adamjee maths

A-LEVEL MATHS / EDEXCEL / FREE RESOURCES

Algebra and functions

Question paper

23 questions

Exam questions and marking instructions remain credited to their board.

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1. The point $P(6, -4)$ lies on the curve with equation $y = f(x), x \in \mathbb{R}$

Find the point to which P is mapped when the curve with equation $y = f(x)$ is transformed to the curve with equation

(a) $y = f(x + 2)$

(1)

(b) $y = f^{-1}(x)$

(1)

(c) $y = 2|f(x)| - 3$

(2)

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Question 1 continued

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6. A scientist is monitoring the flight of sea birds after they leave their nests on a cliff.

The height above the sea, h metres, of one of the birds is modelled by the equation

$$h = A - B\,t^{1.5} \qquad h \geqslant 0 \qquad 0 \leqslant t \leqslant T$$

where t seconds is the time after the bird leaves its nest and A, B and T are positive constants.

Given that

- the bird was 17.6 m above the sea exactly 4 seconds after leaving its nest
- the bird was 11.9 m above the sea exactly 9 seconds after leaving its nest

(a) find a complete equation for the model.

(4)

Find, according to the model,

(b) the height of the bird's nest above the sea,

(1)

(c) the limitation on the value of T.

(2)

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Question 6 continued

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Question 6 continued

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1. **In this question you must show all stages of your working.**
Solutions relying on calculator technology are not acceptable.

Factorise completely

$$2x^3 - 24x^2 + 40x$$

(3)

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Question 1 continued

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7. Given that

$$\frac{3x^3 - 8x^2 - 6x - 11}{(x+1)(x-3)} \equiv Ax + B + \frac{C}{x+1} + \frac{D}{x-3} \qquad x \in \mathbb{R} \quad x \neq -1, 3$$

find the value of each of the constants A, B, C and D.

(4)

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Question 7 continued

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11. A company is trying to determine the most profitable selling price for a new toy.

Given that

- if the selling price of each toy is £30, the company expects to sell 1500 toys in one year
- if the selling price of each toy is £50, the company expects to sell 300 toys in one year

Using a **linear** model, with y being the expected number of toys sold in one year and x pounds being the selling price of the toy,

(a) find an equation for y in terms of x.

(3)

Given that

- the cost of making each toy is £10
- the company has additional costs of £8 000 per year

(b) show that, according to the model, the yearly profit, P, in **thousands** of pounds, is given by

$$P = -0.06x^2 + 3.9x - 41$$

(3)

Use the model given in part (b) to answer parts (c), (d) and (e).

Given that the company wishes to make a profit on sales of the toy,

(c) find the range of possible selling prices of the toy.

(2)

(d) Hence, or otherwise, deduce the selling price of the toy that maximises the profit.

(1)

In one particular year, the company sold the toy for £35 and made £21 750 profit.

(e) Use this information to evaluate the suitability of the model.

(2)

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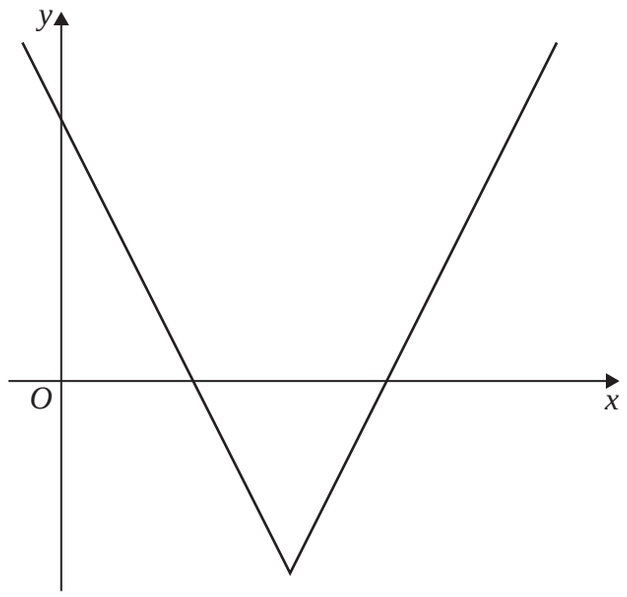


Figure 3

Figure 3 shows a sketch of the graph with equation $y = \mathrm{f}(x)$ where

$$\mathrm{f}(x) = 4\left|x - 3\right| - 5 \qquad x \in \mathbb{R}$$

Given that a is a constant and $\left|a\right| = 1$

(a) find the possible values of $\mathrm{f}(a)$

(2)

The function g is defined by

$$\mathrm{g}(x) = 2x + 17 \qquad x \in \mathbb{R}$$

(b) Find the range of $\mathrm{g}\,\mathrm{f}(x)$

(2)

The function h is defined by

$$\mathrm{h}(x) = kx \qquad x \in \mathbb{R}$$

where k is a constant.

