Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 1

Question:

Solve the following inequality

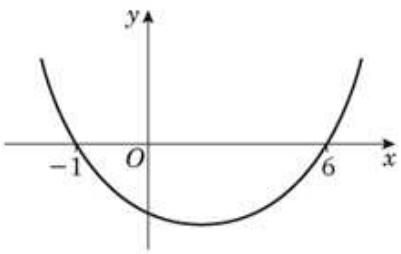
$x^2 < 5x + 6$

Solution:

$$x^2 - 5x - 6 < 0$$
$$(x - 6)(x + 1) < 0$$

critical values $x = -1$ or 6

sketch



solution is $-1 < x < 6$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 2

Question:

Solve the following inequality

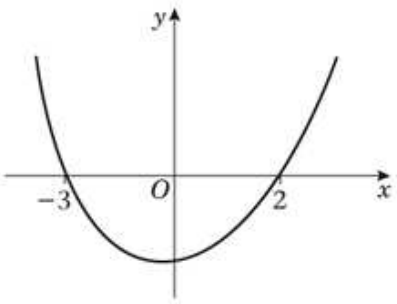
$x(x + 1) \geqslant 6$

Solution:

$$x^2 + x \geqslant 6$$
$$(x + 3)(x - 2) \geqslant 0$$

critical values $x = 2$ or -3

sketch



solution is $x \geqslant 2$ or $x \leqslant -3$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 3

Question:

Solve the following inequality

$$\frac{2}{x^2 + 1} > 1$$

Solution:

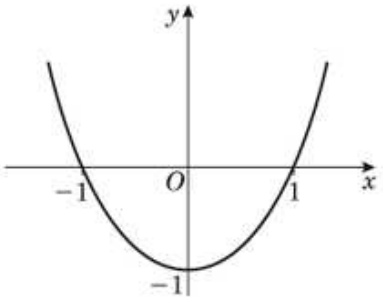
$2 > x^2 + 1$

$0 > x^2 - 1$

You can multiply by $x^2 + 1$ because it is always positive.

critical values $x = \pm 1$

sketch



solution is $-1 < x < 1$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 4

Question:

Solve the following inequality

$$\frac{2}{x^2 - 1} > 1$$

Solution:

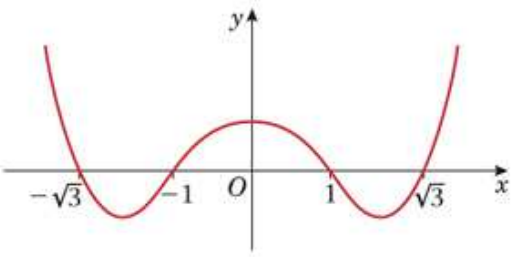
$$\frac{2}{\cancel{(x^2 - 1)}} \times (x^2 - 1)^2 > (x^2 - 1)^2$$

$$0 > (x^2 - 1)[x^2 - 1 - 2]$$

$$0 > (x - 1)(x + 1)(x - \sqrt{3})(x + \sqrt{3})$$

critical values $x = \pm 1, \pm\sqrt{3}$

sketch



solution is $-\sqrt{3} < x < -1$ or $1 < x < \sqrt{3}$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 5

Question:

Solve the following inequality

$\frac{x}{x-1} \leqslant 2x \quad x \neq 1$

Solution:

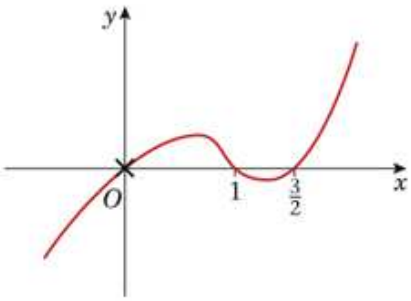
$\frac{x}{(x-1)} \times (x-1)^2 \leqslant 2x(x-1)^2$

$0 \leqslant x(x-1)[2x-2-1]$

$0 \leqslant x(x-1)(2x-3)$

critical values $x = 0, 1, \frac{3}{2}$

sketch



solution is $x > \frac{3}{2}$ or $0 < x < 1$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 6

Question:

Solve the following inequality

$$\frac{3}{x+1} < \frac{2}{x}$$

Solution:

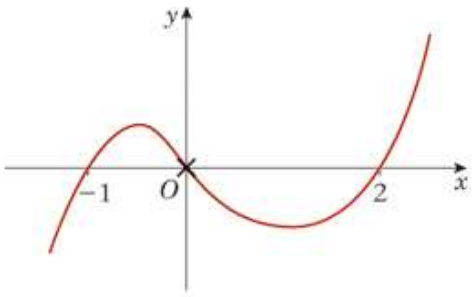
$$\frac{3}{\cancel{(x+1)}} \times (x+1)^{\cancel{2}}x^2 < \frac{2}{\cancel{x}} \times (x+1)^2x^{\cancel{2}}$$

$$x(x+1)[3x - 2(x+1)] < 0$$

$$x(x+1)(x-2) < 0$$

critical values $x = 0, -1, 2$

sketch



solution is $x < -1$ or $0 < x < 2$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 7

