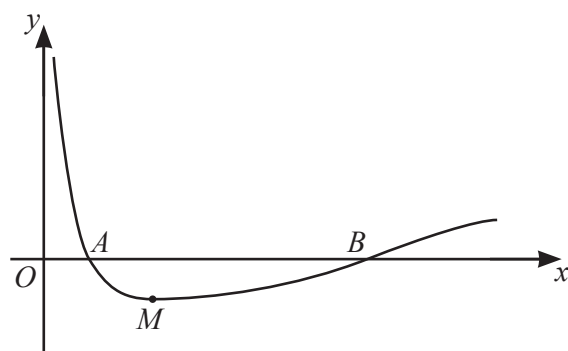
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5 A curve has the equation $y = \frac{3}{2x^2 - 5}$.

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(a) Find the exact coordinates of M . [4]

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9709 Mathematics Paper 1 - Differentiation

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94. Question part 2/3 | 9709 Feb-March 2024 P1 V2 Q11

(b) Find the area of the region bounded by the curve and the line segment AB .

[7]

[illegible]

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[illegible]

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4 The equation of a curve is $y = f(x)$, where $f(x) = (2x - 1)\sqrt{3x - 2} - 2$. The following points lie on the curve. Non-exact values have been given correct to 5 decimal places.

$A(2, 4)$, $B(2.0001, k)$, $C(2.001, 4.00625)$, $D(2.01, 4.06261)$, $E(2.1, 4.63566)$, $F(3, 11.22876)$

(a) Find the value of k . Give your answer correct to 5 decimal places. [1]

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The table shows the gradients of the chords AB , AC , AD and AF .

Chord	AB	AC	AD	AE	AF
Gradient of chord	6.2501	6.2511	6.2608		7.2288

(b) Find the gradient of the chord AE . Give your answer correct to 4 decimal places. [1]

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(c) Deduce the value of $f'(2)$ using the values in the table. [1]

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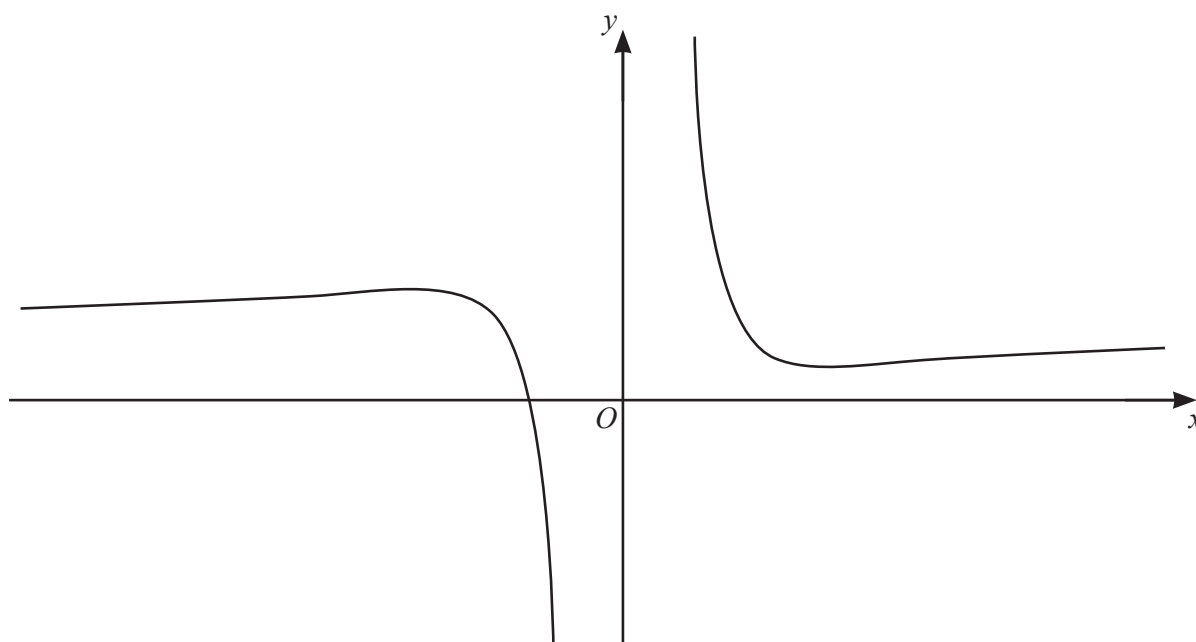
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(a) Find the set of values of x for which $f(x)$ is decreasing. [5]