Given that the equation $\mathrm{f}(x) = \mathrm{h}(x)$ has no solutions,

(c) find the range of values of k.

(4)

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Question 12 continued

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1. $g(x) = 3x^3 - 20x^2 + (k + 17)x + k$

where k is a constant.

Given that $(x - 3)$ is a factor of $g(x)$, find the value of k.

(3)

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Question 1 continued

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5. The function f is defined by

$$f(x) = \frac{2x - 3}{x^2 + 4} \qquad x \in \mathbb{R}$$

(a) Show that

$$f'(x) = \frac{ax^2 + bx + c}{\left(x^2 + 4\right)^2}$$

where a, b and c are constants to be found.

(3)

(b) Hence, using algebra, find the values of x for which f is decreasing.
You must show each step in your working.

(3)

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Question 5 continued

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3. The point $P(3, -2)$ lies on the curve with equation $y = f(x)$, $x \in \mathbb{R}$

Find the coordinates of the point to which P is mapped when the curve with equation $y = f(x)$ is transformed to the curve with equation

(i) $y = f(x - 2)$

(ii) $y = f(2x)$

(iii) $y = 3f(-x) + 5$

(4)

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Question 3 continued

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2. **In this question you must show all stages of your working.**

Solutions relying entirely on calculator technology are not acceptable.

$$f(x) = 4x^3 + 5x^2 - 10x + 4a \qquad x \in \mathbb{R}$$

where a is a positive constant.

Given $(x - a)$ is a factor of $f(x)$,

(a) show that

$$a(4a^2 + 5a - 6) = 0$$

(2)

(b) Hence

(i) find the value of a

(ii) use algebra to find the exact solutions of the equation

$$f(x) = 3$$

(4)

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Question 2 continued

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2. $f(x) = (x - 4)(x^2 - 3x + k) - 42$ where k is a constant

Given that $(x + 2)$ is a factor of $f(x)$, find the value of k.

(3)

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Question 2 continued

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5. The height, h metres, of a tree, t years after being planted, is modelled by the equation

$$h^2 = at + b \qquad 0 \leqslant t < 25$$

where a and b are constants.

Given that

- the height of the tree was 2.60 m, exactly 2 years after being planted
- the height of the tree was 5.10 m, exactly 10 years after being planted

(a) find a complete equation for the model, giving the values of a and b to 3 significant figures.

(4)

Given that the height of the tree was 7 m, exactly 20 years after being planted

(b) evaluate the model, giving reasons for your answer.

(2)

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Question 5 continued

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10. The function f is defined by

$$f(x) = \frac{8x + 5}{2x + 3} \qquad x > -\frac{3}{2}$$

(a) Find $f^{-1}\left(\frac{3}{2}\right)$

(2)

(b) Show that

$$f(x) = A + \frac{B}{2x + 3}$$

where A and B are constants to be found.

(2)

The function g is defined by

$$g(x) = 16 - x^2 \qquad 0 \leqslant x \leqslant 4$$

(c) State the range of g^{-1}

(1)

(d) Find the range of $f\,g^{-1}$

(3)

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Question 10 continued

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1. $f(x) = ax^3 + 10x^2 - 3ax - 4$

Given that $(x - 1)$ is a factor of $f(x)$, find the value of the constant a.

You must make your method clear.

(3)

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Question 1 continued

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4. The function f is defined by

$$f(x) = \frac{3x - 7}{x - 2} \qquad x \in \mathbb{R}, x \neq 2$$

(a) Find $f^{-1}(7)$

(2)

(b) Show that $ff(x) = \frac{ax + b}{x - 3}$ where a and b are integers to be found.