Question:

Solve the following inequality

$$\frac{3}{(x+1)(x-1)} < 1$$

Solution:

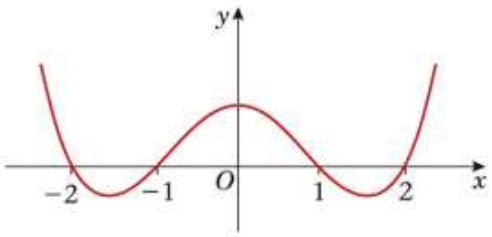
$$\frac{3}{(x+1)(x-1)} \times (x+1)^2(x-1)^2 < (x+1)^2(x-1)^2$$

$$0 < (x+1)(x-1)[x^2 - 1 - 3]$$

$$0 < (x+1)(x-1)(x-2)(x+2)$$

critical values $x = \pm 1, \pm 2$

sketch



solution is $x < -2$ or $-1 < x < 1$ or $x > 2$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 8

Question:

Solve the following inequality

$$\frac{2}{x^2} \geqslant \frac{3}{(x+1)(x-2)}$$

Solution:

$$\frac{2}{x^2} \times (x+1)^2(x-2)^2 \geqslant \frac{3(x+1)^{\cancel{2}}(x-2)^{\cancel{2}}}{\cancel{(x+1)(x-2)}}$$

$$(x+1)(x-2)[2x^2 - 2x - 4 - 3x^2] \geqslant 0$$

You can multiply across x^2 since it is positive.

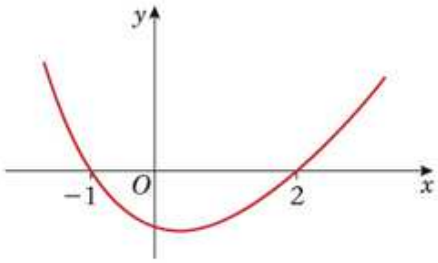
$$(x+1)(x-2)(-4 - 2x - x^2) \geqslant 0$$

or $$0 \geqslant (x+1)(x-2)(x^2 + 2x + 4)$$

$x^2 + 2x + 4$ has no real roots

$\therefore$ critical values $x = 2$ or -1

sketch



solution is $-1 < x < 2 \quad x \neq 0$

or $-1 < x < 0$ or $0 < x < 2$

NB $x = 2$ and $x = -1$, $x = 0$ are invalid in the original expression.

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Exercise A, Question 9

Question:

Solve the following inequality

$$\frac{2}{x-4} < 3$$

Solution:

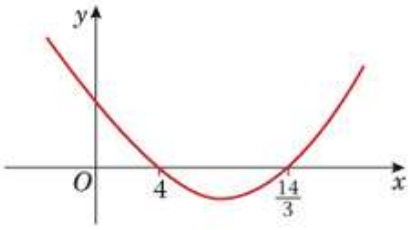
$$\frac{2}{x-4} \times (x-4)^2 < 3(x-4)^2$$

$$0 < (x-4)[3x-12-2]$$

$$0 < (x-4)(3x-14)$$

critical values $x = 4, \frac{14}{3}$

sketch



solution is $x < 4$ or $x > \frac{14}{3}$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 10

Question:

Solve the following inequality

$$\frac{3}{x+2} > \frac{1}{x-5}$$

Solution:

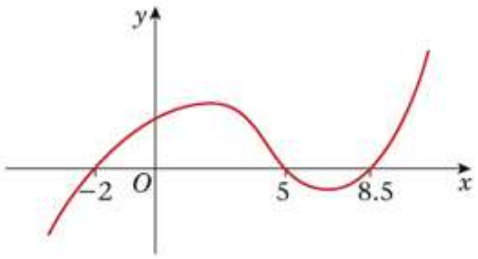
$$\frac{3}{\cancel{(x+2)}} \times (x+2)^2(x-5)^2 > \frac{1}{\cancel{(x-5)}} \times (x+2)^2(x-5)^2$$

$$(x+2)(x-5)[3x-15-(x+2)] > 0$$

$$(x+2)(x-5)(2x-17) > 0$$

critical values $x = -2, 5, 8.5$

sketch



solution is $-2 < x < 5$ or $x > 8.5$

Solutionbank FP2

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Exercise A, Question 11

Question:

Solve the following inequality

$$\frac{3x^2 + 5}{x + 5} > 1$$

Solution:

$$\frac{3x^2 + 5}{\cancel{(x+5)}} \times (x + 5)^{\cancel{2}} > (x + 5)^2$$

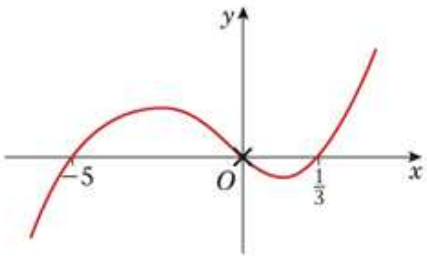
$$(x + 5)[3x^2 + 5 - (x + 5)] > 0$$

$$(x + 5)(3x^2 - x) > 0$$

$$(x + 5)x(3x - 1) > 0$$

critical values $x = 0, \frac{1}{3}, -5$

sketch



solution is $-5 < x < 0$ or $x > \frac{1}{3}$

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Exercise A, Question 12

Question:

Solve the following inequality

$$\frac{3x}{x-2} > x$$

Solution:

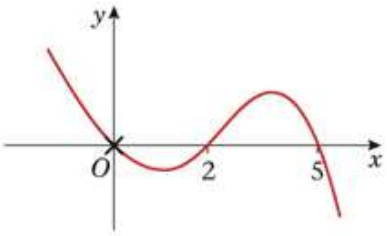
$$\frac{3x}{x-2} \times (x-2)^2 > x(x-2)^2$$

$$x(x-2)[3-(x-2)] > 0$$

$$x(x-2)(5-x) > 0$$

critical values $x = 0, 2, 5$

sketch



Note this is a $-x^3$ curve.

solution is $x < 0$ or $2 < x < 5$

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Exercise A, Question 13

Question:

Solve the following inequality

$$\frac{1+x}{1-x} > \frac{2-x}{2+x}$$

Solution:

$$\frac{1+x}{\cancel{1-x}} \times (1-x)^{\cancel{2}}(2+x)^2 > \frac{2-x}{\cancel{2+x}} \times (1-x)^2(2+x)^{\cancel{2}}$$

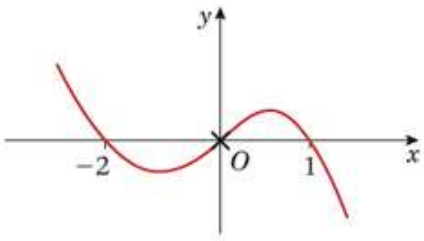
$$(1-x)(2+x)[(1+x)(2+x) - (2-x)(1-x)] > 0$$

$$(1-x)(2+x)(x^2+3x+2-(x^2-3x+2)) > 0$$

$$(1-x)(2+x)6x > 0$$

critical values $x = 1, -2, 0$

sketch



Curve is $y = -x^3$ shape.

solution is $x < -2$ or $0 < x < 1$

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Exercise A, Question 14

Question:

Solve the following inequality

$$\frac{x^2 + 7x + 10}{x + 1} > 2x + 7$$

Solution:

$$\frac{x^2 + 7x + 10}{x + 1} \times (x + 1)^2 > (2x + 7) \times (x + 1)^2$$

$$(x + 1)[x^2 + 7x + 10 - (2x + 7)(x + 1)] > 0$$

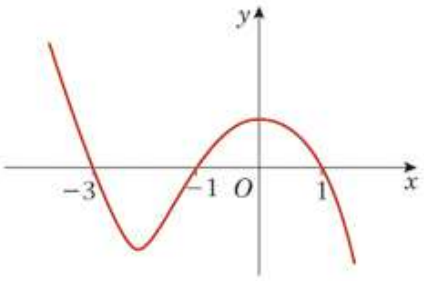
$$(x + 1)[x^2 + 7x + 10 - 2x^2 - 9x - 7] > 0$$

$$(x + 1)(3 - 2x - x^2) > 0$$

$$(x + 1)(1 - x)(x + 3) > 0$$

critical values $x = -1, 1, -3$

sketch



This is $y = -x^3$ shape.

solution is $x < -3$ or $-1 < x < 1$

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Exercise A, Question 15

Question:

Solve the following inequalities

a $\frac{x+1}{x^2} > 6$

b $\frac{x^2}{x+1} > \frac{1}{6}$

Solution:

a $\dfrac{x+1}{x^2} > 6$

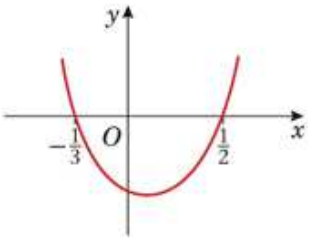
$0 > 6x^2 - x - 1$

You can multiply by x^2 since it is > 0.

$0 > (3x + 1)(2x - 1)$

critical values $x = -\frac{1}{3}, \frac{1}{2}$

sketch



solution is $-\frac{1}{3} < x < \frac{1}{2}$ But $x \neq 0$

or $-\frac{1}{3} < x < 0$ or $0 < x < \frac{1}{2}$

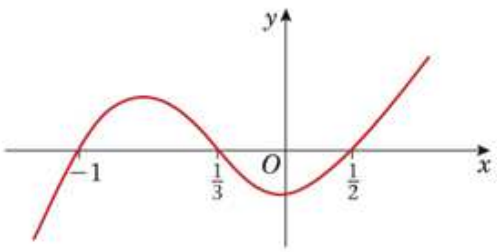
b $\dfrac{x^2}{x+1} \times (x+1)^2 > \frac{1}{6}(x+1)^2$