[illegible]

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Topical questions | 121 questions

96. Question part 2/3 | 9709 May-June 2024 P1 V1 Q11

- (b) A triangle is bounded by the y -axis, the normal to the curve at the point where $x = 1$ and the tangent to the curve at the point where $x = -1$.

Find the area of the triangle. Give your answer correct to 3 significant figures. [8]

[illegible]

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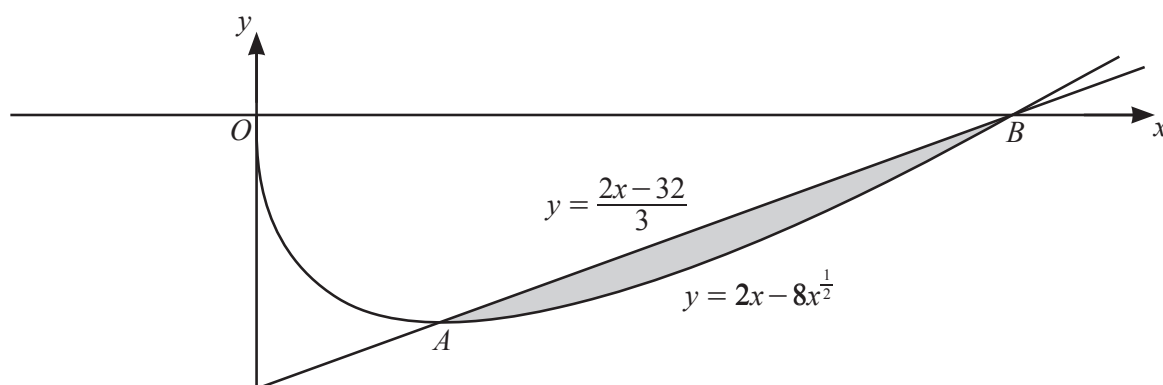
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97. Question part 1/2 | 9709 May-June 2024 P1 V2 Q6

- 6** The curve with equation $y = 2x - 8x^{\frac{1}{2}}$ has a minimum point at A and intersects the positive x -axis at B .

(a) Find the coordinates of A and B . [4]

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Find the area of the shaded region between the curve and the line.

[5]

[illegible]

(a) Determine the set of values of x for which $f(x)$ is decreasing. [4]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

98. Question part 2/2 | 9709 May-June 2024 P1 V2 Q9

(b) Given that $f(1) = -1$, find $f(x)$.

[4]

[illegible]

- Find the rate at which the x -coordinate of point P is increasing when $y = 32$. [4]

[illegible]

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Topical questions | 121 questions

99. Question part 2/3 | 9709 May-June 2024 P1 V2 Q10

- (b)** Point A on the curve has y -coordinate 32. Point B on the curve is such that the gradient of the curve at B is -3 .

Find the equation of the perpendicular bisector of AB . Give your answer in the form $ax + by + c = 0$, where a , b and c are integers. [6]

[illegible]

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5 The equation of a curve is $y = 2x^2 - \frac{1}{2x} + 3$.

(a) Find the coordinates of the stationary point. [3]

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(b) Determine the nature of the stationary point. [2]

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(c) For positive values of x , determine whether the curve shows a function that is increasing, decreasing or neither. Give a reason for your answer. [2]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

101. Question | 9709 Oct-Nov 2024 P1 V1 Q2

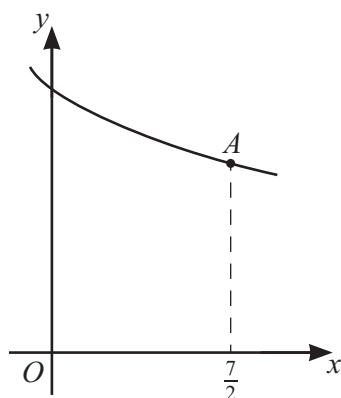
- 2** The curve $y = x^2 - \frac{a}{x}$ has a stationary point at $(-3, b)$.