(3)

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Question 4 continued

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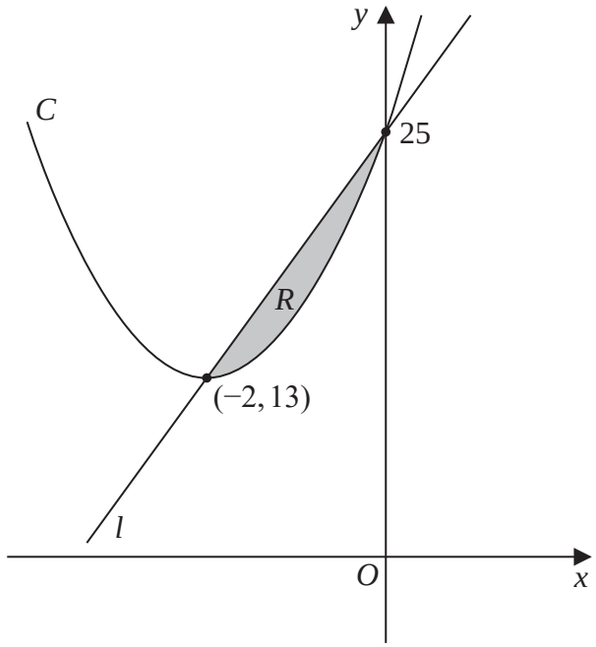


Figure 1

Figure 1 shows a sketch of a curve C with equation $y = f(x)$ and a straight line l.

The curve C meets l at the points $(-2, 13)$ and $(0, 25)$ as shown.

The shaded region R is bounded by C and l as shown in Figure 1.

Given that

- $f(x)$ is a quadratic function in x
- $(-2, 13)$ is the minimum turning point of $y = f(x)$

use inequalities to define R.

(5)

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1. $f(x) = 3x^3 + 2ax^2 - 4x + 5a$

Given that $(x + 3)$ is a factor of $f(x)$, find the value of the constant a.

(3)

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Question 1 continued

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5. $f(x) = 2x^2 + 4x + 9 \qquad x \in \mathbb{R}$

(a) Write $f(x)$ in the form $a(x + b)^2 + c$, where a, b and c are integers to be found.

(3)

(b) Sketch the curve with equation $y = f(x)$ showing any points of intersection with the coordinate axes and the coordinates of any turning point.

(3)

(c) (i) Describe fully the transformation that maps the curve with equation $y = f(x)$ onto the curve with equation $y = g(x)$ where

$$g(x) = 2(x - 2)^2 + 4x - 3 \qquad x \in \mathbb{R}$$

(ii) Find the range of the function

$$h(x) = \frac{21}{2x^2 + 4x + 9} \qquad x \in \mathbb{R}$$

(4)

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1. Given

$$2^x \times 4^y = \frac{1}{2\sqrt{2}}$$

express y as a function of x.

(3)

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Question 1 continued

(Total for Question 1 is 3 marks)

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7. A small factory makes bars of soap.

On any day, the total cost to the factory, £y, of making x bars of soap is modelled to be the sum of two separate elements:

- a fixed cost
- a cost that is proportional to the number of bars of soap that are made that day

(a) Write down a general equation linking y with x, for this model.

(1)

The bars of soap are sold for £2 each.

On a day when 800 bars of soap are made and sold, the factory makes a profit of £500

On a day when 300 bars of soap are made and sold, the factory makes a loss of £80

Using the above information,

(b) show that $y = 0.84x + 428$

(3)

(c) With reference to the model, interpret the significance of the value 0.84 in the equation.

(1)

Assuming that each bar of soap is sold on the day it is made,

(d) find the least number of bars of soap that must be made on any given day for the factory to make a profit that day.

(2)

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11. (a) Use binomial expansions to show that $\sqrt{\frac{1+4x}{1-x}} \approx 1+\frac{5}{2}x-\frac{5}{8}x^2$

(6)

A student substitutes $x=\frac{1}{2}$ into both sides of the approximation shown in part (a) in an attempt to find an approximation to $\sqrt{6}$

(b) Give a reason why the student **should not** use $x=\frac{1}{2}$

(1)

(c) Substitute $x=\frac{1}{11}$ into

$$\sqrt{\frac{1+4x}{1-x}}=1+\frac{5}{2}x-\frac{5}{8}x^2$$

to obtain an approximation to $\sqrt{6}$. Give your answer as a fraction in its simplest form.

(3)

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Answer ALL questions. Write your answers in the spaces provided.

1.

$$g(x) = \frac{2x + 5}{x - 3} \qquad x \geqslant 5$$

(a) Find gg(5).

(2)

(b) State the range of g.

(1)

(c) Find $g^{-1}(x)$, stating its domain.

(3)

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Question 1 continued

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11.

$$\frac{1+11x-6x^2}{(x-3)(1-2x)} \equiv A + \frac{B}{(x-3)} + \frac{C}{(1-2x)}$$

(a) Find the values of the constants A, B and C.

(4)

$$\mathrm{f}(x) = \frac{1+11x-6x^2}{(x-3)(1-2x)} \qquad x > 3$$

(b) Prove that $\mathrm{f}(x)$ is a decreasing function.

(3)

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