$(x + 1)[6x^2 - (x + 1)] > 0$

$(x + 1)(3x + 1)(2x - 1) > 0$

critical values $x = -1, \frac{1}{2}, -\frac{1}{3}$

sketch



solution is $-1 < x < -\frac{1}{3}$ or $x > \frac{1}{2}$

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Exercise B, Question 1

Question:

Solve the following inequality

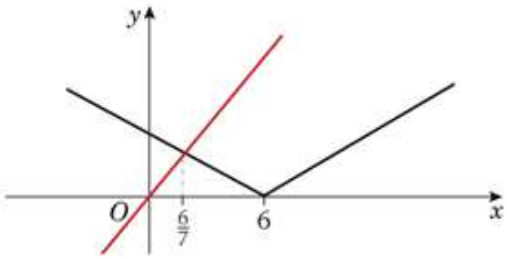
$|x - 6| > 6x$

Solution:

$|x - 6| > 6x$

$$\begin{array}{lll} x - 6 = 6x & \text{or} & -(x - 6) = 6x \\ \Rightarrow \quad -6 = 5x & \Rightarrow & 6 = 7x \\ -1.2 = x & \Rightarrow & \frac{6}{7} = x \end{array}$$

sketch



only $x = \frac{6}{7}$ is valid

solution is $x < \frac{6}{7}$

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Exercise B, Question 2

Question:

Solve the following inequality

$|t - 3| > t^2$

Solution:

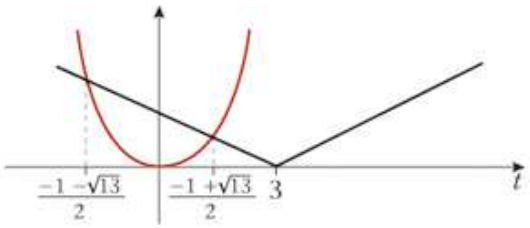
$|t - 3| > t^2$

$t - 3 = t^2$ or $-(t - 3) = t^2$

$\Rightarrow \quad 0 = t^2 - t + 3 \quad \Rightarrow \quad 0 = t^2 + t - 3$

$t =$ no solution $\quad t = \dfrac{-1 \pm \sqrt{1 + 12}}{2}$

sketch



$|t - 3|$ is above t^2 for $\dfrac{-1 - \sqrt{13}}{2} < t < \dfrac{-1 + \sqrt{13}}{2}$

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Exercise B, Question 3

Question:

Solve the following inequality

$|(x - 2)(x + 6)| < 9$

Solution:

$|(x - 2)(x + 6)| < 9$

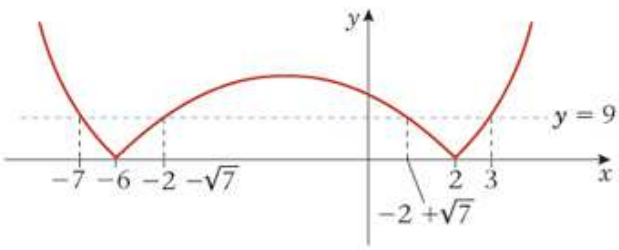
$x^2 + 4x - 12 = 9$ or $-(x^2 + 4x - 12) = 9$

$\Rightarrow \quad x^2 + 4x - 21 = 0$ $\qquad 0 = x^2 + 4x - 3$

$(x - 3)(x + 7) = 0$ $\qquad x = \dfrac{-4 \pm \sqrt{16 + 12}}{2}$

$x = 3$ or -7 $\qquad x = -2 \pm \sqrt{7}$

sketch



Line $y = 9$ is above curve for $-7 < x < -2 - \sqrt{7}$ or $-2 + \sqrt{7} < x < 3$

Solutionbank FP2

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Exercise B, Question 4

Question:

Solve the following inequality

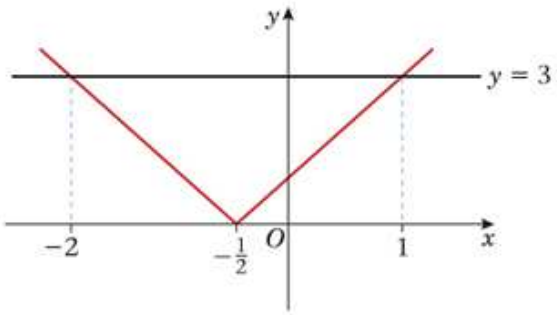
$|2x + 1| \geqslant 3$

Solution:

$|2x + 1| \geqslant 3$

$$\begin{array}{rrcr} & 2x + 1 = 3 & \text{or} & -(2x + 1) = 3 \\ \Rightarrow & 2x = 2 & & -4 = 2x \\ & x = 1 & & -2 = x \end{array}$$

sketch



solution is $y = 3$ is below the V when

$x \leqslant -2$ or $x \geqslant 1$

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Exercise B, Question 5

Question:

Solve the following inequality

$|2x| + x > 3$

Solution:

$|2x| + x > 3$

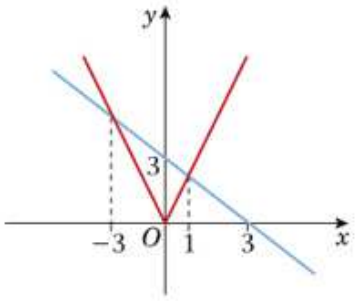
Rearrange: $|2x| > 3 - x$

$2x = 3 - x$ or $-2x = 3 - x$

$\Rightarrow \quad 3x = 3 \qquad -x = 3$

$\Rightarrow \quad x = 1$ or $x = -3$

sketch



$y = 3 - x$ is below V for

$x < -3$ or $x > 1$

Solutionbank FP2

Edexcel AS and A Level Modular Mathematics

Exercise B, Question 6

Question:

Solve the following inequality

$$\frac{x+3}{|x|+1} < 2$$

Solution:

$$\frac{x+3}{|x|+1} < 2$$

Rearrange: $x + 3 < 2|x| + 2$ — Because $|x| + 1$ is positive you can multiply across.

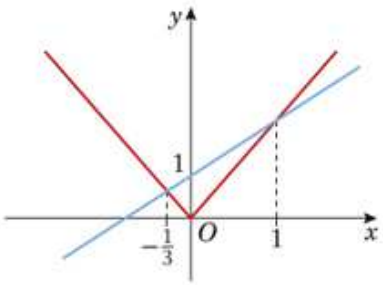
i.e. $x + 1 < 2|x|$

$x + 1 = 2x$ or $x + 1 = -2x$

$\Rightarrow$ $1 = x$ $\Rightarrow$ $3x = -1$

$x = -\frac{1}{3}$

sketch



Line $y = x + 1$ is below V when $x < -\frac{1}{3}$ or $x > 1$

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Exercise B, Question 7

Question:

Solve the following inequality

$$\frac{3-x}{|x|+1} > 2$$

Solution:

$$\frac{3-x}{|x|+1} > 2$$

Rearrange: $3 - x > 2|x| + 2$ — You can multiply by $|x| + 1$ since it is > 0.

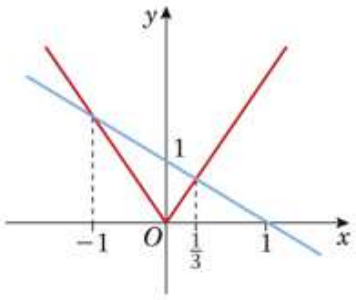
$$1 - x > 2|x|$$

$1 - x = 2x$ or $1 - x = -2x$

$\Rightarrow$ $1 = 3x$ $x = -1$

$\frac{1}{3} = x$

sketch



The line $y = 1 - x$ is above the V for $-1 < x < \frac{1}{3}$

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Exercise B, Question 8

Question:

Solve the following inequality

$$\left|\frac{x}{x+2}\right| < 1 - x$$

Solution:

$$\left|\frac{x}{x+2}\right| < 1 - x$$

$$\frac{x}{x+2} = 1 - x \quad \text{or} \quad -\frac{x}{x+2} = 1 - x$$

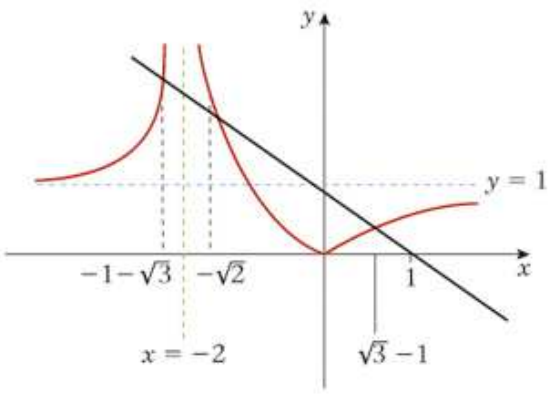
$$\Rightarrow \quad x = (1 - x)(x + 2) \qquad -x = (1 - x)(x + 2)$$

$$x^2 + 2x - 2 = 0 \qquad x^2 - 2 = 0$$

$$x = \frac{-2 \pm \sqrt{12}}{2} \qquad x = \pm\sqrt{2}$$

$$x = -1 \pm \sqrt{3}$$

sketch



NB $x = +\sqrt{2}$ is invalid.