Find the values of the constants a and b .

[4]

[illegible]

7



(a) Find the equation of the tangent to the curve at A . Give your answer in the form $y = mx + c$. [4]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

102. Question part 2/2 | 9709 Oct-Nov 2024 P1 V1 Q7



- (b)** Find the area of the region bounded by the curve and the lines $x = 0$, $x = \frac{7}{2}$ and $y = 0$. [4]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

103. Question part 1/2 | 9709 Oct-Nov 2024 P1 V1 Q9

9 The equation of a curve is $y = 4 + 5x + 6x^2 - 3x^3$.

(a) Find the set of values of x for which y decreases as x increases.

[4]

[illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

103. Question part 2/2 | 9709 Oct-Nov 2024 P1 V1 Q9



- (b)** It is given that $y = 9x + k$ is a tangent to the curve.

Find the value of the constant k .

[4]

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3 The equation of a curve is $y = 2x^2 - 3$. Two points A and B with x -coordinates 2 and $(2 + h)$ respectively lie on the curve.

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105. Question part 1/3 | 9709 Oct-Nov 2024 P1 V2 Q10

(a) Find the equation of the normal to the curve at the point $(1, 0)$. [3]

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(b) Find $f(x)$. [4]

[illegible]

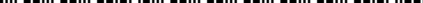
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$$125x^2 - 128x + 192 = 0.$$

- (c) Determine, making your reasoning clear, whether f is an increasing function, a decreasing function or neither. [3]

[illegible]

Topical questions | 121 questions



If you use the following page to complete the answer to any question, the question number must be clearly shown.

[illegible]

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11 The equation of a curve is $y = kx^{\frac{1}{2}} - 4x^2 + 2$, where k is a constant.

- [illegible]

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- Find this value of k . [6]

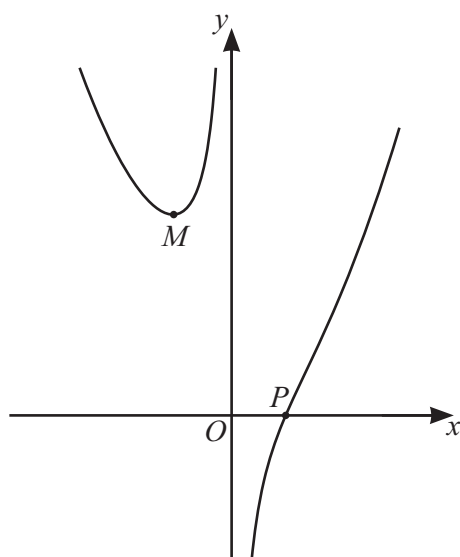
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If you use the following lined page to complete the answer(s) to any question(s), the question number(s) must be clearly shown.

[illegible]



(a) Find the gradient of the curve at P . [2]

[illegible]

(b) Find the coordinates of M . Give each coordinate correct to 3 significant figures. [3]

[illegible]

Topical questions | 121 questions

2 The equation of a curve is such that $\frac{dy}{dx} = 4(2x-5)^3 - 9x^{\frac{1}{2}}$. The curve passes through the point $A\left(4, -\frac{11}{2}\right)$.

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[illegible]

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7 The equation of a curve is $y = 4x^2 + \frac{9}{x^2} - 8$.

- Find the rate at which the x -coordinate of point P is changing when $x = 2$. [4]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

109. Question part 2/2 | 9709 May-June 2025 P1 V1 Q7



(b) Find the coordinates of the stationary points of the curve and determine their nature.

[5]

[illegible]

Topical questions | 121 questions

4 A point P is moving along the curve with equation $y = ax^{\frac{3}{2}} - 12x$ in such a way that the x -coordinate of P is increasing at a constant rate of 5 units per second.