The line $y = 1 - x$ is above the curve for $x < -1 - \sqrt{3}$

or $-\sqrt{2} < x < -1 + \sqrt{3}$

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Exercise B, Question 9

Question:

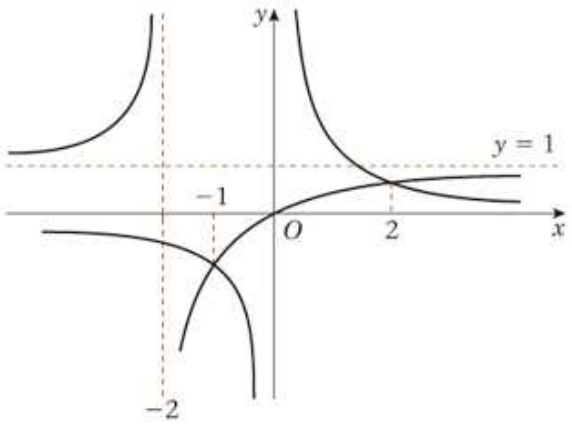
Solve the following inequalities

a On the same axes sketch the graphs of $y = \frac{1}{x}$ and $y = \frac{x}{x+2}$.

b Solve $\frac{1}{x} > \frac{x}{x+2}$.

Solution:

a



b $\frac{1}{x} = \frac{x}{x+2} \quad \Rightarrow \quad x + 2 = x^2$

i.e. $0 = x^2 - x - 2$

$0 = (x - 2)(x + 1)$

$x = 2$ or -1

$\frac{1}{x}$ is above $\frac{x}{x+2}$ for $-2 < x < -1$ or $0 < x < 2$

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Exercise B, Question 10

Question:

Solve the following inequalities

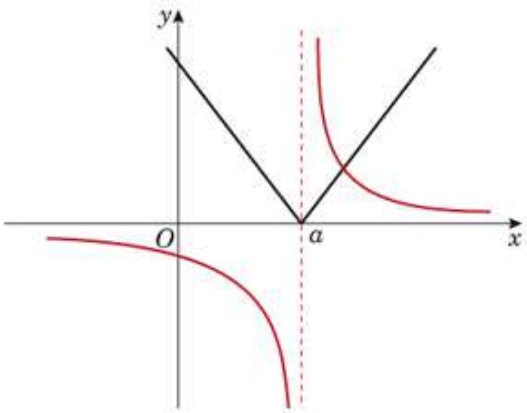
a On the same axes sketch the graphs of $y = \frac{1}{x-a}$ and $y = 4|x-a|$.

b Solve, giving your answers in terms of the constant a, $\frac{1}{x-a} < 4|x-a|$.

Solution:

a

(Assume $a > 0$)



b $\frac{1}{x-a} = 4(x-a)$

Only this case needs to be considered because the right hand branch of V has the intersection.

$\frac{1}{4} = (x-a)^2$

$\pm\frac{1}{2} = x - a$

$x = a \pm \frac{1}{2}$

From sketch $x = a + \frac{1}{2}$.

V is above when $x < a$ or $x > a + \frac{1}{2}$

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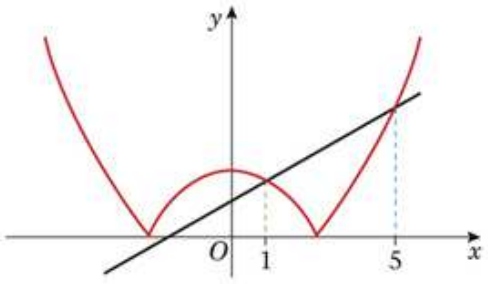
Exercise C, Question 1

Question:

Solve the inequality $|x^2 - 7| < 3(x + 1)$

Solution:

sketch: $|x^2 - 7| < 3(x + 1)$



$x^2 - 7 = 3x + 3$ or $-(x^2 - 7) = 3x + 3$

$\Rightarrow \quad x^2 - 3x - 10 = 0 \quad \Rightarrow \quad 0 = x^2 + 3x - 4$

$(x - 5)(x + 2) = 0 \qquad 0 = (x + 4)(x - 1)$

$x = -2$ or $5 \qquad x = -4$ or 1

From the sketch, only $x = 1$ and $x = 5$ are valid.

Line is above the curve for $1 < x < 5$

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Exercise C, Question 2

Question:

Solve the inequality $\frac{x^2}{|x| + 6} < 1$

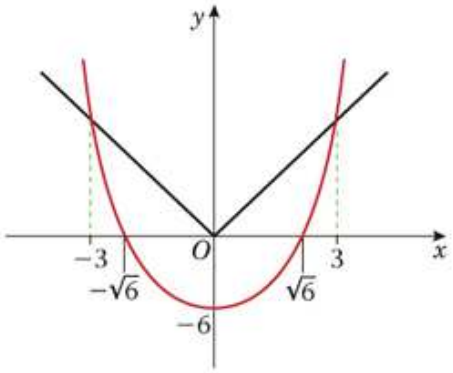
Solution:

$$\frac{x^2}{|x| + 6} < 1$$

Rearrange: $x^2 < |x| + 6$ — Multiply by $|x| + 6$ since it is positive.

or $x^2 - 6 < |x|$

sketch:



	$x^2 - 6 = x$	or	$x^2 - 6 = -x$
$\Rightarrow$	$x^2 - x - 6 = 0$		$x^2 + x - 6 = 0$
	$(x - 3)(x + 2) = 0$		$(x + 3)(x - 2) = 0$
	$x = -2$ or 3		$x = 2$ or -3

From the sketch the intersections are $> \sqrt{6}$ $\therefore x = \pm 3$

Curve is below V for $-3 < x < 3$

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Exercise C, Question 3

Question:

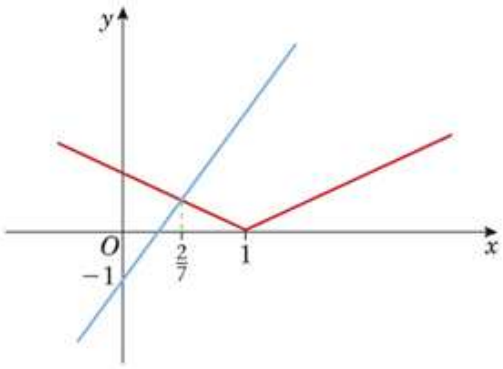
Find the set of values of x for which $|x - 1| > 6x - 1$

Solution:

$|x - 1| > 6x - 1$

	$x - 1 = 6x - 1$	or	$-(x - 1) = 6x - 1$
$\Rightarrow$	$0 = 5x$		$2 = 7x$
$\Rightarrow$	$x = 0$		$\frac{2}{7} = x$

sketch:



$x = 0$ is not valid so only critical value is $x = \frac{2}{7}$

V is above the line for $x < \frac{2}{7}$

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Exercise C, Question 4

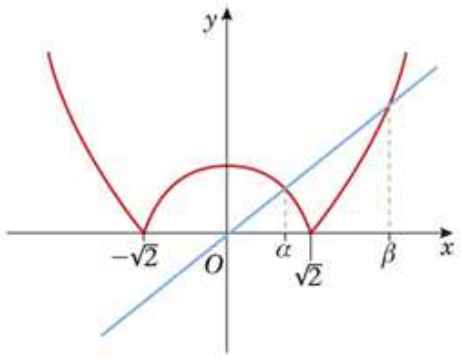
Question:

Find the complete set of values of x for which $|x^2 - 2| > 2x$

Solution:

$|x^2 - 2| > 2x$

sketch:



$x^2 - 2 = 2x$ or $-(x^2 - 2) = 2x$

$\Rightarrow x^2 - 2x - 2 = 0$ $\Rightarrow 0 = x^2 + 2x - 2$

$x = \frac{2 \pm \sqrt{12}}{2}$ $x = \frac{-2 \pm \sqrt{12}}{2}$

$x = 1 \pm \sqrt{3}$ $x = -1 \pm \sqrt{3}$

β is a solution of this equation so must be $1 + \sqrt{3}$

α is a solution of this equation so must be $\sqrt{3} - 1$

The line is below the curve for $x > 1 + \sqrt{3}$ or $x < \sqrt{3} - 1$

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Exercise C, Question 5

Question:

Find the set of values of x for which $\frac{x+1}{2x-3} < \frac{1}{x-3}$

Solution:

$$\frac{x+1}{\cancel{2x-3}} \times (2x-3)^{\cancel{2}}(x-3)^2 < \frac{1}{\cancel{x-3}} \times (2x-3)^2(x-3)^{\cancel{2}}$$

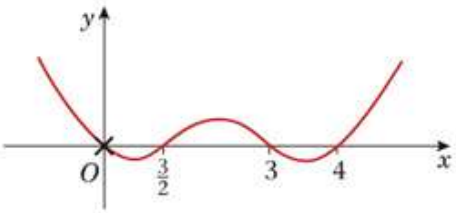
$$(2x-3)(x-3)[(x+1)(x-3)-(2x-3)] < 0$$

$$(2x-3)(x-3)(x^2-2x-\cancel{3}-2x+\cancel{3}) < 0$$

$$(2x-3)(x-3)x(x-4) < 0$$

critical values $x = \frac{3}{2}, 3, 4, 0$

sketch



$0 < x < \frac{3}{2}$ or $3 < x < 4$

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Exercise C, Question 6

Question:

Solve $\frac{(x+3)(x+9)}{x-1} > 3x - 5$

Solution:

$$\frac{(x+3)(x+9)}{\cancel{x-1}} \times (x-1)^{\cancel{2}} > (3x-5) \times (x-1)^2$$

$$(x-1)[x^2 + 12x + 27 - (3x^2 - 8x + 5)] > 0$$

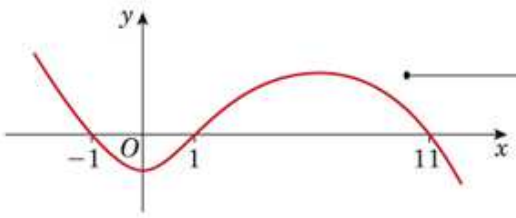
$$(x-1)(22 + 20x - 2x^2) > 0$$

$$(x-1)(11 + 10x - x^2) > 0$$ — Divide by 2.

$$(x-1)(11-x)(1+x) > 0$$

critical values $x = 1, -1, 11$

sketch:



This is a $y = -x^3$ shape.