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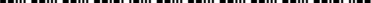
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Topical questions | 121 questions

9 The equation of a curve is such that $\frac{d^2y}{dx^2} = -\frac{24}{x^3}$. It is given that the curve has a stationary point at $(-2, 19)$.

[illegible]

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- [illegible]

- [illegible]

9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

112. Question | 9709 May-June 2025 P1 V3 Q1

1 A curve has equation $y = 2x + \frac{12}{x^2}$.

Find the equation of the tangent to the curve at the point $(-2, -1)$. Give your answer in the form $y = mx + c$. [4]

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114. Question part 1/2 | 9709 May-June 2025 P1 V3 Q10

10 A curve C has equation $y = \frac{9}{2x-5} + 2x - 5$.

(a) Find the coordinates of the two stationary points. [4]

[illegible]

(b) Find $\frac{d^2y}{dx^2}$ and hence determine the nature of each stationary point. [3]

[illegible]



(c) The curve C is transformed to the curve C_1 using a translation of $\begin{pmatrix} -3 \\ 7 \end{pmatrix}$ followed by reflection in the x -axis.

(i) State the coordinates of the maximum point of C_1 . [1]

[illegible]

(ii) Find the equation of C_1 in the form $y = \frac{a}{bx+c} + dx + e$, where a, b, c, d and e are integers. [3]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

115. Question part 1/2 | 9709 May-June 2025 P1 V5 Q8

- 8** The equation of a curve is $y = x^3 + ax^2 + bx + 5$. The curve has a stationary point at $(1, 9)$.

- (a) Find the values of the constants a and b . [5]

[illegible]

- [3]

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- [3]

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$$\frac{dy}{dx} = \frac{8}{x^2} - \frac{10}{(2x-3)^2}.$$

-
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- [illegible]

Topical questions | 121 questions

[illegible]

Topical questions | 121 questions



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Topical questions | 121 questions

117. Question | 9709 Oct-Nov 2025 P1 V2 Q4

- 4** The equation of a curve is such that $\frac{dy}{dx} = kx^3 + \frac{2}{x^2}$, where k is a constant. The curve passes through the point $S(2, 20)$ and the gradient of the curve at S is $\frac{65}{2}$.

(a) Find the value of k . [1]

- (b)** The coordinates of a point T on the curve are $(1, t)$.

Find the value of t . [5]

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- [illegible]

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(c) Find the range of g in terms of the constant a . [1]

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119. Question | 9709 Oct-Nov 2025 P1 V3 Q3

- 3
- The equation of a curve is $y = f(x)$, where $f(x) = \frac{1}{2}x^{\frac{2}{3}}(x - 2)^2$. The following points lie on the curve. Non-exact values of the y -coordinates are given correct to 6 decimal places.

$A(8, 72), B(8.001, k), C(8.01, 72.300388), D(8.1, 75.038882)$

- (a)
- Find the value of k . Give your answer correct to 6 decimal places.
- [1]

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The table below shows the gradients of the chords AB and AC , given correct to 4 decimal places.

Chord	AB	AC	AD
Gradient of chord	30.0039	30.0388	

- (b)
- Find the gradient of the chord AD . Give your answer correct to 4 decimal places.
- [1]

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- (c)
- State what the values in the table suggest about the value of $f'(8)$.
- [1]

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9709 Mathematics Paper 1 - Differentiation

Topical questions | 121 questions

120. Question part 1/3 | 9709 Oct-Nov 2025 P1 V3 Q11

11 The equation of a curve is $y = \frac{8}{3x-8} - \frac{6}{x-1}$.

(a) Find the coordinates of the point at which the tangent to the curve at the point $(3, 5)$ intersects the line $y = -8x$. [6]

[illegible]

[3]

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[4]

[illegible]



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[illegible]

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

A diagram of a cylinder. A horizontal line segment from the center of the top circular face to its edge is labeled $r\text{ cm}$. A vertical line segment along the right side of the cylinder, representing its height, is labeled $h\text{ cm}$.

(a) Show that the volume, $V\text{cm}^3$, of the tank is given by

$$V = \frac{\pi r(600 - r^2)}{2}.$$

[3]

[illegible]

This image shows a full page of white paper with horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.

[illegible]