$x < -1$ or $1 < x < 11$

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Exercise C, Question 7

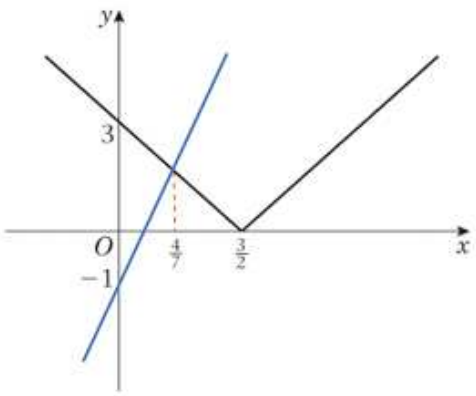
Question:

a Sketch, on the same axes, the graph with equation $y = |2x - 3|$, and the line with equation $y = 5x - 1$

b Solve the inequality $|2x - 3| < 5x - 1$

Solution:

a



b $|2x - 3| < 5x - 1$

$2x - 3 = 5x - 1$ or $-(2x - 3) = 5x - 1$

$\Rightarrow \quad -2 = 3x \qquad\qquad 4 = 7x$

$-\frac{2}{3} = x \qquad\qquad \frac{4}{7} = x$

From sketch this is not valid.

Line is above V for $x > \frac{4}{7}$

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Exercise C, Question 8

Question:

a Use algebra to find the exact solution of $|2x^2 + x - 6| = 6 - 3x$

b On the same diagram, sketch the curve with equation $y = |2x^2 + x - 6|$ and the line with equation $y = 6 - 3x$

c Find the set of values of x for which $|2x^2 + x - 6| > 6 - 3x$

Solution:

a

$2x^2 + x - 6 = 6 - 3x$ or $-(2x^2 + x - 6) = 6 - 3x$

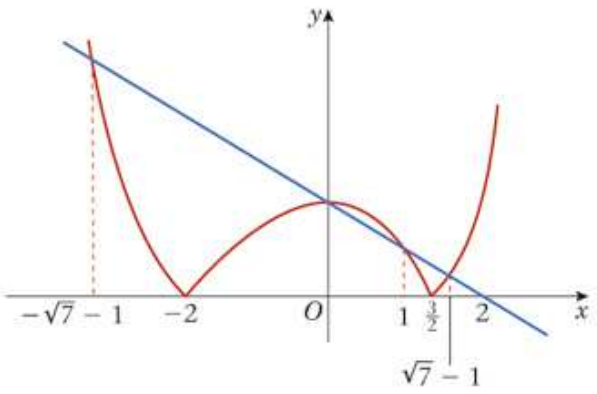
$2x^2 + 4x - 12 = 0$ $0 = 2x^2 - 2x$

$2(x^2 + 2x - 6) = 0$ $0 = 2x(x - 1)$

$x = \dfrac{-2 \pm \sqrt{28}}{2}$ $x = 0$ or 1

$= -1 \pm \sqrt{7}$

b



$2x^2 + x - 6 = 0$

$(2x - 3)(x + 2) = 0$

$x = -2$ or $\frac{3}{2}$

c The line is below the curve for $x > \sqrt{7} - 1$ or $0 < x < 1$ or $x < -\sqrt{7} - 1$

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Exercise C, Question 9

Question:

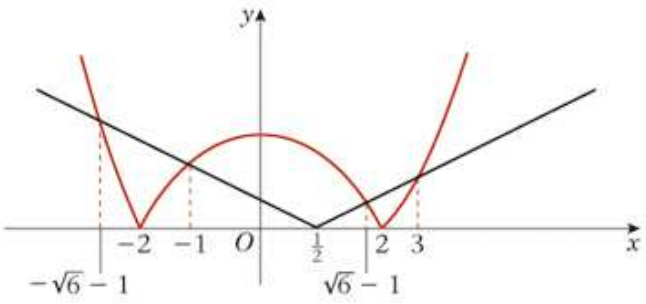
a On the same diagram, sketch the graphs of $y = |x^2 - 4|$ and $y = |2x - 1|$, showing the coordinates of the points where the graphs meet the x-axis.

b Solve $|x^2 - 4| = |2x - 1|$, giving your answers in surd form where appropriate.

c Hence, or otherwise, find the set of values of x for which $|x^2 - 4| > |2x - 1|$

Solution:

a



b

$x^2 - 4 = 2x - 1$ or $x^2 - 4 = -(2x - 1)$

$\Rightarrow x^2 - 2x - 3 = 0$ $\Rightarrow x^2 + 2x - 5 = 0$

$(x - 3)(x + 1) = 0$ $x = \dfrac{-2 \pm \sqrt{24}}{2}$

$x = -1$ or 3 $x = -1 \pm \sqrt{6}$

c V is below the curve for

$|x^2 - 4| > |2x - 1|$

when $x > 3$ or $-1 < x < \sqrt{6} - 1$ or $x < -\sqrt{6} - 1$